REPORT OF THE

INTERNATIONAL JOINT COMMISSION

UNITED STATES AND CANADA

on the

POLLUTION OF RAINY RIVER AND LAKE OF THE WOODS

WASHINGTON - OTTAWA

February 1965

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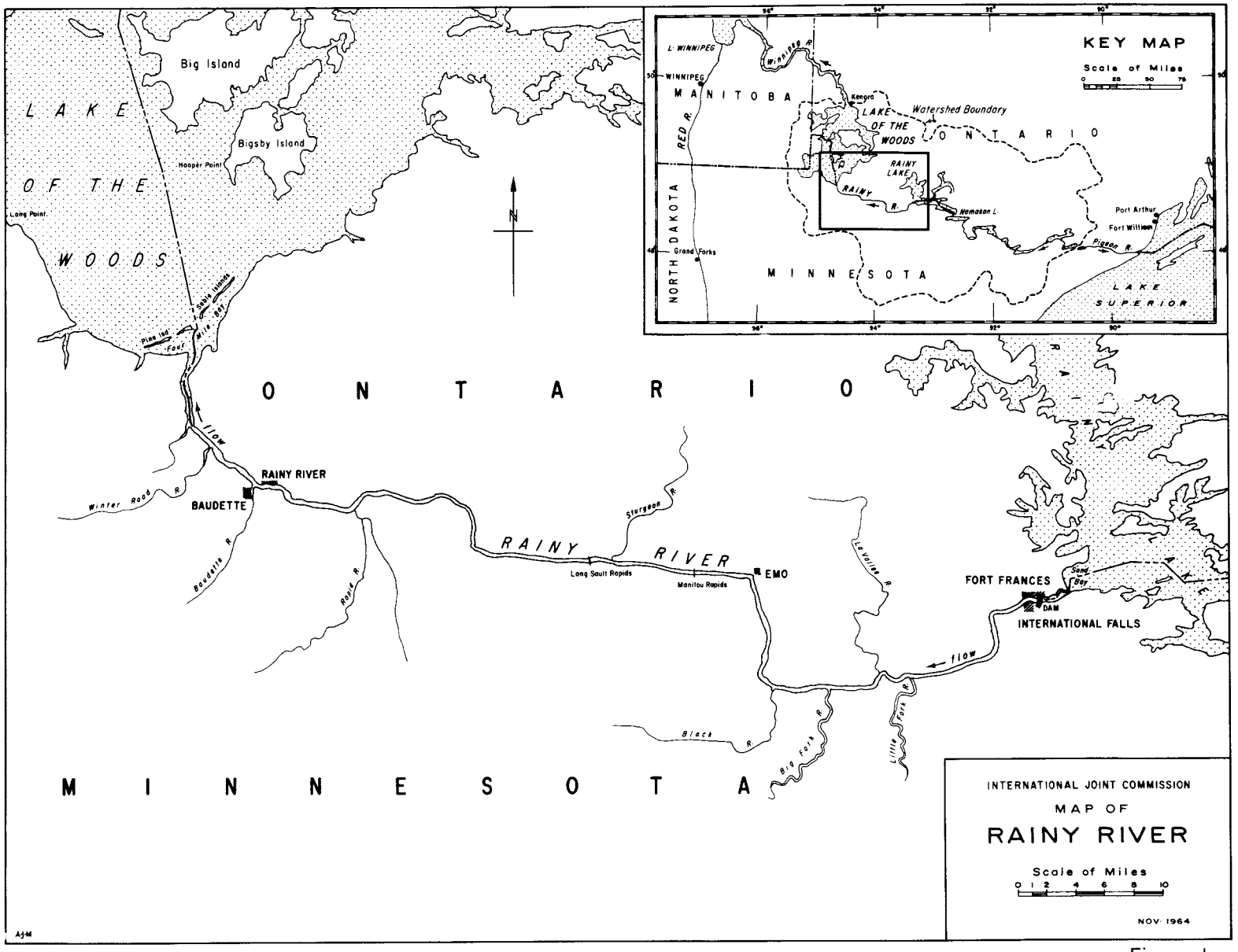
KEY MAP
Scale of Miles
L. WINNIPEG
WINNIPEG
MANITOBA
Kenora
LAKE OF THE WOODS
Watershed Boundary
ONTARIO
RED R.
RAINY LAKE
RAINY R.
Namakan L.
Port Arthur
Fort William
Pigeon R.
NORTH DAKOTA
Grand Forks
MINNESOTA
LAKE SUPERIOR
LAKE OF THE WOODS
Big Island
Bigsby Island
Hooper Point
Long Point
Pine Isl.
Four Mile Isl.
Sable Islands
ONTARIO
flow
RAINY RIVER
BAUDETTE
Winter Road R.
Sturgeon R.
Bordelais R.
Rapid R.
RAINY RIVER
Long Sault Rapids
Manitou Rapids
EMO
Lavallee R.
FORT FRANCES
Sand Bay
DAM
INTERNATIONAL FALLS
flow
Black R.
Big Fork R.
Little Fork R.
MINNESOTA
INTERNATIONAL JOINT COMMISSION
MAP OF
RAINY RIVER
Scale of Miles
NOV. 1964
AJM

Figure 1

Letter of Transmittal

The following letter was sent to the Secretary of State, Washington, D.C., by the secretary of the United States Section of the International Joint Commission and to the Secretary of State for External Affairs, Ottawa, Canada, by the secretary of the Canadian Section of the International Joint Commission:

March 12, 1965

Sir,

I have the honour to transmit to you the "Report of the International Joint Commission on the Pollution of Rainy River and Lake of the Woods" dated February 24, 1965.

Under the reference of May 30, 1959, the Commission was requested by the Governments of Canada and the United States to inquire into and report upon the pollution of Rainy River and Lake of the Woods. A copy of the report of the Advisory Board dated October 1964 is attached.

Yours sincerely,

D. G. Chance,
Secretary,
Canadian Section.

W. W. Bullard,
Secretary,
United States Section.

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Report of the
INTERNATIONAL JOINT COMMISSION

On May 30, 1959 the Prime Minister, for the Government of Canada, and the Secretary of State, for the Government of the United States, sent the following Reference to the International Joint Commission through identical letters addressed respectively to the Canadian and United States Sections of the Commission:

"I have the honour to advise you that the Governments of the United States and Canada have been informed that the waters of the Rainy River and the Lake of the Woods are being polluted by sewage and industrial wastes emptied into these waters. Having in mind the provisions of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side, the two Governments have agreed upon a joint Reference of the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The Commission is requested to inquire into and to report to the two Governments upon the following questions:

(1) Are the waters referred to in the preceding paragraph, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?

(2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgment, be most practicable from the economic, sanitary and other points of view?

(4) If the Commission should find that the construction or maintenance of remedial or preventive works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location, and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.

"For the purpose of assisting the Commission in making the investigation and recommendations provided for in this Reference, the two Governments will, upon request, make available to the Commission the services of engineers and other specially qualified personnel of their governmental agencies, and such information and technical data as may have been acquired by such agencies or as may be acquired by them during the course of the investigation.

"The Commission should submit its report and recommendations to the two Governments as soon as practicable."

APPOINTMENT OF ADVISORY BOARD

Following receipt of the Reference, the Commission on October 8, 1959 appointed an Advisory Board, comprised of four members from each country to carry out the necessary technical investigations and studies.

As presently constituted the Advisory Board consists of:

Canadian Section W. R. Edmonds, Chief, Public Health Engineering Division, Department of National Health and Welfare, Chairman;

R. E. Tait, Senior Chemical Engineer, Public Health Engineering Division, Department of National Health and Welfare;

G. M. Galimbert, Assistant General Manager, Ontario Water Resources Commission; and,

F. A. Voege, Director of Laboratories, Ontario Water Resources Commission.

United States Section L. F. Warrick, Technical Services Consultant, Division of Water Supply and Pollution Control, Public Health Service, Department of Health, Education and Welfare, Chairman;

H. C. Clare, Regional Program Director, Water Supply and Pollution Control, Public Health Service, Department of Health, Education and Welfare;

L. H. Smith, Executive Engineer, Minnesota Water Pollution Control Commission; and,

S. A. Frellsen, Director, Division of Waters, Minnesota Department of Conservation.

Previous members were:

J. R. Menzies (Chairman), formerly Chief, Public Health Engineering Division, Department of National Health and Welfare (deceased), of the Canadian Section;

A. E. Berry, formerly General Manager and Chief Engineer, Ontario Water Resources Commission (retired), of the Canadian Section; and,

H. G. Rogers, formerly Executive Engineer, Minnesota Water Pollution Control Commission (deceased), of the United States Section.

DESCRIPTION OF THE AREA

The Rainy River and Lake of the Woods are boundary waters located in western Ontario and north central Minnesota. Rainy River links Rainy Lake and the Namakan Chain of Lakes with Lake of the Woods. Figure 1 is a map of the area.

This report is confined to the Rainy River and that portion of Lake of the Woods south of a line drawn between Long Point, Minnesota and Hooper Point on Bigsby Island, Ontario.

Rainy River drains an area of 20,850 square miles, divided almost equally between Ontario and Minnesota. Two-thirds of the watershed lies above the outlet of Rainy Lake.

The average discharge from Rainy Lake into the Rainy River is 8,000 cfs (cubic feet per second); however, twenty percent of the time the flow is less than 5,000 cfs. At the mouth of Rainy River the average flow is over 10,000 cfs.

The outflow from Rainy Lake is controlled by the Minnesota and Ontario Paper Company at a dam at International Falls, subject to the terms of an Order issued by the International Joint Commission dated June 8, 1949 which prescribes the levels to be maintained on Rainy Lake. The outflows reflect the operation of the dam to achieve the lake levels prescribed in the Commission's Order. During periods of low water supply when the paper mill is operating only five days a week, the discharge from Rainy Lake on weekends is less than half of the weekly mean.

Rainy River is about 86 miles long with an average width of 600 feet. It has few meanders. The mid-channel depth varies from 10 to 20 feet. The average water surface gradient between Fort Francis and Baudette is one and a half inches per mile except at Manitou and Long Sault Rapids. Below Baudette the drop is one inch per mile. The result is a slow to sluggish current. Generally rounded, smooth, grass-covered banks abruptly rise 25 to 35 feet on both sides of the stream. The river has a narrow flood plain.

The southern portion of Lake of the Woods is shallow, generally free from islands and bounded by low, sandy or marshy shores with gently curving outlines.

The predominant industry in the area is the manufacture of pulp, paper and associated products, and related operations. The paper plant at International Falls is owned by Minnesota and Ontario Paper Company.[1] The plant at Fort

[1] Subsequent to the completion of the investigation, Minnesota and Ontario Paper Company merged with Boise Cascade Corporation and will operate as a division of that Corporation.

Frances is owned by Ontario and Minnesota Paper Company Limited, a wholly owned subsidiary of Minnesota and Ontario Paper Company. The manufacturing processes at both plants are integrated to such an extent that they operate in effect as one mill. The production of pulp is based on the groundwood, sulphite and kraft processes. In 1961 the average wood consumption was approximately 1,530 cords per day. At that time the average daily production was 730 tons of paper and 710 tons of insulite board and about 670 persons were employed at Fort Frances and 2,200 at International Falls.

Agriculture is the second most important industry with some 2,235 farms in the Rainy River drainage basin. Approximately 213,500 acres in Minnesota and 90,300 acres in Ontario are cultivated. Livestock is of prime importance on most farms. The principal crops are hay, grain and potatoes. Many farmers supplement their incomes by cutting pulpwood or timber during winter months.

Recreational facilities have been developed along the Minnesota side of the river between Baudette and Lake of the Woods.

According to the 1960 census, approximately 47,000 persons live in the watershed. About 9,500 reside in Fort Frances, 9,300 in International Falls and South International Falls, 1,100 in Rainy River, Ontario and 1,600 in Baudette, Minnesota. Fifty-eight percent of the population is rural.

THE INVESTIGATION

Field investigations pursuant to the Reference and under the general direction of the Commission were carried out by the Advisory Board in the summers of 1960, 1961 and 1962 and in January 1962 with personnel from the United States Public Health Service, the Canadian Department of National Health and Welfare, the Ontario Water Resources Commission and the Minnesota Department of Health. The facilities used included a complete mobile bacteriological laboratory, a trailer laboratory and the main chemical laboratory in the International Falls sewage treatment plant. Field studies included: analysis of water samples taken from Rainy River and its tributaries and portions of Rainy Lake and Lake of the Woods; float tests for determining the direction of currents; visual and microscopic investigation of water and benthalogical samples; and investigation of the sources of waste. Water samples were analysed for coliform organisms, pH (hydrogen ion concentration), temperature, dissolved oxygen, biochemical oxygen demand, turbidity, solids (total, suspended and volatile), lignin, chemical oxygen demand, phenol, calcium, alkalinity, conductivity and hardness. The analytical procedures conformed to standard methods. Bottom samples were examined for bark, ships, fibres and types of soil.

The Advisory Board established 89 sampling points at 17 cross-sections distributed throughout the whole length of Rainy River, 10 sampling points on the tributaries of the Rainy River, 22 sampling points in Rainy Lake near its outlet and 23 in Lake of the Woods. In addition waste surveys were made at both pulp and paper plants. These surveys consisted of sampling and measuring the flow in each of the 18 major sewer outlets for continuous periods up to seven days. The samples were held and composited at each outlet at the end of each shift. During the course of the survey over 3,300 bacterial examinations and 26,200 chemical determinations were made.

Biological and fishery studies were carried out in the summer of 1962 by the Minnesota Department of Conservation under contract with the United States Public Health Service. The effect of wood fibres on various phases of fish development in Rainy River was also studied.

The Advisory Board submitted to the Commission nine semi-annual progress reports, one summary report for the Hearing and a final report dated October 1964. A special report accompanying the progress report of April 1963 described in detail all phases of the investigation.

The Commissioners carried out an inspection of the Rainy River area, the two paper plants and the sewage treatment works at International Falls in August 1960 and again in September 1962.

A Public Hearing was held by the Commission at International Falls on August 28, 1963 to obtain further information on the extent, causes and effects of pollution in the Rainy River and to obtain the views of the interested parties. The Commission heard the testimony of state and provincial officials, civic representatives from International Falls, Fort Frances, Rainy River and Baudette, delegates from community associations, resort owners, representatives from mill unions, the president, officers and consultants of the Minnesota and Ontario Paper Company, and private individuals. Subsequent briefs were also studied by the Commission.

FINDINGS

After considering the results of the investigation, the evidence presented at the Public Hearing and subsequent briefs, the Commission arrived at the series of findings outlined below.

1. Multiple Uses of Rainy River

(a) *Domestic Water Supply:* Three communities obtain their domestic water supply from Rainy River. International Falls and South International Falls procure processed water from Minnesota and Ontario Paper Company's modern purification plant just above the International Bridge. The town of Rainy River obtains its domestic supply from the river. The only treatment given is chlorination. The estimated high cost of constructing and operating a suitable filtration plant forced Baudette to change its source of water supply from Rainy River to a "hard water" well.

(b) *Industrial Water Supply:* The pulp and paper mills at Fort Frances and International Falls use 83 million U.S. gallons (69 million Imperial gallons) per day, Minnesota and Ontario Paper Company has capacity to use up to 10,500 cfs for the generation of power at International Falls.

(c) *Domestic Sewage Disposal:* Sanitary sewage from four of the five sewered communities is discharged to Rainy River for final disposal. International Falls has secondary treatment facilities. Baudette provides primary treatment. The town of Rainy River has only sedimentation facilities. Fort Frances completed the construction of primary treatment works subsequent to the investigation. The fifth community, South International Falls, discharges its effluent into Rainy Lake.

(d) *Industrial Waste Disposal:* Industrial waste and sewage from the pulp and paper mills are discharged directly into Rainy River. Facilities to permit diversion of all domestic sewage from the paper mills to municipal systems are now under construction.

(e) *Recreation:* Most of the recreational developments are located in the section of Rainy River adjacent to Lake of the Woods. This resort area attracts those interested in fishing and boating. In 1959 vacationers spent an estimated $480,000 in this area.

2. Transboundary Movement

The currents of Rainy River cross and recross the international boundary. Observations on the movement of 72 floats released in the upper reaches of the river established the transboundary movement of these waters. Conductivity studies confirmed the results of the float tests. The constituents in these waters are thoroughly mixed at Manitou and Long Sault Rapids, about 30 miles downstream from International Falls.

3. Extent of Pollution

The quality of the waters under reference, after receiving domestic and industrial wastes, is discussed hereunder in relation to five indicators: coliform concentration, biochemical oxygen demand, dissolved oxygen, suspended solids and lignin. A detailed graphical presentation of the extent of pollution is found in Figures 2 to 6.

(a) *Coliform Concentration:* The coliform group of bacteria is used as an indicator group because these bacteria are the normal inhabitants of the intestines. The coliform group when found in water indicates that the water may have been contaminated with human or animal excreta. Fecal material contains a large number of coliform bacteria which are usually associated with the pathogenic group, a class of bacteria harmful to man. It would be impracticable to examine each water sample for all known pathogens since each identification would require a separate analysis. Hence, if the coliform group is present, it is assumed that the pathogens which represent a public health hazard are also present.

