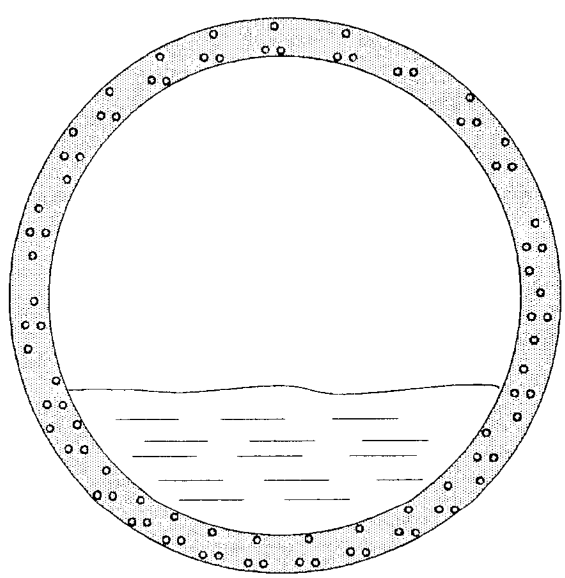
City of Winnipeg
Waterwork, Waste
and Disposal Department

Phase 1 Technical Memorandum for

Combined Sewer Overflow Management Study

INFRASTRUCTURE

Technical Memorandum No. 2



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In Association With:

Gore & Storrie Limited and EMA Services Inc.

June 1994

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This Technical Memorandum is for information to the Phase 1 Workshop participants. It is a draft document intended for internal discussion and is not intended as a report representing the policy or direction of the City of Winnipeg.

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LIST OF ILLUSTRATIONS

1.0 BACKGROUND

The City of Winnipeg is served by three water pollution control centres and their associated sewerage systems. The location of the plants and the boundaries and nature of their tributary sewer systems are shown on Figure 1-1. Wastewater is collected from the tributary areas and transported to the plants by interceptor systems. As can be seen from the figure, the sewerage systems comprise combined sewers, separate sewers (wastewater and land drainage) and separate (land drainage) sewers with retention ponds. The latter systems have been used extensively in new developments.

2.0 SEWERAGE SYSTEMS

2.1 OVERVIEW

The older, central area of the City is served by combined sewers. Dry weather flow (DWF) and a nominal fraction of wet weather flow (WWF) is diverted to an interceptor sewer, which in turn conveys the sewage to the treatment plant (WPCC). The capacities of the combined sewers are many times greater than the flows diverted to the interceptor sewers, since they were developed to convey storm runoff to the rivers. There are 42 individual combined sewer districts which have a total area of approximately 10,500 hectares (ha) and which are shown on Figure 1-1.

Since about 1961, separate sewer systems have been installed in all new developments within the City of Winnipeg. The land drainage sewers from these areas, which discharge directly into the City's rivers, serve an area of some 10,000 ha.

Stormwater runoff from separate areas can also be stored temporarily in retention ponds to attenuate peak discharge, and thus reduce the size of land drainage outfall sewers and associated costs. Generally, such pond drainage areas are located in suburban areas which are some distance from rivers. The total drainage area served by systems with retention ponds is presently about 7,700 ha. This area is expected to grow substantially in the future.

COMBINED SEWER DISTRICTS	
1	ALEXANDER
2	ARMSTRONG
3	ASH
4	ASSINIBOINE
5	AUBREY
6	BALTIMORE
7	BANNATYNE
8	BOYLE
9	CLIFTON
10	COCKBURN/CALROSSIE
11	COLONY
12	CORNISH
13	DESPINS
14	DONCASTER
15	DOUGLAS PARK
16	DUMOULIN
17	FERRY ROAD
18	HART
19	HAWTHORNE
20a	JEFFERSON EAST
20b	JEFFERSON WEST
21	JESSIE
22	LAVERENDRYE
23	LINDEN
24	MAGER
25	MARION
26	METCALFE
27	MISSION
28	MOORGATE
29	MUNROE
30	NEWTON
31	PARKSIDE
32	POLSON
33	RIVER
34	RIVERBEND
35	ROLAND
36	SELKIRK
37	STRATHMILLAN
38	ST. JOHN'S
39	SYNDICATE
40	TUXEDO
41	TYLEHURST
42	WOODHAVEN

SEPARATE SEWER DISTRICTS	
43	AINSLIE
44	BROOKLANDS
45	CHARLESWOOD
46	CHELSEA
47	CRANE
48	FORT GARRY
49	LAKESIDE MEADOWS
50	LINDEN WOODS
51	MAGER SEPARATE
52	MAPLES
53	MISSION GARDENS
54	MISSION SEPARATE
55	NORTH KILDONAN
56	NORTH MAIN
57	OAKLEIGH
58	PARKDALE
59	PULBERRY
60	RIVERBEND SANITARY
61	SOUTHDALE
62	SOUTH ST. VITAL
63	ST. NORBERT
64	ST. VITAL
65	TRANSCONA
66	TRANSCONA CNR
67	TRANSCONA WEST
68	TUXEDO
69	TYNDALL PARK
70	VALLEY GARDENS
71	WILLOW
72	WINDSOR PARK

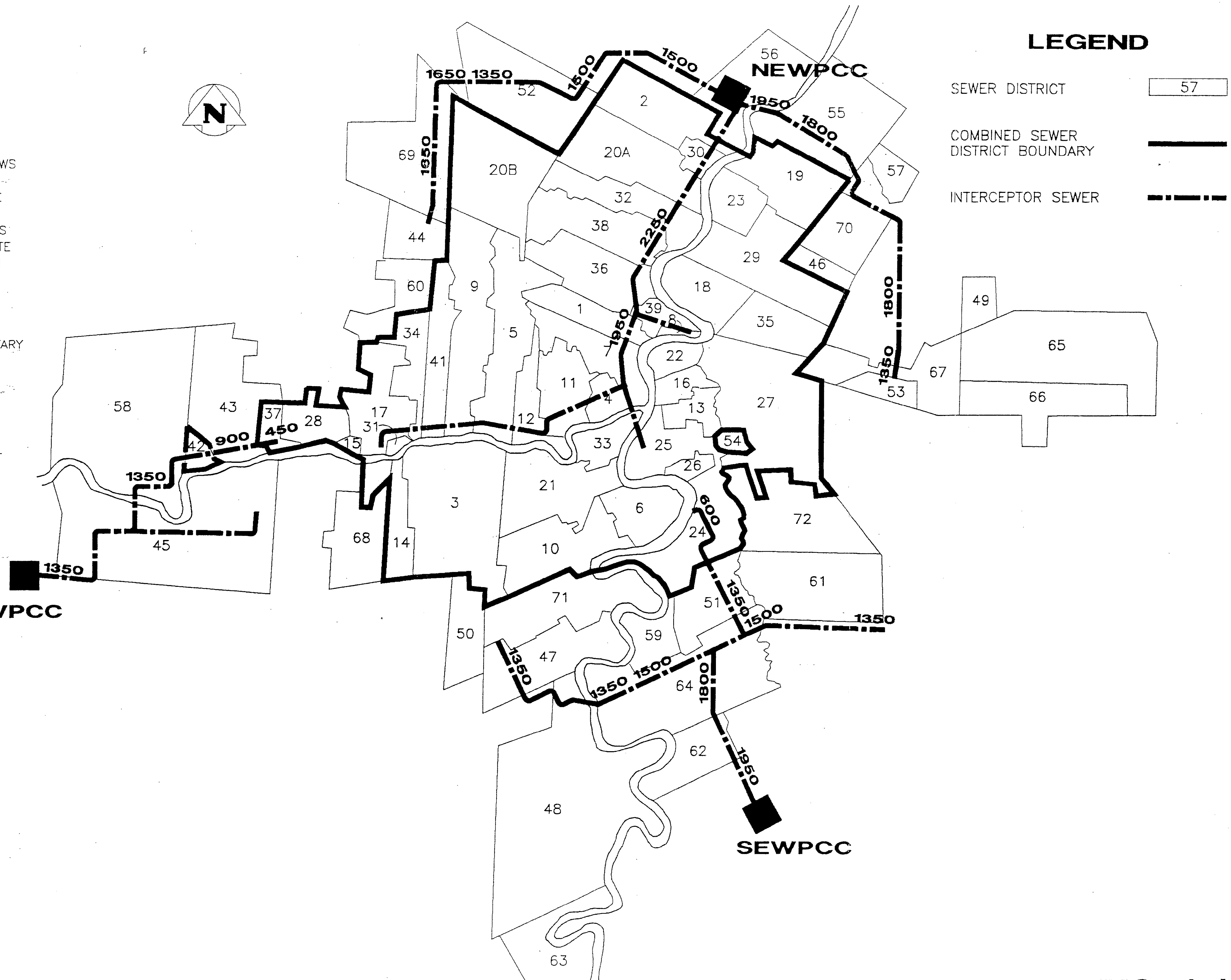


FIG 1-1

Table 2-1 shows the estimated number and nature of the discharge points to the Winnipeg rivers.

The following discussion elaborates on the various sewerage systems in the City.

2.2 SEPARATE SEWERAGE SYSTEM

The location of the separate sewerage systems within the City of Winnipeg, and the treatment plants to which they are tributary, are shown in Figure 2-1. The separate systems comprise two types:

- those whose land drainage sewers convey runoff directly to the rivers; and
- those whose land drainage systems convey water to storm retention ponds and thence to the rivers.

The separate sanitary sewers collect domestic, commercial and industrial wastewater and convey it to the water pollution control centres. Under dry weather conditions virtually all sanitary sewage flows from the separate districts are conveyed to the plants. Accordingly, under dry weather conditions, wastewater is given secondary treatment at the WPCCs.

As indicated on Table 2-1 there are some separate sanitary sewer overflows into the river. During extreme wet weather, stormwater enters the sewers through weeping tiles, manholes and other infiltration. Occasionally, during heavy rainstorms or with power outages at pumping stations, the flow exceeds the capacity of the sanitary sewer and the excess wastewater is overflowed to the river. The likely probability of occurrence of these sanitary overflows is between 1 in 5 years to 1 in 10 years. Land drainage flows in the separate sewerage districts are discussed in Sections 3.1 and 3.2.

