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INTRODUCTION

Hydrometric data, a type of water resources data, have a wide variety of uses and users. Basic hydrometric data are essential for the wise management of Canadian water resources and are necessary to regulate resources during times of extreme flows, to develop water for the most beneficial uses, to ensure that each user receives his equitable share and, as well, to achieve these purposes in the most economical manner. This booklet, illustrating the wide variety of uses of hydrometric data, was prepared in response to many enquiries received by the Water Resources Branch, Department of the Environment, over a long period of time.

HISTORY OF HYDROMETRIC DATA COLLECTION

The hydrometric data collection program initiated by the federal government in 1894 has gradually, but significantly, expanded. By 1975, through federal-provincial agreements, the government of Canada was collecting data at more than 2300 locations on rivers and lakes in most of Canada; only Quebec, among the provinces, conducts its own program.

The growth of hydroelectric generation as a prime user of water at the turn of the century was among the first events that accentuated the need for reliable data on a continuous basis. Large-scale irrigation in the West was another factor. Also the Boundary Waters Treaty of 1909 with the United States necessitated constant monitoring of flows at the International Boundary. As more uses for water developed, the need increased for more water resources data to ensure that man-made dams and other water resources structures would be safe, economical and in accord with statutory regulations.

TYPES AND CATEGORIES OF HYDROMETRIC DATA

In this booklet, the following types of observations are included in the term hydrometric data:

1) streamflow and water level data involving water levels, water discharges, water temperatures, water depths and river widths, water velocities,
2) sediment data including sediment concentrations, particle sizes, sediment loads, river channel deformation, and
3) other related data concerning ice thickness, duration of ice cover, time-of-travel, water equivalent of snow pack, glacier changes.

All of these data may be categorized according to three different time frames.

Historic or Archival Data

This category implies that there is no immediacy for the use of the data, which normally have been collected for a long period of time. These data are very important because accumulated data can be used statistically to provide such parameters as averages and percentage of the time that certain conditions may be expected to prevail. For example, the water level in a specific reach of river has, on the average, exceeded x feet once every 10 years. Another example would be data for a particular location at a specified point in time for use in litigation. These data form the basis of sound engineering design of water resources developments.

Present or Real Time Data

Technologists speak of real time in relation to earth satellites and telemetry of data. This category of data is for immediate use, such as in operating a structure or system and in sharing the quantity of water available. A detailed example is provided later with respect to the flow over Niagara Falls.

Forecast Data

This category could be called data in advance, i.e., forecasts of hydrologic events. The value of forecasts of floods is self-evident, but forecasts of low flows in navigation channels and of seasonal supply for irrigation and power production are also important and are being provided.

METHODS OF DATA COLLECTION

Water levels are the basic measurement from which several other quantities are derived. Levels are recorded on automatic equipment or are observed on a simple manual gauge and recorded by an observer.

Discharges are calculated from observations of depths, velocities and widths at various locations across a stream by people in boats or on bridges or cableways or wading in the stream. These measurements must be taken by people. The only automatic equipment available to make a total discharge measurement is still very much in the experimental stage. Separate items of equipment are available for observation of depths and velocities.

Discrete water temperatures are usually observed at the same time a discharge measurement is taken; recording thermographs, however, are available.

Ice thickness and duration information is a by-product of winter discharge measurements.

Time-of-travel of water from one location to another is measured by the observation of tracers injected into the stream or by the analysis of past records, if available.

The water equivalent of a snow pack is estimated by weighing samples of snow extracted by a special sample tube.

Sediment data are acquired by sampling water and river-bed material with scientifically designed equipment.

River channel deformations are observed with sounding equipment used for taking sediment and discharge measurements.

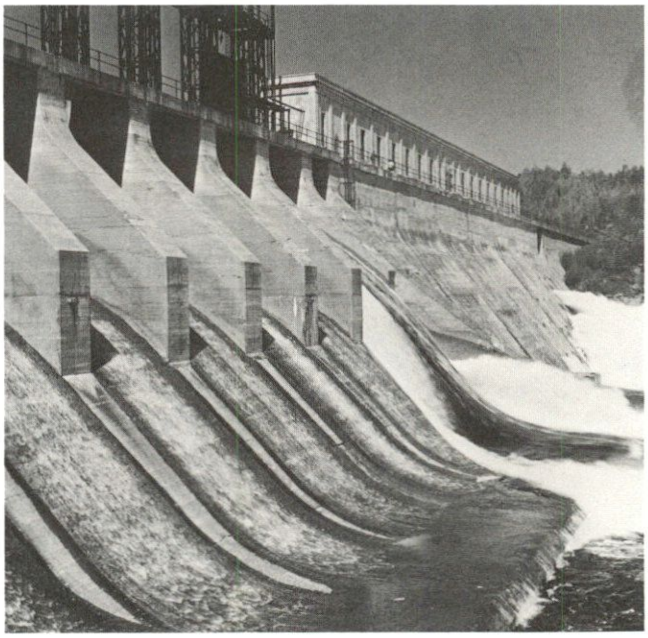
Glacier changes are measured with the use of photography and land survey procedures.