Raw sewage contains 10 to 25 million coliform organisms per 100 ml (millilitres). The median coliform count was less than 35 per 100 ml in Rainy Lake above the known sources of pollution. The word median in the term "median coliform count" is used to designate that value which is so related to the other values in a given set of samples that exactly as many values exceed it as fall short of it. An average value is the arithmetic mean of a number of samples.

Three miles above the dam at International Falls at the outlet from Rainy Lake, the median coliform count in Rainy River varied from 8 to 44 per 100 ml. Immediately below Fort Frances near the Ontario shore the coliform count ranged up to 147,000 per 100 ml. The median count in 1960 was 47,000. About a mile below International Falls near the Minnesota shore the median coliform count was 66,000; near the Ontario shore, 3,900. The median coliform concentration remained high for the next twelve miles downstream. Twelve miles below International Falls it varied from 7,200 to 15,000 per 100 ml. This is at least four hundred times greater than the count above the dam. Ten miles below Long Sault Rapids the median coliform count ranged between 4,600 and 6,700 per 100 ml. The concentration of coliform bacteria gradually decreased as the water progressed downstream. Near Baudette, in 1961 the median coliform count was 2,000 per 100 ml. In Lake of the Woods the average coliform count was only 7 per 100 ml.

(b) *Biochemical Oxygen Demand:* Aerobic decomposition of organic matter requires oxygen. The amount of decomposible matter contained in the water can be estimated by determining the amount and rate of oxygen utilization. This determination is called the biochemical oxygen demand or BOD and is the amount of oxygen consumed over a 5-day period at a constant temperature of 20°C. A British Royal Commission on sewage disposal to river systems suggested with respect to BOD levels, the following river classification based on the standard 5-day BOD test: BOD-1 ppm "very clean", 2 ppm "clean", 5 ppm "doubtful", and 10 ppm "bad". One ppm (part per million) is equal to one mg/l (milligram per litre).

At the outlet from Rainy Lake the BOD varied from 0.9 to 2.6 mg/l. Near the Ontario shore immediately below Fort Frances the BOD increased to 6.1 mg/l. About a mile below the mill at International Falls the average BOD near the Minnesota shore was 15.8 mg/l, in the middle of the river 3.5 mg/l, and near the Ontario shore 3.4 mg/l. Twelve miles below the pulp and paper plants the BOD varied from 4.0 to 7.4 mg/l—four times greater than the concentration above the dam. Ten miles below Long Sault Rapids biological stabilization reduced the BOD to 2.0 mg/l. In the Baudette-Rainy River area a slight increase in BOD was noted. In Lake of the Woods the average BOD was 1.7 mg/l.

(c) *Dissolved Oxygen:* A drop in the dissolved oxygen content indicates the presence of organic pollution. The point of maximum de-oxygenation may be

some distance down river from the point of pollution, because the de-oxygenation of water by industrial wastes and sewage is a comparatively slow process. The oxygen deficiency is replaced by acquisition of oxygen from the atmosphere and by photosynthesis.

A substantial reduction in dissolved oxygen causes suffocation of fish. The second edition of Water Quality Criteria by the California State Water Quality Control Board cites the conclusions of M. M. Ellis that under average stream conditions, 3.0 mg/l of dissolved oxygen, or less, should be regarded as hazardous, and to maintain a varied fish fauna in good condition the dissolved oxygen concentration should remain at 5.0 mg/l or higher. The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission recommended that the minimum dissolved oxygen concentration for a well rounded warm water fish population should not be less than 5 mg/l during at least 16 hours of any 24 hour period and at no time should the dissolved oxygen content be less than 3 mg/l.

About a mile above the dam at International Falls the average DO (dissolved oxygen) concentration varied from 7.7 to 8.2 mg/l; the DO saturation varied from 85 % to 90%. Twelve miles below the paper mills the average DO varied from 5.1 to 6.4 mg/l—a drop of 2.0 mg/l; the saturation varied from 58% to 73%—a drop of 25%. Ten miles below Long Sault Rapids the minimum DO value was 3.9 mg/l while the average value varied from 5.4 to 5.8. As the water progressed downstream the average DO dropped to 4.1 mg/l or 47% saturation near Baudette. In 1961 the minimum values in the reach of the river near Baudette varied from 0.9 to 1.1 mg/l or 10% saturation. Below Baudette the DO concentration began to recover due to algae in the slow moving water. In Lake of the Woods the average DO rose to 7.7 mg/l or 88% saturation.

(d) *Suspended Solids*: The concentration of suspended solids indicate the extent of pollution due to the discharge of solids into the river. All settleable solids are suspended solids until they have settled on the bottom of the water course. Dissolved or colloidal solids, such as sulphite waste liquors, may be synthesized by bacteria in the stream to form suspended and settleable sludge. Turbidity is attributable to suspended and colloidal matter. The analytical data on the concentration of suspended solids excludes floating masses and bottom deposits.

In general the standards for water quality for most States require substantially complete removal of suspended solids attributable to sewage, industrial or other wastes.

At the outlet of Rainy Lake the average suspended solids concentration for each of the four sampling points was relatively low, varying from 4.2 to 7.1 mg/l. Immediately below Fort Frances near the Ontario shore the concentration of suspended solids was as high as 87.0 mg/l with an average value of 31.9. About a mile below International Falls near the Minnesota shore the concentration was as high as 212.8 mg/l with an average value of 36.8. The concentration of suspended solids in the middle of the river was 14.2 mg/l and near the Ontario shore 12.3. Twelve miles below International Falls the average concentration varied from 11.0 to 20.8 mg/l—a threefold increase over the levels found at the outlet from Rainy Lake. Below Long Sault Rapids the average suspended solids varied from 9.9 to 15.1 mg/l. In this reach of the river about half of the suspended solids were of organic origin. Immediately below Baudette the average suspended solids varied from 7.9 to 15.7 mg/l. In Lake of the Woods the average was 10.0 mg/l.

(e) *Lignin*: Wood is made up of cellulose combined with lignin, a substance related to carbohydrates. Lignin degenerates very slowly. It is a common constituent of water flowing through wooded and swampy areas and is usually associated with a brown color in water. The pulping process liberates the lignin from the wood fibres. Thus the lignin concentrations identify the type of waste being discharged into the Rainy River.

At the outlet from Rainy Lake the average lignin concentration varied from 0.6 to 1.2 mg/l. Near the Ontario shore immediately below the Fort Frances plant

the average lignin concentration was 2.2 in 1961. About a mile below the International Falls plant the average lignin concentration in 1961 was 9.5 mg/l near the Minnesota shore. The maximum concentration was 27.0. Twelve miles below the paper plants the average lignin concentration varied from 1.8 to 4.5 mg/l—a threefold increase over the values at the outlet from Rainy Lake. In the reach of Rainy River between Emo and Lake of the Woods lignin concentration was fairly uniform. Average values ranged from 1.4 to 3.1 mg/l. The average lignin concentration in Lake of the Woods was 1.5 mg/l.

Water of good quality entered Rainy River from Rainy Lake. Significant changes in water quality were found immediately below Fort Frances and International Falls. The strong wastes from the domestic and industrial sewer outlets were concentrated near each shore. Twelve miles downstream from International Falls the wastes had spread across the river. Essentially complete mixing of the wastes was attained by the time the water reached Long Sault Rapids about half way between the source of Rainy River in Rainy Lake and its outlet into Lake of the Woods. The effects of sedimentation and biological stabilization became more evident as the water progressed downstream. Serious pollution as indicated in Figures 2 to 6 existed throughout the Rainy River from Fort Frances to Lake of the Woods. The waters of Lake of the Woods showed a remarkable recovery when compared to the contaminated condition in the upper reaches of Rainy River. The water quality of Lake of the Woods is satisfactory.

4. Sources of Pollution

The water quality of the streams entering Rainy River below International Falls was determined. The median coliform count on the ten tributaries was relatively low, varying from 70 to 1,200; the average BOD ranged from 1.2 to 4.5 mg/l, a range from "clean" to nearly "doubtful"; the average dissolved oxygen varied from 4.4 to 6.9 mg/l; the average lignin concentration ranged from 1.4 to 3.9 mg/l; and the average suspended solids varied from 6.3 to 41.7 mg/l. Furthermore, since these ten tributaries contribute only fifteen percent of the total flow of the Rainy River, they cannot be regarded as a major source of pollution.

The estimated BOD load due to domestic wastes was 2,800 pounds per day. International Falls, with secondary treatment, contributed only 9 percent of the entire domestic waste load; Baudette, with primary treatment, contributed 18 percent; Rainy River, with only sedimentation, represented 5 percent; and Fort Frances, with no treatment at the time of the investigation, was responsible for 58 percent. The remaining 10 percent of the domestic BOD load was contributed by villages on the tributaries. The entire domestic BOD load discharged to Rainy River is about one percent of the combined domestic and industrial BOD load.

The major source of pollution was found to be the sewer oulets of the Minnesota and Ontario Paper Company's plants at Fort Frances and International Falls. All wastes from these plants, with the exception of 60 percent of the domestic sewage from the International Falls plant, were discharged to the Rainy River without treatment.

The sewer outlets at the International Falls plant discharged screened overflow from the pulp thickener, waste from the woodroom and bark recovery plant, overflow from the ash pond which receives the main boiler plant ashes, waste water from the sulphite screens and wet room, diluted spent sulphite liquor, bleach plant wastes, kraft mill wastes including lime sludge, wastes from the insulite mill, sewage wastes from the paper mill, backwash from the filtration plant and cooling water from the asphalt rodding mill. The Fort Frances plant discharged waste from the rotary bark screens, waste from the Tyler screens, waste from the sulphite deckers, lean white water overflow and sewage from the paper mill.

The mill surveys in 1960 and 1961 found the waste waters carried a high bacterial content. The BOD load contributed by the two plants was approximately 255,000 pounds per day. This is equivalent to the oxygen demand of the domestic wastes from a city of one and one half million people. Despite the effectiveness of the bark pond, before it washed out during the high water of 1962, the suspended solids load, including bark, fibre, chips and lime sludge, discharged to the Rainy River from the mill outlets exceeded 100 tons per day. Of this total the woody materials amounted to 61.5 tons per day. The lignin content of the waste was consistently high.

The Minnesota and Ontario Paper Company's brief of August 1964 confirmed the results of the Board's survey. The Company estimated that their overall daily discharge into the river included 57.2 tons of fibre and 60 tons of calcium carbonate (lime sludge).

5. Effects of Pollution

The discharge of untreated domestic wastes into Rainy River is a danger to health since the sewage contains organisms of diseases transmittable to humans. The coliform bacteria count in the first sixty miles below International Falls exceeded 6,000 per 100 ml. Thus, the river cannot be used safely as a source of drinking water unless there is auxiliary pre-treatment in addition to conventional purification. The waters of Rainy River, according to health authorities, are unsuitable for bathing.

The discharge of wastes from the pulp and paper mills has limited the development of river property between Fort Frances and Baudette. The unsightly and often odorous deposits along the shorelines and river bottom caused by suspended solids such as bark, fibre, chips and lime sludge has lessened the attractiveness of waterfront areas. The nutrients in the industrial wastes promoted the prolific growth of Sphaerotilus, a filamentous bacterium, in the upper reaches of the river. These slime masses attached to submerged or largely submerged obstructions and trapped fresh fibres have an objectionable appearance especially when the water level in the river recedes. The presence of suspended solids and slimes in the river has increased the cost of obtaining a satisfactory water supply at Baudette.

Biologically, Rainy River was most affected by wood fibres and associated wastes discharged from the pulp and paper mills. Benthos (the flora and fauna found at the bottom of streams, lakes and oceans) development was impeded. A number of the more desirable fish food organisms could not contend with the river environment during the summers with normal flows. In Four Mile Bay, at the outlet of Rainy River, the distribution of benthic animals was markedly affected by the pattern of sedimentation of wood waste materials. The condition of the river imposed limitations on the number of fish species in the upper eleven miles. Younger age groups of game fish were less numerous than normally anticipated. The fish population, according to witnesses at the Hearing, has been drastically reduced over the past twenty-five years.

The majority of organisms avoided fresh wood fibre deposits. Fresh wood fibres served as a nucleus for Sphaerotilus growth. The wood sugars (Xylose, Dextrose, and Fructose) from the pulping process not only have a high oxygen demand but also encourage the growth of Sphaerotilus which has a deleterious effect on fish propagation and fish food organisms.

Research studies established that survival conditions for Walleye eggs in Rainy River below International Falls were poor in 1961 and 1962. Survival to fry (the first stage of a fish after the egg) was less than one percent in 1961 and varied from 0.02 to 6.0 percent in 1962. Survival in controls from the same lots at the Waskish State Hatchery were 69.6 percent in 1961 and 41.4 percent in 1962. The principal cause of low survival was Sphaerotilus, a bacterium slime, covering the eggs during incubation. This prevented successful emergence of the fry.

The sulphites in the mill wastes readily become oxidized by removing the dissolved oxygen from the receiving waters. The fish population was jeopardized by dissolved oxygen levels being below 4 mg/l for appreciable periods in the ten mile reach of the river above Baudette.

The waters of Rainy River are polluted to such a degree that they are unsatisfactory for recreation. Sludge banks and floating islands of bark, fibre and chips, floating scum from lime sludge wastes, and malodorous conditions caused by bottom deposits has adversely affected the aethetic value of Rainy River. The deposits of woody materials are over three feet thick in some areas of its outlet in Four Mile Bay. The river is unsafe for recreational bathing due to its polluted condition. Fibre and slime entanglement on fish lines is so serious that sport fishing is limited to the fast waters of the Sioux and Manitou Rapids and the lower ten miles of the river. A witness testified at the hearing that outboard motors become so clogged with fibres that they have to be overhauled every two weeks. Fishermen who formerly used the resort facilities in the lower reach of the river have, in recent years, gone to other places because they did not like fishing under such conditions.

6. Effects of Weekend Flow Reduction

During periods of low inflow into Rainy Lake the weekend discharge from the dam at International Falls was reduced to less than half of the weekday average. This lowered the water level in the upper half of the river above Manitou Rapids, exposing unsightly banks and part of the river bed. As a result, bottom animals and fauna on the exposed areas were destroyed and malodorous conditions developed.

7. Remedial Measures Constructed or Planned

The Ontario Water Resources Commission in 1964 completed the construction of a pollution control plant with facilities for primary treatment of sewage from Fort Frances. It is operated by the Ontario Water Resources Commission under an agreement with the City of Fort Frances.

The pulp and paper companies are in the process of completing the connection of their sanitary sewers in the Fort Frances and International Falls mills with the respective municipal treatment plants. The companies have also announced that they plan to complete some of the necessary in-plant waste segregation and recovery projects by 1967. These projects include bark burning facilities in the new steam plant, improved bark and waste wood recovery facilities at the Fort Frances plant, better recovery of fibre at the insulite mill, and modification of the sulphite chemical-cooking plant to utilize half of the calcium carbonate now being wasted. These in-plant improvements will be an initial step towards reducing the pollutants in the mill wastes and as such will be helpful in improving the quality of the waters of Rainy River.

CONCLUSIONS

The conclusions of the Commission with regard to each of the questions contained in the Reference are as follows:

Question 1

Are the waters of the Rainy River and the Lake of the Woods, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?

The Commission finds that the waters of Rainy River are being polluted on each side of the international boundary to an extent that is injurious to property and a hazard to health on the other side of the boundary. The water quality of Lake of the Woods appears to be satisfactory.

Question 2

If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

The Commission finds that the Rainy River downstream from the Fort Frances-International Falls area is polluted to such an extent that it is a potential menace to health, unfit for bathing, discourages the development of water front property, is unsuitable for the growth of many forms of aquatic life and unattractive for recreation. The major cause of pollution is the discharge of untreated wastes from the two pulp and paper plants owned by Minnesota and Ontario Paper Company and its subsidiary company. The other sources of pollution at the time of the investigation were the discharge of domestic wastes from Fort Frances and to a lesser degree the effluents from the sewage treatment plants at Baudette, International Falls and Rainy River.

Question 3

If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgement, be most practicable from the economic, sanitary and other points of view?

In the judgement of the Commission the following measures are the most practicable for remedying the situation:

(a) adoption by Governments of the "Water Quality Objectives for the Rainy River" recommended hereunder;

(b) acceptance of these Objectives as the minimal criteria by the enforcement agencies in both countries;

(c) adoption and implementation by the paper companies and the municipalities of definite programmes for carrying out the remedial measures necessary to meet the Objectives; and,

(d) continuing surveillance by the Commission to ensure maximum practicable progress towards meeting the Objectives.

Question 4

If the Commission should find that the construction or maintenance of remedial or preventive works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location, and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.

The Commission considers that the remedial measures at the two pulp and paper plants should include an extension of the scheduled in-plant segregation and recovery projects to cover all processes, external treatment of all high-solids wastes, recovery or treatment of spent sulphite liquor, and continuous waste monitoring. Due to the complex nature of the two plants the companies were unable to supply a firm estimate of the costs of the necessary remedial works. A table indicating the costs for similar treatment works at other pulp and paper mills is attached as an appendix to the Advisory Board's report. The Commission considers that the cost of these pollution abatement measures should be borne by Minnesota and Ontario Paper Company. The cost is high for correction, but it is higher for the continuance of the defilement of these waters.

The Commission considers that the primary treatment plants at Fort Frances, Baudette and Rainy River should be extended to provide secondary treatment at the earliest practical date. A long term programme of separation of domestic sewage from storm water should be adopted. The estimated cost for secondary treatment of domestic wastes is $200,000 for the United States municipality and $508,000 for the Canadian municipalities. Such costs should be borne by the municipalities responsible. Federal, State or Provincial assistance is available under certain circumstances.