TABLE 2-1

OUTFALLS TO RIVERS

CITY OF WINNIPEG OUTFALLS			
WPCC EFFLUENT	COMBINED SEWER OVERFLOWS	LAND DRAINAGE	EMERGENCY SANITARY OVERFLOWS[A]
RED RIVER			
• NEWPCC • SEWPCC	45	40	7
ASSINIBOINE RIVER			
• WEWPCC	31	50	7
TOTALS			
3	76	90	14

PLANT SERVICE AREAS
&
LAND DRAINAGE INVENTORY

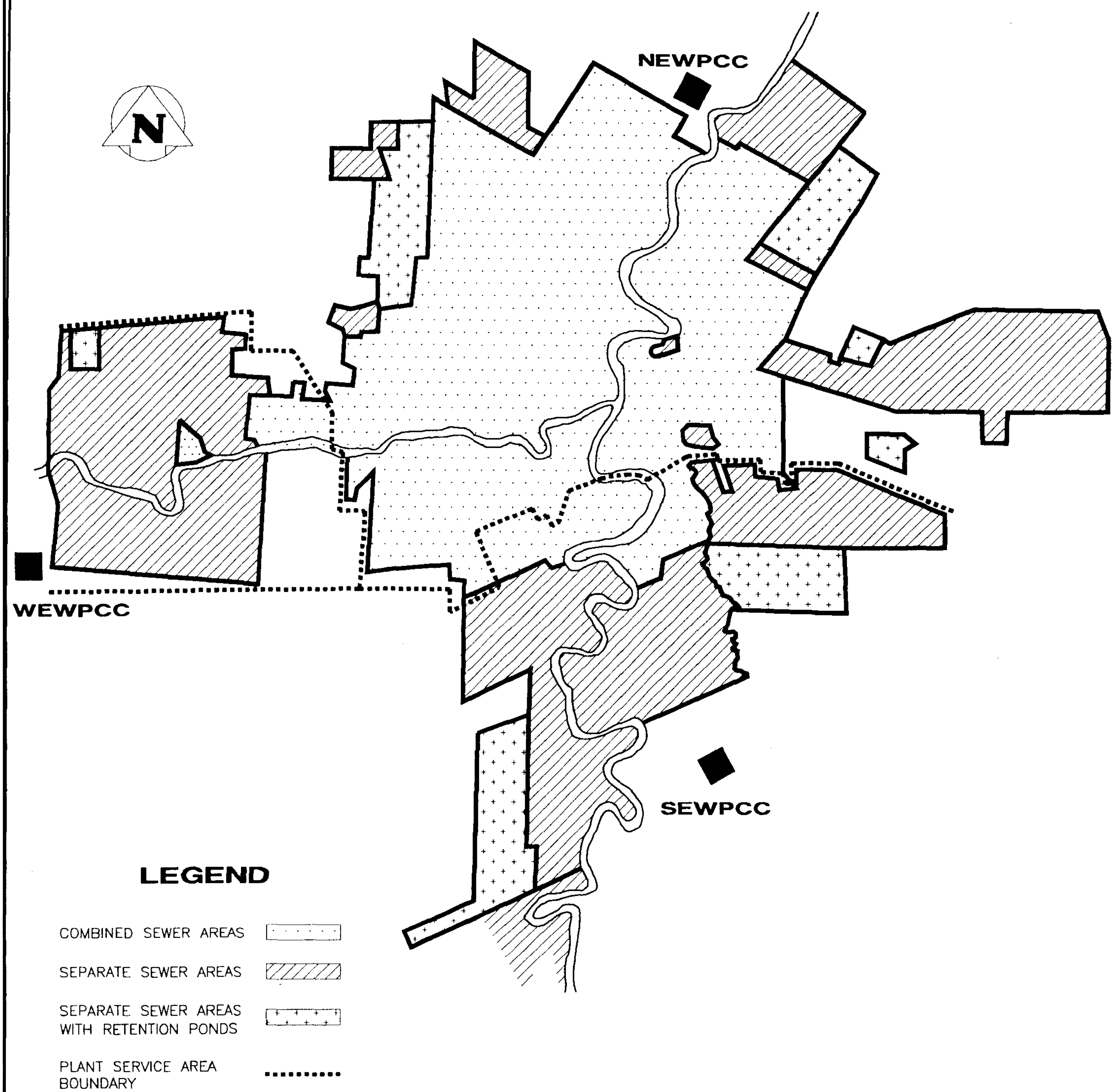


FIG. 2-1

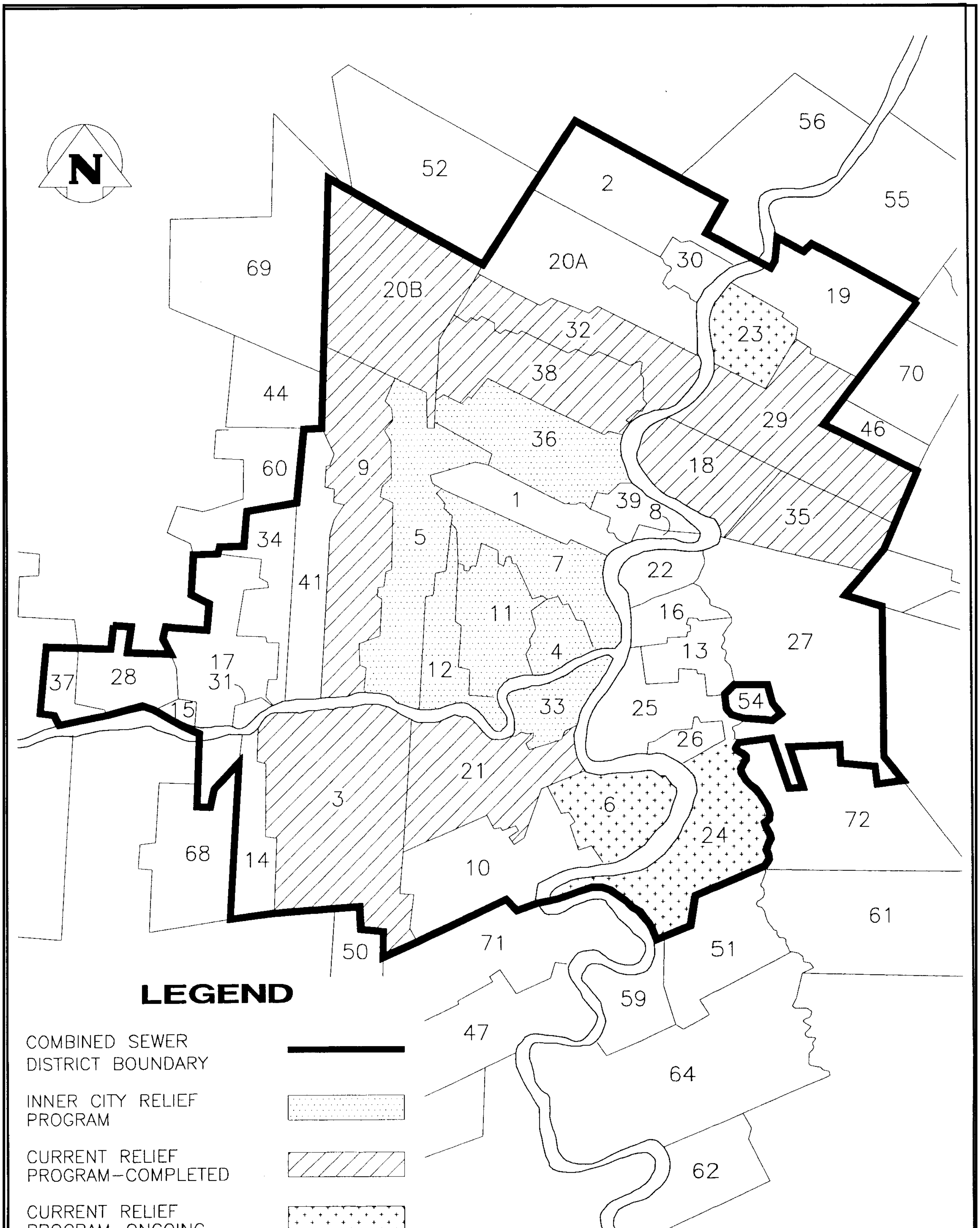
2.3 COMBINED SEWER SYSTEMS

From 1880 to 1930, combined sewers were built in Winnipeg to improve drainage and sanitation within the rapidly growing City. The sewers collected surface runoff and wastewater, and discharged both directly to the rivers. Such sewers have since been called combined sewers and combine the functions of storm sewers and sanitary sewers in that both surface runoff and wastewater is transported in one pipe. In the 1930s, river pollution, resulting from the discharge of untreated wastes from a population of over 250,000, combined with a cycle of low river flows, resulted in an intolerable situation. The Greater Winnipeg Sanitary District was created at that time, and were charged with the responsibility to collect and treat the wastes within the area. Interceptors were built to convey flows from the combined sewers to the NEWPCC. The collection was effected by building weirs at each combined sewer outfall to the river to divert the flows to pumping stations or gravity sewers. These flows were then conveyed via the Main Interceptor to the plant.

During dry weather, all the wastewater is collected and transported via interceptors to the water pollution control centre (WPCC) for treatment. However, almost all runoff events (rainfall and snowmelt) result in surface runoff that is greater than the interception capacity of the infrastructure which conveys flow to the interceptors. During these periods the excess, which comprises diluted raw sewage, is overflowed to the river. In the case of Winnipeg, the amount of flow interception is typically about 2.75 times dry weather flow.

The CSO districts within the City of Winnipeg have had a history of basement flooding. Accordingly, the City initiated programs to relieve such flooding. The first of these programs ran from 1965 to 1977 and resulted in the relief of seven inner-city districts, through the use of the Rational Method. In 1977, the second program was initiated and has continued until now. This second program used the stormwater management model (SWMM) as the analytical tool. During this program, some nine districts have been relieved. In addition, work is currently being carried-out in three additional districts. Figure 2-2 is a plan of the City's combined sewer districts. It shows the location of the relieved districts and differentiates between the two programs, as well as indicating the three areas currently in the process of being relieved.

