A PRELIMINARY SURVEY

OF THE

SANITARY CONDITION

OF THE

NORTH SASKATCHEWAN RIVER

IN THE VICINITY OF

EDMONTON, ALBERTA

1950 - 51

PREPARED BY

DIVISION OF SANITARY ENGINEERING

DEPARTMENT OF PUBLIC HEALTH

PROVINCE OF ALBERTA

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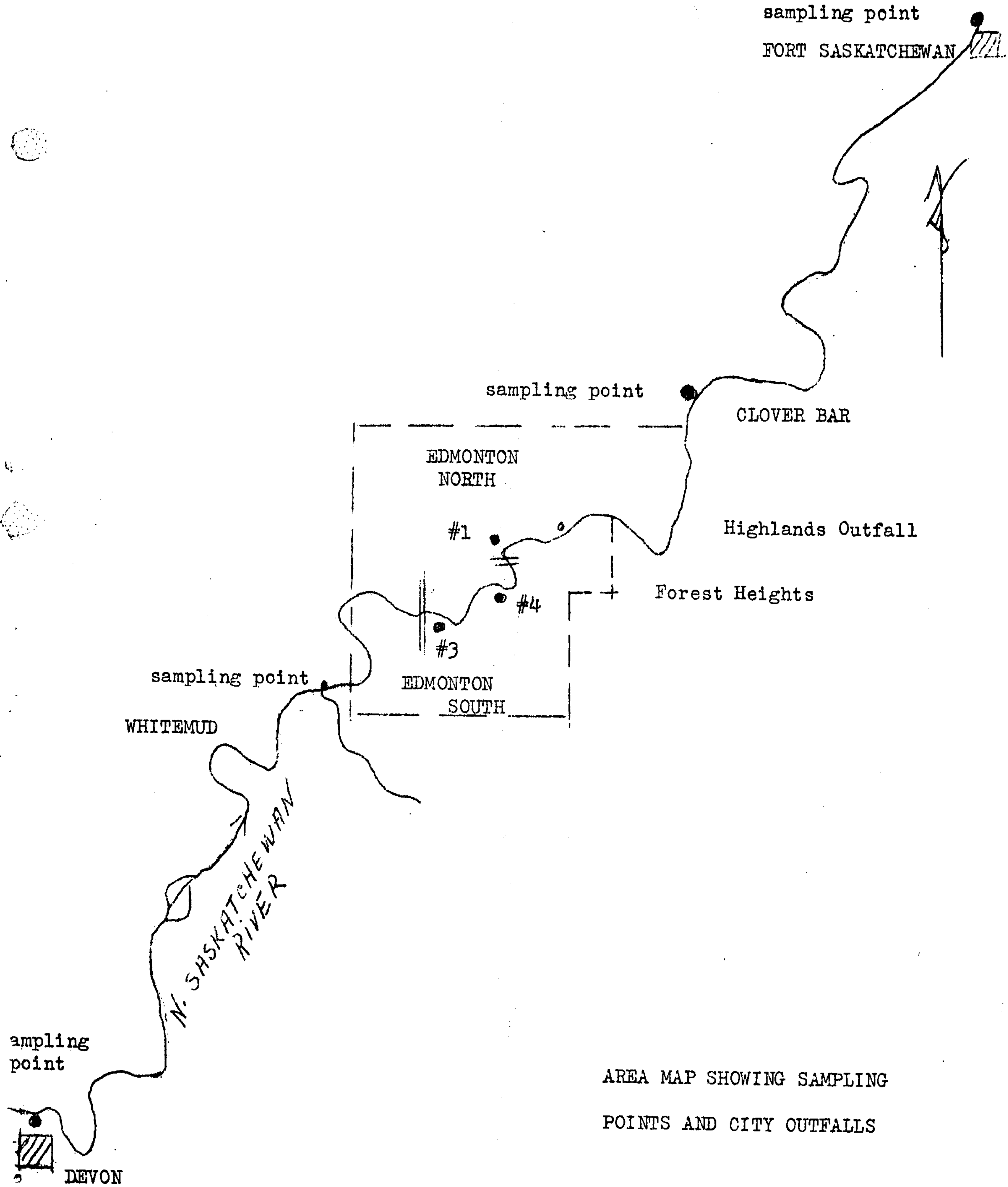


AREA MAP SHOWING SAMPLING

POINTS AND CITY OUTFALLS

NATURE OF WORK

The initial work ~~conducted on~~ of this Stream Sanitation Project was carried out on the North Saskatchewan River and was concerned mainly with the pollutional load from the City of Edmonton. The increase in population in the City along with the evident future industrial growth along the North Saskatchewan River, created a need for such a survey. The inadequacy of the present treatment plants for city sewage, and the need for more treatment facilities required that river conditions be analysed so that treatment facilities of the correct type should be installed.

The North Saskatchewan River is a large stream which flows from the Rocky Mountains eastwards through Alberta and Saskatchewan and thence into Manitoba and Lake Winnipeg. It was, in the early 1900's, used by barges which freighted up and down the river prior to the building of railroads in the area. It is not at the present time used for navigation. The river is a relatively rapid flowing stream and carries a high sediment load especially in the months following break up. This fact along with the great variation in stage of the river, 38.5 feet, do not make it a stream in which game fish are plentiful. There is at the present time a limited amount of fishing in the river, mostly for goldeye. The most prominent fishing points are at the mouth of Whitemud Creek above Edmonton and the Sturgeon and Redwater Rivers below Edmonton.

From November to April, the river has an ice cover on it. Ice cutting was extensive in the area above Edmonton until the Town of Devon was located about twenty miles upstream. Since that time, little if any commercial ice cutting has been done on the river. It was noted that the farmers in the Fort Saskatchewan area were cutting ice on the river and doubtlessly many other farmers use the river as a source of ice in spite of warnings from Sanitary Inspectors.

STREAM USE AS A SOURCE OF WATER

The North Saskatchewan River is used as a source of water by the Towns of Devon and Redwater and the City of Edmonton. It is also used as a source of water by the Provincial Jail at Ft. Saskatchewan. The Town of Ft. Saskatchewan has for some time been contemplating the use of the river as a source of water for the Town. The present condition of the river would not allow its use as a raw water supply for a town below the City of Edmonton with the usual type of water treatment plant. The Town of Redwater has installed a filter gallery on an island in the river. The water must percolate through over 100 feet of soil before it enters the gallery. This method of water treatment has been very successful at Redwater.

As proven by the typhoid cases in the winter of 1950-51, there are quite a few farmers who use the river as a source of water for domestic use.

INDUSTRIAL WATER SUPPLIES

One of the prime needs of any industry is an adequate source of water. Whether the water is used in actual processing or in cooling units, it must be available in large quantities at a reasonable cost.

All major industries locating below the City of Edmonton will be using the river as a source of raw water. At the present time, the oil refineries, Celanese Corporation and the proposed pulp and paper mill are interested in the quality of the water in the river.

RECREATIONAL

A few Scout Camps are located on the river. There is some swimming in the river by children in spite of the fact that local authorities do not permit same. The water being cold and turbid is not conducive to bathing.

PURPOSE OF THE STREAM POLLUTION SURVEY

1. To determine river conditions: (a) bacteriological; (b) physical; (c) chemical.

2. Investigate special waste problems - oil refineries.

3. To determine nature and volume of pollution.

4. To set some standards for treatment of wastes going into the North Saskatchewan River.

METHOD OF CARRYING OUT SURVEY

The survey was made by methods now accepted as the most accurate means of gauging stream pollution.

From the public health viewpoint, bacterial counts were made on the river to ascertain the density of bacteria present. The number of coliform organisms in a stream indicates the possible number of pathogenic bacteria present, and is therefore of prime concern to Public Health authorities. If the river is to be used as a source of water for a municipal supply, there are certain limits to the number of bacteria which a treatment plant using coagulation, filtration and chlorination can be expected to remove and yet supply a finished water which will meet generally accepted bacterial standards for a public water supply. The generally accepted figure for allowable bacterial densities in a raw water to be given full treatment is about 5,000 B. Coli per 100 ml.* With double chlorination, the allowable is about 20,000 per 100 ml.

* From Phelps Stream Sanitation (Streeter).

In connection with the possibilities of odors from the stream and the killing of natural aquatic life, the indices used are the Biochemical Oxygen Demand and the Dissolved Oxygen content of the stream. The standards in this respect usually call for a minimum dissolved oxygen content in the stream of four parts per million.

One other aspect of stream pollution problems is aesthetic. In the Province of Alberta where there are relatively few streams in the prairie area which flow year around, it is important that these few water courses should not be so polluted with visible floating material, grease, and garbage as to di ,ract from their natural beauty.

Suspended material, grease, organic solids and garbage pose a problem for water treatment and for water intake structures for industries below the City.

Oil wastes flowing into the river are important in connection with the possible manufacture of paper products.

METHOD OF CARRYING OUT FIELD WORK

Sampling points were chosen so that truly representative samples might be obtained from the river. This required that the samples be taken some distance down stream from the City so that there would be adequate mixing in the river prior to sampling. With this in mind, the main point of sampling was chosen at Fort Saskatchewan above the point of outfall of the sewer from the Provincial Jail. (Figure 1) In order to see if there was any channeling of the sewage as far downstream as this point, samples were taken near each bank and in mid-stream. The samples were labelled mid-stream, north bank and south bank. (See Figure 3 & Table 3). After the results of a few months of sampling were correlated, it became apparent that there was no great variation in either bacterial counts or chemical analysis of the water at different sections in the river so that much of the work done later in the winter was carried out by sampling in mid-stream only.