WATER QUALITY OBJECTIVES

Limitations on Waste Disposal

The Commission recognizes that the maximum beneficial use of available water resources should be permitted and unreasonable use of water should be prevented. The disposal of wastes into a river should be controlled so as to achieve the highest quality consistent with the maximum benefit to all users.

The Commission considers that discharging suitably treated domestic and industrial wastes into the river is a reasonable use of these waters provided that such use does not create a hazard to public health or cause undue interference with the rights of others to use these waters for legitimate purposes. In boundary waters as defined in the Boundary Waters Treaty of 1909, the wastes discharged into the river must be such as not to cause injury to health or property in the other country. Undue interference with the development of desirable types of aquatic life constitutes an injury to property even though it may be the property of the public at large.

The Commission recognizes that water quality requirements should not only safeguard public health and protect the beneficial uses of these waters but also permit legitimate use of these waters for the disposal of adequately prepared wastes. Water quality objectives should not exclude all impurities from the water course; nor should they tolerate the maximum quantity of domestic and industrial wastes that the stream can assimilate. Objectives designed to alleviate pollution in a specific stream or body of water are not necessarily applicable to other water courses where the conditions may be quite different.

The Objectives recommended hereunder are designed to permit the use of Rainy River for waste disposal only to such extent as would be compatible with the rights of others to enjoy the use of these waters for legitimate purposes. The pollution problem on the Rainy River was investigated on the basis of existing local conditions and current knowledge. If in the future there should be a substantial change in the uses to be made of the waters of Rainy River or in the quantity and nature of the wastes discharged into these waters, the Objectives recommended hereunder should be reviewed and amended as necessary to take into account the new factors so as to ensure that there will be no injury to health or property.

The Commission recognizes that the primary responsibility in the field of water pollution rests with the Provinces and the States. However, each Federal Government has an obligation to the other under Article IV of the Boundary Waters Treaty of 1909 which provides that "boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health and property on the other." Thus the achievement of the water quality Objectives recommended hereunder will require the cooperation of the two levels of government in both countries.

Water Quality Objectives for the Rainy River

A. GENERAL OBJECTIVE

In general all wastes, including sanitary sewage, garbage, refuse, storm water and industrial effluents, should be in such a condition when discharged into the river that they do not create conditions which will adversely affect the use of these waters as a source of domestic or industrial water supply, or for navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities.

B. SANITARY SEWAGE, STORM WATER AND WASTES FROM WATERCRAFT

The coliform MPN (most probable number) median value should not exceed 2,400 per 100 ml at any point in the stream following initial dilution except in public recreational bathing areas where the median coliform values should not exceed 1,000 per 100 ml. The bacterial determinations used for this Objective include the presumptive and confirmed tests, or the MF (membrane filter) procedure for the coliform group of bacteria as given in "Standard Methods for the Examination of Water and Sewage," American Health Association, New York.

Solids and chemical constituents should be removed from all sanitary sewage, storm water and wastes from watercraft to such an extent that the effluents do not interfere with the above mentioned uses.

C. SUSPENDED SOLIDS

The discharge of suspended solids, including but not limited to floating materials such as bark, butts, sawdust, fibres and lime sludge, should be reduced to a point that they are not conducive to slime growths, formation of sludge islands and banks, and do not injure fish or wildlife or their habitats.

This objective will be met if facilities are provided to remove substantially all suspended solids from the pulp and paper mill's effluent.

D. DEOXYGENATING WASTES

The dissolved oxygen should not fall below 5 mg/l at the average monthly flow which is exceeded 95 percent of the time in the critical month, nor below 3 mg/l at the minimum daily flow that is exceeded 95 percent of the time in the critical month.

This Objective will be met if the treatment provided substantially removes the solids, bacteria, chemical constituents and other substances capable of reducing the dissolved oxygen in these waters to an unreasonable extent.

E. NUTRIENTS FOR SLIME BACTERIA

The discharge of nutrients, including but not limited to wood sugars, should be controlled to the extent that they do not promote the nuisance growths of Sphaerotilus and other slime bacteria in the river.

This Objective will be met if there is a marked reduction or complete removal of nutrients in the effluents.

F. PERIODIC REVIEW

Specific Objectives for water quality, including but not restricted to phenols, pH, odour, color, turbidity, oils and highly toxic wastes, will be added when the Commission after a review of new and existing uses and wastes, determines that such amendments are necessary to meet the General Objectives as set forth in A above.

RECOMMENDATIONS

1. The Commission recommends that the "Water Quality Objectives for the Rainy River" as set forth above be adopted by the two Governments as the criteria to be met in maintaining the waters of the Rainy River in satisfactory condition, as contemplated by Article IV of the Boundary Waters Treaty of 1909. Furthermore, the Commission recommends that the State of Minnesota and the Province of Ontario adopt these Objectives as the minimal criteria in formulating their respective State and Provincial water quality standards for the Rainy River.
2. The Commission recommends that the appropriate authorities require the industries and municipalities concerned to initiate, at the earliest possible date and pursuant to a definite time schedule, construction of the pollution abatement facilities necessary to achieve and maintain the said Objectives.
3. The Commission recommends that it be specifically authorized by the two Governments to establish and maintain continuing supervision over the waters of Rainy River in relation to pollution through a board to be appointed by the Commission. In carrying out this supervisory function, the Commission would notify those responsible for any pollution found objectionable in relation to the said Objectives and, in the event that assurance were not received that such pollution would be corrected within a reasonable time, would recommend to the appropriate authority or authorities having jurisdiction in respect thereof the action deemed necessary or advisable. The Commission would also, as the occasion required, review the quality of the waters of the Rainy River and recommend such amendments to the specific Objectives, B to F above, as may be necessary in order to conform with the General Objective, A above.

Signed this 24th day of February, 1965.

A. D. P. HEENEY
EUGENE W. WEBER
D. M. STEPHENS
RENÉ DUPUIS
CHARLES R. ROSS

Figure Not Included

Figure Not Included

Figure Not Included

Figure Not Included

Figure Not Included

REPORT OF THE
ADVISORY BOARD ON WATER POLLUTION
RAINY RIVER AND LAKE OF THE WOODS

TO THE

INTERNATIONAL JOINT COMMISSION
UNITED STATES AND CANADA

1960 - 1962 INVESTIGATIONS

October 1964

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Letter of Transmittal

To: INTERNATIONAL JOINT COMMISSION,
UNITED STATES AND CANADA

The Advisory Board submits herewith its abridged report on pollution of the Rainy River and Lake of the Woods Section of the International Boundary Waters covered by reference to the Commission dated May 30, 1959.

Pursuant to the appointment of the Advisory Board on October 8, 1959, technical investigations and studies over a three-year period have covered those aspects of pollution deemed necessary for the Commission to answer the questions contained in the reference referred to them from the Governments of Canada and the United States.

Respectfully submitted,

ADVISORY BOARD ON POLLUTION OF
BOUNDARY WATERS—RAINY RIVER
AND LAKE OF THE WOODS

October 2, 1964

L. F. WARRICK
Chairman

W. R. EDMONDS
Chairman

FOREWORD

Detailed information and technical data on studies and investigations are not contained in this report, but are available for reference purposes in the "Report of the Advisory Board on Water Pollution, Rainy River and Lake of the Woods to the International Joint Commission, United States and Canada, on the Pollution of International Boundary Waters, 1960-1962 Investigations, Rainy River and Lake of the Woods, Minnesota and Ontario, April 1963."

The latter report is available through the offices of the International Joint Commission in Ottawa, Canada and Washington, D.C. in the United States.

ADVISORY BOARD ON WATER POLLUTION

RAINY RIVER AND LAKE OF THE WOODS

CANADA

William R. Edmonds (Chairman), Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa

Robert E. Tait, Senior Chemical Engineer, Public Health Engineering Division, Department of National Health and Welfare, Ottawa

UNITED STATES

Louis F. Warrick (Chairman), Technical Services Consultant, Division of Water Supply and Pollution Control, Public Health Service, Department of Health, Education and Welfare, Washington, D.C.

Herbert C. Clare, Regional Program Director, Water Supply and Pollution Control, Public Health Service, Department of Health, Education and Welfare Regional Office, Kansas City, Missouri

ONTARIO

George M. Galimbert, Assistant General Manager, Ontario Water Resources Commission, Toronto

Fred A. Voege, Director of Laboratories, Ontario Water Resources Commission, Toronto

MINNESOTA

Lyle H. Smith, Executive Engineer, Minnesota Water Pollution Control Commission, Minneapolis Sidney A. Frellsen, Director, Division of Waters, Minnesota Department of Conservation, St. Paul

INTRODUCTION

Reference to the International Joint Commission

". . . The Governments of the United States and Canada have been informed that the waters of the Rainy River and the Lake of the Woods are being polluted by sewage and industrial wastes emptied into these waters. Having in mind the provisions of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side, the two Governments have agreed upon a joint Reference (dated May 30, 1959) of the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The Commission is requested to inquire into and to report to the two Governments upon the following questions:

(1) Are the waters referred to in the preceding paragraph, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?

(2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgment, be most practicable from the economic, sanitary and other points of view?

(4) If the Commission should find that the construction or maintenance of remedial or preventive works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location, and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.

"For the purpose of assisting the Commission in making the investigation and recommendations provided for in this Reference, the two Governments will, upon request, make available to the Commission the services of engineers and other specially qualified personnel of their governmental agencies, and such information and technical data as may have been acquired by such agencies or as may be acquired by them during the course of the investigation.

"The Commission should submit its report and recommendations to the two Governments as soon as practicable."

Directive to the Advisory Board

Pursuant to the reference of the two Governments the International Joint Commission appointed an Advisory Board on Water Pollution for Rainy River and Lake of the Woods and issued a directive dated December 15, 1959, as follows:

"1. The Advisory Board on Water Pollution—Rainy River and Lake of the Woods was established by the International Joint Commission on 8 October 1959, and the following were appointed to serve on the Board:

United States Section:
- Mr. L. F. Warrick (Chairman)
- Mr. H. C. Clare
- Mr. S. A. Frellsen
- Mr. H. G. Rogers*

* Retired from the Board on March 9, 1962, and on that date was succeeded by Lyle H. Smith.

Canadian Section:

Mr. J. R. Menzies (Chairman)**
Dr. A. E. Berry***
Mr. R. E. Tait
Mr. F. A. Voege

2. The Board will carry out the technical investigations and studies necessary to enable the Commission to prepare and submit its report and recommendations to the Governments of the United States and Canada, as requested by the two Governments in a Reference to the Commission dated 30 May 1959. A copy of the said Reference is attached hereto. (See page 27)

3. Field investigations should be directed initially to pollution of the waters of Rainy River, of tributaries of Rainy River insofar as the quality of the tributary waters affects the quality of the waters of Rainy River and of Lake of the Woods insofar as the quality of its waters are affected by the quality of waters discharged to it from Rainy River. The Board will advise the Commission if it appears that more extensive investigation of pollution of the waters of Lake of the Woods would be desirable.

4. The Board will furnish a preliminary report to the Commission on or before 31 March 1960 containing a general outline of the existing situation as regards pollution in the area under Reference, and of the procedure proposed for carrying out the investigation.

5. The Board is authorized to establish such committees and working groups as may be required to effectively discharge its responsibilities, to enlist the cooperation of technical officers of other Federal, Provincial or State Departments or agencies in the United States and Canada and to make such expenditures for travel as may be found necessary.

6. The Board is requested to carry out its investigation as expeditiously as possible and to keep the Commission currently informed of developments and progress. To this end, the Board will prepare and submit semi-annual progress reports to the Commission on or about 31 March and 30 September of each year and such other reports from time to time as the Commission may direct or as the Board may consider desirable."

General Purpose and Conduct of Study

The following is an outline of the work program carried out by the Advisory Board pursuant to this directive:

(a) to ascertain the nature, distribution, and extent of pollution in the indicated boundary waters and tributaries,

(b) to evaluate effectiveness of existing facilities for pollution control in relation to boundary water quality objectives,

(c) to appraise needs for further remedial measures, and

(d) to provide other data and information to assist the Commission in carrying out its responsibilities under the Reference.

The pollution survey work was started in July 1960, along the Rainy River and Lake of the Woods near the mouth of the River and was conducted by technical personnel in field units employed by Canada and the United States. Activities on both sides and in sampling designated sections of these international waters were closely coordinated, beginning with three months of intensive field work during that summer. Because it was essential for the field observations to cover seasonal conditions to properly evaluate effects of pollutants, winter, spring and summer studies were conducted in 1961 and 1962.

The work involved:

(a) Chemical, physical, bacteriological and biological analyses of water samples obtained from designated sections of the boundary waters;

** Following the death of J. Ross Menzies on December 9, 1961, William R. Edmonds was appointed Chairman of the Canadian Section on March 8, 1962.

*** Retired from government service on March 31, 1963, and was succeeded by George M. Galimbert on May 1, 1963.

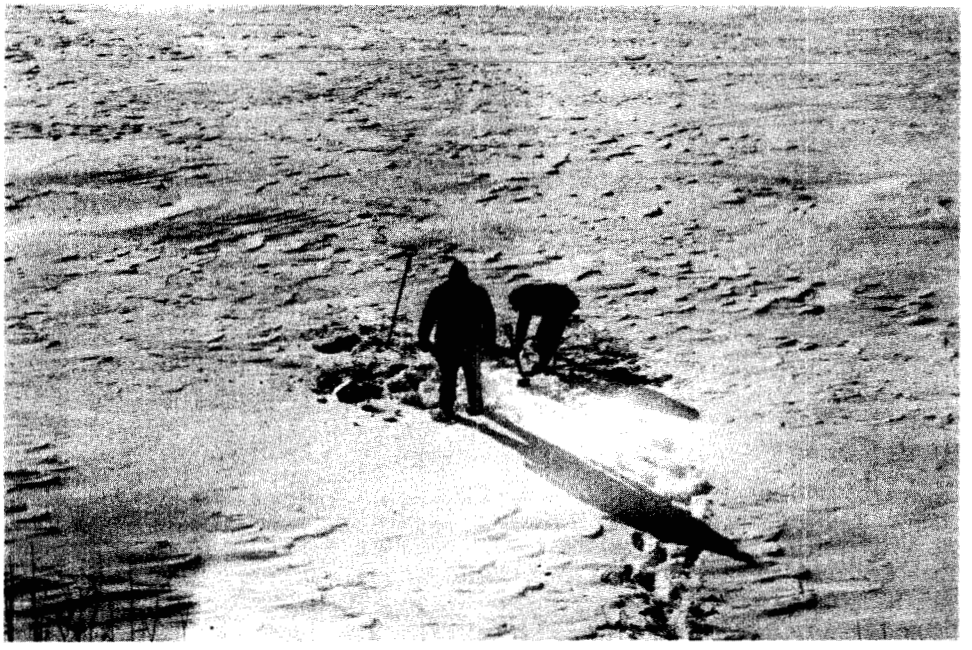

FIGURE 7. Winter sampling through the ice during Rainy River—Lake of the Woods boundary water survey, January, 1962.

FIGURE 8. Rainy River sampling. Left to right, Lawrence A. Schmid, U.S. Public Health Service; Thomas Shelton, Minnesota Department of Health; Richard Klippel, U.S. Public Health Service. August 1962. (International Falls Daily Journal Photograph)

(b) Analyzing fish populations, bottom-living fish-food organisms and other benthic invertebrates;

(c) Measuring, sampling and analyzing pollutants, including studies of the character and sources of municipal and industrial wastes and their effects on uses of these international waters;

(d) The determination of transboundary movement of pollution;

(e) Coordination of field assignments and maintenance of technical liaison between personnel of Federal, Provincial, State and local cooperating agencies in the United States and Canada;

(f) Collection and collation of related data including topography, geology, climate, population, land use and development, and hydrology; and

(g) Appraisal and interpretation by the Board of data and information obtained for preparation of reports to the International Joint Commission.

Uses of Rainy River Waters

(a) *Domestic Water Supply:* The Minnesota and Ontario Paper Company obtains water from the Rainy River just above the International Bridge. Its modern water purification plant, which includes flocculation, sedimentation, filtration and chlorination, processes water for the cities of International Falls and South International Falls, as well as for the mill manufacturing processes. In the lower watershed on the Ontario side the town of Rainy River obtains water from the river with chlorination as the only treatment.

(b) *Sewage Disposal:* The sanitary sewage, either as treated effluent or raw sewage, from each of the sewered communities located on the main stem is discharged to the Rainy River for final disposal. International Falls and South International Falls both have adequate secondary treatment facilities but South International Falls discharges its effluent to Rainy Lake rather than to Rainy River. Baudette is the only other sewered municipality on the Minnesota side of the Rainy River and it has provided primary treatment facilities. On the Ontario side only the Towns of Fort Frances and Rainy River have public sewers. Fort Frances has primary treatment works under construction and Rainy River has only sedimentation facilities which are inadequate.

The most concentrated sewage loading occurs in the Fort Frances-International Falls area where the treated wastes from approximately 9,500 people in Fort Frances and the satisfactorily treated wastes of nearly 9,000 people in the International Falls area are added to these waters. Emo, Ontario, is planning the construction of treatment facilities.