The basement flooding relief program is discussed further in Section 4.0.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LEGEND
COMBINED SEWER
DISTRICT BOUNDARY
INNER CITY RELIEF
PROGRAM
CURRENT RELIEF
PROGRAM-COMPLETED
CURRENT RELIEF
PROGRAM-ONGOING

FIG. 2-2

2.4 WATER POLLUTION CONTROL CENTRES

The major dry weather discharges to the rivers are treated effluents from the three Water Pollution Control Centres (WPCC). The City of Winnipeg has recently completed an intensive program of pollution control upgrading, which resulted in the provision of the best practicable secondary treatment for all continuous dry weather wastewater flows. It is noteworthy that none of the plants practice effluent disinfection. Design effluent quality is 15/15 (TSS/BOD). Details of plant design and operations are provided in a separate Technical Memorandum (Number 3). A summary of the basic statistics relating to the plants are given in Table 2-2.

2.4.1 North End WPCC (NEWPCC)

The NEWPCC is the largest of the three plants. It has been built in several stages since its opening in 1937. The plant consists of primary and oxygen activated sludge secondary treatment processes, including sludge digestion, and dewatering facilities. A major expansion of the secondary process, including its conversion to a high-purity process, has been completed recently. In the last decade, virtually every component of the process has been upgraded. A sludge dewatering facility, providing a service to all three WPCCs, was completed at the NEWPCC in 1990. The NEWPCC is generally considered to be a "state-of-the-art" conventional secondary treatment plant. The NEWPCC treats the flows from 36 of the 42 combined sewer districts.

2.4.2 South End WPCC (SEWPCC)

The SEWPCC is the second largest of the three regional treatment plants. The area primarily comprises separate sewer systems, although three of the combined sewer districts are tributary to the SEWPCC.

The SEWPCC was commissioned in 1974. It provides primary treatment and an oxygen-based activated sludge secondary treatment process. All of the components of the original plant were recently expanded. This expansion program (begun in 1986 and completed in 1993) upgraded the plant to the current "state-of-the-art" technology.

TABLE 2-2

TREATMENT PLANT CHARACTERISTICS

FACILTY	CAPACITY ADWF ML/d	AREA SERVED (ha)	% OF CITY'S SEWAGE FLOW TREATED	RECENT EXPANSION COST $M
NEWPCC	302	16,200	70	> 100
SEWPCC	56	7700	20	40
WEWPCC	32	3900	10	40

2.4.3 West End WPCC (WEWPCC)

The WEWPCC is the smallest of the three plants in the City. Except for two combined sewer districts north of the Assiniboine River, and part of a third, the service area is served by separate sewer systems. Some parts of Charleswood continue to use ditches for land drainage.

A major plant expansion began in 1986 and was completed in 1994. This program involved abandonment of the then-existing facultative sewage lagoons and the replacement of the existing mechanical plant, with a conventional activated sludge secondary facility.

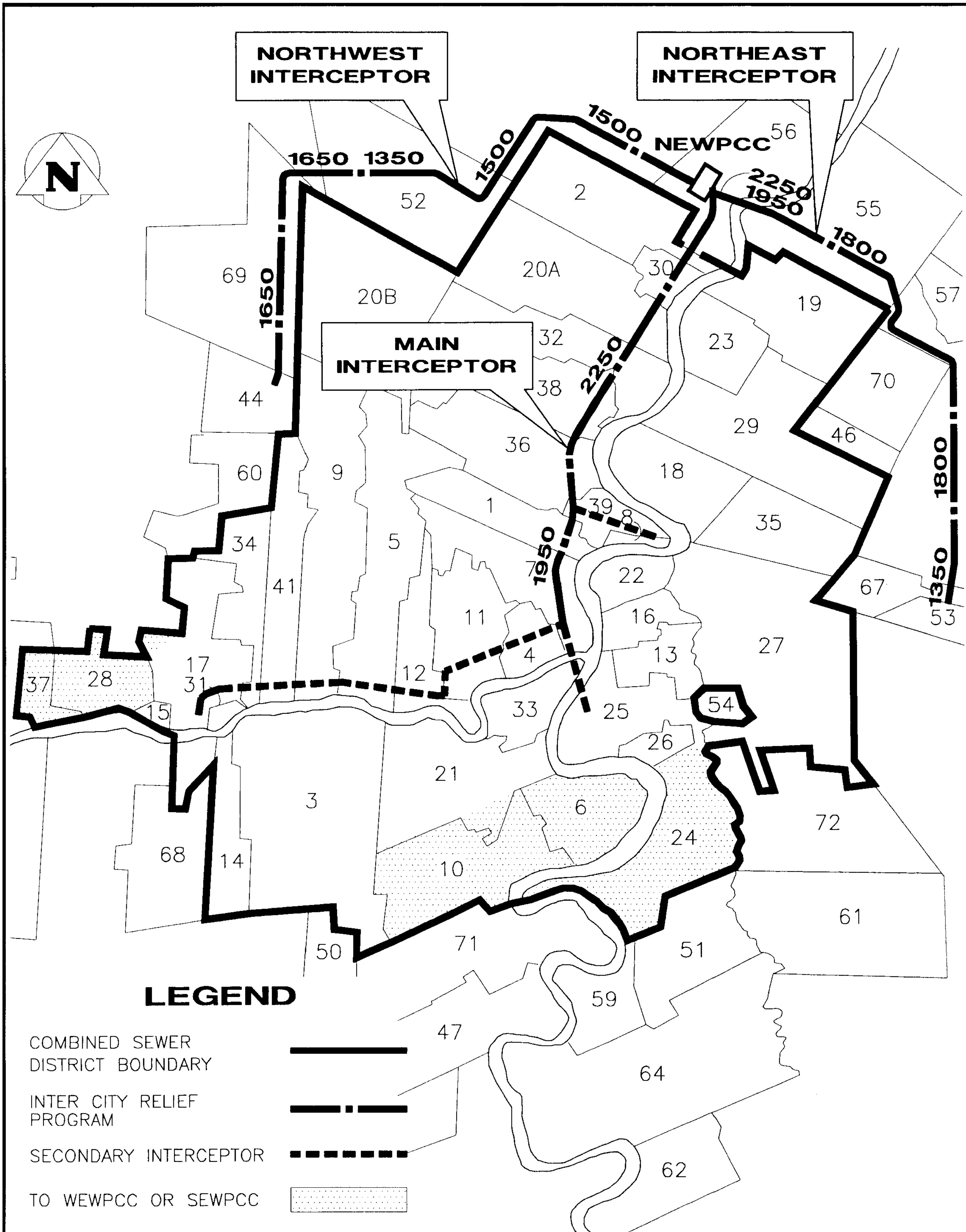
2.5 MAJOR INTERCEPTOR SYSTEMS

There are five major interceptors within the City. The NEWPCC Interceptor system comprises three main trunks (MacLaren 1961[1]). The SEWPCC and WEWPCC each have one interceptor system. The three interceptor sewer systems are indicated in Figure 1-1 and are described briefly below.

2.5.1 NEWPCC Interceptors

The interceptor system for the NEWPCC consists of three main sewers and is illustrated on Figure 2-3. The Main Interceptor serves the older areas of the City and, for the most part, serves combined sewer districts. It is designed to carry 2.75 times average dry weather flow (ADWF). The Northeast and Northwest Interceptors serve newer developments in the service area and were accordingly designed to carry separate sanitary sewage to the NEWPCC with significant allowance for extraneous flow, mostly weeping tile flow, during runoff events.

The flows from all three interceptors discharge into the NEWPCC surge well and are thence pumped to the treatment processes.


NORTHWEST INTERCEPTOR
NORTHEAST INTERCEPTOR
MAIN INTERCEPTOR
NEWPCC
N
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1350
1500
2250
1950
1800
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20A
20B
30
32
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LEGEND
COMBINED SEWER DISTRICT BOUNDARY
INTER CITY RELIEF PROGRAM
SECONDARY INTERCEPTOR
TO WEWPCC OR SEWPCC

FIG. 2-3

The Northeast Interceptor has a relief point just upstream of the inverted siphon crossing of the Red River, just across the river from the NEWPCC.

Since most of the combined sewer flows generated in the City are tributary to the Main Interceptor, the nature and details of its operation are important to the study of CSOs to the rivers. These factors are discussed in Section 5.0. As discussed therein, the Main Interceptor has two identified major relief points and a number of potential, smaller relief points.

2.5.2 SEWPCC Interceptor

The collection for the SEWPCC consists of one main interceptor. The area is almost entirely serviced by separate sewers except for the three tributary combined sewer districts. The main segment is the St. Vital interceptor, with two main branches as shown in Figure 1-1. These two interceptors are the St. Boniface-St. Vital and the Fort Garry-St. Vital.

The D'Arcy pumping station collects the wastewater from the Fort Garry interceptor and pumps it across the Red River. The major emergency overflow points of the SEWPCC interceptor system are at the D'Arcy pumping station for the Fort Garry systems and the St. Mary's outfall for the St. Vital interceptor. It is designed to deliver about 3 x DWF to SEWPCC (MacLaren 1986)[2], i.e., the SEWPCC is designed for this PWWF).

2.5.3 WEWPCC Interceptor

The service area for the WEWPCC system comprises 23 tributary areas. Only the areas of Woodhaven, Strathmillan and Moorgate are served by combined sewers. All other tributary areas are served by separate sanitary and land drainage sewer systems. Some parts of Charleswood are still served by open ditches for surface drainage of stormwater.

Wastewater generated north of the Assiniboine River is transported in the St. James Interceptor which follows the river and flows from east to west along Assiniboine Avenue and Assiniboine Crescent. A major overflow provision for the St. James Interceptor is located at the Parkdale Outfall, just upstream of the interceptor crossing of the Assiniboine River.

Wastewater generated south of the Assiniboine River is transported in the Grant Avenue Trunk/Charleswood Westdale Interceptor. The trunk sewer flows westward under Grant Avenue and becomes the Charleswood interceptor. Prior to entering the Community Row pumping station, the wastewater from St. James is added to the Charleswood/Tuxedo flows. The combined flow is then lifted into the Charleswood Intercepter and conveyed to the Perimeter Road pumping station and subsequently into the WEWPCC. The Perimeter Road pumping station pumps all wastewater flow to the WEWPCC. The WEWPCC is designed for 3.5 times DWF (MacLaren 1986).