Occasional samples were taken near Oliver and others were taken above the City to gauge the effect of Devon sewage disposal on the river. Some samples were also taken above the Devon sewer outfall. Sampling points are shown on Figure 1.

In obtaining summer samples, use was made of a boat and outboard motor provided for the project. Winter samples were obtained by cutting holes through the ice.

Dissolved oxygen and B.O.D. samples were taken by means of a sampler designed after sketchs shown in Standard Methods of Water Analysis. Bacterial samples were taken by dipping the bottles below the surface with the opening pointing upstream so as to avoid possible contamination from handling.

TREATMENT OF SAMPLES

Bacterial samples were brought into the Laboratory as soon as possible. In some cases it was necessary to store the samples over night, In such cases the samples were placed in a refrigerator. The bacteriological tests were made by the Provincial Laboratory. The method of obtaining the most probable numbers was to incubate ten tubes for each sample (five tubes each of two dilutions). After some preliminary work, it was possible to get fairly accurately the dilutions required for a reasonable number of positive and negative tubes for each sample. The Most Probable Number (M.P.N.) were then obtained by using tables in Standard Methods of Water Analysis.

The dissolved oxygen, carbon dioxide, pH, and alkalinity were run in the field immediately after sampling. Laboratory facilities are set up in a panel truck used on the project. The 5 day 20° C. test was used in running Biological Oxygen Demand Tests.

OUTLINE OF CITY SEWERAGE

The lack of metering facilities in the City sewage treatment plants did not allow an accurate means of measuring the amount of sewage flow either being by-passed or treated. Flows were approximated and some of the city measurements of flow used. The system of sewers in the City is a combined one except for minor portions. During periods of rainfall and surface runoff, the flows are much too high to be handled by the treatment plants and any flow exceeding the capacity of the plants is bypassed directly into the river, receiving no treatment whatsoever. While the trend today in most new developments is to keep the storm water drains separate from the sanitary drains, this is not being done in Edmonton. The cost of installing separate systems in the portion of the City already built up would be so high that it would be difficult to justify. This means that there will always be, in times of storm runoff, some sewage going into the river without any treatment whatsoever. Bar screens could possibly be installed to catch large solids.

DRY WEATHER FLOWS

At present, the treatment facilities in the City are so overloaded that there is at all times some sewage being bypassed directly into the river. It is estimated that the percentage of sewage thus going into the river without any form of treatment is about 20% of the total sewage flow. In addition to this amount being bypassed, the treatment plants now in use are overloaded so that they are not giving the sewage the treatment that would be indicated by the plants in existence.

SEWAGE TREATMENT IN EDMONTON (See Figure 2)

Sewage treatment in the City is carried out by four treatment plants:

No. 1 Plant - The number one treatment plant is the main plant in the City. It handles the sewage from the major portion of the City to the north of the North Saskatchewan River and is located on the north side of the river near the Dawson Bridge. The treatment provided by this plant consists of coarse screens, fine screening and settling, all of these treatment processes being classified as primary treatment. The detention period in the settling tanks is approximately 40 minutes at operating conditions in 1950. This detention period is sufficient to reduce the settleable solids (Imhoff Cone) to about 0.3 ml. per 1,000 ml. The period of detention for primary settling should be 1½ to 2 hours.

The screenings and the settled sludge are digested in a separate digestion tank which is heated. Adjoining sludge beds provide for drying of sludge. The dried sludge is hauled away and used as a mulch.

It is interesting to note that at one time secondary treatment was given City sewage at this plant, the process being one of aeration and biological activity (activated sludge). The tanks used for this process are now not being used. The concrete is cracked in several places and the arrangement of the tanks and the tank cross section does not allow for easy conversion to settling tanks. It is not known if there was any rational survey made as to the need of this secondary type of treatment process when it was installed or why its use was discontinued.

No. 3 Plant - the number three treatment plant is the only one in the City which provides for secondary treatment of the sewage. The plant consists of bar screens, primary settling, contact aeration and secondary settling. The sludge from the primary and secondary settling tank is removed to a heated digestion tank. Drying beds are adjacent to the digestion tank. This sewage treatment plant is in the vicinity of the South Side Swimming Pool. There are no offensive odors from this plant.

The plant was built in 1922 and from conversational sources, it was built after some publicity was given to a law suit brought against the City by riparian owners below the City. The design capacity of the plant is for 10,000 persons. The plant itself is greatly overloaded in spite of the fact that a considerable amount of sewage is being bypassed into the river without any form of treatment.

There were not enough tests run on the influent and the effluent of the plant to accurately ascertain its efficiency in B.O.D. and bacterial removal. The process is basically sound and if the plant were operated at design capacity there is little doubt that the results would be quite good.

Results of sampling at #1 and #3 plants are given in Table 1.

No. 4 Plant - The number four treatment plant is located in the Mill Creek area. The process at this plant is one of screening and settling only. At one time secondary treatment was given the sewage at this plant but due to complaints from nearby residents about odors, secondary treatment was stopped.

Highland Disposal Plant - In 1950, the Highland area in the central east portion of the City to the north of the Saskatchewan River was serviced with sewers and plans for a treatment plant made. It is the evident intention of the City to install a grit chamber, fine screens and provision for chlorination at this plant. There has been some delay in building this plant, some of it because the City is waiting for recommendations from the Department of Public Health as to what type of treatment to install. At the present time, all sewage flow in this area is flowing directly into the river with no treatment whatsoever.

At most of the city plants it is the practice to skim off the grease in the settling basins and to run it directly into the river. This is being done because grease is somewhat difficult to handle at the treatment plants.

In the Forest Heights area sewerage has recently been installed. It was the plan of the City to put in a septic tank to settle the sewage in this area and run the effluent down a coulee to the North Saskatchewan River. This plan did not meet with the approval of the Provincial Sanitary Engineer when it was submitted in the fall of 1950. Up to the time of writing this report, the sewers in this area have not been in use. The area served by this outfall is quite large with a probable future population of over 3,000. The present population served is approximately 500.

It is suggested that if it is a matter of urgency that the outfall be installed, that the City be allowed to install the outfall at this time with no treatment provided but that definite plans and guarantees be made that sewage treatment be installed by the fall of 1951.

A septic tank does not give satisfactory sewage treatment. It will have to be cleaned out periodically, this process creating odors in the adjoining area. It is most likely that the City will have to replace this unit in the next few years with a better type of sewage treatment.

OTHER WASTE DISPOSAL INTO THE NORTH SASKATCHEWAN RIVER

Devon Sewage:- The sewage from the Town of Devon flows into the North Saskatchewan. The treatment facilities consist of a septic tank followed by an aeration pond. The time of detention in the pond is approximately two or three days. The effluent from the pond passes into a chlorination chamber where it is chlorinated prior to going into the river. The effluent is very clear with very little suspended sewage solids in it. It has been found that the chlorination of the sewage has not been very efficient. At many times the chlorinator has not been working.

The bacterial counts in the sewage effluent are very high and result in a coliform count in the river of about 500 per 100 ml. in the winter time when the river flow is low. This number of bacteria can be easily handled by the water treatment facilities in Edmonton. The possibility of spreading disease through the use of the water between Devon and Edmonton by private individuals was evidenced in the past winter by the cases of typhoid caused by drinking raw river water.

The effect on the dissolved oxygen in the stream is negligible.

Oil Wastes:- The oil refineries below Edmonton are putting in oil separators for their effluent. These separators are of standard design approved by the American Petroleum Institute and very little oil passes into the river. Most of the oil treated separates easily from the water wastes. Inspection of the effluent from the Imperial Oil Refinery showed no visible oil waste.

The oil companies run tests on the effluent daily and the amount of oil going out in the waste is of the order of 25 ppm in a volume of waste of 10 mg. This when diluted in the river gives an oil content of less than 0.5 p.p.m. This low concentration should cause no problem downstream.

Oil Wastes from the City:- At times there is an oil slick on the river below the City. While this may at times be due to accidental spills at the refinery, it is very often due to oil which flows down the City sewers. Very frequently the sewage treatment plants are bothered with large quantities of oil coming into the plants. No provision is made at the plants for treatment of this oil so that it is bypassed into the river. City ordinances prohibit the disposal of oil into the sewer system and the City is trying to trace down and stop this dumping of oil into the City sewers. It is felt that the railways having converted to oil burning steam and diesel locomotives, may at times dump some oil into the sewers although nothing definite has been found to substantiate this theory. The number 3 plant is the one most often affected by this oil flow.

Sanitary Sewage from Industrial Plants:- Sanitary sewage from industrial plants below Edmonton contributes a minor amount of pollution. Septic tanks are used to settle out solids, this effluent then running into the river.

RESULTS OF TESTS ON THE NORTH SASKATCHEWAN RIVER

Bacteriological:- The results of the bacteriological tests made on the River are shown in Figure 3. The averages are also shown on the same figure. Results for tests above the City are given in Table 2. Figures 3 and 5 show the results of taking around the clock bacterial tests on the river below Edmonton. Figure 3 also shows the results of B.O.D., dissolved oxygen and test for chlorides. River flows for the period are shown in Table 6. These were obtained from the Dominion Government hydrographic records.