(c) *Navigation:* At present the Rainy River is little used for navigational purposes. Log rafts are towed across Rainy Lake to the mills at Fort Frances and International Falls during the summer. The dam at the mills, the two rapids, and modern land transportation facilities tend to discourage the use of the river for navigation for commercial purposes.

(d) *Power:* At International Falls-Fort Frances the Minnesota and Ontario Paper Company uses water from the Rainy River below Rainy Lake reservoir for the operation of a steam and hydroelectric plant.

Three hydroelectric stations are located at the outlet of Lake of the Woods in Canada. These stations are important in controlling the water level in Lake of the Woods and the lower reaches of the Rainy River.

(e) *Industrial Uses for Water Supply and Wastes Disposal:* The pulp and paper mills at Fort Frances and International Falls are the only industries which use water directly from Rainy River. Large quantities of good quality water are essential to their operations. Essentially all of the used water is returned directly to the river. In some operations the water is not appreciably changed while in other operations the character is altered. The Minnesota and Ontario mill at International Falls processes approximately 1,000 cords of pulpwood daily

requiring about 55 million U.S. gallons (46 million Imperial gallons) of water per day. The Ontario and Minnesota mill at Fort Frances processes approximately 500 cords of pulpwood daily using about 23 million Imperial gallons of water (28 million U.S. gallons) per day. (Industrial wastes treatment is discussed in separate action.)

(f) *Recreational Uses:* Rainy River from International Falls-Fort Frances to Baudette is little used for recreational purposes. The high levels of color, turbidity, and suspended solids, render this reach of the river generally unattractive for bathing, boating, and fishing. Some sport fishing is done in the Long Sault and Manitou Rapids areas.

The section of Rainy River adjacent to Lake of the Woods has a well developed resort area and attracts a considerable number of people interested in fishing and boating. Boats are available in this area for transportation to various sections of Lake of the Woods. Canoeing in the area has been popular for many years.

Estimates based on the Minnesota Arrowhead Association's Vacation Travel Survey, 1958-1959, indicate that approximately one and one-half percent of the resort facilities in the 19 County Vacation Travel Survey Area are located on the Rainy River or the Wheelers Point area of Lake of the Woods. It is estimated that the total annual expenditure of tourists and vacationers in this area is about $480,000.

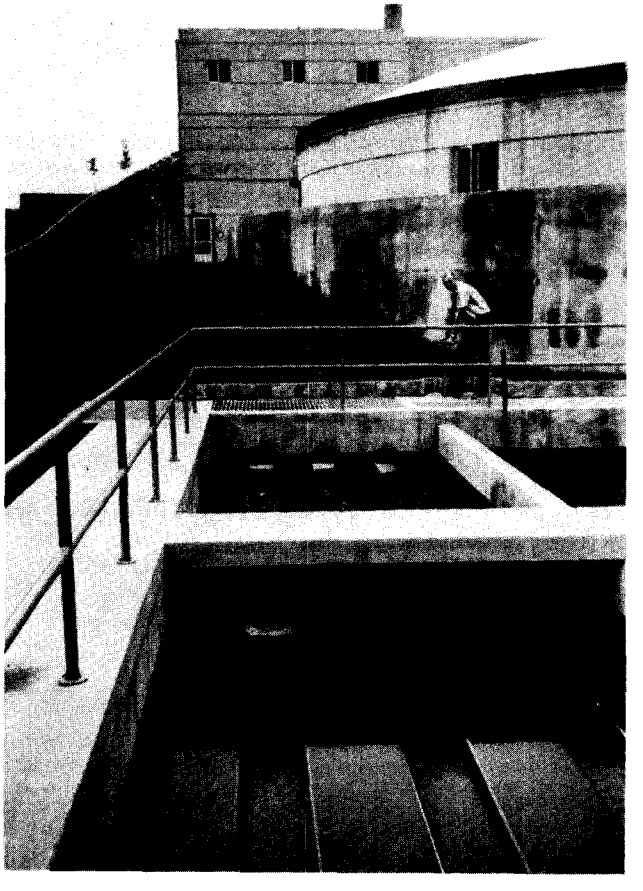

FIGURE 9. Final clarifier, filter and operating house, International Falls waste treatment plant. August 3, 1962.

(g) *Fisheries:* Sport fishing is carried on extensively in Lake of the Woods and in the lower reaches of the river. Muskellunge, small mouth bass, walleyed pike, great northern pike, crappies, rock bass, bullheads, perch and sturgeon are common to this area. Rainy River above Baudette is not widely used as a fishing area.

No commercial fishing is permitted in the Rainy River. Lake of the Woods has an extensive and valuable fishery, and commercial fishing licenses are issued by both the State of Minnesota and the Province of Ontario.

Transboundary Movement of Pollution

In the Treaty of 1909 between the two countries it was agreed that "the boundary waters shall not be polluted on either side to the injury of health or property on the other." In the reference for this investigation an answer was sought to the question of whether transboundary movement of pollution was taking place, to what extent, and in what localities. The information utilized in answering these questions in the present investigation was obtained from float studies, and a review of the analytical data compiled during the survey periods.

Boundary Water Quality Control Objectives

Water quality objectives are essential for determining the remedial measures necessary for correcting pollution. Objectives may be established in two ways: (1) through limitation of the quantity of deleterious substances allowed to enter the receiving streams, or (2) through limitation of these substances within the receiving waters. Whichever type of objective is used, the end result must be the same, namely, maintenance of the water in a condition suitable for all appropriate uses.

Objectives adopted for boundary waters quality control establish the ultimate aim of corrective measures. Objectives must be defined if water quality is to be improved and maintained, and they must be impartial in setting goals for all uses. Each purpose will require a specific quality of water. In the majority of cases, the uses of any one watercourse are varied, and complex interrelationships must be considered in objectives consistent with all uses.

The objectives for boundary water quality control which were recommended in 1950 by the International Joint Commission for the connecting channels of the Great Lakes and were subsequently accepted by the Governments of Canada and the United States, adhere to the above principles. The following is an excerpt from the report of the International Joint Commission to the Governments of Canada and the United States on the pollution of boundary waters dated October 11, 1950:

> "All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged into any stream that they will not create conditions in the boundary waters which will adversely affect the use of these waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish and wild life, bathing, recreation, agriculture and other riparian activities.
> In general, adverse conditions are caused by:
>
> (A) Excessive bacterial, physical or chemical contamination.
>
> (B) Unnatural deposits in the stream, interfering with navigation, fish and wild life, bathing, recreation, or destruction of aesthetic values.
>
> (C) Toxic substances and materials imparting objectionable tastes and odors to waters used for domestic or industrial purposes.
>
> (D) Floating materials, including oils, grease, garbage, sewage solids, or other refuse." (Such as foam, slime growths, or sludge islands.)

The general objectives quoted above are equally applicable to the waters of Rainy River.

DESCRIPTION OF RAINY RIVER AND TRIBUTARIES

Rainy River above its mouth in the Lake of the Woods drains an area of 20,850 square miles, 10,850 square miles in the Province of Ontario, and 10,000 square miles in the State of Minnesota. The watershed boundaries are shown in Figure 1, or the frontispiece. The stream is about 86 river miles in length, flowing from east to west along a fairly direct course. There are several bends in the stream but the channel is far from being tortuous. The stream is wide at practically all points, and the depth seldom exceeds 20 feet. The stream is further characterized by several wooded islands which divide the water into definite channels.

Outflow from Rainy Lake, controlled in accordance with the Order[1] of the International Joint Commission, dated June 8, 1949, frequently produces very low flow in the River on weekends. At such times, on Sunday and early Monday, the effects of the uncontrolled flow are evident in the area from International Falls to Manitou Rapids, and at many locations large portions of the usual river bottom are exposed to view.

Tributaries to the Rainy River proper enter from both sides of the stream. The drainage area on the Canadian side approximates 600 square miles and on the United States side about 5,700 square miles. The principal streams on the Canadian side are the La Vallee, Sturgeon, and Pine Rivers. On the Minnesota side the Little Fork, Big Fork, Black, Rapid, Baudette, and Winter Road Rivers are worthy of note. The Little Fork and Big Fork Rivers drain the greater part of the area with 1,849 and 2,063 square miles in their respective watersheds. The mean flows in these two rivers are 972 and 653 cubic feet per second (cfs), respectively.

Rainy River is a remarkable river in that it nearly fits its banks and has few meanders. Throughout much of its course the banks rise abruptly on both sides. The banks have generally rounded, smooth, grass covered slopes. In the upper part of its course the immediate banks are generally 25 to 35 feet high. At many points the river valley is not greater than two or three times the width of the river itself. The river has very little flood plain even in its lower portion.

The average width of the river is approximately 200 yards, and its depth in mid-channel generally varies from 10 to 20 feet. Downstream from the dam at Fort Frances there are two rapids influencing the flow in the stream. The first occurs at Manitou Rapids, 35 miles downstream from Fort Frances, where a rocky barrier causes a constriction of the channel of the river to about half its normal width. The fall here is about 1.5 feet. Seven miles farther downstream the Long Sault Rapids begin. They are caused by boulders in the bed of the stream, and extend for about two miles with an estimated total fall of 5.5 feet.

The average gradient for the surface of the water is 2.5 inches per mile from Fort Frances to the Rainy River-Baudette area. Disregarding the rapids this is reduced to 1.5 inches per mile. Below Baudette the gradient is approximately one inch per mile.

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[1] The IJC Order of June 8, 1949 directs the Companies to operate the dam at International Falls in such a manner that the *level* of Rainy Lake will not exceed specified elevations on specific dates. When the elevation of Rainy Lake is below the elevations prescribed by the rule curve an *average* discharge of 6,000 cfs will be in effect. The discharge is reduced to 4,000 cfs when Rainy Lake is below elevation 1108.11 on July 1, and when the level at any time is more than two feet below the rule curve providing the inflow is less than 10,000 cfs. Except as noted the IJC does not regulate the outflows of Rainy Lake.

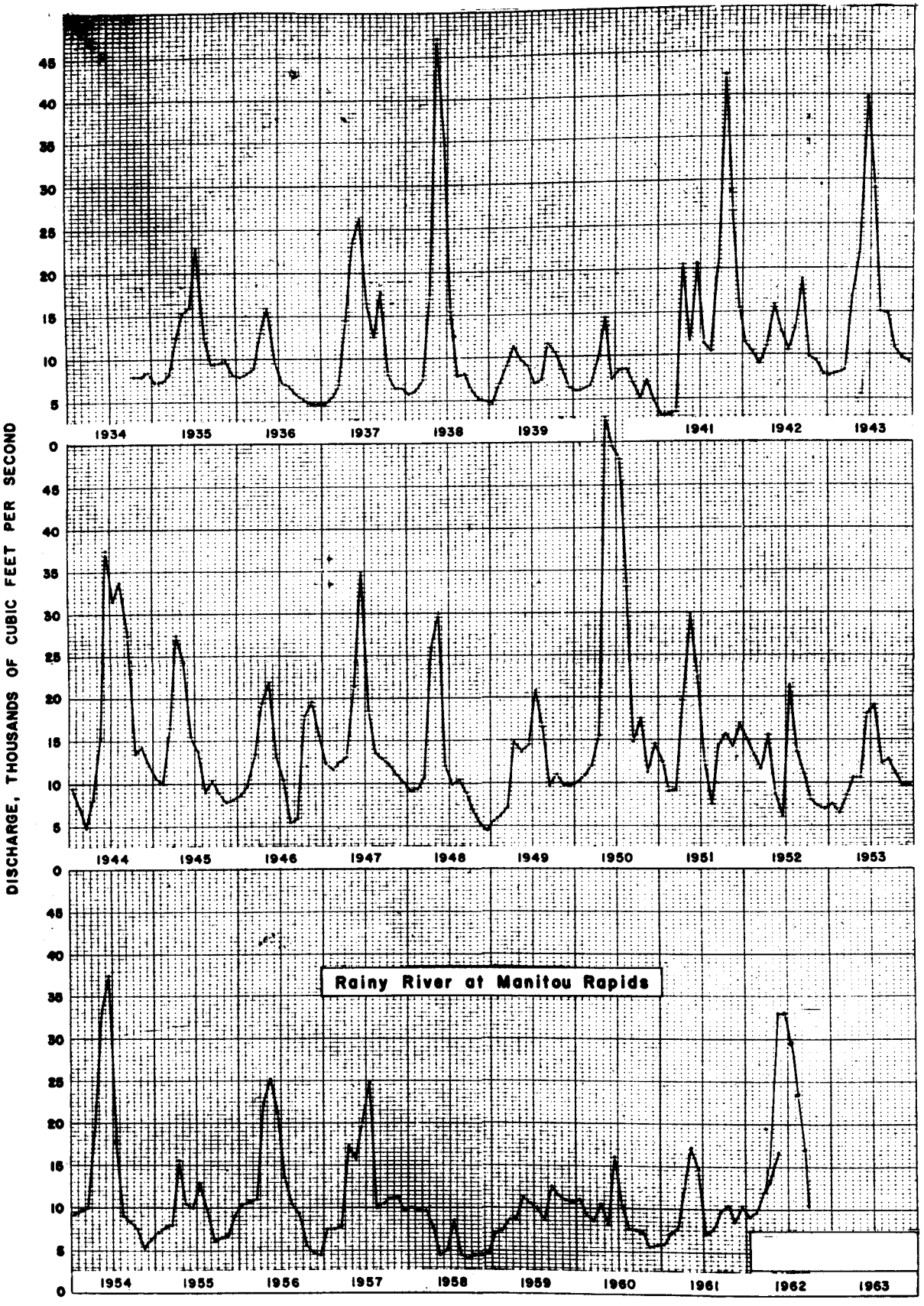

FIGURE 10. Hydrograph of Rainy River Manitou Rapids.

Flow Characteristics at International Falls—Fort Frances

The watershed above this station is approximately 14,900 square miles, of which 10,360 square miles are in Ontario and 4,540 square miles are in Minnesota.

(a) *Discharge and runoff data:* (Discharge records, 56 water years, October 1, 1905 to September 30, 1961; runoff records, 45 water years, October 1, 1905 to September 30, 1950)

Flow	Maximum daily	— 47,900 cfs	(July 7, 1950)
	Minimum daily	— 40 cfs	(April 20, 1941)
	Mean	— 9,100 cfs	
Annual runoff	Maximum	— 19.05 inches	— (1950)
	Minimum	— 2.94 inches	— (1924)
	Mean	— 8.24 inches	

Monthly runoff - Maximum 3.86 inches (June 1950)
Data above is based on unadjusted records.

(b) *Flow duration data:* (Records available from October 1, 1909 to September 30, 1961)

Exceeded 99.8 per cent of the time —
1,000 cfs daily flow

Exceeded 50 per cent of the time —
8,000 cfs daily flow

The flow duration data, because of the regulation of upstream reservoirs do not reflect natural conditions. The outflow from Rainy Lake is controlled by the Minnesota and Ontario Paper Company at the dam at International Falls - Fort Frances subject to the terms of an Order[1] issued by the International Joint Commission.

Flow Characteristics at Manitou Rapids

The watershed above this gaging station is about 19,400 square miles. It includes, in addition to the headwaters area, the watershed of the Big Fork and Little Fork Rivers comprising 3,900 square miles, and 600 square miles tributary to minor streams entering the Rainy River.

(a) *Discharge and runoff data*: (Complete records available for 34 water years, October 1, 1928 to September 30, 1962)

Flow	Maximum	— 71,600 cfs	(May 12, 1950)
	Minimum daily	— 928 cfs	(Dec 26, 1929)
	Mean	— 11,800 cfs	
Annual runoff	Maximum	— 16.31 inches	— (1950)
	Minimum	— 3.13 inches	— (1931)
	Mean	— 8.26 inches	

Monthly runoff - maximum 3.15 inches (May 1950)

(b) *Flow duration data:* (Complete records available from October 1, 1933 to September 30, 1962)

Exceeded 99.6 per cent of the time—
3,000 cfs daily flow

Exceeded 50 per cent of the time—
10,000 cfs daily flow

[1] See footnote, page 35.