3.0 WET WEATHER OPERATION

Wet weather discharges to the Red and Assiniboine rivers (from the City of Winnipeg) occur during rainfall and snowmelt events. These discharges comprise direct land drainage, urban runoff from land drainage sewers, overflow from sanitary sewers, and discharge from combined sewers. The total volume and discharge rate of WWF is extremely variable.

The different wet weather sources can be classified as:

- land drainage sewer discharge;
- retention pond drainage;
- separate sanitary sewer overflows;
- combined sewer overflows; and
- wastewater plant bypasses.

The nature and extent of each of these sources are discussed in the following sections. Quality and volumes of discharges are discussed in Technical Memorandum #1 entitled "Problem Definition".

3.1 LAND DRAINAGE SEWER RUNOFF

These sewers carry urban stormwater drainage and are designed to exclude sanitary sewage. The total volume and discharge rate depends upon the intensity and duration of the rainstorm or snow melt. The quality of the runoff depends on the material picked up by the runoff and also depends on the storm characteristics, street cleaning, and the duration since the last storm. Fecal contamination of this runoff is usually attributed to non-human origin (i.e., from animals and birds). The areas in which the land drainage sewers (separate sewers) are located are shown in Figure 1-1. Generally, separate sewers are located in the suburban areas of the city. The total area of separate storm sewers, exclusive of separate areas with ponds, is currently about 10,000 hectares. This area will grow moderately in the future.

3.2 RETENTION POND DRAINAGE

Stormwater runoff can be stored temporarily in retention ponds to reduce the size of land drainage sewers and associated costs. The nature of the retention pond drainage is very similar to land drainage runoff. This urban land runoff drains to a retention pond where it is temporarily stored and discharged at a slower rate to the river. The time that the runoff is held in the retention pond generally improves the quality of the discharge to the river. Settling and die-off of organisms tend to reduce the coliform concentrations in pond discharge.

Generally, pond drainage areas are located in the suburban areas with land drainage systems which are some distance from the rivers. The total area with pond drainage is presently about 7,700 ha and this area is expected to grow substantially in the future.

3.3 SEPARATE SANITARY SEWER OVERFLOWS

During extreme wet weather, stormwater enters the sanitary sewers through weeping tile, manholes and other infiltration. This excess flow is classified as "extraneous flow" since storm water is intended to be directed to a separate storm sewer. Occasionally, during heavy rainstorms or with power outages at pumping stations, the flow exceeds the capacity of the sanitary sewer and the excess wastewater is overflowed to the river. This overflow, although small in quantity, is essentially diluted raw sewage. Sanitary sewer overflows occur only rarely. Under these conditions, overflows to sewers can occur at lift stations. These do not occur with the same frequency as combined sewer overflows. The overflows are estimated at about 10% of land drainage discharges, which likely overstates the actual discharges (Wardrop/Tetr*ES* 1991[3]).

The areas in which the separate sanitary sewers are located are the same as the land drainage sewers and retention pond drainage. The total area of separate sanitary land use is presently about 17,700 ha and will grow moderately in the future as all new developments utilize a separate sanitary sewer system.

3.4 COMBINED SEWER OVERFLOWS

The combined sewer systems are described in Section 2.3. They comprise about 10,000 ha. The area of combined sewer systems will not increase in future. There are over 70 overflow points from sanitary combined sewer systems to the rivers (this number includes relief sewers).

About 30 to 50 times per year, rainfall or snow melt is significant enough to cause runoff at a larger rate than can be intercepted. Overflows do not occur at the same time or from all overflow points during a rain storm, (i.e., as a result of varying intensity, duration, and distribution).

3.5 PLANT BY-PASSES

Rainfall or snowmelt can cause the peak wet weather flow (PWWF) at the plants to be 3 to 3.5 times ADWF (MacLaren 1986). The flow in excess of peak DWF (about 1.7 times ADWF) bypasses secondary treatment and receives only primary treatment. Therefore, the quality of the plant discharge to the river deteriorates somewhat during a PWWF event.

3.6 RURAL LAND DRAINAGE

Within the urban limits of the City of Winnipeg, there exists about 18,000 ha of land that is not serviced. This area will also contribute runoff to the rivers but is relatively small in comparison to the overall drainage area of the study area.

4.0 BASEMENT FLOODING RELIEF PROGRAM

4.1 HISTORICAL PERSPECTIVE

Basement flooding in the City of Winnipeg has been recognized as a major problem for many years. It usually results from intense summer rainfalls and is most prevalent in the combined sewer systems. Concern with the extent and severity of the problem resulting in two major storm programs being initiated since 1970:

1) The inner-city program of the 1960s (primarily based on the Rational Method analysis).
2) The 1977 program with priorities revised in 1978 and subsequently (primarily based on analysis using the Stormwater Management Model [SWMM]).

The main features of the 1977 program are as follows:

- The program was of 10 years duration with $600 million/year being allocated, plus $500,000/year for local relief and studies.

- The upgrading program was to provide protection from a storm with 5 year return frequency in all combined sewer districts. This was to be followed by a further upgrading to a 10 year level of protection (generally realized through inlet control).

- The program was also to provide a 10 year level of protection in all separate sewer districts.

- The program was to be implemented in four phases, based on district-by-district priorities as determined through reported floodings.

The 1977 program was revised in 1986. Since that time, the relief program has been based on the priorities of the report by the City of Winnipeg entitled "Basement Flooding Relief Program Review - 1986" (City of Winnipeg 1986). The study determined that a 5-year level of protection, using relief piping, was the appropriate level of service and was economically viable. The findings were based on the assessment of Figure 4-1 "Benefit-Cost Analysis for Entire Study Area". The relief alternatives considered and the recommendations are summarized in Table 4-1 "Relief Alternatives". The study findings, as given in the Executive Summary (City of Winnipeg 1986) of that report, are as follows:

- The most appropriate relief alternative for basement flooding is relief piping for a five year level of protection along with inlet restriction which will eliminate flooding from most locations from rainfall events up to a 10 year return. The estimated cost to provide relief by this method for the 34 combined sewer districts is $110 million.

- The five year level of protection for recently relieved combined sewer districts can be increased to a 10 year level by inlet restriction at an estimated capital cost of $1 million.

- Staged monitoring, preliminary engineering and advance of detail design, and development of a downspout disconnection program is estimated to cost $4 million.

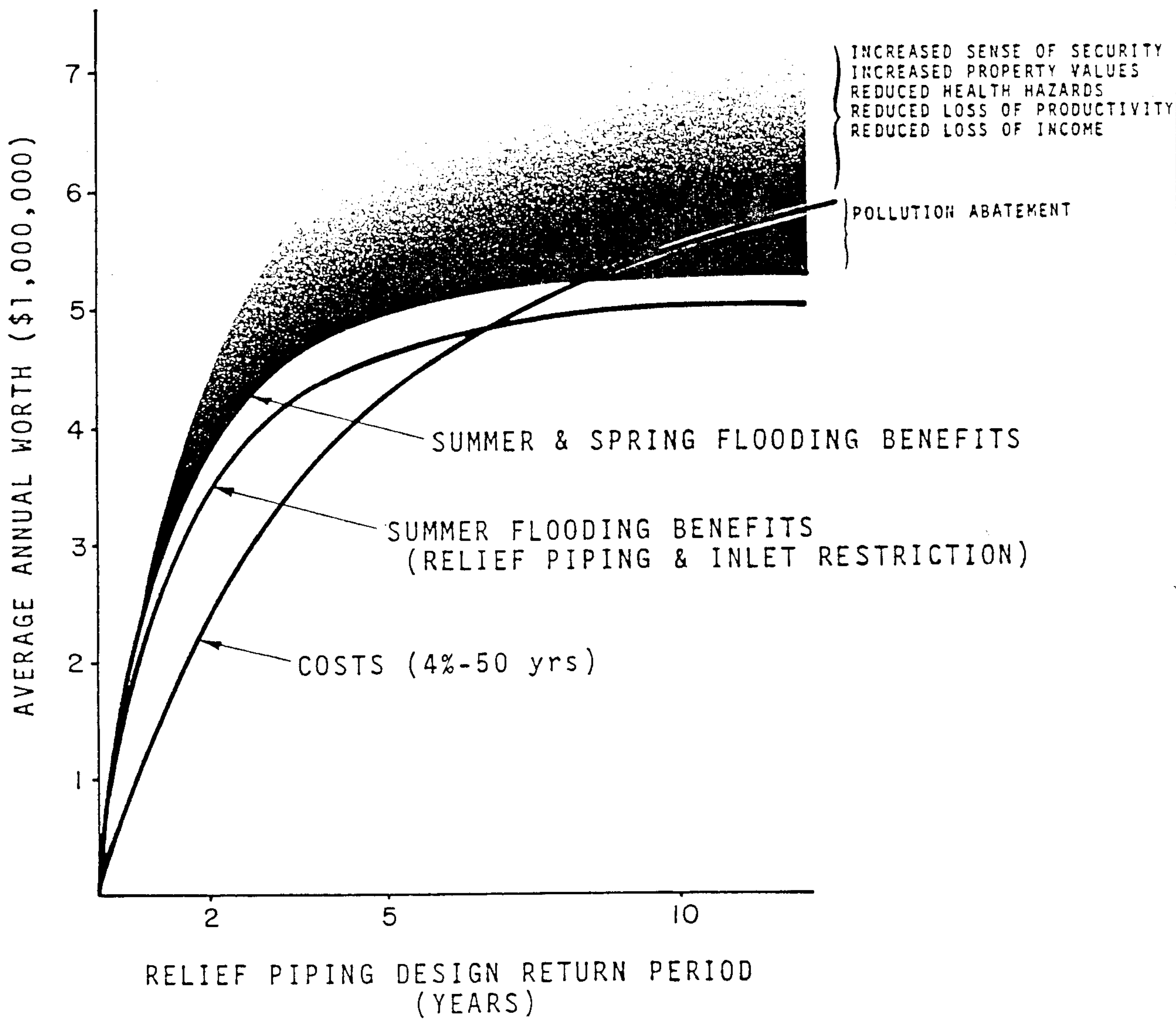
- Table 4-2 shows a breakdown of the estimated program costs, which total $115 million (1986).