Some attempt was made to correlate the bacterial counts with the variation in flow in the river. Because of the inherent variation in the bacterial tests, corrections for river flows did not in any way serve to simplify the results. It was decided therefore to present the data in its original form. The same difficulty was apparent in trying to correct the bacterial counts for the time of day which they are taken. The 24 hour results, however, give a visual picture of the variation in bacterial counts over the day (Fig. 3 and 5).

The only bacterial tests made were for Most Probable Number of Coliform organisms, the 48 hour results of test tube incubations being used in the computation of most probable numbers.

Dissolved Oxygen Tests:- The results of the tests for dissolved oxygen are shown in Figure 6. The data for same is given in Table 4. It was found that during the summer months when there was re-aeration of the water in the river, the dissolved oxygen content was very close to saturation. A table of saturation values for dissolved oxygen is given in Table 7. The B.O.D. results are also shown in Figure 6. It was found that for the summer months, the B.O.D. of the river was less than 1 p.p.m.

Referring to Figure 7, it is evident that the amount of dilution given the City sewage during the months of May to September is so high that there is little danger that there will be any concern as to the amount of dissolved oxygen in the river during that period.

Winter Tests:- The results of the winter testing for dissolved oxygen and biochemical oxygen demand are shown in Figure 6 (see winter months). The ice cover on the river is usually present from the month of November to April.

These tests show that there is a considerable reduction in the amount of dissolved oxygen in the river. The dissolved oxygen content above the City is about 13 p.p.m., the dissolved oxygen at Fort Saskatchewan is about 5 p.p.m. with a B.O.D. at Fort Saskatchewan of about 2.5 p.p.m.

A limited number of tests for dissolved oxygen at Redwater show an average content of 4 p.p.m. Because of the fact that there is an ice cover on the river, there is little possibility of odors being given off from the river.

Visual Tests:- (Summer Period) During the period of sampling, the visual appearance was noted. During periods of high flow (April to September), the effect of sewage pollution was not visible. The high turbidity of the water during this period hid any suspended solids which were present. Bottle samples at times showed some organic material of sewage origin.

During this period of high flow, the result of garbage disposal into the river by the City was evident. On one trip by boat down the river from Edmonton to Fort Saskatchewan, it was very surprising to see a Model T. Ford frame bouncing off the bottom of the river as it drifted in the river current. Cardboard boxes, wooden boxes, packing material, etc. was present on the river surface. Some packing cases were seen as far as 200 miles down stream from the City during this period.

In the month of September when the river level lowered, there was a lot of garbage strewn along the river banks. This garbage was also evident in a short period after spring break up and before the river level rose to any great extent.

This City has for a number of years been dumping garbage along the river bank. The location of the garbage dump is shown on Figure 3. An excuse for this garbage disposal has been that the garbage has been dumped along the river in order to reduce errosion of the bank of the river. Each period of high water washes away much of the garbage dump creating the problem of unsightly stream banks downstream.

The garbage dumped along the river is for the most part not putrescible material. It consists mainly of packing cases, bottles, oil drums, scrap and junk. Putrescible material is for the most part burned in the City incinerator.

During periods of low flow, grease deposits were present along the shores of the river. This was apparent in the months of September and October. The grease deposits form a slimy layer on the rocks and gravel on the river banks. In this same period, there was a lot of floating organic material present on the river surface. This material, doubtlessly of sewage origin, consisted of some fecal matter but a large portion was slime growths which had evidently been forming on the river bottom and had broken loose after reaching a certain thickness.

Winter Period:- During the winter months, the sewage in the river was very apparent. Looking down through holes in the ice, one could see toilet paper, chicken feathers, and fecal matter floating by. The water itself during the period of ice cover is very clear and this fact probably leads to its use by some riparian owners as a source of drinking water. Samples of ice did not show apparent signs of having large suspended solids frozen in it. No odors were present at the holes chopped in the ice. The tests for dissolved oxygen showed that there was some residual (Table 4, Figure 6).

The actual amount of suspended solids was difficult to ascertain. In looking down through the water, one was looking at a depth of about 5 feet or more and at a width of a few feet. Suspended solids were always visible although a single bottle sample might fail to bring up any of the large floating material. Some of this suspended material was caught in a cheese cloth net for close examination.

An opening cut in the ice showed grease and sludge present after a period of a few days, with some odor present (Oliver).

Rotary screens at the inlet of Imperial Oil Refinery collect large amounts of organic material.

TASTE IN FISH

The limited amount of fishing in the North Saskatchewan does not warrant particular attention. It is interesting, however, to note that reports have come in of an oily taste in fish caught downstream from Edmonton. This taste has begun soon after the operation of the oil refinery. Sufficient data is lacking on this taste problem. It does, however, seem to indicate that oil wastes may be responsible even though they are present in minute quantities.

Since this is a problem affecting other streams where game fish are plentiful, more work should be done on finding the effect of oil wastes on fish.

COMMENTS ON CITY SEWAGE TREATMENT

It is evident that the existing facilities for the treatment of sewage must be expanded. The primary problem is one of reducing visible signs of pollution along the river and lowering of the bacterial counts. The dissolved oxygen balance in the river is very favorable during the summer, however it approaches the critical stage during the winter when the river is covered with ice and at its low flow stage.

The visible signs of pollution, i.e. suspended solids and floating material such as grease would be removed effectively by proper primary treatment of all dry weather flow.

Bacterial counts are reduced effectively by primary treatment followed by secondary treatment. A further reduction may be obtained by chlorinating the secondary effluent. If only primary treatment is being provided, fairly good results may be obtained by chlorinating the settled sewage. Chlorination of screened sewage is not satisfactory as the particles of material passing through the screens will not be disinfected efficiently.

The dissolved oxygen balance in the river will be improved by the primary treatment of all of Edmonton's sewage. However in the not too distant future, secondary treatment will be required. In view of this, the design for primary treatment facilities should provide for the addition of secondary treatment units when needed.

THEORETICAL CONSIDERATIONS

Most of the results of sampling cannot be treated by theoretical considerations because of the lack of figures of sewage flow from the City. It is felt, however, that a short outline of theoretical considerations is necessary.

Effect of various sewage treatment processes:- The reduction in bacterial count, B.O.D. and suspended solids afforded by various treatment methods is approximately as follows:

Treatment Process	Per Cent Removal		
	Bacteria	B.O.D.	Suspended Solids
Fine Screening	10 - 20	5-10	5 - 10
Primary Settling	25 - 75	25-40	40 - 70
Secondary Treatment			
Trickling Filters	90 - 95	80-95	70 - 90
Activated Sludge	90 - 95	85-95	85 - 95
Chlorination of Settled Sewage	90 - 95		

Bacterial Considerations:- The number of bacteria (E. Coli) contributed by one individual per day is of the order of 300 billion. While this in no way indicates the number of pathogenic bacteria which may be present, it must be assumed that the proportion of pathogenic bacteria varies with the coliform count. The following table gives an indication of the death rate of bacteria in rivers. It can be assumed that the death rate of typhoid, dysentery and cholera organisms is approximately the same.

The following table is taken from "Phelps Stream Sanitation".

Days	Per Cent Bacteria Remaining	
	Cold Water	Warm Water
2	11	10
4	5	2
6	3	0.5
8	2	0.2
10	1.5	0.15
20	0.9	0.03

Since low temperatures prevail in the North Saskatchewan River for the greater portion of the year, the lower death rate should be used. There has not been sufficient work done on the North Saskatchewan River to check this table of bacterial death rates.

Dissolved Oxygen and B.O.D. Relationships:- The factors which must be taken into account in considering the dissolved oxygen balance in a stream are:

a. The initial dissolved oxygen available. This varies with the temperature of the water if there is no previous pollution of the stream (see Table 6).

b. The amount of oxygen required to stabilize the organic material in the sewage flowing into the stream. This is measured by running B.O.D. tests on the sewage. The rate of this reaction is important.

c. Re-aeration in the stream. The rate of re-aeration varies with the oxygen deficit (amount below saturation) and the turbulence of the stream. There is no re-aeration in the presence of ice cover.

The oxygen balance in a stream can be computed from the following formula:

$$D_t = \frac{k_1 \ La}{k_2 - k_1} \left(10^{-k_1 t} - 10^{-k_2 t}\right) + D_a \, 10^{-k_2 t}$$

D_t = dissolved oxygen deficit at time t days in p.p.m.

k_1 = rate constant of B.O.D. (varies with temperature).

k_2 = rate constant of re-aeration varies with temp. and stream characteristics

La = first stage B.O.D. at point of pollution p.p.m.

Da = oxygen deficit at the point of pollution p.p.m.

t = time in days from the time of pollution.

The following table gives various values of k_1 and k_2 assuming values of 0.1 and 0.2 respectively at 20° C.

Temperature °C.	k_1	k_2
0	0.04	0.146*
5	0.05	0.163
10	0.06	0.170
15	0.08	0.180
20	0.10	0.20

These values have been computed from $k_{1(t)} = k_{1(20)} \times 1.047^{(T-20)}$

$$k_{2(t)} = k_{2(20)} \times 1.0159^{(T-20)}$$

* The North Dakota Department of Health Report of the Red River of the North Research investigation gives this figure as .034.