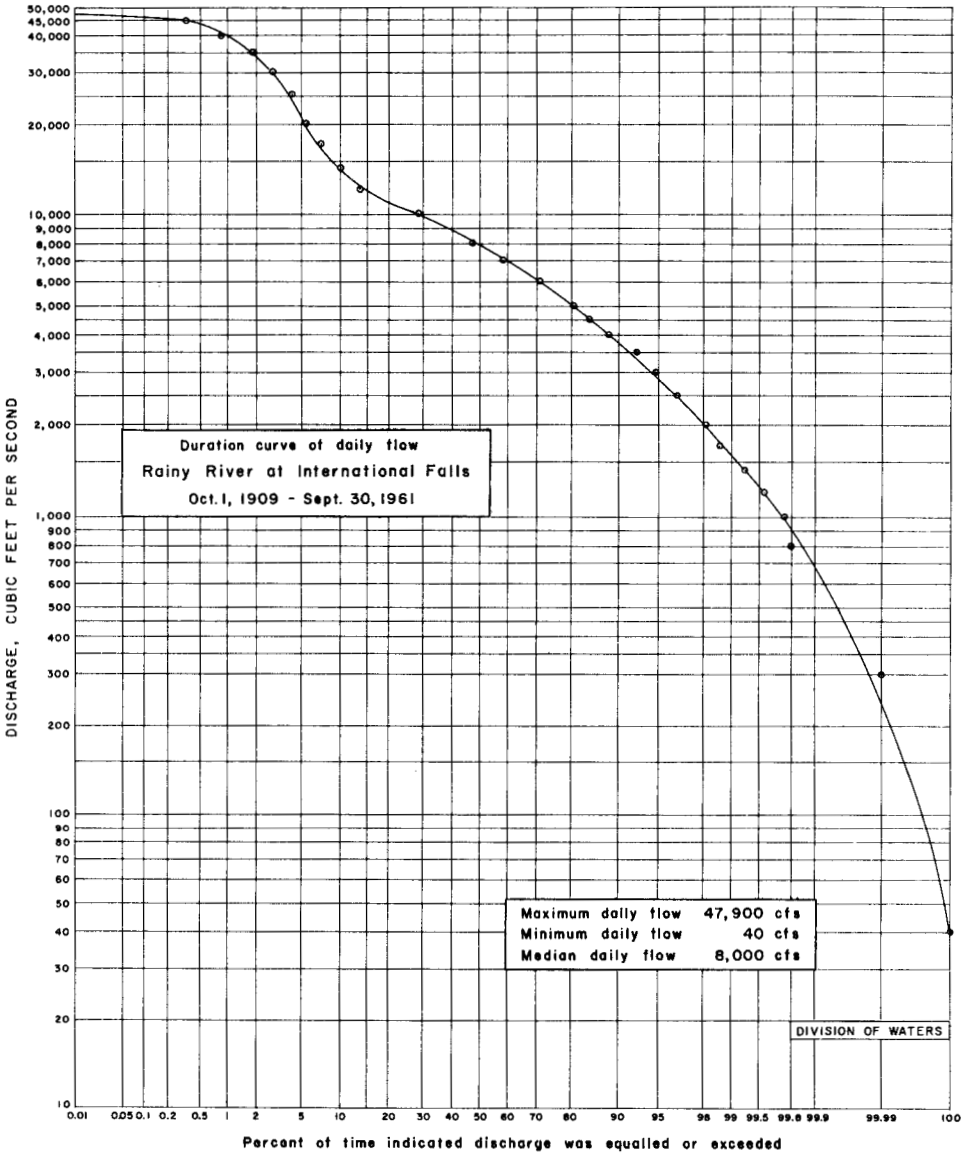

FIGURE 11. Duration Curve of Rainy River at International Falls.

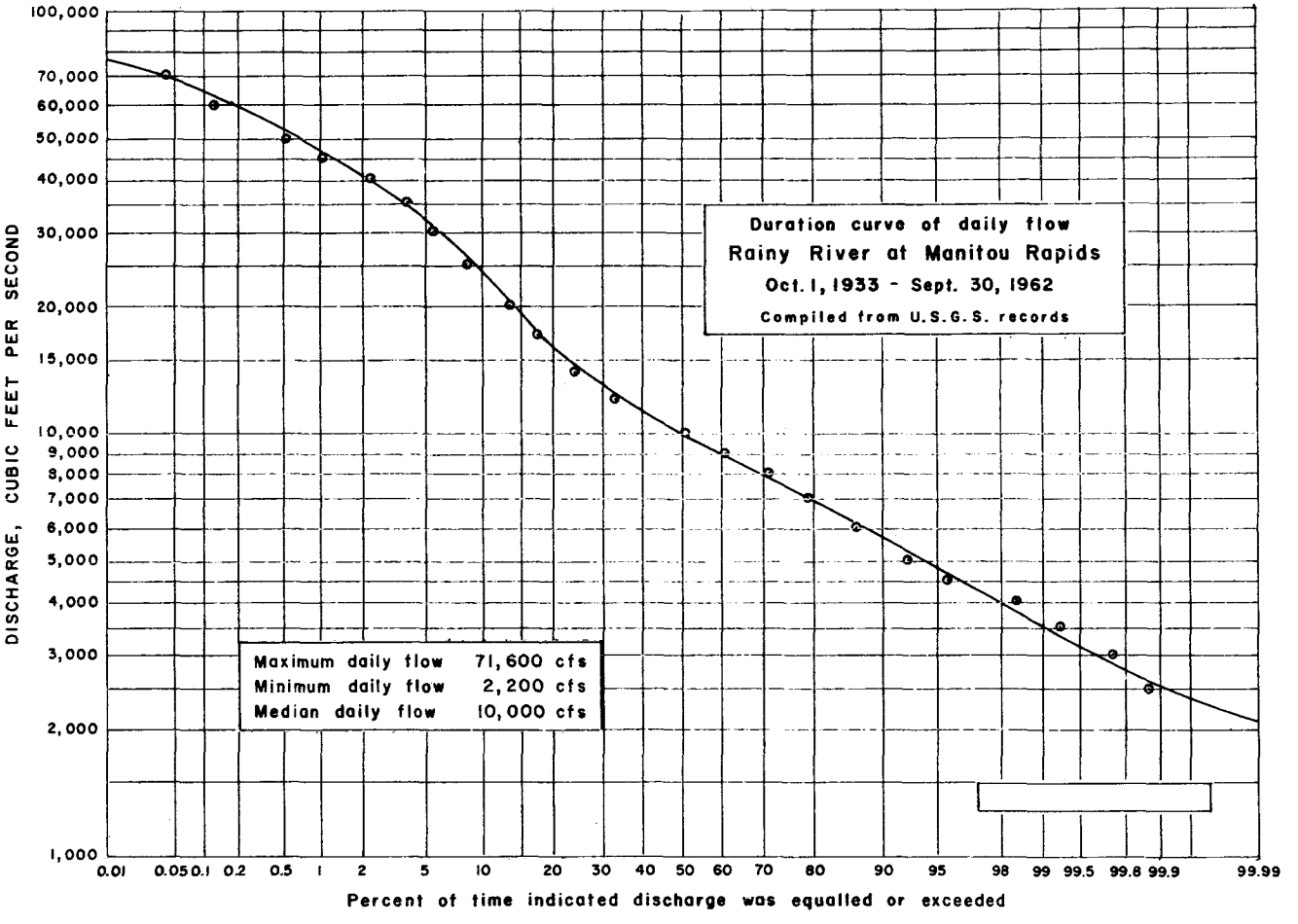

FIGURE 12. Duration Curve of Rainy River at Manitou Rapids.

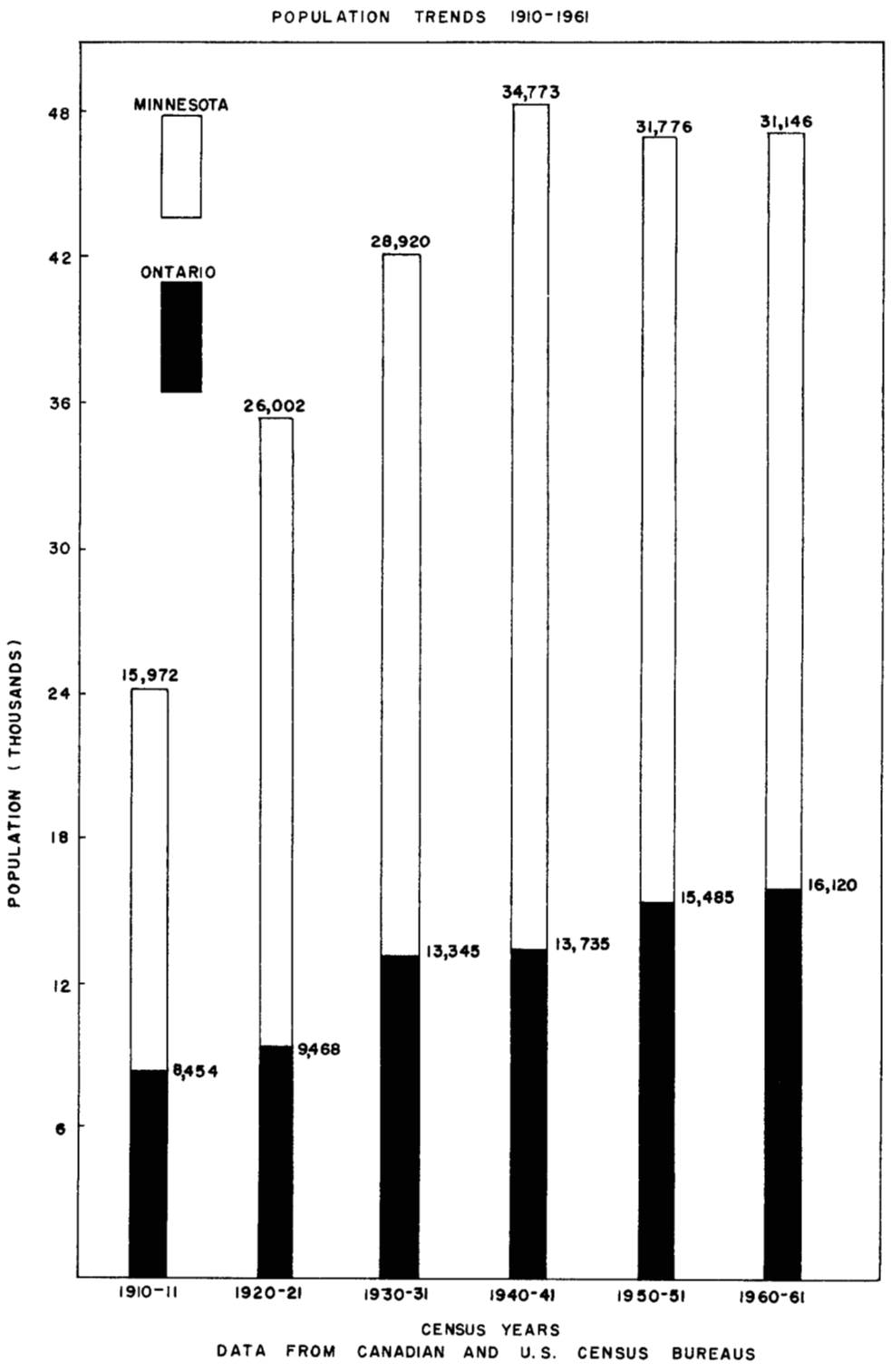

FIGURE 13. Population Trends 1910-1961.

Population

The population in the area based on the census of 1960 totaled approximately 47,000. Five communities have populations in excess of 1000. Their combined total equals 42 per cent of the population in the watershed. Population growth was moderate up to 1940 and since has declined slightly. Recent increases in urban population have been more than offset by declines in rural population. Population density expressed in persons per square mile is approximately 27 in Ontario and slightly over 5 in Minnesota.

TABLE 1—URBAN POPULATION CHANGES

Municipality	1910	1920	1930	1940	1950	1960
Fort Frances, Ontario	2,780	2,818	5,003	5,410	8,114	9,481
Rainy River, Ontario	1,572	1,404	1,680	1,150	1,348	1,168
International Falls, Minn.	1,487	3,448	5,036	5,626	6,269	6,778
South Int. Falls, Minn.	—	283	939	1,299	1,840	2,479
Baudette, Minnesota	1,565	1,531	1,036	1,459	1,349	1,597
TOTALS	7,404	9,484	13,694	14,944	18,920	21,503

LAND USE AND DEVELOPMENT

The Rainy River watershed in both Canada and the United States is used for forest products industries, agriculture, silviculture, recreation, fur farming, and commercial fishing. In International Falls and Fort Frances extensive pulp and paper manufacturing facilities have developed. In the early days, lumbering was the outstanding industry, but presently it is of lesser significance.

The Ontario-Minnesota Pulp and Paper Co. Ltd. at Fort Frances is located on the north bank of the Rainy River at the end of the power and control dam. The production of pulp is based entirely on the groundwood process, supplying the needs for newsprint and specially paper production, as well as supplying a portion of the pulp required for the International Falls operation. Sulfite pulp used in the production of paper is pumped in a pipeline as slush stock from the U.S. mill. Kraft pulp that is used is trucked in from the International Falls plant. Average wood consumption is approximately 500 cords per day and the average paper production approximates 400 tons per day. The total mill employment averages about 640 persons.

The Minnesota and Ontario Paper Company at International Falls is located on the south bank of the Rainy River, opposite the Canadian mill, at the end of the power and control dam. Pulp is produced by the groundwood process, the sulfite process, and the kraft process. A portion of the pulp from the latter two processes is supplied to the Fort Frances mill for its paper production. The wood delivered for sulfite, Kraft and Insulite pulp production averaged approximately 340, 240, and 170 cords per day, respectively, in 1960 and 330, 290, and 410 cords per day in 1961. Finished products averaged approximately 320 and 330 tons of paper per day in 1960 and 1961, respectively, and 440 and 710 tons of Insulite board daily in 1960 and 1961. The total mill employment averages about 2,000.

Recreational facilities such as summer cottages, resorts, fishing areas and bathing beaches are present on the Rainy River near Lake of the Woods. Along Rainy River between Fort Frances and Baudette limited recreational facilities have been developed. In the latter section of the river very few summer homes, practically no bathing areas, and few boats are encountered. In the lower part of the river, especially near the Sioux and Manitou Rapids, there is a limited

amount of sport fishing. Along the reach of the river from Baudette to the mouth there has been extensive development of recreational facilities and there is considerable sport fishing.

Practically all of the farming in the Minnesota section of the watershed is found in Koochiching and Lake of the Woods counties. Approximately 864 farms comprising 213,500 acres are included in the two counties. The principal crops are hay, grains, and potatoes. In Ontario, farming is restricted to a strip of about five to seven miles in depth back from the river. A large number of farmers, it was stated, do not have sufficient livestock and acres of land under cultivation to provide a sufficient income. Many supplement their income by cutting pulpwood or timber during the winter months. A number of farms are no longer used for agricultural purposes. Most of the non-urban employment in the area is in cutting of pulpwood and related activities.

EFFECTS OF POLLUTION

Human Health

The danger to health in the use of these waters is measured most readily by the coliform determinations. Major purposes for which these waters are used include domestic water supply, bathing, and recreation. All of these uses are closely allied to public health and may be injuriously affected by the discharge of sewage.

Limits of pollution beyond which a health menace may exist are not universally accepted. Waters containing excessive coliform bacteria are considered unsuitable for use as a source of drinking water supply unless treated by means of prolonged preliminary storage or some other satisfactory measure in addition to conventional water purification methods. All sewage pollution must be considered as a potential health hazard. Pollution also may add an extra burden in the form of higher costs for water purification, necessitated by the failure of some upstream user to treat adequately the wastes produced. Similarly, many riparian owners who may wish to use these waters are not in a position to secure the protection provided by modern and properly controlled purification processes that can be installed by municipal bodies. The presence of sewage pollution in bathing areas also constitutes a health hazard.

Injury to Property

Discharge of inadequately treated sewage and industrial wastes into surface waters is a deterrent to potential development of riparian property and the use of such water for municipal and industrial purposes adds to the cost of water supply. Suspended solids, fiber, bark, chips, and foam cause deposits along shorelines. These deposits are unsightly and often highly odorous. Similar deposits are common on the river bottom.

During the summer season decomposition liberates gases from these deposits which often lift sections of the deposits to the water surface. Obnoxious odors are released from the floating masses, and bottom deposits. Such conditions adversely affect the use of waters for recreational purposes.

Nutrients contained in industrial wastes and municipal sewage effluents contributed to algal and slime growth.

Slimes are a nuisance in covering objects that remain submerged or largely submerged. Slime masses attached to various submerged objects and structures contribute to unsightly conditions.

Fiber entanglement with slimes may seriously interfere with angling and other fishing methods.

Sphaerotilus growths almost invariably occur in reaches below the entry of untreated pulp mill wastes.

Preservation of Aquatic Life

The danger to aquatic life resulting from pollutants discharged to the Rainy River would likely result from the deposition of solids, the promotion of slime growths and the depletion of dissolved oxygen. The artificial regulation of flows may also have an effect.

Solids in the form of fiber are an important constituent of paper mill wastes. Where the current permits, the fiber will settle out and blanket the bottom making it an unsuitable habitat for most useful fish food organisms and unsuitable for survival and hatching of fish eggs. Wood sugars, a constituent of paper mill effluents have been shown to promote the growth of the slime bacteria Sphaerotilus in receiving waters. These have been shown to be deleterious to fish and fish food organisms. The organic constituents of paper mill effluents exert an oxygen demand on the receiving water and for this reason may jeopardize fish populations. The oxygen requirement of fish is well understood so that suitable parameters can be established which will ensure satisfactory fish populations.

The regulation of water flow becomes important when bottom fauna is affected by exposure of extensive areas of bottom and when dilution water is required to maintain oxygen levels.

FIGURE 14. Bottom sampling, Rainy River survey. Left to right, John Evans, Ontario Water Resources Commission; Richard Klippel, U.S. Public Health Service; Lawrence A. Schmid, U.S. Public Health Service. August 1962. (International Falls Daily Journal Photograph)

EXTENT OF POLLUTION

The extent of pollution in Rainy River has been measured by chemical, bacteriological, biological and physical examinations. The analytical results as charted in Figures 2 through 6, appended, show that pollution is due to both domestic and industrial wastes. Sampling covered Rainy Lake near its outlet, Rainy River, streams tributary to Rainy River, Lake of the Woods near the mouth of Rainy River and various pulp and paper mill sewers.