- Downspout disconnection is economically attractive and capable of providing immediate benefits to every district. As a supplemental method with five year relief piping and inlet restriction, it will in most cases increase protection beyond the 10 year level. It is a prerequisite for sanitary sewer separation alternatives.

- Sanitary sewer separation is equivalent in cost to relief piping for 9% of the study area.

- Pipelining is not currently cost-effective as a general approach to relief, however it may have merits for future dual applications of pipe rehabilitation and basement flooding relief.

- Flood insurance is inappropriate as an alternative to basement flooding relief.



BENEFIT-COST ANALYSIS FOR ENTIRE STUDY AREA

Figure 4-1

TABLE 4-1

RELIEF ALTERNATIVES

RELIEF ALTERNATIVES CONSIDERED	RECOMMENDED
• Relief piping	• 1 in 5 year protection
• At-source storage	• Inlet control to go from 5 year to 10 year protection
• Downspout Disconnection	• Economical supplement to relief piping
• Sewer separation	• Selective, too costly as regional solution
• Flood Proofing (backwater valve and sump pump)	
• Storage	• Costlier than relief piping
• Pipelining (hydraulic)	• Not cost-effective
• Flood insurance (no relief)	• Inappropriate

TABLE 4-2

ESTIMATED PROGRAM COSTS (1986 DOLLARS)

	SEWER DISTRICT	TOTAL COST (MILLIONS) INCLUDING BURDENS
5-Year Relief Piping with Inlet Restriction		
	Alexander	$ 4.39
	Armstrong	7.28
	Assiniboine	0.11
	Aubrey	1.66
	Baltimore	4.84
	Bannatyne	1.02
	Cockburn/Calrossie	8.44
	Colony	1.02
	Cornish	0.60
	Doncaster	0.68
	Dumoulin/LaVerendrye	1.82
	Ferry Rd/Douglas	9.15
	Hawthorne	6.64
	Jefferson East	9.23
	Linden	6.18
	Mager	5.69
	Marion/Despins	9.40
	Metcalfe	0.20
	Mission	7.46
	Moorgate	3.37
	Newton	2.03
	River	0.28
	Riverbend	5.38
	Selkirk	3.72
	Strathmillan	2.68
	Syndicate/Boyle	2.99
	Tuxedo	0.67
	Tylehurst	2.04
	Woodhaven	0.62
TOTAL - PIPING WITH RESTRICTORS		$ 110.0
Inlet Restriction for Existing Relieved Districts		1.0
Monitoring and Preliminary Engineering in Advance of Detailed Design and Downspout Disconnection Program Development		4.0
TOTAL PROGRAM COSTS		$ 115.0

Source: City of Winnipeg, 1986

The recommended priority schedule, as developed in the 1986 report are shown in Table 4-3.

Selected recommendations from the 1986 report (City of Winnipeg 1986) are as follows:

"• All remaining unrelieved combined sewer districts be upgraded to a five year level of protection against basement flooding with relief piping and supplemented where possible with inlet restriction, to protect for storms up to a 10 year return period at a total estimated cost of $110 million (1986 dollars)."

"• In view of the benefit-cost ratio shown in Table 4-3, Council may wish to reassess the policy of a five year level of protection....Accordingly, the Department review and report on the basement flooding relief program by 1988 prior to proceeding with relief in sewer districts which have a benefit-cost ratio of less than 1.0."

"• Inlet restriction be implemented in recently relieved combined sewer areas to increase the level of service from a five year to a 10 year level of protection..."

"• "Staged monitoring, preliminary engineering and advanced detail design and development of downspout disconnection program be undertaken..."

"• Recommendation 5 dealt with a relief of a specific combined sewer district".

"• An annual budget of $7.6 million would be appropriated from 1993 to 2005."

It is to be noted that pollution control and sewer rehabilitation were not discussed in this report.

4.2 CURRENT STATUS

Sixteen combined sewer districts, out of 42 in total, have been relieved. This has been effected primarily through installation of relief piping, with selective local separation where economically feasible. Funding of the relief program has varied. This variation has been due primarily to budget constraints although heavy rainfalls and extensive flooding in 1993/94

TABLE 4-3

BASEMENT FLOODING RELIEF PROGRAM (5-YEAR PIPING WITH INLET RESTRICTION)

Recommended Priority Schedule - 15 Year Implementation Program

PROJECT PRIORITY		COST (x$1000)*		PROJECT YEAR	BENEFIT-COST** RATIO (4% - 50 yrs)
Localized Relief	District Relief	Project	Cumulative		
	Assiniboine	111	111	1	11.1
	Colony	1022	1133	1	5.1
Mager		3145	4278	1	3.4
Armstrong		418	4696	1	3.2
	River	277	4973	1	3.1
Riverbend		250	5223	1	3.1
Tylehurst		706	5929	1	2.2
Selkirk		2551	8480	2	2.0
Hawthorne		230	8710	2	1.8
	Baltimore	4840	13550	2	1.8
Linden		1731	15281	3	1.7
Strathmillan		1600	16881	3	1.6
Dumoulin/Lav		892	17773	3	1.6
Moorgate		1457	19230	3	1.5
	Alexander	4393	23623	4	1.2
	Ferry Road	9146	32769	5	1.2
Mission		2523	35297	5	1.2
Marion/Desp.		2562	37859	6	1.2
Cockburn/Cal.		4138	41997	6	1.1
	Jeff. East	9232	51229	7	1.1
	Newton	2026	53255	8	1.0
	Bannatyne	1024	54279	8	1.0
Syndicate/Boy.		2446	56725	8	0.9
Aubrey		704	57429	8	0.8
	Moorgate	1909	59338	9	0.8
Cornish		287	59625	9	0.8
	Linden	4449	64074	9	0.8
	Woodhaven	619	64693	9	0.8
Tuxedo		520	65213	9	0.7
	Riverbend	5136	70349	10	0.6
	Dumoulin/Lav.	932	71281	10	0.6
	Armstrong	6858	78139	11	0.6
	Selkirk	1172	79311	11	0.6
	Hawthorne	6406	85717	12	0.6
	Cockburn/Cal.	4302	90019	13	0.6
	Strathmillan	1082	91101	13	0.6
	Mission	4929	96030	14	0.6
	Doncaster	679	96709	14	0.6
	Syndicate/Boy.	546	97255	14	0.6
	Marion/Desp.	6838	104093	15	0.5
	Mager	2549	106642	15	0.5
	Aubrey	952	107594	15	0.5
	Metcalfe	204	107793	15	0.5
	Tuxedo	154	107952	15	0.5
	Tylehurst	1340	109292	15	0.5
	Cornish	316	109608	15	0.4

* Costs are in terms of 1986 dollars and include relief piping with inlet restriction.

** Benefits include average annual flooding damage reductions estimated for spring and summer conditions for 5-year relief piping with inlet restriction.

Source: City of Winnipeg, 1986

have resulted in increased pressures to relieve flooding. Basement flooding continues to be an issue. The floods of 1993/94 resulted from rainfalls well in excessive of the design event.

4.3 THE RELIEF PROGRAM AND CSO CONTROL

Pollution control has not been a component of the City of Winnipeg's CSO relief program. Nor has sewer rehabilitation.

Several of the studies undertaken for the relief program have examined the potential for combined sewer overflow control. These have included in-line storage, with and without optimization through real-time control, sewer separation (beyond that proposed for basement flooding relief and end-of-pipe treatment) as well as non-structural/best management technology such as street cleaning, sewer flushing, catch basin cleaning, roof leader disconnection and public education.

Some of the basement flooding studies recommended alternatives which included localized sewer separation.

The basement flooding relief program and combined sewer overflow control have competing objectives. The relief program results in an increased number of outfalls to the river and may increase CSO volume (marginally). It also adds to the potential in-line storage. Combined sewer overflow control seeks to reduce a number and frequency of overflows.

Details of the CSO control aspects of the Basement Flooding Relief Program Studies are discussed in Technical Memorandum 5 - Control Alternatives.

5.0 MAIN INTERCEPTOR

From a CSO perspective, the interceptor system tributary to the NEWPCC is the most important, since 9,200 ha of the 10,500 ha of combined sewer districts are tributary to it and DWF from all of these is conveyed via the Main Interceptor. Accordingly, the Main Interceptor is the segment of infrastructure of the most significance and interest to the current study.

Preliminary hydraulic investigations of the Main Interceptor were made during the Phase 1 study to determine, if possible, the manner in which the Interceptor performed in wet weather flow (WWF) conditions. The results and the implications of these investigations are discussed below.