The ultimate first stage B.O.D. varies with temperature as follows:

Temperature °C.	Relative First Stage B.O.D.
5	0.7
10	0.8
15	0.9
20	1.0

Summer Conditions:- The low summer flow is 2700 c.f.s. and the summer temperature about 20° C. in the North Saskatchewan River. Assuming a first stage B.O.D. of 0.25 pound per capita per day at 20° C. and a critical time of 3 days, it can be shown from equation 1 that the equivalent population that can be handled by the North Saskatchewan River in summer time is about 900.000. This checks with the rule of thumb of a dilution ration of 3 c.f.s. per 1,000 population. There is thus very slight chance of oxygen depletion during summer months.

Winter Conditions:- For winter conditions with no re-aeration present, the following relationship is used:

$$x = La \quad (1 - 10^{-k_1 t})$$

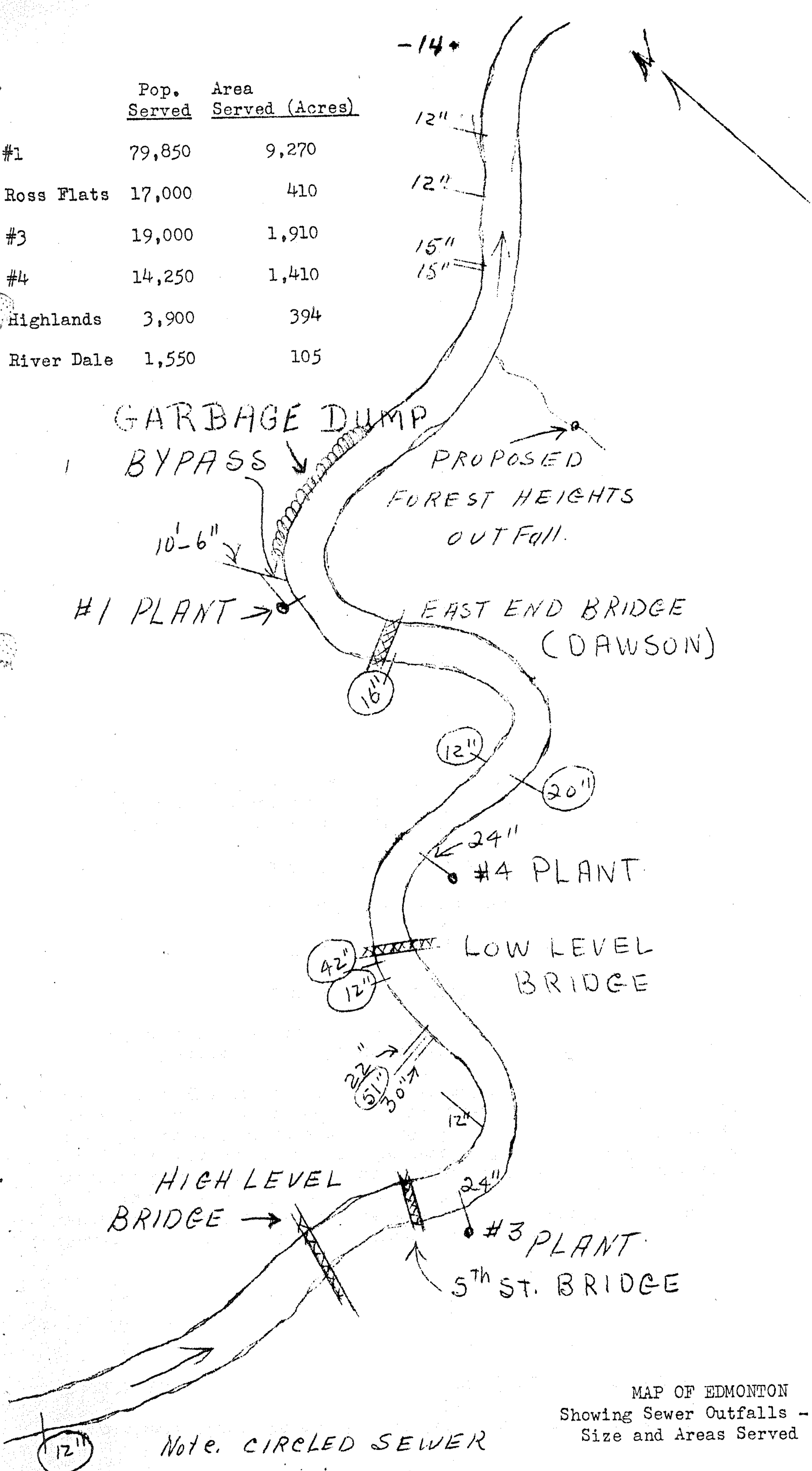
x = oxygen used in t days p.p.m.

k = B.O.D. rate constant

La = ultimate first stage B.O.D. p.p.m.

Taking the allowable deficit as 9 p.p.m. (saturation 13.0 and the lower limit at 4.0 p.p.m.), it can be shown that the allowable population equivalent is 280,000 with a flow of 600 c.f.s. in the river.

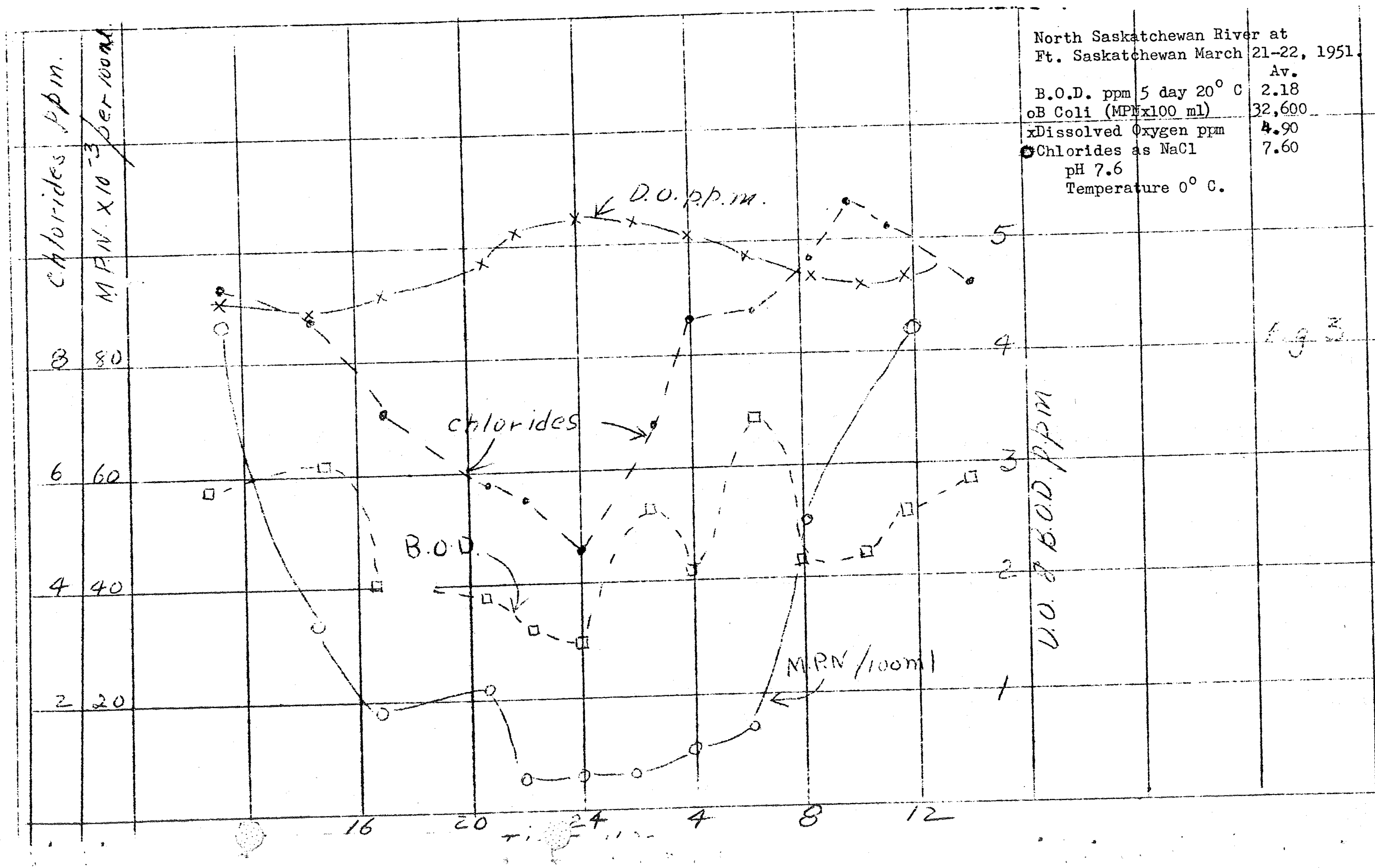
	Pop. Served	Area Served (Acres)
#1	79,850	9,270
Ross Flats	17,000	410
#3	19,000	1,910
#4	14,250	1,410
Highlands	3,900	394
River Dale	1,550	105