WATER DATA USERS AND USES

In this section, three detailed examples of data uses, as well as synoptic examples, are given. The simple, but detailed, illustrations should be particularly helpful to students and other readers who have little or no familiarity with water resources development projects.

The engineer, attempting to forecast the amount of flood waters expected in a forthcoming spring runoff period, would be seriously handicapped without knowledge of the floods of former years in the area. If a large spring flow is expected and the river basin has ample reservoir storage available, the engineer would probably request that reservoirs be lowered as much as possible in advance of the high flows to temper the flood threat. If a less than average spring flow is anticipated, instead of draining the reservoir, possibly some attempt might even be made to increase the amount in storage to ensure a sufficient supply later in the fall and winter when there is little or no inflow to the reservoir. If there is no reservoir capacity or other means to take up some of the flood flows, the engineer's measures to control the flood would be limited. Nevertheless, on the basis of data available and other factors, including estimations of the rate of snowmelt, he could provide a warning to persons in the path of the flood and indicate the probable flood level so that sandbagging could be placed high enough to keep the flooding river within bounds.

There are numerous instances where equitable sharing of flow is required; one example is the cascading waters of Niagara Falls. Above the Falls, water is drawn out of the river by United States and Canadian power producers, who, if given the opportunity, could efficiently use all of the flow. At the Falls, however, the scenic value is so great that Canada and the United States have an agreement, based on the Boundary Waters Treaty of 1909 and the Niagara Diversion Treaty signed in 1950. It ensures a flow of 100,000 cubic feet per second (cfs) over the Falls during daylight hours, and at least 50,000 cfs during night hours in the tourist season.



Hydroelectric power

Without flow data, this agreement could not be enforced with any assurance, nor could the sharing of water for power production between Canada and the United States be equitable.

During the construction of a dam and the consequent formation of a reservoir, it is conceivable that the dam could be built without sufficient knowledge of the volume of water that it was to hold back. If the volume to be stored was much less than expected, such a reservoir would be considered "over designed" and would have entailed far more expense than was necessary. If the volume to be stored was greater than expected, not only would the dam be inadequate but also it is probable that the reservoir spillway could not release the stored water rapidly enough, and it is possible that failure of the dam itself could occur, with serious repercussions as a massive wall of water hurtled downstream.

These examples have illustrated instances where water resources data are imperative if certain goals are to be achieved. It is not the intent of this booklet to cover all such instances in detail.

A list, divided into categories illustrating many of the other uses for which data are required and also some of the users, follows.

Water Level Data

1) Insurance companies ask for water levels at specific sites to help ascertain the risk of flooding of a subject piece of real estate.

Flood

2) Municipalities prone to flooding (portions of Ottawa on the Rideau River, and Medicine Hat on the South Saskatchewan River) need to know historic maximum and minimum levels as well as forecast levels, if available, for flood protection and prevention and, in some cases, for land use zoning.

3) Fishermen, oil companies, canoeists, lumber companies, real estate agents and cottage owners all request data on water levels.

4) Water levels are extremely important to people designing or operating municipal water intakes.

5) Lawyers frequently request certified water level recorder charts and have subpoenaed Water Survey of Canada personnel as expert witnesses to appear in court in connection with litigation over water levels being controlled at too high or too low a level. The lowering of Lake Athabasca by the Portage Mountain (W.A.C. Bennett) Dam on the Peace River is such a case.

6) Historic water levels have been used in at least one instance to assess the position of the ancient shoreline on Lake Michigan to locate the best site to begin some archaeological explorations. The same information was used in court to settle a dispute over the boundaries of two adjacent properties, which were described originally as they related to the shoreline.

Water supply

7) Water levels are of fundamental importance in the design of dyking systems, e.g., the extensive Fraser River dyking system.