Rainy River

Water of good quality entered Rainy River at Ranier. The bacterial quality decreased appreciably from Ranier to the International Bridge but the chemical and physical characteristics changed only slightly. At the first two ranges below the pulp and paper mills[1], ranges 83.3 and 82.2, significant changes in the water quality were found. At the former range the effects of the Ontario mill discharges and the Fort Frances domestic wastes were evident. On the Minnesota side of this range no appreciable changes were found in the physical and chemical characteristics of the water, but the coliform count increased from about 150 to 500 per 100 ml. At 50 feet from the Ontario shore at range 83.3 the coliform counts ranged up to 140,000 per 100 ml, the DO dropped by about 0.5 mg/l, and the BOD increased three to fourfold.

At range 82.2 the effect of the discharges from the Minnesota mill became evident. The coliform count near the Minnesota shore ranged up to 36,000 per 100 ml. The BOD at station 1/.00 averaged approximately 15 mg/l, a tenfold increase. The average DO dropped to 6.0 mg/l, down from 7.7 mg/l in Rainy Lake outlet. The suspended solids increased 300 to 400 percent and the lignin content increased nearly sixfold. Near the mid-point of the river at this range the average values of the chemical tests were not greatly changed from those found above the mill sewers, indicating channeling of the flow, with the strong wastes concentrated near each shore. The coliform count is a sensitive indicator of pollution, and near the mid-point of range 82.2 the count was approximately 12 to 15 times that at International Bridge.

At range 77.5 the wastes had spread appreciably across the river, but the concentrations remained high near each shore.

At ranges 71.2 and 64.8 the spread of the wastes across the river became more apparent, and at range 60.2 the BOD and DO levels were nearly uniform across the river, with values of about 3.0 and 6.0 mg/l, respectively. The turbidity, color, and lignin were also moderately uniform across the river at this range. The suspended solids and coliform count were somewhat higher in midstream than near the banks.

At range 36.4, below the Manitou and Long Sault Rapids, there were no appreciable differences in values at all sampling stations across the river, Essentially complete mixing had been attained. Sedimentation and bacterial stabilization had reduced the BOD to approximately 2.0 mg/l, and the turbidity to about six units. The volatile solids content at this range was approximately double that found at the International Bridge.

As the water progressed downstream the DO dropped slowly to a level of about 4.0 mg/l near Baudette. In the Baudette-Rainy River area a slight increase in BOD and suspended solids, and a slight decrease in DO were noted, due to the presence of wastes from the two communities. A short distance downstream an appreciable rise in DO occurred, perhaps due to greater concentration of algae in slow moving water in this area.

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[1] The pulp and paper mills are located at ranges 83.4 and 83.5.

FIGURE 15. View showing scum floating down river past International Falls waste treatment plant. 1962.

FIGURE 16. Member of field crew holding scum taken from river near International Falls waste treatment plant. 1962.

At range 1.3 (Wheeler's Point) just above the mouth of Rainy River the channel is wide. Near the Ontario shore the water is shallow, heavy weed growths are present, and the flow is sluggish. In the main channel adjacent to the Minnesota shore DO levels of 4.0 and 5.0 mg/l were noted while near the Ontario shore DO values ranged from 6.0 to 7.7. Temperature, pH, color and BOD were also higher along the Ontario shore.

Biologically, Rainy River appeared to be most affected by wood fiber and associated materials discharged from the pulp and paper mills. Nutrient elements contained in municipal sewage effluents and industrial wastes contributed to algal and slime growth. Studies completed have provided basic information on the abundance and distribution of the majority of organisms under present conditions. These data, when compared with future conditions and biotas, will allow estimation of benefits accruing from improved waste treatment, or other effects related to industrial and municipal development and growth.

FIGURE 17. Typical accumulation of wood slivers and fibrous material observed along U.S. shore of Rainy River. August 4, 1962.

(a) *Suspended Fiber:* Fresh suspended wood fiber was associated with Sphaerotilus (slime) growths. The fiber often served as a substrate, both when suspended and caught on obstructions, and Sphaerotilus growth generally declined in reaches where wood fiber disappeared. Fresh wood fiber deposits were unfavourable to the majority of bottom animals. In the main path of wood fiber flow, finer fibers occurred near the river surface and coarser fibers near the bottom. Weight per volume also increased with depth. Freshly discharged fibers were eventually lost to sedimentation, but river deposits were reduced or removed by a number of actions and no continuous year to year buildup was noted. Experiments with line sets indicated fiber entanglement at a rate that would seriously interfere with angling and other fishing methods. Higher river stages slowed sedimentation of fresh wood fiber and maintained its suspension over greater stream distances.

(b) *Slime (Sphaerotilus) Growth:* This filamentous bacterium began proliferation in reaches below entry of the pulp mill wastes. Areas containing materials conducive to its growth were rather sharply delimited by the presence of fresh suspended wood fiber. It formed slimy coating on various obstructions,

including trapped wood fibers, in the upper river. Experiments indicated complete coatings were developed from a few initial fibers within 72 hours in late summer. Dislodged filaments were more concentrated than algae in a number of plankton samples.

FIGURE 18. Suspended bark, fibers, and chips adhering to tree. After high flow in spring of 1962. (Elm Island, July 23, 1962)

Growth rates noted in summer would appear to make slimes a nuisance only in covering objects that remain submerged or largely submerged for at least two or three days. Slime masses attached to various obstructions contribute to unsightly conditions.

(c) *benthos*: Bottom animals were eliminated from areas that were exposed by weekly regulated declines in water level in 1960 and 1961. The great majority of organisms avoided fresh wood fiber deposits (they were tolerated by sludge worms, some midges, and some snails) but aged fiber mixed with natural materials had no marked deleterious effects on other common groups. In many instances varied and comparatively concentrated populations resided in bottom deposits that contained aged wood fiber. Higher river stages (increased dilution) contributed to greater variety of organisms in 1962. Forms most tolerant of wood pulp fiber and associated industrial waste products were the only ones found in any great concentration. A number of forms avoided the upper river entirely, and others seemingly may live there only in areas right of center during the years of normal river stages. With the exception of sludge worms and some midges, concentration of organisms was less than would normally be expected for a stream environment of this type, and it may reasonably be assumed that benthos development was generally impeded by the waste complex entering the river from the Fort Frances-International Falls area.

A number of the more desirable fish food organisms were evidently unable to contend with conditions developed during summers with normal river stages. Animals that offered greatest quantities of fish food were crayfish, fingernail clams and midges.

(d) *fishes*: Collecting operations netted 44 species of fish that may normally be expected in this general area. The sturgeon, Acipenser fulvescens, was not taken in nets, but specimens inadvertently caught on set lines were observed and

FIGURE 19. View showing bark, fiber, chips and slime adhering to nets. Summer of 1962. One and a half miles below Ontario and Minnesota mills.

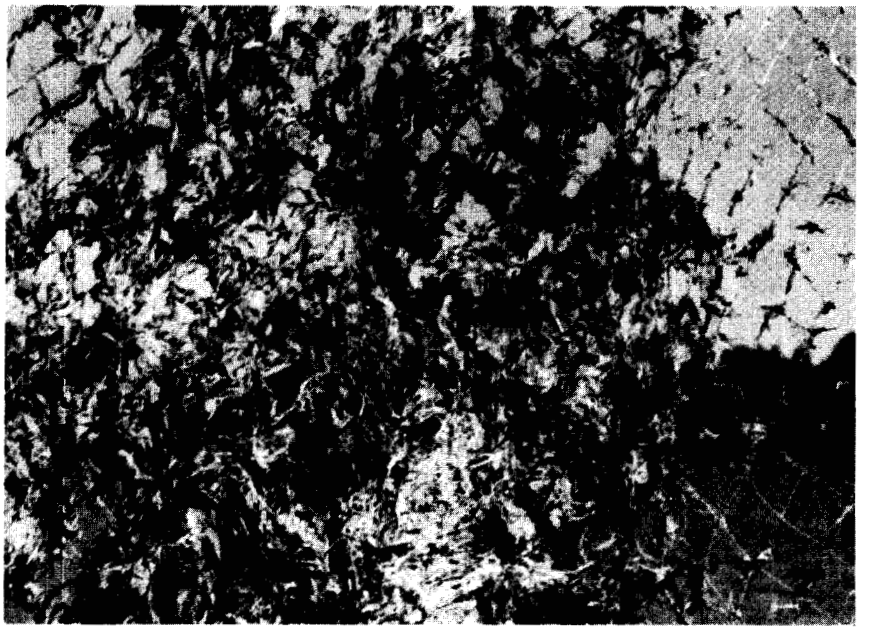

FIGURE 20. Close up of Fig. 19.

photographed by survey personnel. Abundance of fish in terms of pounds per unit area or annual harvestable crop could not be determined. Angler records were lacking and collection difficulties occasioned by high water and wood fiber fouling of nets prevented comparison of catches with those obtained by similar methods in other waters. Large numbers of certain species and a wide spectrum of age groups indicate substantial populations of larger species. The river environment seemingly imposed limitations on the number of species only in the upper 11 miles where six indigenous forms failed to occur. A number of species reproduce in Rainy River. The walleye population appears to be augmented by migration from Lake of the Woods or tributary streams. Independent studies conducted at the University of Minnesota[1] indicate that Sphaerotilus growth on walleye eggs reduces their hatchability.

Angler utilization is considerably less than the indicated fish population would sustain. Attraction for anglers is reduced by accumulation of wood fibers on fishing lines and unsightly Sphaerotilus growths. The fishery survey was carried out during a year of abnormally high water. The flows during the periods June 19 to July 17 and July 23 to August 6, 1964 averaged 29,000 cfs at Manitou Rapids, and it is possible that greater dilution so afforded allowed greater than usual survival of spring-spawned fish. Younger age groups of game fish were less numerous than normally anticipated. The fish population was similar on both sides of the river and fishing opportunity appeared to be equally divided. Fishing sites and access routes are more numerous on the American shore.

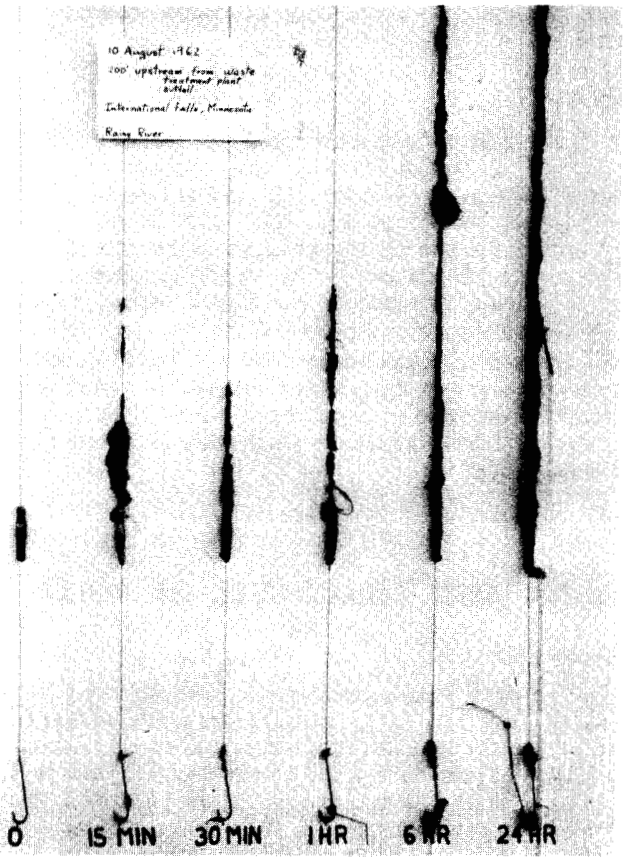

FIGURE 21. Suspended matter adhering to fishing line. 1962

[1] Smith, Lloyd L. Jr., and Kramer, Robert H., "Survival of Walleye Eggs in relation to Wood fibers and Sphaerotilus natans in the Rainy River, Minnesota," Transcription American Fisheries Society Vol. 92:3.

Transboundary Movement of Pollution

It is apparent from float studies conducted that trans-boundary currents occur at various places in the Rainy River. In the International Falls-Fort Frances area 55 floats were released. Of these, 31 crossed the International Boundary line and ten recrossed it within four miles of the point of release. Seven crossed from the Canadian to the United States side and 24 from the United States to the Canadian side.

In the vicinity of range 77.5, approximately six miles below the outlet of Rainy Lake, 11 of 17 floats released in the river crossed the boundary line from the Canadian side to the United States side. In the Rainy River-Baudette area the current is slow and ill-defined. Twenty-one floats released in this area showed only six crossings of the boundary, all from the Canadian to the United States side.

Limited conductivity studies in the Fort Frances-International Falls area indicated the pattern of transboundary movement of pollution in the river. A great increase in conductivity occurred along the United States shore just below the pulp and paper mill in Minnesota, due to the addition of quantities of inorganic wastes. The increased conductivity gradually spread across the river as the water moved downstream. By the time the water reached the junction of the Little Fork River (approximately 11 miles) the conductivity was uniform three-fourths of the distance across the stream from the United States shore.

In the vicinities of Manitou and Long Sault Rapids the flow is spread uniformly across the channel with very thorough mixing of the water and pollutional matter.

Lake of the Woods

The water from Rainy Lake undergoes appreciable changes as it passes down Rainy River. A comparison of the characteristics of Rainy Lake water with those of Lake of the Woods water shows that the pH has increased 0.4 units and the hardness, calcium and alkalinity have nearly doubled. The coliform density in Lake of the Woods water showed a remarkable recovery from the highly contaminated condition in the upper reaches of Rainy River. The dissolved oxygen deficiency noted in the lower section of Rainy River disappeared and the DO level approximated those found at Rainy Lake outlet.

The overall picture of Lake of the Woods water quality is satisfactory. Bacterial contamination is low, the oxygen demand is moderate, the DO is high, and the concentration of other substances is normal for a lake of this region. Extensive fiber deposits were found in Four Mile Bay but none was found in Lake of the Woods proper.

SOURCES AND CHARACTER OF POLLUTION

Industrial Wastes

Industry contributes the greatest volume and strength of waste to Rainy River. These wastes affect the water mainly from a physical and chemical rather than a bacterial standpoint. These industrial wastes are characterized by high oxygen demand, high suspended solids content, objectionable appearance, and the presence of nutrients which promote slime growths. The bulk of the industrial waste discharge occurs in the Fort Frances-International Falls area. The sewage originating in Fort Frances is now discharged to Rainy River after primary treatment. The Ontario and Minnesota Paper Co. Ltd. has recently reported 17 percent of the mill sanitary sewage is discharged into the municipal sewerage system. The remaining 83 percent goes directly into Rainy River with the mill wastes. At International Falls all industrial wastes, with the exception

of the pulp and paper wastes, are discharged to the municipal sewers and consequently are given biological treatment. The pulp and paper wastes are discharged directly to Rainy River. Approximately 22 per cent of the domestic sewage from the Minnesota and Ontario Paper Company is included with their industrial wastes. The remaining 78 per cent is segregated and diverted to the International Falls municipal sewer system.

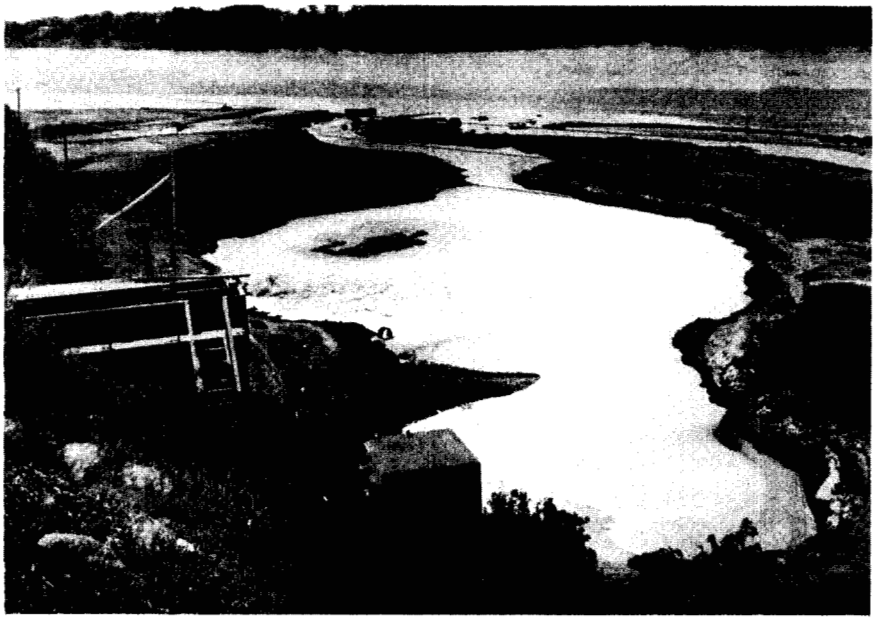

FIGURE 22. M&O Plant Sulfite Sewer basin—only one left intact after high water of May-June, 1962.