Note. CIRCLED SEWER SIZES INDICATE seperate STORM DRAINS

MAP OF EDMONTON
Showing Sewer Outfalls - Location, Size and Areas Served

fig 2

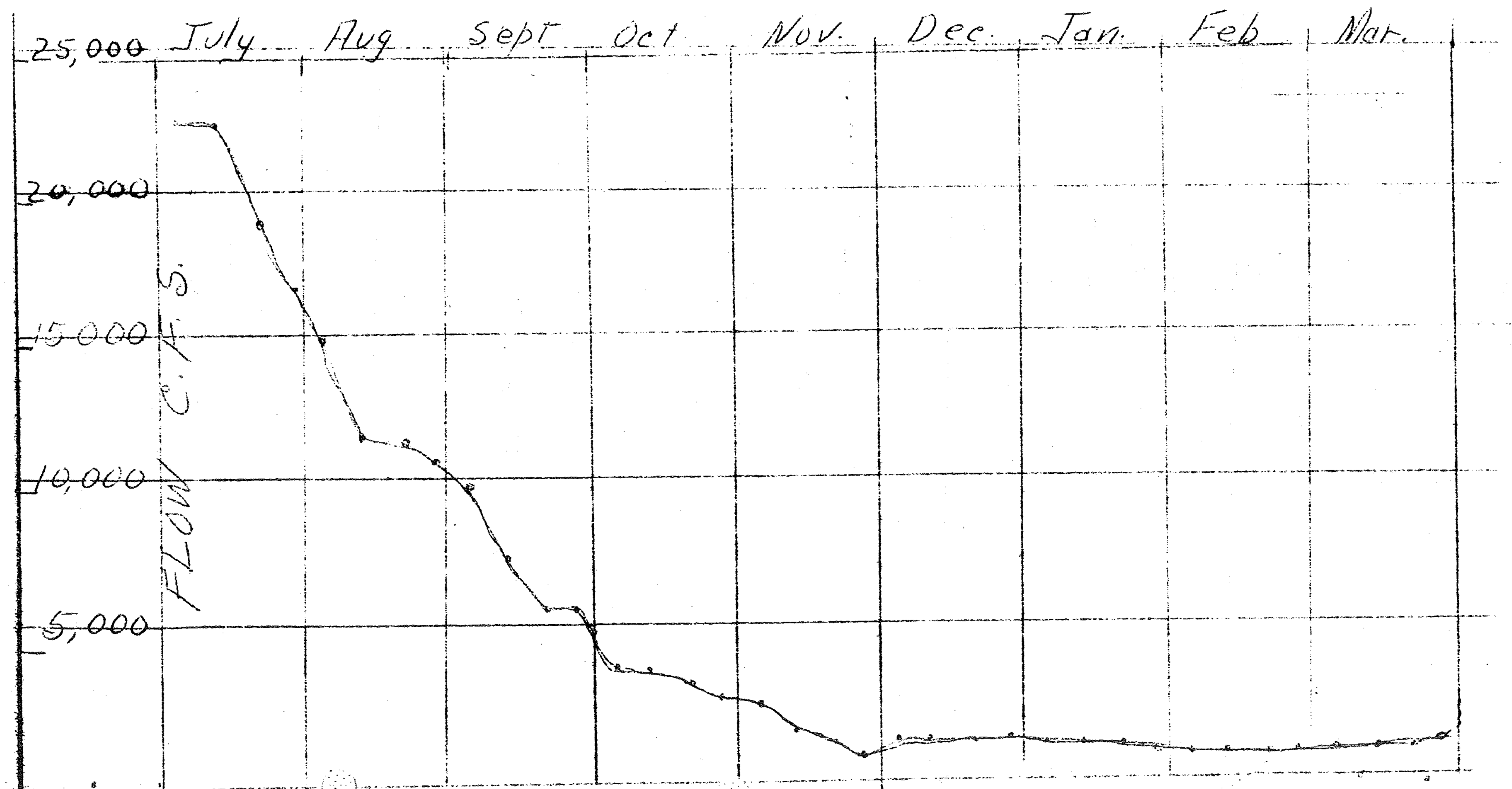


North Saskatchewan River at
Ft. Saskatchewan March 21-22, 1951.
Av.
B.O.D. ppm 5 day 20° C 2.18
oB Coli (MPNx100 ml) 32,600
xDissolved Oxygen ppm 4.90
Chlorides as NaCl 7.60
pH 7.6
Temperature 0° C.
Chlorides ppm.
MPN x10⁻³ per 100ml.
D.O. ppm.
chlorides
B.O.D.
MPN/100ml
D.O. & B.O.D. ppm
Fig 3

FLOW IN NORTH SASKATCHEWAN RIVER

July 1950 to March 1951

fig 4



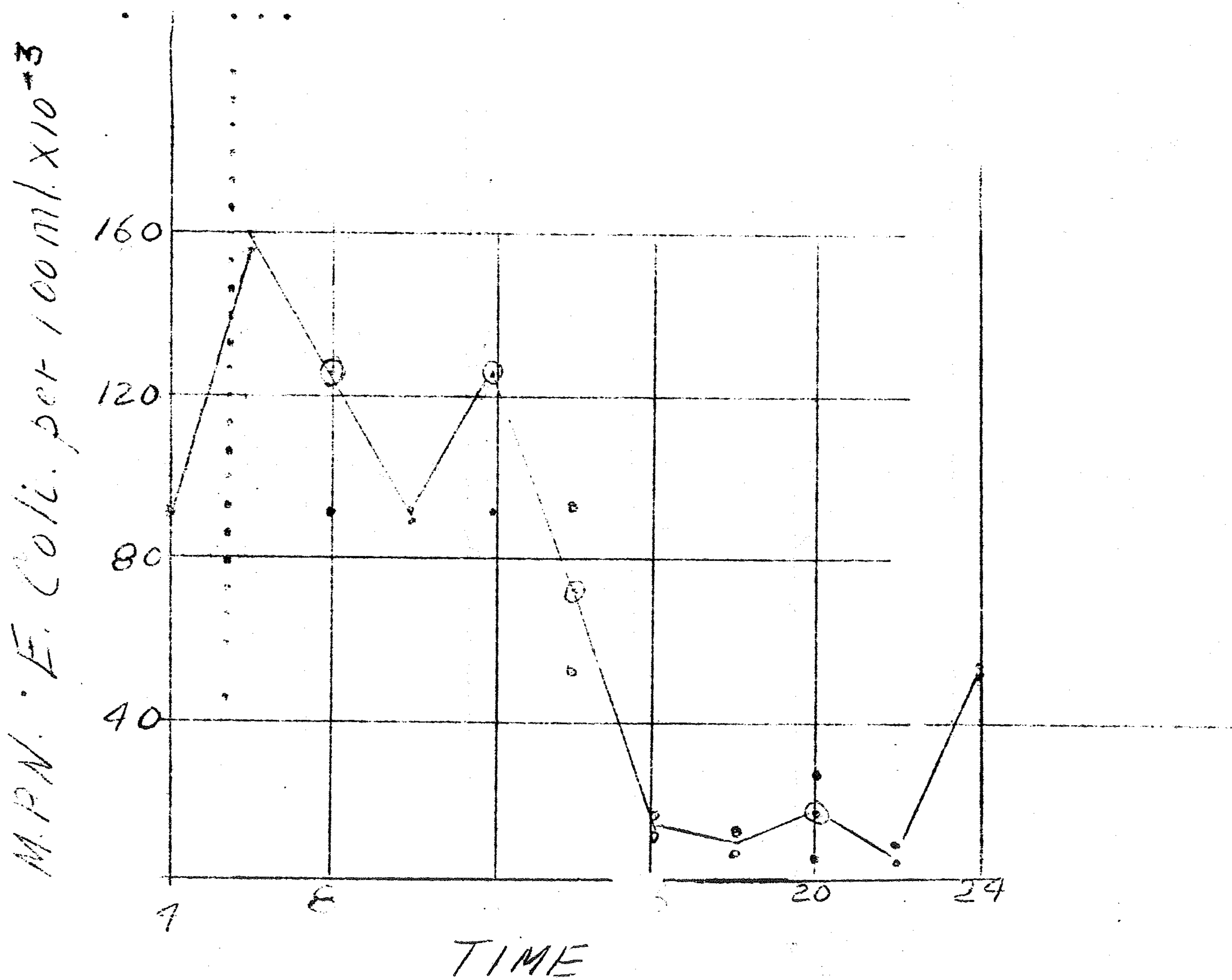
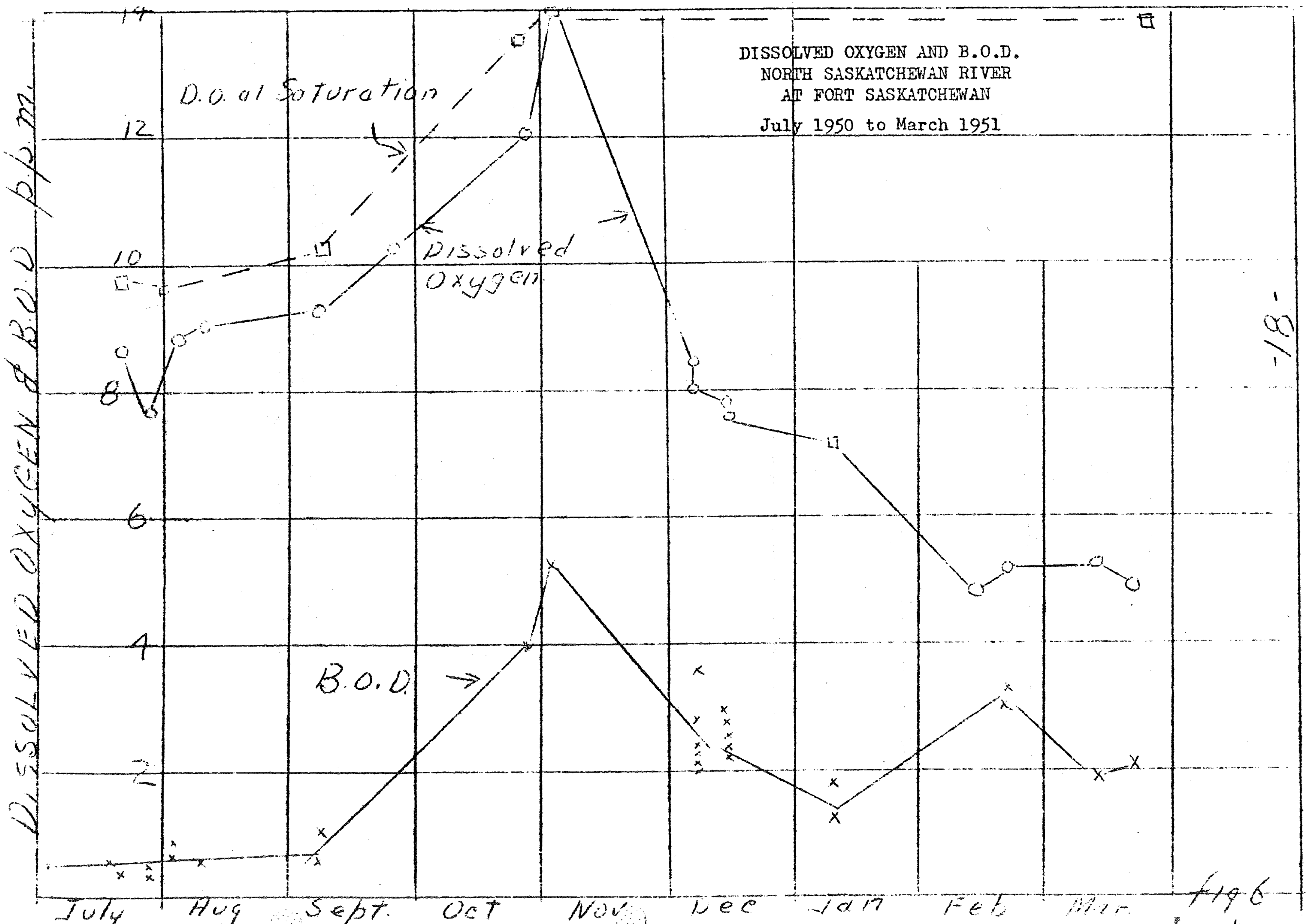