8) Point Pelee farm damage, resulting from a storm over Lake Erie on November 14, 1972, and severe shoreline erosion on the north shore of Lake Ontario in 1972, were problems directly related to water levels and for which data were requested for comparison with normal conditions and past high water levels.

9) Knowledge of water levels and corresponding volumes in reservoirs is frequently needed. For example, levels on all the reservoirs on the Frenchman River system in southern Saskatchewan are recorded because the river crosses the international boundary and is controlled according to the terms of an International Joint Commission Order involving the Milk and St. Mary rivers.

Irrigation

Water Discharge Data

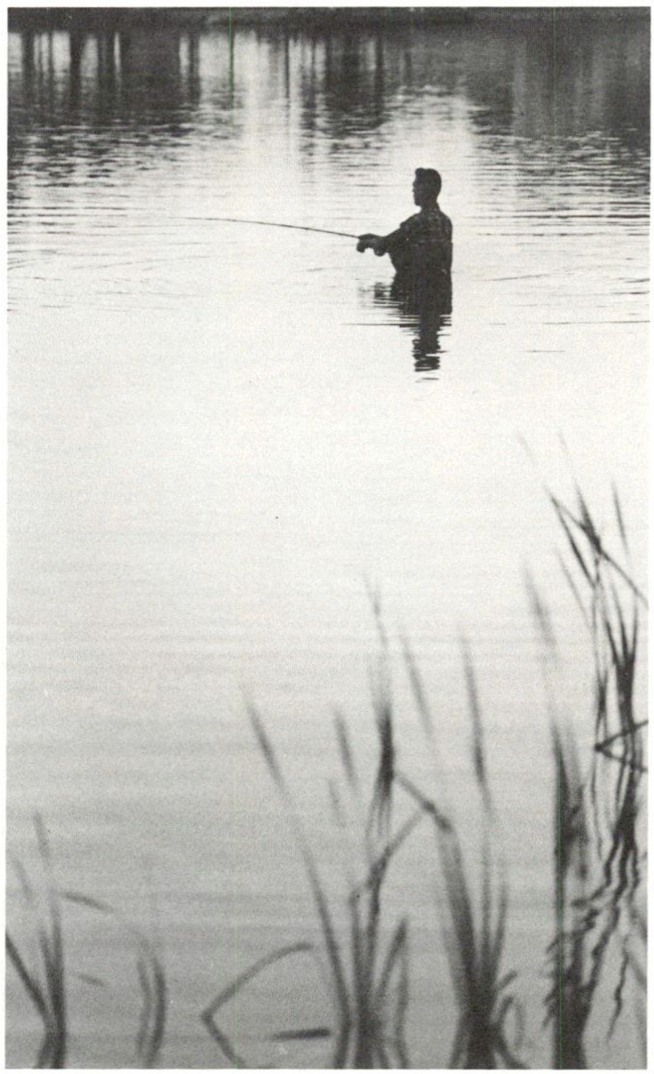
1) Water discharge data are essential in the design of every structure that impounds or diverts water. Average discharge figures are needed to determine the feasibility of the project, maximum discharge figures are necessary to ensure the safety of the structure without incurring needlessly high costs, and low flow figures are needed to determine the amount of storage needed to meet the intended purpose. The frequency and sequence of occurrence of any value of discharge are very important aspects.

2) The consultants designing culverts under the Mackenzie Highway requested data on high flows to be expected each spring in the numerous small streams crossing the proposed highway route. They wanted to ensure that the culverts were large enough to carry the flows without excessive velocities, which would hinder fish from migrating upstream.

3) Low flow information is often critical for municipalities and industries. For example, the potash industry in Saskatchewan required data on low flows, particularly in intermittent streams, during its establishment.

4) Low flows for the year in many Canadian streams occur under ice cover when the water has a low dissolved oxygen content and are, therefore, important from a quality standpoint. Municipalities are frequent users of low flow data.

5) The Water Survey of Canada measures the quantity of water diverted to some irrigation projects in southern Alberta. This is the basis on which the Province charges the operators for the water.



Conservation

Recreation

Water Temperatures

1) Water temperatures are requested by departments of health and by people concerned with fisheries, both on federal and provincial levels. The data are also important in environmental impact studies. Two specific requests received involved the evaluation of the long-term impact of a thermal electric generating plant and of timber-cutting operations along river banks.