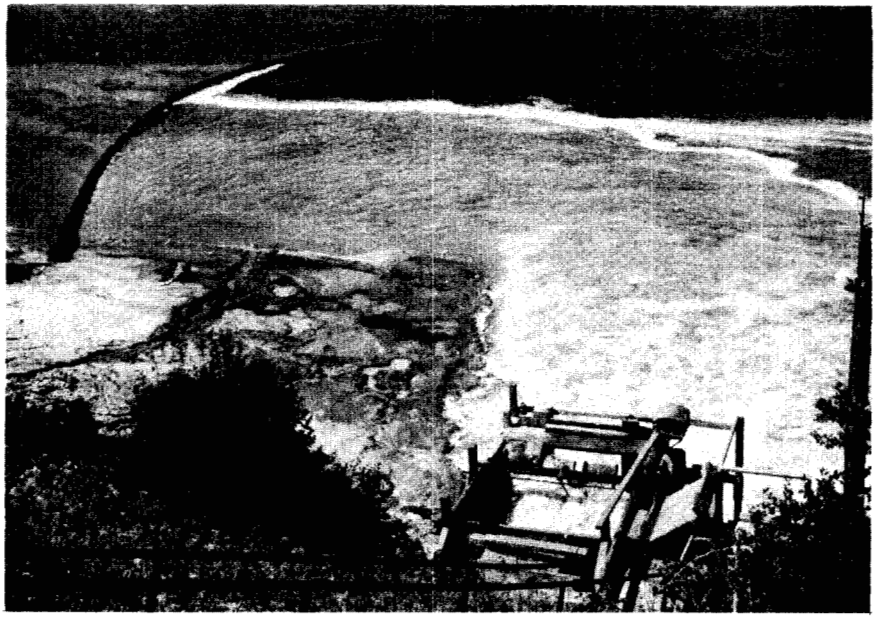

FIGURE 23. Flow Measuring and Sampling Installation at M&O plant—note barrel baffle to hold back floating material. August 2, 1962.

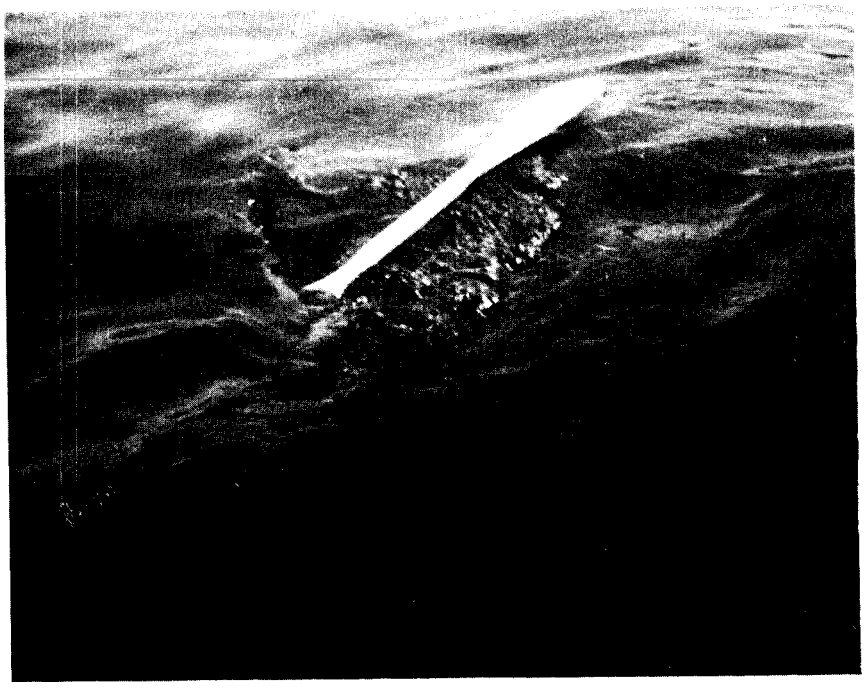

FIGURE 24. Floating mat of bark, fiber and chips with paddle supported on it. 1962.

FIGURE 25. Fibrous sludge deposits along shore of Rainy River at International Falls, Minnesota. August, 1962.

Pulp and Paper Mill Surveys

Waste surveys of the mills of the Minnesota and Ontario Paper Company and of the Ontario-Minnesota Pulp and Paper Company Ltd. were made during the summer periods of 1960 to 1962. The surveys of the Minnesota mill were made in 1960 and 1961 under the supervision of members of the staff of the Section of Water Pollution Control, Minnesota Department of Health. The surveys of the Ontario mill were made under the supervision of members of the staff of the Ontario Water Resources Commission in 1960, 1961, and 1962.

Sources of Industrial Waste

Almost the entire industrial waste load is discharged from the outlets of the two pulp and paper mills.

The total daily volume of mill wastes is approximately 77,000,000 U.S. gallons. This volume includes condenser and cooling water as well as process wastes. These effluents contain large quantities of pollutants which have an adverse effect on the receiving stream.

The BOD load contributed to the stream daily by the two mills in 1961 totalled about 255,000 pounds. This oxygen demand is the equivalent of that from the domestic waste of a city of one and one-half million people.

The suspended solids load, including bark, fiber, chips, and lime sludge, discharged from the mill outlets exceeded 100 tons/day. Of these suspended solids, woody materials amount to 61.5 tons/day or about four per cent of combined net production of both mills. Suspended matter of this type is the cause of deposits along the shore and on the river bottom. These deposits are unsightly and often produce obnoxious odors.

FIGURE 26. Bark, fiber, and chip deposits in an eddy of Manitou Rapids. July 23, 1962.

Sources of Domestic Waste

On the United States side the City of International Falls represents the major portion of the sewered population. This community has secondary treatment facilities and its BOD load to the stream represents approximately nine per cent of the entire domestic waste load. Baudette, with only primary treatment, discharges a domestic BOD load of approximately 18 per cent of the total.

On the Canadian side Fort Frances, which presently has treatment works under construction discharges an estimated domestic BOD load of about 58 per cent of the total. Emo is only partially sewered and provides no treatment. At present it contributes a small BOD load. Rainy River Village has only primary treatment. Its waste load contributes about five per cent of the total domestic BOD to Rainy River. The remaining domestic BOD is contributed by villages located on tributaries of Rainy River. The data show that the domestic BOD load to the river from each of the tributaries is relatively light and insignificant.

It is expected that the coliform load on the river from each community, except where chlorination is practiced, is approximately proportional to the domestic BOD load. It is of interest to note that the entire domestic BOD load is about one per cent of the combined domestic and industrial BOD load.

Wastes from navigation and careless dumping of refuse along the shore and from other sources are relatively negligible in Rainy River.

EFFECTS OF REDUCED WATER FLOWS

In complying with the International Joint Commission Order[1] of June 8, 1949, the dam is operated to conserve water over weekends during periods of dry weather. As a consequence of this, the level of the river particularly above the Manitou Rapids, drops and exposes extensive areas of what would normally be river bottom. This results in the elimination of bottom fauna on the exposed bottom, renders travel on the river difficult and causes unsightly and odorous conditions to develop.

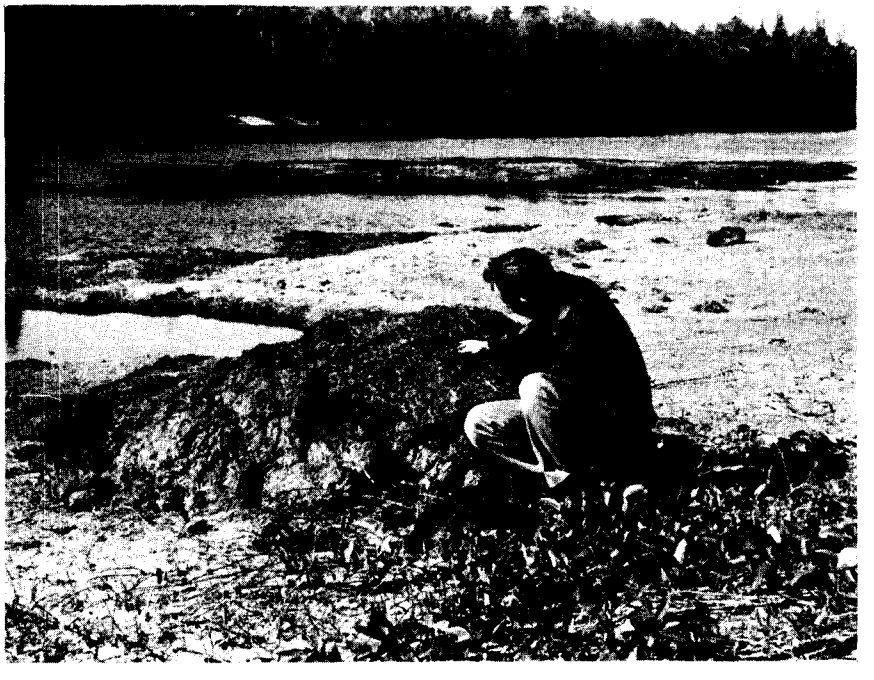

FIGURE 27. Sludge bank of bark, fiber and chips. 1962.

[1] See footnote, page 35.

DISCUSSION

Two methods for dealing with water pollution problems are commonly advocated. One viewpoint advocates the utilization of the stream for carrying away as much waste as it can tolerate without interfering too seriously with normal stream uses. The other would exclude all impurities from watercourses. Between these divergent views is a course which the Board feels will meet the situation. This course has been followed in developing the Rainy River water quality objectives. No tolerance limit, whether for the effluent or for the stream, can be expected to remain fixed. It must change with changing conditions and each change should be in the public interest.

The large volume of water flowing between the United States and Canada should be regarded as a natural resource to be shared by both countries. It should not be wantonly destroyed by pollution from municipalities, from industries, or from any other source. An intelligent policy of safeguarding these waters from gross pollution should be fostered and encouraged so that they will be used for the highest public good. The Rainy River should not be regarded as a public sewer for carrying away wastes of all kinds, however, its reasonable utilization for the disposal of adequately treated effluents may be permitted.

Rainy River Water Quality Objectives

In more specific terms, adequate controls of pollution will necessitate the following objectives for:

A. SANITARY SEWAGE, STORM WATER AND WASTES FROM WATER CRAFT

Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for the purposes aforementioned.

Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the coliform M.P.N. median value does not exceed 2,400 per 100 ml at any point in the waters following initial dilution.

As applied to public recreational bathing areas the provisions would be met if median coliform values do not exceed 1,000 per 100 ml. Bacterial determinations are to include the presumptive and confirmed tests, or the M.F. procedure, for the coliform group of bacteria as given in "Standard Methods for the Examination of Water and Sewage." In the future when techniques have been adopted as standard, consideration shall be given to differentiating between fecal and non-fecal coliform organisms.

B. INDUSTRIAL WASTES

(1) *Chemical Wastes - Phenolic Type*

Industrial waste effluents from phenolic hydrocarbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplied and may taint the flesh of fish. Adequate protection should be provided for these waters if the concentration of phenol or phenolic equivalents does not exceed an average of 2 p.p.b. and a maximum of 5 p.p.b. at any point in these waters following initial dilution.

(2) *Chemical Wastes, Other than Phenolic*

Adequate protection should be provided if:

(a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5.

(b) For the protection of water supplies, the odor-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odor number in excess of eight due to such added material.

(c) Unnatural color and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the aforementioned uses.

(d) Oils are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wild life or their habitat, or will adversely affect public or private recreational development or other legitimate shoreline developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 p.p.m., or a sufficient amount to create more than a faint iridescence.

(e) Suspended solids, including but not limited to floating materials, bark, butts, sawdust, wood refuse, foam, and like substances, are reduced to a point such that they are not conducive to slime growths, formation of sludge islands, or will not injure fish or wildlife or their habitat, or will not adversely affect public or private recreational developments or other legitimate shoreline developments or uses. The provision of this Objective pertaining to "floating," or suspended, solids will be met for pulp and paper wastes if facilities that effect substantially complete removal of all suspended solids are provided by the mills.

(3) *Highly Toxic Wastes*

Adequate protection should be provided for these waters if substances highly toxic to human, fish, aquatic, or wild life are eliminated or reduced to safe limits.

(4) *Deoxygenating Wastes*

Adequate protection of these waters should result if sufficient treatment is provided for the substantial removal of solids, bacteria, chemical constituents and other substances capable of reducing the dissolved oxygen content of these waters unreasonably. The provision of this Objective, pertaining to dissolved oxygen reduction, would be met if the dissolved oxygen does not fall below 5 mg/l at the monthly average flow which is exceeded 95 per cent of the time in the critical month, nor fall below 3 mg/l at the minimum daily flow that is exceeded 95 per cent of the time in the critical month.

(5) *Nutrients for Slime Bacteria*

The discharge of nutrients, including wood sugars, shall be controlled or reduced to the extent necessary to prevent nuisance growths of Sphaerotilus or other slimes in the river.

In developing these water quality objectives for the Rainy River, the General Objectives set forth on page 34 apply. It is the considered judgment of the Advisory Board that if sewage and industrial waste treatment facilities are provided so that the water quality control objectives enumerated above may be met, the waters of the river will be made suitable for the different uses mentioned and any accumulated deposits on the river bottom will be reduced or eliminated within a reasonable period of time.

Remedial Measures

Stream pollution exists in Rainy River. This pollution has an injurious effect on actual or potential uses of these waters for domestic and industrial water supplies, bathing, recreation, and fish life. Pollutants cross from each side of the boundary to the other. A further question in the terms of the reference concerns the measures for progressively remedying the situation. If such measures are to be effective, they must raise the quality of the waters to the point where they can be used satisfactorily for these various purposes.

Disposal of Industrial Wastes

The volume of industrial wastes, exclusive of that carried in municipal sewers, discharged directly into these boundary waters, is 77 million U.S. (64 million Imp.) gallons per day, nearly 30 times the volume of municipal wastes. These wastes carry large quantities of deleterious substances, which seriously affect the quality of the receiving waters and may adversely affect property values.

In contrast to the disposal of domestic sewage, industrial wastes are so varied in composition that no uniform treatment process is applicable. Each waste must be considered individually in the light of the deleterious substances present. Limits of tolerance for certain of these substances in industrial effluents have been included in the "Rainy River Water Quality Objectives" as interpreted for these waters. The problem of industrial waste treatment is one for the industry involved.

The usual procedure in solving mill waste problems is to provide waste recovery and utilization in-plant insofar as practical, followed as needed by such treatment and disposal procedures as best suited to local conditions. The Board is cognizant of the need for a phased program in the construction of abatement works and submits its views on how solution of this problem might be accomplished.

It is suggested that waste treatment for the Minnesota and Ontario Pulp and Paper mills be largely as follows, with construction to be undertaken in stages for those parts where experience with the operation of initial works may be required to guide the design of succeeding projects.

1. Complete segregation of sanitary sewage, including facilities such as lifts, and discharge to the municipal sewage treatment plant.
2. Primary treatment, or equivalent, for all high-solids wastes to effect essentially complete removal and satisfactory disposal of all suspended solids, including but not limited to bark, butts, wood fiber, sawdust, refined fiber, clay, ashes and lime-sludge.
3. Adequate flow measuring and recording devices and facilities for composite sampling of the flow from each sewer to provide continuous monitoring at all times.
4. Recovery and control, or treatment, of spent sulfite liquor.

The facilities to be provided should be adequately designed and constructed to ensure satisfactory operation over a period of many years. Approval of plans for such facilities by the Minnesota and Ontario water pollution control agencies is required, and the plans may also be reviewed by the technical advisers to the International Joint Commission. Joint facilities to serve both mills are considered desirable wherever practical.

The methods of treatment to be employed and details of design should be left to the discretion of the companies; however, the following comments are offered:

1. Complete segregation of the sanitary sewage may necessitate abandonment of some existing sewers and construction of new ones which can be connected to the municipal system.
2. The existing bark pond may possibly be used, if reconstructed to provide firm dikes, an increase in size, protection from flooding, and division into parallel cells to maintain a satisfactory effluent during dredging operations, or another method of treatment such as mechanical clarifiers may be used. A high degree of segregation of high-solids waste streams probably will be necessary. Lime re-burning might be considered as an alternate to collection and disposal of the lime sludge by storage.

3. Collection of the concentrated sulfite liquor and storage for intermittent discharge may be feasible to control slime growths. Changing the sulfite pulping process to a recoverable base chemical might be considered as an alternate if it is found necessary to reduce the high BOD of the spent sulfite liquor. This may also be done by concentration and burning, or other means.

Disposal of Municipal Wastes

Since municipal sewage carries the organisms of diseases transmissible to humans, the discharge of this waste is of major concern in these boundary waters. The large volume of municipal wastes, totalling three million U.S. (2.5 million Imp.) gallons per day, discharged into these waters adds a heavy bacterial load. About 50 per cent of this is receiving some treatment, but the treatment in some cases is primary only. In addition to the domestic sewage from the sewered population of 21,500 in the area under Reference, the municipal sewers carry a limited amount of industrial wastes.

It is the opinion of the Advisory Board that satisfactory quality in these waters, as outlined in the "Rainy River Water Quality Objectives" will not be obtained until all municipal wastes are given continuous treatment of a high degree, and more efficient or secondary treatment will have to be provided where this has not already been accomplished. It is recognized that local conditions on either side of the boundary may give additional impetus to the need for this higher degree of treatment. The completion of the construction of such works will require an appreciable period, but action should be taken without delay to inaugurate this program leading to the attainment of secondary treatment for all municipalities discharging wastes into these waters.

This program for the treatment of sewage will not fully accomplish the desired objective unless concurrent action is taken to deal with the overflows from combined sewers. A long term program leading to the separation of domestic sewage from storm water should be adopted. Sanitary sewage must also be segregated from mill wastes for proper treatment in the municipal treatment facilities.

Cost and Financing

The following estimates are submitted on costs for remedial measures in answer to this question in the terms of the reference. The municipal costs are for the provision of secondary treatment. Industrial costs were estimated by industries involved on the basis of compliance with the "Rainy River Water Quality Objectives."