5.1 WET WEATHER OPERATIONS

5.1.1 System Characteristics

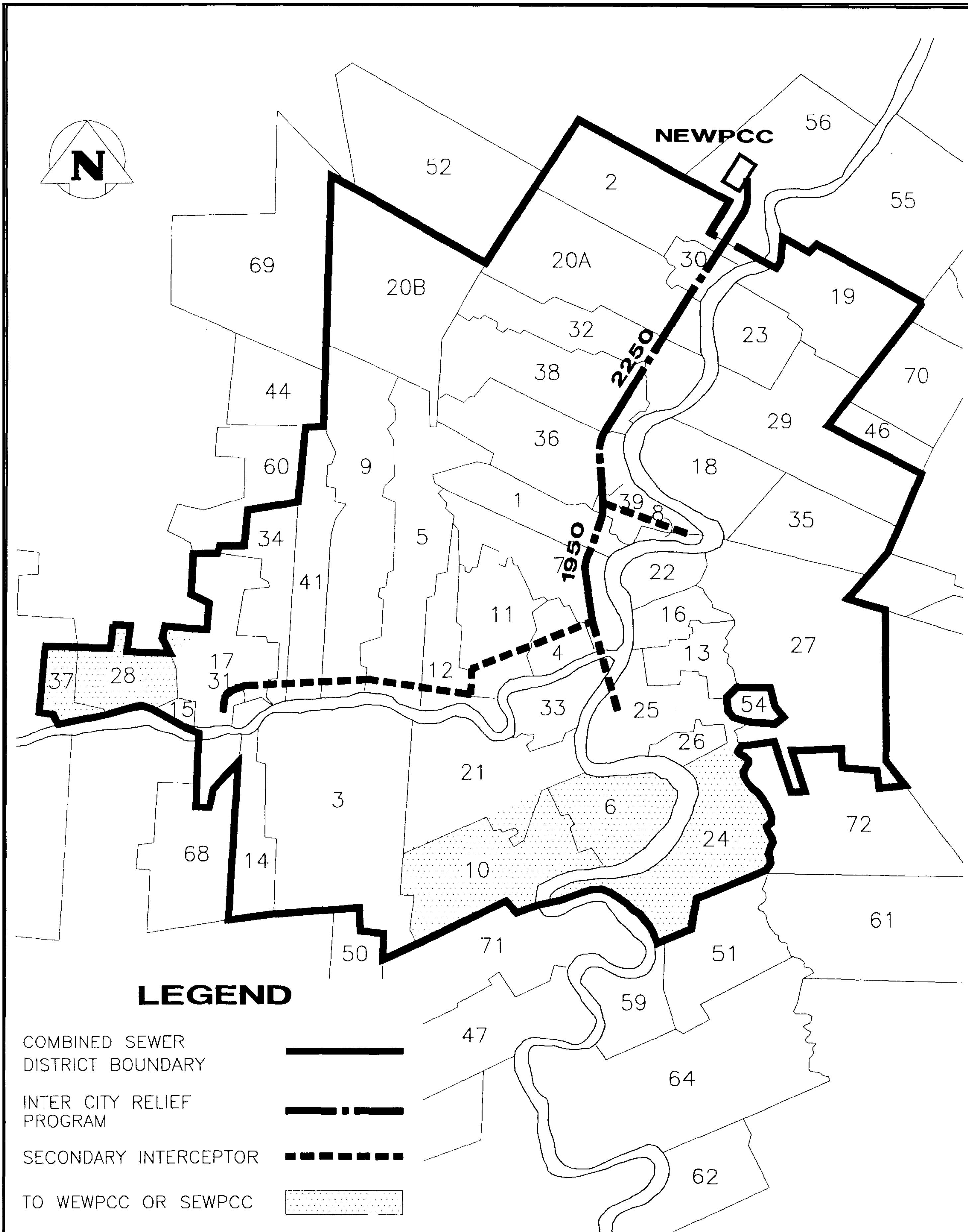
The limits of the combined sewer districts are shown on Figure 5-1. Also shown in this drawing are the main elements of the Main Interceptor and along with their size. The extent of the CSO districts which are tributary to the three plants are also indicated on the Figure.

The Main Interceptor sewer conveys DWF and WWF to the surge well at the NEWPCC. Pumping operations are controlled by level sensors. The levels in the surge well are maintained just above the obvert of the main interceptor to prevent foul air from entering the plant. As the flow increases, the number of pumps on-line also increases.

The size of the main interceptor ranges from 750 to 2250 mm in diameter.

The normal means of effecting the diversion of flows, up to 2.75 times average DWF (ADWF) from the combined sewer districts, is shown in Figure 5-2. An adjustable weir is located in the combined sewer trunk, which diverts flow through an off-take pipe, to a pumping station or a gravity connection, and thence to the interceptor. In some districts the sill of the flap or sluice gate is used as this control mechanism. Where adjustment is possible, the diversion capacity of the weirs is checked by the City of Winnipeg in winter-time and the weirs are set to divert no less than 2.75 times ADWF. Figure 5-3 is a plan of a typical connection between the combined sewer trunk and the main interceptor sewer.

At one time the flows diverted by gravity to the main interceptor were controlled by hydraulically-operated regulator gates. Some of the pumped diversions were also so controlled. In addition, many of the pumped connections had comminutors (to protect the


N
NEWPCC
56
55
52
2
20A
30
69
20B
19
32
23
2250
70
38
44
29
46
36
18
9
60
1
39
8
35
34
5
1950
7
22
41
11
16
27
17
4
13
37
28
12
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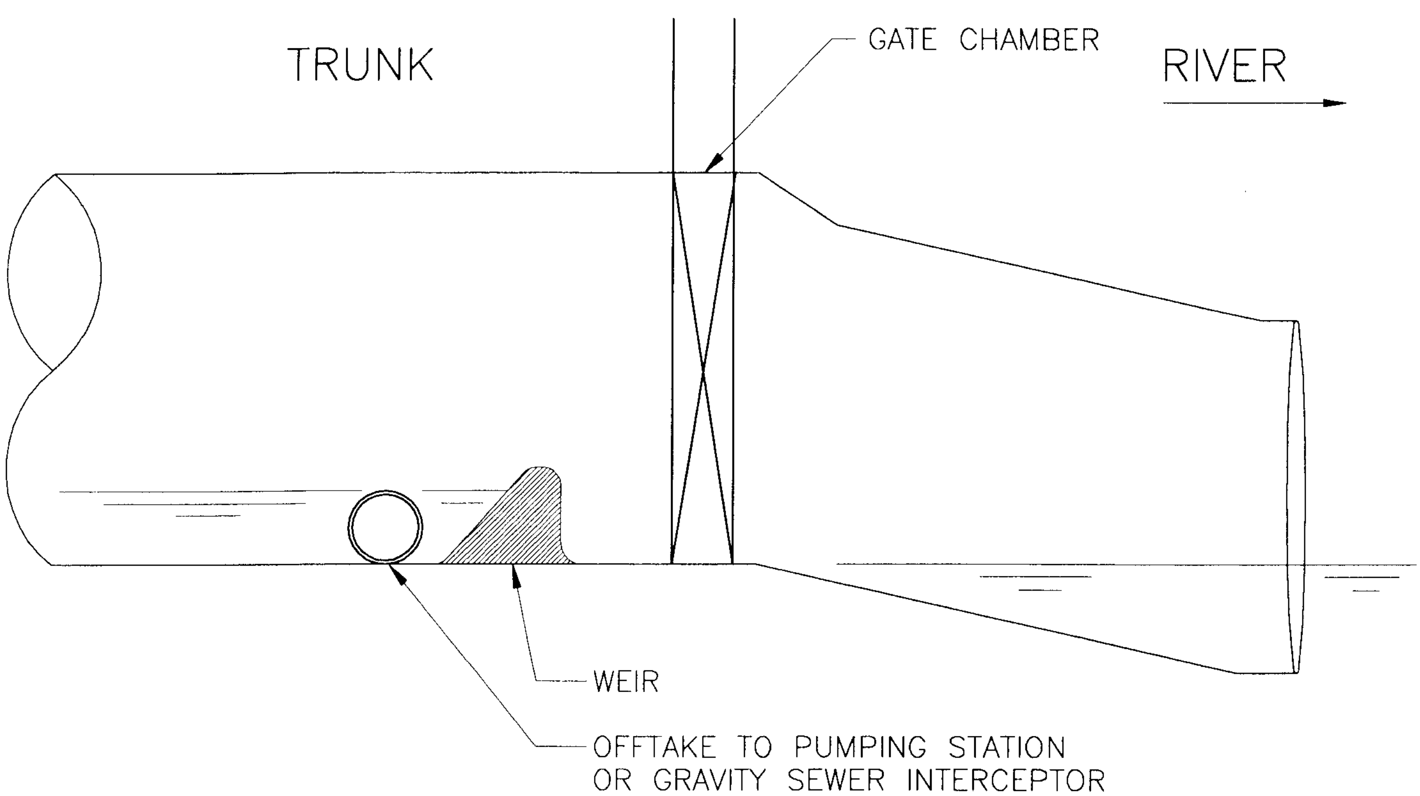
26
21
3
6
72
24
68
14
10
61
71
51
50
59
47
64
62
LEGEND
COMBINED SEWER
DISTRICT BOUNDARY
INTER CITY RELIEF
PROGRAM
SECONDARY INTERCEPTOR
TO WEWPCC OR SEWPCC

FIG. 5-1

TYPICAL WEIR DIVERSION



DIVERSION CAN BE:

- **CONCRETE WEIR**
- **SILL OF FLAP OR SLUICE GATE**

FIG. 5-2

INTERCEPTOR OVERFLOW

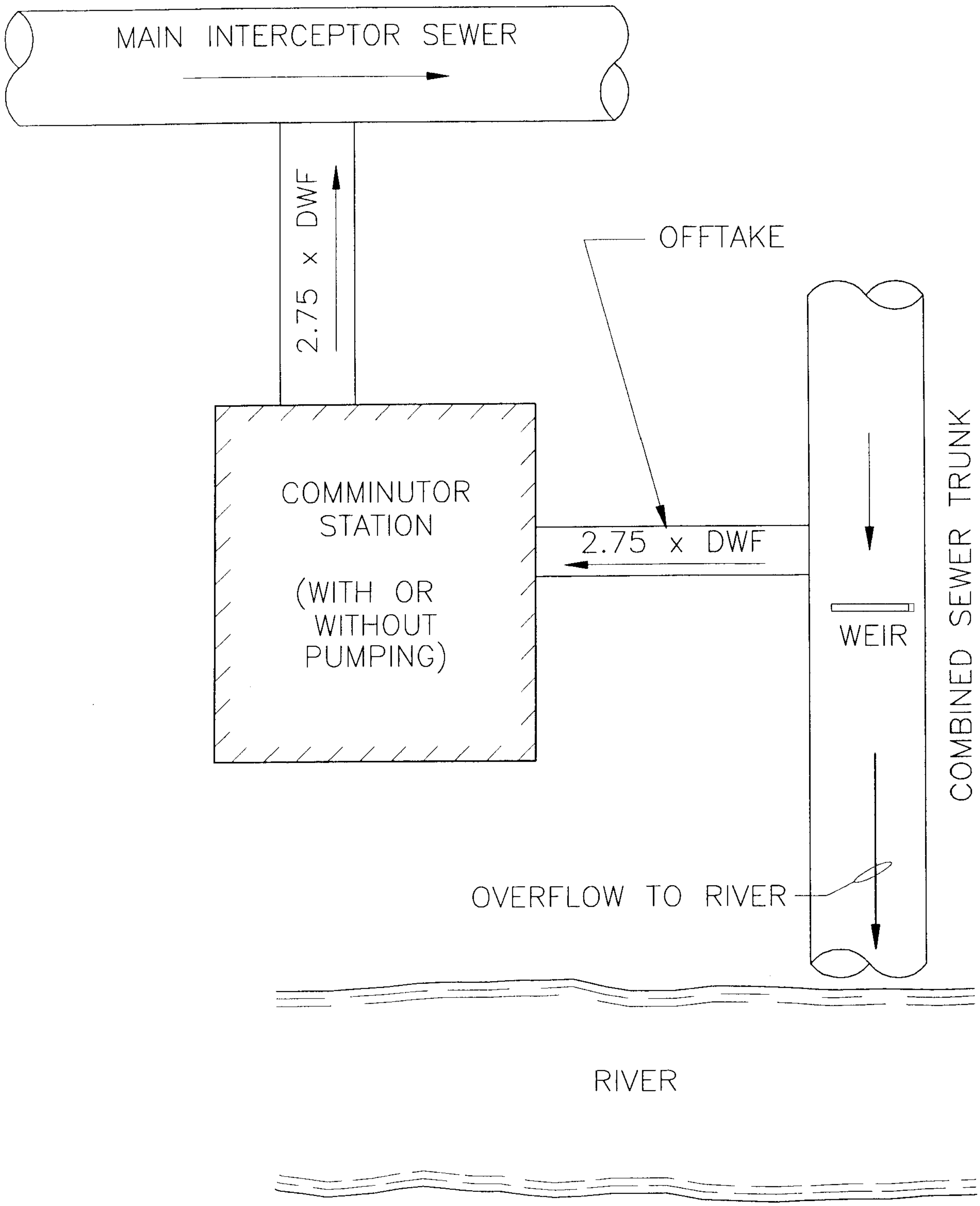


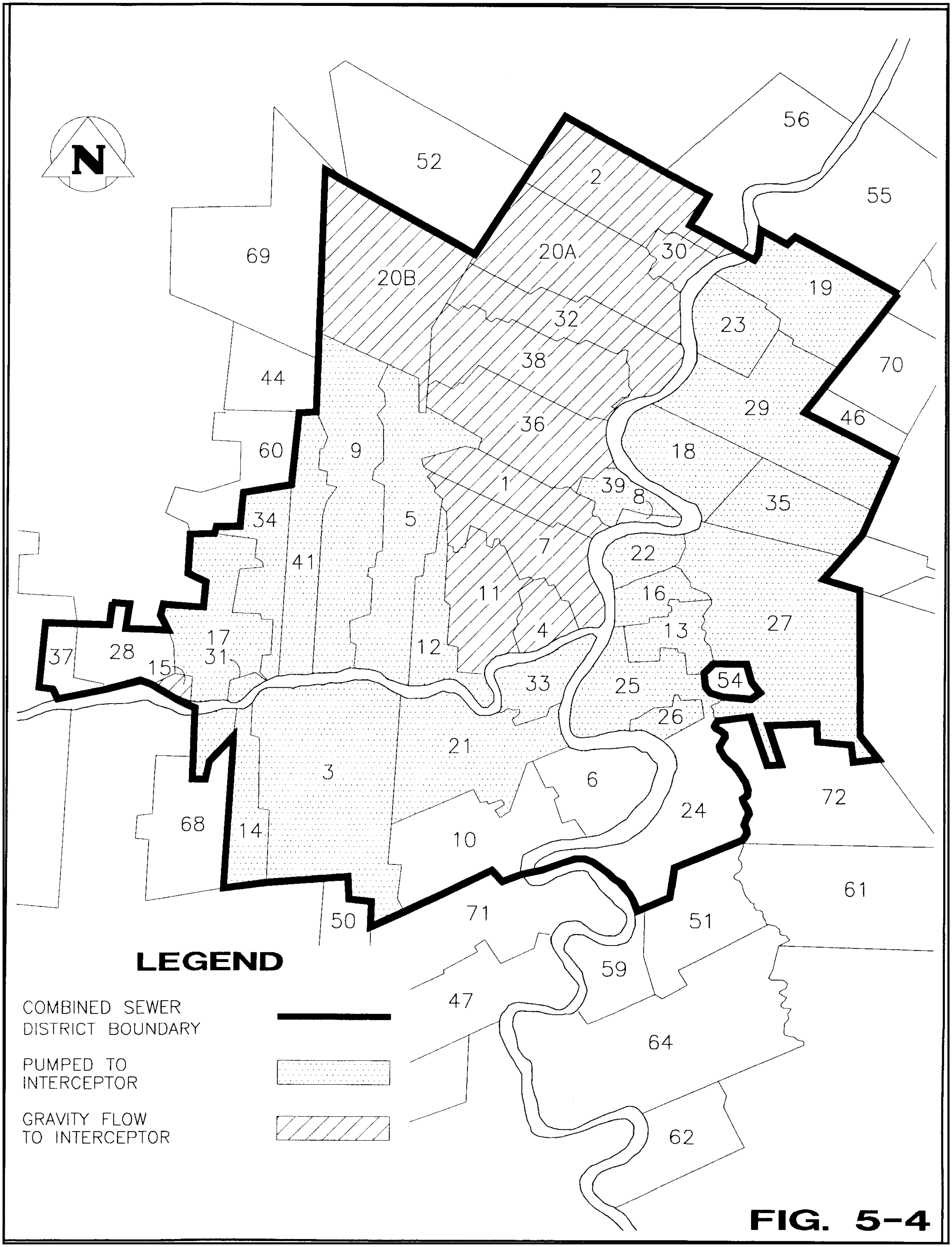
FIG. 5-3

pumps from debris) located downstream of the regulator gates and between the combined sewer trunk and the interceptor. Table 5-1 is a list of the districts which have such gates and indicates those gates which have been locked open and those gates which are functional. The gates have been abandoned because of operating difficulties and the high operating and maintenance costs. It also indicates those offtakes on which comminutors are still in place and functioning.

Of the 36 combined sewer districts connected to the Main Interceptor, 25 are pumped (as noted, generally at 2.75 times DWF). Flows from 11 of the districts are conveyed by gravity. The districts and their means of connection to the interceptor are indicated on Figure 5-4. In the case of the gravity connections, the contributions to the interceptor from each district are a function of the size of the conveyance pipe, its length and, most importantly, the inlet head. In the case of those connections with hydraulically controlled regulator gates, the setting and effectiveness of these devices will also control the flow diverted. As can be seen from Table 5-1, 4 of the 11 districts connected by gravity to the interceptor are no longer controlled by hydraulic gates. This means that the quantity of flow diverted to the interceptor is only limited by the hydraulics of the offtake piping.

So far as can be determined from the available records, there are two major overflows designed so as to relieve the interceptor in cases of extreme surcharge. These overflow points are located in the Jefferson district and the St. John's district. A sketch plan of the St. John's district interceptor overflow is provided on Figure 5-5. The 1500 mm diameter connection between the combined sewer and the "Old Comminutor Station" would act as an overflow from the Interceptor to the River in times of excessive flow in the Interceptor. However, since there is apparently no flap gate (non-return valve) on the combined sewer side of the connection, it is equally possible for combined sewer flows to discharge directly into the Interceptor when the latter is not so surcharged. The Jefferson District overflow is also 1500 mm in diameter and does have a flap gate designed to prevent combined sewage discharge into the Interceptor. We understand, however, that this flap gate cannot close (i.e., it is "frozen" in position with about a 300 mm gap). Accordingly, it also can allow the combined sewage to enter the Interceptor. Both of these overflow points will be inspected (along with all other interception points) during the proposed Phase 2 inspection program.

The implications of these conditions are discussed in Section 5.1.2.


N
52
56
55
2
20A
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69
20B
19
32
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38
70
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46
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60
9
18
1
39
8
35
34
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7
22
41
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16
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3
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72
24
68
14
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71
51
50
59
47
64
62
LEGEND
COMBINED SEWER DISTRICT BOUNDARY
PUMPED TO INTERCEPTOR
GRAVITY FLOW TO INTERCEPTOR

FIG. 5-4

TABLE 5-1

LIFT STATION HYDRAULIC GATES

DISTRICT #	DISTRICT	HYDRAULIC GATES		COMMINUTOR		G or P
		FUNCTIONING	LOCKED OPEN	YES	NO	
1	Alexander	✓			✓	G
2	Armstrong		✓		✓	G
5	Aubrey*	✓		✓		P
7	Bannatyne	✓			✓	G
10	Cockburn		✓		✓	P(?)
11	Colony		✓		✓	G
16	Dumoulin	✓			✓	P
17	Ferry Road*	✓		✓		P
19	Hawthorne*	✓		✓		P
20a	Jefferson-Main		✓		✓	G
21	Jessie	✓			✓	P
23	Linden*	✓		✓		P
26	Conway/ Moorgate	✓			✓	P
29	Munroe	✓			✓	P
30	Newton	✓			✓	G
32	Polson	✓			✓	G
34	Riverbend	✓			✓	P
36	Selkirk		✓		✓	G
38	St. Johns	✓			✓	G
41	Tylehurst*	✓		✓		P

* Comminutors are operating in these stations.

There are no other hydraulic gates in the system.