Water Level, Depth, Channel Changes

1) Shipping companies, such as the Northern Transportation Company on the Mackenzie River, need to know water levels on a continuing basis and preferably in advance during the shipping season to load ships and barges to the maximum draft without danger of grounding.
2) Water levels are used to establish the datum to which water depths are related on navigational charts.
3) Plots of stream cross sections at the measuring sites are requested by pipeline companies and departments of highways. The information to plot cross sections must be obtained from original field notes.

Water Level, Depth, Velocity

1) Several provincial departments of highways regularly request water level, depth and velocity information for the design of bridge piers and abutments.
2) Water levels, depths and channel widths are used as a basis for designing and calculating rock cuts and dredging in navigable waterways.

Sediment Concentrations, Particle Sizes and Loads

1) Data on sediment concentrations and loads are also in great demand. Since sediment information is a very good indicator of the undesirable consequences of development in a basin, background or pre-development information is often requested so that comparisons can be made of conditions before, during and after development. The shelved Pickering Airport development is an example of such a case.
2) Other reasons for collecting sediment data are
   a) to assess the reduction of reservoir capacity (information needed before construction),
   b) to determine the reduction of canal capacity (information needed before construction),
   c) because sediment particles are vehicles for carrying toxic pollutants in streams (this is an area of co-operation with other agencies),
   d) to assess the disposition of sediment when natural stream conditions are altered:
      i) water diverted into canals could damage canals and crop land,
      ii) dyking prevents bank overflow, but may cause new downstream problems because the sediment that would have settled out on the flooded lands will eventually be deposited in the channel downstream, increasing the risk of bank overflow at that location. In some severe cases the stream bed has been raised in this manner and artificially contained within dykes well above the elevation of surrounding land, creating a potentially disastrous situation.

iii) upstream dams reduce flood peaks, thus reducing sediment flushing action causing gradual buildup of stream beds, thereby increasing potential flood hazards, completing a vicious circle,

e) to evaluate the fouling of municipal water supply systems (consideration in design and operation),

f) to assess the effects on power generation — wear on turbines and penstocks,

g) to determine the effects on fish spawning grounds and other aquatic organisms, and

h) to help determine the degree of land erosion.

Ice Thickness and Duration of Ice Cover

1) Approximate ice thickness data, a by-product of winter discharge measurements, are requested by fishermen, logging companies, pipeline companies and people planning transportation services across large lakes or rivers in the winter.

Time-of-Travel

1) This information is being requested more frequently. One example was a request by the City of North Battleford, Saskatchewan, which suspected that municipal and industrial wastes from the City of Edmonton, 300 miles upstream, were affecting the quality of its water supply in the winter. The time-of-travel between the two cities was requested. Observations were also made recently on the Qu'Appelle River for environmental impact assessment studies.

2) Time-of-travel for water to flow from one location to another at various stream levels is very important in routing streamflows in forecasting equations. Time-of-travel information is also used in formulating contingency plans in the event of an accidental contamination of a stream. This information is helpful in determining the extent of the effects of pollution loading, resulting from inflows of municipal sewage and industrial wastes. Although a few time-of-travel studies have been made by direct field measurement using tracer dyes, more frequently the point velocity data available from streamflow measurements are used to estimate the information needed.

Water Equivalent — Snow Packs

1) Snow-pack water equivalent is used by both the Water Resources Branch and provincial agencies to provide an indication of potential floods and to estimate seasonal water supplies.

Glacier Changes

1) Surveys are made every two years to determine changes in volume of a few selected glaciers in western Canada in an attempt to determine long-term trends in runoff patterns in the area.

SUMMARY

Most of the uses mentioned are related to private agencies or provincial governments. In addition, there is a very large demand for hydrometric data from other elements within Environment Canada, particularly for use in environmental impact assessment studies, and considerable demand from some other federal government departments, the International Joint Commission and regulatory agencies, such as the Lake of the Woods Control Board.

The Water Survey of Canada, a Division of the Water Resources Branch, Environment Canada, is the largest collector of hydrometric data in Canada. All of the data categorized in this booklet are available from the Water Resources Branch. Some of the information, such as daily discharges, are provided on magnetic tape. Indexes, daily discharges, water levels, snow survey data, sediment data and data about glaciers are available in published form. The remainder of the data, although not in published form, may be obtained from the files of any of the seven District Offices of the Water Survey of Canada or at Headquarters. Contact may be made at this address:

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