(a) *Costs for municipalities*: For the second stage or secondary treatment of municipal wastes the costs are estimated as:

United States	$ 200,000
Canadian	508,000
Total	708,000

(b) *Costs for Industries*: In response to a request in behalf of the Advisory Board the Minnesota and Ontario Paper Company, early in 1963, estimated that costs for treatment works which would accomplish the general objectives of the International Joint Commission for boundary waters quality control would exceed $11 million. At the same time the Company indicated that it was ". . . difficult, if not impossible, to determine on such short notice and without detailed engineering studies what facilities should be constructed and where they should be located, . . ." The figure was therefore given as a ". . . rough order-of-magnitude estimate . . ." without attempting to separate the estimate as between the International Falls and Fort Frances mills. The Company also indicated that

in making a ". . . submission of this rough estimate it is not to be construed as indicating that we accept the idea that the general objectives of the I.J.C. for boundary waters quality control should be applied to Rainy River, or that we consider the construction of the facilities you list to be necessary or desirable, or that the expenditure involved can be justified on any basis."

The facilities to which the Company referred in the statement above are essentially those given in the section of this report entitled "Remedial Measures for Disposal of Industrial Wastes."

At the hearing held in International Falls, Minnesota, on August 28, 1963, the President of the Company indicated that the $11 million estimate previously supplied ". . . is one of the rounder numbers I have heard, $10 million plus 10 per cent for contingencies. It goes beyond the capability or the responsibility of the engineers who were involved in this sort of brainstorming operation. . ."

At this hearing the President of the Company further indicated that he did not know whether treatment facilities which would accomplish results in conformance with the objectives ". . . could be accomplished for $11 million, or whether it would cost $20 million. It is just impossible to know."

From the above, it is obvious that the Company has supplied no firm estimate of the costs of necessary treatment works. It is further apparent to the Board that the $11 million figure is unrealistic and probably includes what may be termed "process improvements" as distinguished from waste treatment works.

A table indicating costs for treatment works for other pulp and paper mill waste treatment facilities which have been constructed in the United States within the past ten years is included in the Appendix as Table 2. This table is being presented for the purpose of indicating the general range of cost for treatment facilities. None of the figures given can be applied directly to the International Falls-Fort Frances mills.

The Board feels that it is unable to develop reliable estimates for these facilities. If the International Joint Commission feels that a reliable estimate is necessary a consulting engineer should be employed for this purpose. Additional time and funds should be made available to the Advisory Board to permit the employment of an engineer to develop these estimates. However, the Board does not recommend that a consulting engineer be employed by the Commission for this purpose, since the Board considers that the engineering study for installation of remedial measures is a responsibility of the industry.

Remedial works for treating municipal wastes must be constructed through public funds. Industrial wastes are the responsibility of the industry. Experience has demonstrated that in certain industries it is possible to reclaim from the wastes useful by-products which may partially offset the cost of treatment. The treament or control of these wastes, however, whether profitable or otherwise, must be regarded as a part of the cost of production.

Review of Improvements Completed, Underway, or Planned to Remedy Conditions

Since 1949 the pulp and paper companies have initiated various measures to provide greater plan efficiency and recovery, increased production and new products. Some of these measures have directly or indirectly contributed to some extent in reducing the amount of pollution discharged to the Rainy River. Control measures taken over this period include the following:

1. Installation of bark recovery system and bark burning boiler at International Falls;
2. Provision of a bark recovery plant at Fort Frances mill;
3. Construction of a retention pond in the river directly adjacent to the International Falls Plant;

4. Provision of facilities for accumulating, transporting and burning in an incinerator additional bark and fiber;
5. Installation of facilities to recover fiber and waste wood for use in manufacturing insulation board;
6. Improvements to process to increase re-use of water and reduce fiber losses;
7. Installation of save-alls on paper machines at International Falls and Fort Frances and rebuilding and improvement of other paper machine save-alls;
8. Installation of conical bottom stock chests at International Falls;
9. Replacement of gravity type pulp thickeners with vacuum machines;
10. Processing of screen rejects;
11. Re-pulping of kraft rejects;
12. Construction of an Asplund plant to convert screen rejects from insulation board plant;
13. Installation of facilities for recircling effluent from bark presses;
14. Isolation and connection of mill sanitary sewers to International Falls sanitary sewer system; and
15. Improvement of effluent measurement and sampling equipment.

The findings of this investigation indicate the need for provision of additional waste treatment and control facilities which are capable of effectively reducing the existing pollution to the Rainy River. The companies have announced plans to proceed over the next three or four years with plant construction projects, which, on completion, will reduce to some degree certain of the waste effluent constituents. The projects scheduled are as follows:

1. Connection of the remaining sanitary sewers within the International Falls plant to the municipal sewage treatment system during the years 1964 and 1965—estimated at a cost of $89,500, of which $35,000 has been spent to date.
2. Connection of the sanitary sewers within the Fort Frances plant to the new municipal sewage treatment plant now being installed at Fort Frances. This work is scheduled during the year 1964 at an estimated amount of $150,000.
3. Installation of a new steam boiler at International Falls for the primary purpose of supplying the increased demand for process steam, the boiler to be so designed that it can accommodate as fuel all of the bark produced at both Fort Frances and International Falls. This major facility is planned for construction during the years 1963, 1964 and 1965 at an estimated cost of $3,080,000, of which $180,000 is for facilities to permit burning of bark.
4. Rebuilding the facility at Fort Frances for the more efficient separation of bark and waste wood from the stream of water carrying it from the wood room, and providing facilities to convey this material to International Falls where it will be dewatered sufficiently so that it can be burned. The company estimates this measure will reduce the amount of bark and wood wastes discharged to the river from 25.7 tons to 6.8 tons, or a reduction of 74 per cent due to improved bark recovery. This project is scheduled during the years 1964 and 1965 at an estimated cost of $435,000.
5. Providing facilities for recovering and storing for re-use the major part of the fiber now being lost to the river from the Insulite Mill. This project has been modified and expanded recently, and the company now proposes to:
   (a) increase the capacity of the present Asplund pulping plant by increasing the dewatering facilities ahead of it,

(b) install another Asplund plant, and

(c) arrange for the temporary use of a third Asplund plant in which bark and waste wood is now processed so that it can be used on an emergency basis to process coarse pulp in the event of an outage of one of the other two Asplund machines.

The company estimates this project will reduce the wastage of fiber by 6.6 tons per day from the Insulite Mill, or a reduction of 55 per cent. This project is planned for completion in 1965 at an estimated cost of $1,200,000. The company anticipates from their studies that the total reduction in fiber discharged to the river under projects 4 and 5 will be 25.5 tons per day, or 44 per cent.

6. Modification of the sulphite cooking-chemical plant at International Falls so as to utilize in the manufacture of that chemical somewhat over half of the calcium carbonate, of which 60 tons per day are currently being discharged to the river. This is scheduled in the year 1967 at an estimated cost of $145,000.

These in-plant waste segregation and recovery projects should be carried forward on schedule as initial steps towards implementing an effective stream improvement program. Succeeding or possibly concurrent phases of this program should encompass installation or renovation of facilities which will provide the type and degree of treatment outlined in the section "Disposal of Industrial Wastes" (page 57).

CONCLUSIONS AND RECOMMENDATIONS

The investigation of pollution of the boundary waters of Rainy River and Lake of the Woods extended over the period from June 1960 to September 1962, which included a broad range of flows and weather conditions to encompass normal and critical water quality conditions. A comprehensive examination was made of many phases of pollution and relevant information was obtained from many sources. These data were studied and conclusions reached on the questions contained in the terms of reference to the International Joint Commission by the Governments of Canada and the United States. The conclusions of the Board are summarized as follows:

Conclusions

1. These waters are being polluted in many places on both sides of the boundary. Serious pollution exists in the entire river downstream from Fort Frances and International Falls.
2. There is a transfer of pollution from each side of the boundary to the other as demonstrated by float studies and by analytical results.
3. Conditions conducive to injury to health and property exist on both sides of the boundary. This has been manifested in the following ways:

   (a) *Health:* A potential menace is present where waters polluted to the extent of these are used for domestic purposes. The extent of pollution of these waters is such that they cannot be safely used as a potable water supply without complete and continuously effective treatment. Furthermore, they are so polluted in most areas so as to render them unsafe for recreational bathing purposes.

   The pollutants present in these boundary waters must be considered an actual and potential health hazard, whether they be transmitted through public water supplies, bathing beaches, or by other means. If the 1913 to 1962 trend in bacterial pollution is permitted to continue, the time will come when conditions will reach a point where it will be impossible to use these waters safely for domestic purposes.

(b) *Property:* Injury to property has been illustrated in an increase in the cost of water supply for municipalities and in lessened attractiveness of bathing beaches and water front areas which may result in lower valuation of resorts and other properties.

(c) *Industry:* There is evidence that these waters are polluted to such a degree that their use by certain industries may be affected. A potential economic loss to the community, and to industry as well will occur when a plant is unable to locate in an area because of inability to secure a satisfactory water supply.

(d) *Recreation:* These waters are polluted to such a degree that they are unsafe for bathing, unsuitable for fishing, detrimental to fish propagation, unsatisfactory for general recreational purposes and are aesthetically offensive.

Biological characteristics of the river have been altered by waste discharges. Changes in plankton, benthos, fishes and slime growths are related to specific waste effects and river discharge patterns.

Wood sugars discharged in the pulping process are a major source of nutrients for slime growths. Fiber, bark, and chips released from the pulp and paper mills create bottom deposits which rise and cause malodorous conditions along the major portion of the river, and impairment of fish propagation.

4. Some progress has been made in control or elimination of pollution during the period of this investigation. Municipal progress has been shown by construction of treatment facilities at Fort Frances and at South International Falls. Industrial progress to date has been confined mainly to in-plant controls and partial segregation of domestic sewage from industrial wastes.

5. Conferences by the Commission and the Advisory Board with village officials and industrial management showed that financing of the necessary remedial work is the principal hindrance to correction.

6. The condition of these waters requires that additional remedial measures be initiated as early as possible and carried forward in stages, if necessary.

Recommendations

The Advisory Board respectfully offers the following recommendations to the International Joint Commission:

1. Remedial measures for the abatement and control of pollution in the Rainy River section of the boundary waters should be initiated at the earliest possible date to restore and protect the uses of these waters to which the people of both countries are rightfully entitled. Major consideration should be given to uses of water for domestic and industrial supplies, recreation, fish and wildlife, sanitary purposes, and navigation.

2. The "Rainy River Water Quality Objectives," as set forth herein, should be recognized in the development of remedial and pollution-preventive measures by municipalities and industries. These objectives should apply to both existing and new sources of wastes.

3. Disinfection of all municipal effluents should be undertaken to augment primary or secondary treatment as presently provided by all sewered communities; and a program of more efficient or secondary treatment should be inaugurated and completed within a reasonable period of time. Need for more efficient or secondary treatment will be most urgent near large centers of population or where much industrial waste is involved. It is recognized that local conditions on either side of the boundary may give additional emphasis to the need for this higher degree of treatment.

4. Industrial wastes should be utilized, controlled, or treated to comply, as soon as possible, with the "Rainy River Water Quality Objectives."

   The Company has announced its intention of proceeding with construction of additional facilities to further reduce mill waste discharged into the river, as described on pages 60 and 61 herein.

   These in-plant waste segregation and recovery projects should be carried forward on schedule as initial steps towards implementing an effective stream improvement program. Succeeding or possibly concurrent phases of this program should encompass installation or renovation of facilities which will provide the type and degree of treatment outlined in the section "Disposal of Industrial Wastes" (pages 57-58).

5. Action should be taken to minimize slime growths in the river by controlling or reducing the discharge of nutrients.

6. It is recommended that the Commission review its Order of June 8, 1949, as amended by its Order of October 1, 1957, governing the regulation of the levels of Rainy Lake and other boundary waters in the Rainy Lake watershed with the view of eliminating the extremely low flows in the Rainy River now prevalent on weekends below the outlet of Rainy Lake.

7. Watercraft, with toilet facilities, should be equipped with effective devices for treatment of sewage and pollutional matter. Neither refuse nor untreated waste should be discharged overboard in these waters.

8. Definite plans for financing and constructing municipal works needed to remedy pollution should be formulated.

9. Definite time schedules for abatement of industrial waste pollution should be established and followed.

10. Continuing surveillance over pollution control progress should be maintained through a technical committee or board, appointed by the International Joint Commission, with representation from both countries, including Federal, state, and provincial governments.

11. The Commission should take such measures as may be legally available to it to have the pollution abatement and prevention program herein outlined initiated, promoted and effectively prosecuted.

APPENDICES

TABLE 2—ACTIVATED SLUDGE PLANTS AT PULP AND PAPER MILLS IN THE U.S.

Company	Location	Type of Effluent Treated	Capacity Mgd	Type Aerator	Modification	Descriptive Ref. No.
Southland Paper Mills, Inc.	Lufkin, Texas	Kraft Pulping Groundwood	2.0	Diffusers	None	1
West Va. Pulp & Paper Co.	Covington, Va.	Bleached Kraft N.S. Semi-Chem.	16.0	Spargers	None	2
West Va. Pulp & Paper Co.	Luke, Md.*	Bleached Kraft	21.0 (42)**	Spargers	None	3
P. H. Glatfelter Co.	Spring Grove, Pa.	Bleached Kraft Deinking	10.0	Mechanical Surface	Contact Stabilization	4
Scott Paper Co.	Mobile, Ala.	Bleached Kraft	25.0***	Mechanical Surface	None	5 & 11
D. M. Bare Paper Co.	Roaring Springs, Pennsylvania	Bleached Kraft	5.5	Diffusers	None	6
Sonoco Products Co.	Hartsville, S. C.	News & Chip Board	1.0	Diffusers	None	7
Whippany Paper Board Co.	Whippany, N.J.	News & Chip Board	11.0	Spargers	Dynamic	8
Downingtown Paper Co.	Downington, Pa.	News & Chip Board	2.5	Mechanical Surface	None	9
Brandywine Paper Corp.	Downington, Pa.	News & Chip Board	0.2	Spargers	McKinney	—
Kalamazoo Paper Co.	Kalamazoo, Mich.	Deinking Washer Waste	0.5	Spargers	Dynamic	—

Capital costs of the installations presented in the above table are reported to range from $60,000 to $120,000 per million gallons of daily treatment capacity. Overall operation costs are reported to be between 2c and 5c per pound of B.O.D. removed. (10,11) The total investment for out-of-mill treatment and disposal facilities for the mill at Luke, Maryland, and three small communities is $4,500,000; and for the mill at Spring Grove, Pennsylvania, is *$1,662,000, inclusive of lagoons and* other facilities used in addition to the activated sludge treatment.

*Receives some municipal sewage.

**Only half of treatment system required for wastes; 42 mgd could be treated.

***A 70 mgd clarifier provides primary treatment at this mill, along with complete treatment for 25 mgd at a capital cost of $60,000 per mgd of activated sludge capacity.

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Glossary

B. coli or B. coli group	the coli-aerogenes group as used in all editions of Standard Methods of Water Analysis prior to the sixth edition. It is equivalent to the coliform group as defined in later editions of Standard Methods and used during this investigation.
Board, Board of Sanitary Experts, or Advisory Board	Board of Technical Advisers to the International Joint Commission in the investigations described in this report.
Bod	Biochemical Oxygen Demand
Boundary Waters	the waters from main shore to main shore between the United States and Canada, as defined in the Treaty of 1909.
cfs	cubic feet per second
Coliform or coliform group	those organisms which will ferment lactose within 48 hours at 35.5°C in the presence of brilliant green bile and in the proportions contained in standard dehydrated media of that type (tube dilution test); or those organisms which produce a dark colony with a metallic sheen in 20 $\pm$ 2 hours of incubation at 35.5°C on M-Endo-MF Broth (membrane filter test).
Commission	the International Joint Commission; I.J.C.
composite sample	a sample made up of portions collected at definite intervals and mixed before analyses.

DO	dissolved oxygen
fps	feet per second
grab sample	an individual sample all portions of which have been taken at the same time.
IBC	International Boundary Commission
I.J.C.	International Joint Commission
Imp.	Imperial
IMViC	the pattern of biochemical reactions derived from the results of the Indol, the Methyl Red, the Voges-Proskauer and Citrate tests.
International Boundary or boundary	the boundary between the United States and Canada
median	the value which is equaled or exceeded by exactly half the values in the given list.
MF	membrane filter
ug/l	micrograms per liter (approximately equivalent to ppb)
mg/l	milligrams per liter (approximately equivalent to ppm)
mgd	million gallons per day
ml	milliliters
MPN or MPN Index	the most probable number of coliform organisms per 100 ml when calculated from multiple tube dilution tests.
No.	number
P.A.	Public Act
P.L.	Public Law
pH	hydrogen ion concentration
Phelps Index	the indicated number of B. coli per 100 ml when calculated from the results of single tube dilution tests.
primary or partial treatment	the first major step in sewage treatment works, usually screening, grit removal and sedimentation.
secondary treatment	the treatment of sewage by biological methods following primary treatment.
slug or spill	the release of a volume of highly concentrated polluting material over a short period of time.
SS	suspended solids
Standard Methods	Standard Methods for the Examination of Water and Waste Water—Latest Edition.
U. S.	United States
%	per cent