fig 5

BACTERIAL COUNTS NORTH SASKATCHEWAN RIVER
AT FORT SASKATCHEWAN
Sept. 13, 1950

TIME	M.P.N./100 ml.
4	92,000
	92,000
6	160,000
	160,000
8	92,000
	160,000
10	92,000
	92,000
12	92,000
	160,000
14	92,000
	54,000
16	17,900
	13,900
18	13,000
	7,900
20	6,900
	28,000
22	4,500
	11,000
24	54,000
	54,000
Average	70,000 per 100 ml.


DISSOLVED OXYGEN AND B.O.D.
NORTH SASKATCHEWAN RIVER
AT FORT SASKATCHEWAN
July 1950 to March 1951
DISSOLVED OXYGEN & B.O.D. p.p.m.
D.O. at Saturation
Dissolved Oxygen
B.O.D.
14
12
10
8
6
4
2
July
Aug
Sept.
Oct
Nov
Dec
Jan
Feb
Mar
Fig 6

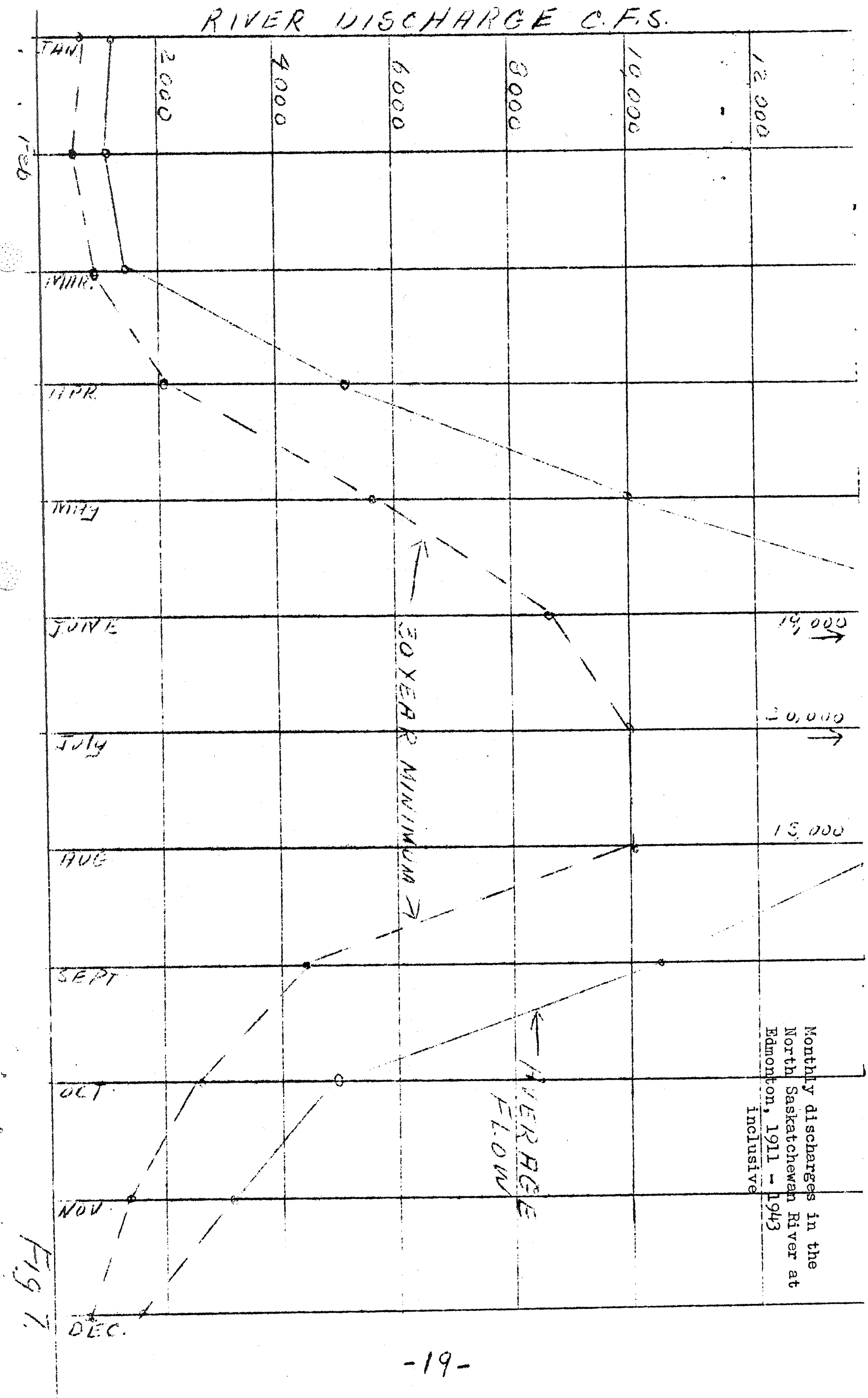


Fig. 7.

Monthly discharges in the North Saskatchewan River at Edmonton, 1911 - 1943 inclusive

NORTH SASKATCHEWAN RIVER AT DEVON

Date	Time	Sampling Point	Temp	pH	CO2 ppm $CaCO_3$	Alk ppm $CaCO_3$	Solids Total	Solids Organic	Solids Mineral	D.O.	BOD	MPN	Remarks
Nov 23	10 am	Ferry Crossing near North Bank	0°C		0	210	796 765	468 543	328 222			0	
Dec 12	10:30	Ferry Crossing Near North Bank	0°C		1	174	567 501	268 269	299 232	12.7	3.7		
Dec 19		Ferry Crossing Near North Bank								11.0 11.2		160+	
Feb 13	1:30 pm	N Sask at Ferry	0°C	7.5	1.6	19	348	132	216	10.5	1.3	16	
Apr 24	1 pm	N Sask at Bridge	4°C	7.8						12.3		54 160	
May 8	11:30 am	N Sask at Bridge	5°C	8.0*	90	1.5				12.0			

TABLE 1

NORTH SASKATCHEWAN RIVER AT WHITEMUD AND EDMONTON

Date	Time	Sampling Point	Temp	MPN per 100 ml	pH	D.O.	BOD	CO_2	Alk	Solids Total	Solids Organic	Solids Mineral	Chlorides
Feb 13	3 pm	SB	0°C	170 79	7.5	10.1	1.0	2.0	163	365	154	211	
Feb 14	1:30 pm	MS		1600	7.4			2.3	162	416	201	215	2.6
		SB		280									
Feb 15	9 am	MS	0°C	540	7.3	10.1		2.4	158	424	181	233	0.4
		SB		180		9.7							0.6
Feb 17	10 am	MS		920									
		MS		350									
		SB		540									
		SB		540									
Mar 12	3:10 pm	MS	0°C		7.8* 7.5	11.0		1.6	160				
Apr 24	5 pm	5 St Bridge Edmonton	4°C	920	8.0*	12.4				915 775	157 435	758 343	
										% settleable in 24 hours.			
May 8	1:45 pm	5 St Bridge Edmonton	5°C	920	8.0*	11.9		1.5	88				

TABLE 2

*pH Meter

NORTH SASKATCHEWAN RIVER AT OLIVER
(Bennet & White Gravel Washer)

Date	Time	Sampling Point	Temp	MPN	pH	D.O.	BOD	CO_2	Alk	Solids Total	Solids Organic	Solids Mineral	Chlorides
Feb 14	4:30 p	MS	0°C	160,000 160,000	7.3	6.10	5.56	4.7	164	434	205	223	8.6
Feb 21	2:45 pm	MS	0°C	540,000 1,600,000	7.4	6.29	6.29	6.5	162	320	88	232	10.8 11.4
	3:55 pm	WB	0°C	540,000	7.6	6.40	5.71			311	76	235	10.1
Mar 13	3:30 pm	MS			7.6*	5.9	5.9	5.8	163				8.3

*pH Meter.

TABLE 2

North Saskatchewan River at Edmonton

Date	Sampling Point	MPN B Coli /100 ml
Nov 25	Powerhouse	49
Nov 29	Powerhouse	540
	"	540
Jan 31	Powerhouse	350
	"	540
Feb 6	Powerhouse	220
Feb 13	Powerhouse	540
Feb 16	Powerhouse	540
Feb 20	Powerhouse	33
Feb 27	Powerhouse	110
Mar 15	Powerhouse	540
Mar 20	Powerhouse	790
Mar 27	Powerhouse	490
Apr 3	Powerhouse	1600
Apr 10	Powerhouse	1700
Apr 16	Powerhouse	920
Apr 17	Powerhouse	79
Apr 24	Powerhouse	330
May 1	Powerhouse	1600
May 3	Powerhouse	1600
May 8	Pumphouse	1700

Sampled by City of Edmonton.

TABLE 2-2

NORTH SASKATCHEWAN RIVER AT FORT SASKATCHEWAN

1950 Date	Time	pH	Temp	MPN B COLI North Bank	MPN B COLI Mid Stream	MPN B COLI South Bank	Remarks
July 18	2 pm	7.5	16°C	22,300	4,100	2,050	
July 20	3 pm	7.5	16°C	40,000	18,000	7,000	
July 25	3 pm		20°C	[illegible]	[illegible]	[illegible]	
July 27	2 pm	7.5	18°C	35,000	35,000	35,000	
July 27	4 pm	7.5	18°C	24,000	24,000	4,500	
July 31	10 am	7.5	17°C	54,000	54,000	17,000	
July 31	12noon	7.5	18°C	17,000	7,900	24,000	
July 31	2 pm	7.6	18°C	17,000	4,500	7,900	
Aug 3	3 pm	8.2	18.3°C	35,000	0	54,000	
Aug 9	2:30pm	7.5	17°C	92,000	17,000	160,000	
Aug [illegible]	4 pm	7.5	17°C	35,000	24,000	17,000	
Aug [illegible]	10 am	7.5	17°C	35,000	35,000	92,000	
Sept 7	2 pm	7.5	15.5°C	20,000	20,000	20,000	
Sept 13	4 am				92,000 92,000		
	6 am				160,000 160,000		
	8 am	7.5	14.5°C		92,000 160,000		
	10 am				92,000 160,000		
	12noon				92,000 160,000		
	2 pm				92,000 54,000		
	4 pm				17,000 13,000		
	6 pm				13,000 7,900		
	8 pm				6,900 28,000		
	10 pm				4,500 11,000		
	12 pm				54,000 54,000		
Oct 26	10 am	7.7	21°C	92,000	160,000	54,000	Visible floating and susp. solids.

TABLE 3

Nov 2	1 pm	7.8	1°C		20,000	20,000	Visible floating and susp. solids & floating ice.
Dec 7	10:30am	7.6	0°C	5,000	11,000		Solid Ice cover (6") Visible floating and susp. solids. Depth of river at sampling pts NB 2', MS 5'
	1pm	7.6	0°C	54,000	17,000		
	3pm	7.6	0°C	11,000	92,000		
Dec 14	10:30 pm			22,000	160,000		Visible floating and susp. solids.
	1 pm			54,000	92,000		"
	5:30 pm			22,000	160,000		"
	6 pm			160,000	160,000		"
Jan 9	10:30 am	7.5 (7.3)	0°C	11,000	17,000		
	5:30 pm	7.5	0°C		6,900		" 18" ice at mid stream
Feb 14	3 pm	7.2	0°C		92,000 92,000		Large amount of white feathery susp. material.
Feb 21	10 am	7.7	0°C		54,000		
	11:30 am	7.5			92,000		
Mar 13	2:30 pm	7.4	0°C				
Mar 21	11:15 am	7.3			92,000		
	2:25 pm				35,000		
	4:10 pm			7,900			
	4:20 pm				17,000		
	8:30 pm			24,000	24,000		
	10 pm			7,900	4,500		
Mar 22	12:01 am				4,500		
	2:15 am				7,900		
	4 am			17,000	11,000		
	6:10 am	7.2		17,000			
	6:15 am				17,000		
	8:05 am			54,000			

TABLE 3

Mar 22	8:10 am			54,000
	9:30 am		35,000	
	9:40 am	7.25		92,000

TABLE 3

Date	Time	pH	Temp	ppm DO	ppm BOD
Dec 14	10:15 am			7.2	2.3, 2.4
	1 [illegible]			7.2	2.4, 2.6, 3.3
	1 pm			7.5	2.6, 3.0
				7.8	2.8, 2.8
				7.8	2.6, 2.5
	5:30 pm			7.8	2.8, 3.0
				7.4	2.9, 2.5
	6 pm			7.4	2.2, 2.3
Jan 9	10:30 am	7.5	0°C	6.7	1.8
		7.3	0°C	6.7	1.2*
	5:30 pm	7.5	0°C	7.2	1.2
Feb 14	3 pm	7.2	0°C	4.9	
Feb 21	10 am	7.7	0°C	5.09	3.19
	11:30 am	7.5	0°C	5.17	3.21
Mar 13	2:30 pm	7.4	0°C	5.2	1.9
Mar 21	11:15 am	7.3		4.7	2.9
	2:25 pm			4.5	3.1
	4:10 pm			4.6*	2.3*
	4:20 pm			4.7	2.1
	8:30 pm			4.85	1.8
					1.6*
	10 pm			5.16	1.6
				5.20*	1.6*
Mar 22	12:01 am			5.32	1.4
	2:15 am			5.40	2.8
	4 am			5.10	2.0
	6:10 am	7.2		4.80	1.8
	6:15 am			4.80	3.6
	8:05 am			4.7	2.2*
	8:10 am			4.7	2.2
	9:30 am			4.6	2.0*
	9:40 am	7.25			2.4

* SAMPLES TAKEN NEAR NORTH BANK. OTHER SAMPLES TAKEN IN MID STREAM.

TABLE 4

NORTH SASKATCHEWAN RIVER AT FORT SASKATCHEWAN

Date	Time	pH	Temp	ppm DO	ppm BOD	
July 18	3 pm	7.5	16°C	8.9	0.6	
July 20	3 pm	7.5	16°C	8.6	0.4	
July 25	3 pm		20°C	7.8		
July 27	2 pm 4 pm	7.5 7.5	18°C 18°C	7.6 7.6	0.4 0.5	
July 31	10 am 12 noon 2 pm	7.5 7.5 7.6	17°C 18°C 18°C	8.6 8.4 8.25	0.7 0.7 0.2	
Aug 3	3 pm	8.2	18.0°C	8.8	0.9 0.7	
Aug 9	2:30 pm 4 pm	7.5 7.5	17°C 17°C	9.0 9.0	0.2 0.4 0.1 0.6	
Aug 23	10 am	7.5	17°C			
Sept 7	2 pm	7.5	15.5°C	9.2	.56 1.10	
Sept 13	4 am 6 am 8 am 10 am 12 noon 2 pm 4 pm 6 pm 8 pm 10 pm 12 pm	7.5	14.5°C			
Oct 26	10 am	7.7	2½°C	12.0	4.0	
Nov 2	1 pm	7.8	[illegible]°C	14	5.3	
Dec 7	10:30 am	7.6	0°C	8.0	2.1* 2.0	2.4* 2.0
	1 pm	7.6	0°C	8.4	3.6* 2.4	2.2* 2.8
	3 pm	7.6	0°C		2.2	2.3

* SAMPLES NEAR NORTH BANK
OTHER SAMPLES FROM MID STREAM. TABLE.

NORTH SASKATCHEWAN RIVER AT FORT SASKATCHEWAN

Date	Time	Sampling Point	pH	CO_2 ppm $CaCO_3$	Alkalinity ppm $CaCO_3$	Solids Total ppm	Solids Organic ppm	Solids Mineral ppm	Chlorides ppm NaCl
Oct 26	10 am	MS	7.7	0	130	222	62	194	
						365	171	241	
Nov 2	1 pm	MS	7.8	0	168	273	88	185	
						277	90	187	
Dec [illegible]	[illegible]:30 am	NB	7.6		203	478	222	256	
		MS		4		491	216	275	
	1 pm	NB	7.6		205	475	209	266	
		MS		4		477	202	245	
	3 pm	MS	7.6						
Dec 14	10:15 am	MS		2.5	186	491	283	208	
		NB				522	286	226	
	[illegible] pm	MS		3.4	180				
		NB							
	5:30 pm	MS		3.5	181				
		NB							
	6 pm	MS				548	307	241	
		NB				557	286	271	
Jan 9	10:30 pm	MS	7.5	3.5	168				
		NB	7.3	3.4	162	731	511	226	
	5:30 pm	MS	7.5			592	392	200	
Feb 14	3 pm	MS	7.2	4.5	165	424	200	224	5.7
Feb 21	10 am	MS	7.7	3.5	169				7.4
	11:30 am	MS	7.5	4.7	167	342	77	265	7.7
									8.2

Mar 13	2:30 pm	MS	7.4 7.7*	5.7	161				4.0
Mar 21	11:15 am	MS	7.3	4.5	163	421	129	292	9.6
	2:25 pm	MS							9.0
	4:10 pm	NB							7.4
	4:20 pm	MS				404	108	296	7.0
	8:30 pm	MS NB							5.7
	10 pm	MS NB							5.1 4.7
Mar 22	12:01 am	MS				324	26	298	4.1
	2:15 am	MS							6.7
	4 am	MS NB							8.7
	6:10 am	NB	7.2						8.7
	6:15 am	MS				408	131	277	8.9
	8:05 am	NB							8.5
	8:10 am	MS							9.7
	9:30 am	NB							10.7
	9:40 am	MS	7.25						

*pH Meter.

NORTH SASKATCHEWAN RIVER AT REDWATER

Date	Time	Sampling Point	Temp	MPN	pH	CO_2	Alk	Solids Total	Solids Organic	Solids Mineral	D.O.	BOD	Remarks
Aug 1°	2 pm	N Sask River		54,000									
Jan 9	3:30 pm	N Sask River	0°C	1°0	7.5	5.0	175	763 735	678 649	85 86	5.7	1.6	
Feb 9	2 pm	N Sask River	0°C	16,000+ 16,000+	7.5	5.0	175	321	76	245	4.0	1.4	

River flow for period July 1950 to April 1951 (c.f.s.)

Date	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	21650	17140	10490	4540	2500	1330	1220	950	954
2	23100	14820	9600	4290	2[illegible]40	1390	1240	936	967
3	24740	13410	9040-	4090	2340	1430	12[illegible]0	936	974
4	23920	13680	9710	3[illegible]90	2230	1510	1290	9[illegible]8	960
5	22170	16620	10360	36[illegible]0	2120	1470	12[illegible]0	9[illegible]8	960
6	21530	16540	10700	3510	2020	1390	1270	94[illegible]	967
7	22530	140[illegible]0	11210	3490	2370	1350	11[illegible]0	936	960
8	23830	12630	9[illegible]10	35[illegible]0	2940	1310	1110	960	954
9	24040	12170	[illegible]920	3540	2310	1290	1100	930	948
10	22410	11830	[illegible]020	3410	1640	1290	1100	900	942
11	21450	11160	7[illegible]20	3360	1210	1300	1090	924	94[illegible]
12	22610	10780	6760	39[illegible]0	1240	1310	10[illegible]0	942	942
13	22970	11720	6530	41[illegible]0	1090	1320	1060	9[illegible]1	942
14	20860	12480	6310	3870	1360	1320	1070	930	936
15	18530	12570	6230	3650	1390	1340	1100	936	948
16	19600	12400	6270	3530	1240	1350	1100	912	942
17	21410	12000	6000	3490	1120	1360	1100	[illegible]	918
18	20780	12960	5850	3360	1090	1360	1090	906	900
19	19410	12000	5700	3200	974	1370	1070	936	876
20	17730	10640	5560	3060	1090	1360	1030	930	894
21	17470	10120	5520	3040	906	1370	1020	936	918
22	17550	9730	5500	3040	790	1350	1000	936	924
23	16200	9710	5620	2960	745	1350	9[illegible]	954	936
24	15210	10250	5790	2750	680	1350	974	936	967
25	15130	10[illegible]0	6100	2620	624	1360	960	954	1000
26	15890	11[illegible]00	6380	2640	552	1370	948	942	1040
27	16760	13570	6400	2610	700	1400	942	948	1070
28	17470	11560	6310	2550	[illegible]40	1420	936	967	1110
29	18340	11210	5890	2750	960	1400	936		1140
30	1[illegible]190	12030	5060	2770	1240	1390	930		1170
31	18300	107[illegible]0		2640		1380	918		1240

TABLE 6

Solubility of Oxygen in Water at 760 mm. Mercury

Temperature degrees C	Oxygen p.p.m.	Temperature degrees C	Oxygen p.p.m.
0	14.62		
1	14.23	16	9.95
2	13.84	17	9.74
3	13.48	18	9.54
4	13.13	19	9.35
5	12.80	20	9.17
6	12.48	21	8.99
7	12.17	22	8.83
8	11.87	23	8.68
9	11.59	24	8.53
10	11.33	25	8.38
11	11.08	26	8.22
12	10.83	27	8.07
13	10.63	28	7.92
14	10.37	29	7.77
15	10.15	30	7.63

For solubilities at other pressures multiply the solubility from this table by the atmospheric pressure in mm. of mercury and divide by 760.

TABLE 7

N o . 1 SEWAGE DISPOSAL PLANT - Data on sewage

1950 Date	TIME	PLANT INFLUENT pH	TEMP °C	B.O.D.	Settle-able Imhoff cone 1 hr.	Solids Total	Mineral	Organic	PLANT EFFLUENT pH	Temp °C	B.O.D.	Settle-able Imhoff Cone 1hr.	Total	Mineral	Organic	Percent Reduction B.O.D.	Org. Sol
Aug 10	10:30 A.M.	7.5	20	361					7.5	20	239					32.8	
Aug 14	10:30 A.M.	8.0	18	331					8.0	18	214					35.4	
aug 15	9:30 A.M.	8.2	17	244							85					65.1	
Aug 16	10:30 A.M.	7.8	19	400					7.9	19	400						
Sept 5	10:00 A.M.	7.7	19	400	3.5 cc	1443	526	917	7.7	19	220		643	309	334	45	63
Sept 5	11:30 A.M.	7.5	20	471					7.5	20			327			31.6	
Sept 5	2:00 P.M.	7.4	20	402		965	407	558	7.4	20	317	4cc	1127	509	618	21.2	-10
Sept 5	4:00 P.M.	7.6	20	351					7.6	20	317					9.7	
sept 6	9:30 A.M.	8.4	19	364	5.5 cc	825	419	406	8.4	19	204	2.0cc	684	425	259	44.0	36
Sept 6	11:30 A.M.	8.5	19.5	400					8.5	19	313					-21.8	
Sept 6	2:00 P.M.	8.4	19	431		924	460	464	8.4	19	362		942	589	453	16.0	2.5
Sept 11	2:15 P.M.	8.4	19	442		1049	452	597	8.4	19	383	8.0cc	942	402	540	13.4	9.5
Sept 11	4:00 P.M.	8.4	19	500		1323	526	797	8.4	19	494		1786	458	1328	- 1.2	-67
~~Sept 12~~																	
May 16	2:30 P.M.			550							375					~~30.0~~	
May 19	10:20 A.M.			240							120						
May 21	10:05 A.M.			400		1500	570	930					930	550	380	55 / 59	59.0

TABLE 8

Aug 1950 To MAY 1951

PRIMARY SETTLING
NO.3 SEWAGE DISPOSAL PLANT

		INFLUENT				Solids				EFFLUENT				Solids			
Date	Time	pH	Temp	BOD	Settleable	Total	Mineral	Organic	DO	pH	Temp	BOD	Settleable	Total	Mineral	Organic	DO
Aug 9	10am			232, 216					0		20 C	335, 323					0
Aug 10	10am			395					3.44			206					
Aug 14	10am	8.6	1600	400					1.40			187					
Aug 15	10am	7.7	1700	200, 1400					3.76			223					
Aug 16	10am	6.8	1800	400					1.24			270, 310					
Sept 19	10:30am	7.4	17.50C	490		1130	461	669		7.4		331		760	328	432	
	1pm				5.5cc								0cc				
Sept 19	2:20pm				7.5cc									[illegible]		[illegible]	
	3:20pm	7.6	1300	650		1091	330	761		7.6				765	299	466	
Sept 20	9:30am	7.3	18.50C	399	6.5cc	722	312	410		7.4			0.5cc	622	278	344	
	11:30am	7.3	19.50C	382		756	224	462		7.3				766	258	508	
Sept 21	10:50am	7.3	19.50C		8.0cc	834	354	480		7.3			0.25cc	692	287	405	
	1:15pm	7.3	19.50C			731	261	470		7.3				730	297	433	
May 16	2pm			382, 362													
May 19	10:05am			274,301, 505,292													
May 21	9:35am			296,294, 171,289		787, 830	403, 408	384, 442									

Aug 1950 to May 1951

TABLE 8