ST. JOHN'S DISTRICT INTERCEPTOR OVERFLOW

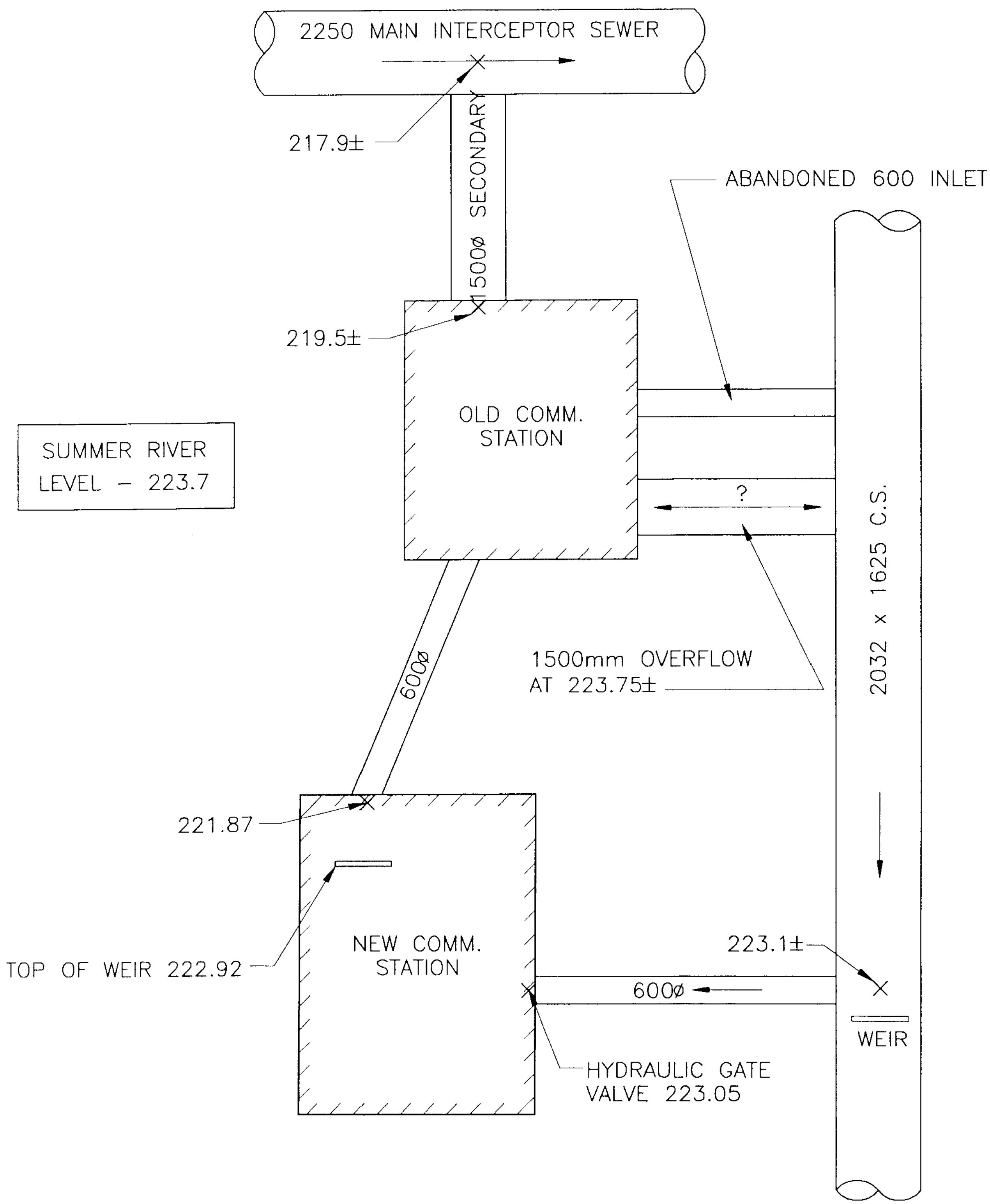


FIG. 5-5

A profile of the Main Interceptor from the NEWPCC to the end of the 1950 mm diameter section is shown on Figure 5-6.

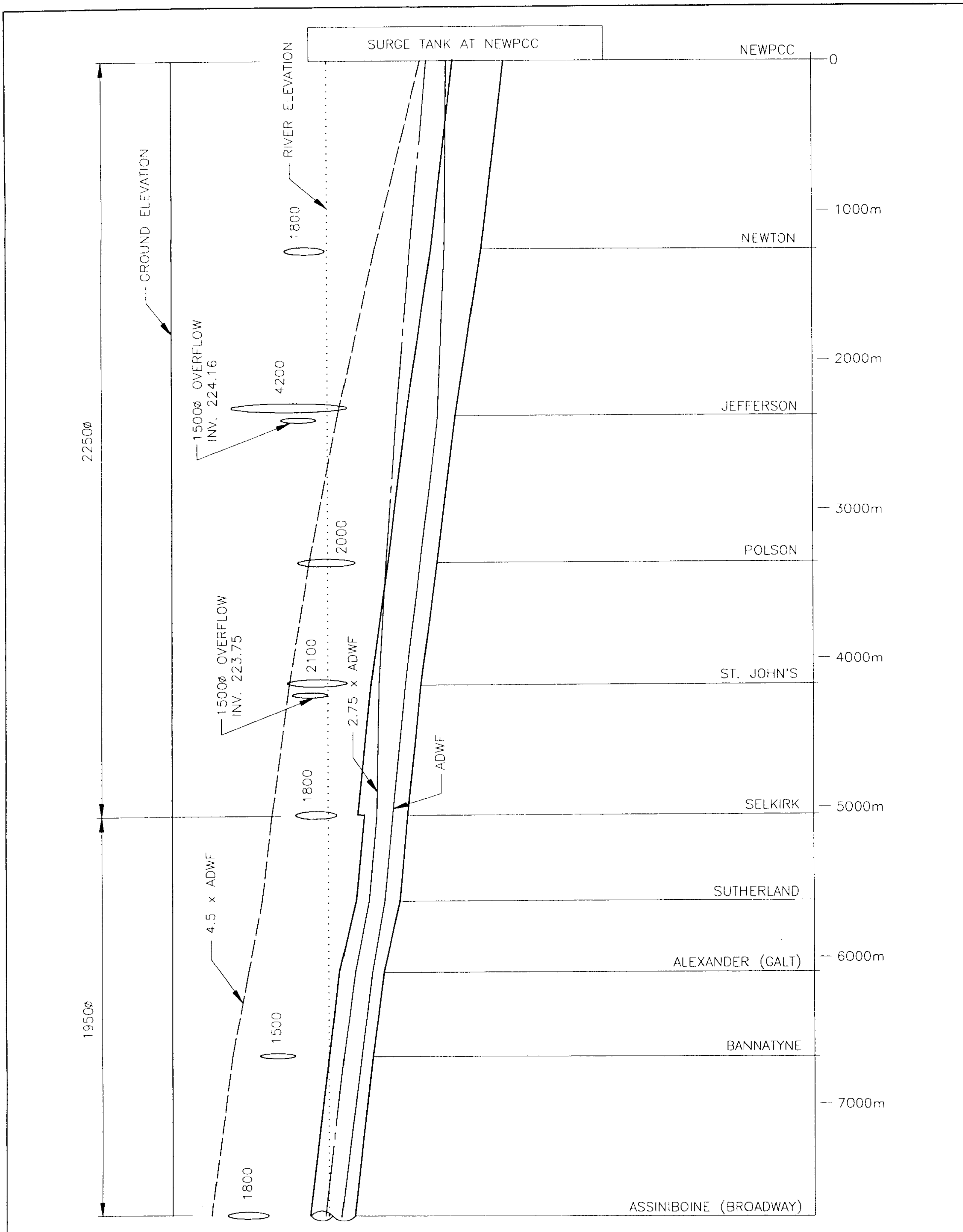
5.1.2 Wet Weather Flow Operation

An attempt was made to determine the manner in which the main segment (that is 1950 mm and 2250 mm diameter) of the Interceptor functioned under WWF conditions. As noted above, during normal summer conditions, the pumps at the NEWPCC are operated so that the crown of the interceptor discharging into the surge well is submerged. Figure 5-6 indicates the manner in which the Interceptor operates under conditions where it is receiving 2.75 times ADWF from its tributary combined sewer districts and ignoring the contribution from the Northwest and Northeast Interceptors. As can be seen, the hydraulic gradeline for this condition presents no hydraulic problem to the operation of the Interceptor or its connections to the combined sewer trunks.

The system was also analyzed at 4.5 times ADWF (760 megalitres per day) to determine how it would react in that situation. At this rate of flow to the North End plant, four and/or five pumps would operate. This condition occurs at the plant on occasion, during WWF conditions. It is recognized that flows would, in part, originate from the NE and NW Interceptor but this flow rate was tested since it could represent an extreme condition in the Main Interceptor.

As can be seen from the hydraulic gradeline, at 4.5 times ADWF in the Interceptor, the 1500 mm diameter connection at St. John's could act as an overflow (assuming that such capacity were to be available in the combined sewer). The overflow at Jefferson however would not be activated under these conditions, due to its higher elevation.

The diagram also indicates that, depending on conditions of flow in the St. John's trunk, it is equally possible that flows from the St. John's combined sewer trunk could discharge into the interceptor at flows less than 4.5 times ADWF. In this situation, the Main Interceptor could be receiving massive WWF inflow from this district under present conditions. The manner in which the Interceptor functions hydraulically is further complicated by the fact that the offtakes from Armstrong, Jefferson, Selkirk and Colony are no longer regulated. Thus,



SURGE TANK AT NEWPCC
NEWPCC
0
RIVER ELEVATION
GROUND ELEVATION
1000m
NEWTON
1800
2000m
1500ø OVERFLOW
INV. 224.16
4200
JEFFERSON
2250ø
3000m
2000
POLSON
1500ø OVERFLOW
INV. 223.75
2100
2.75 x ADWF
4000m
ST. JOHN'S
ADWF
1800
SELKIRK
5000m
4.5 x ADWF
SUTHERLAND
ALEXANDER (GALT)
6000m
1950ø
1500
BANNATYNE
7000m
1800
ASSINIBOINE (BROADWAY)

FIG. 5-6

since they are gravity connections, the amount of flow diverted to the Interceptor is controlled by the hydrostatic head imposed on the off-take piping, by the head in the combined trunk sewer, in combination with the hydraulic losses in the offtake system.

The above assessment is very rudimentary but it does indicate that the way in which the Main Interceptor operates in wet weather is very complex. In addition, insufficient information is available to determine the manner in which the entire system functions during WWF. We are aware that pumped flows are in the order of 2.75 x DWF on average, however, there are a number of gravity connections (some major) whose flows are completely unknown.

The only way in which the Interceptor WWF operation will be determined will be through coarse hydraulic modelling and flow monitoring of the complete NEWPCC Interceptor system (including plant WWF pumping operations).

6.0 MONITORING

The City of Winnipeg has assembled a broad range of monitoring data on rainfall, sewer levels and wastewater quality. Rainfall monitoring is discussed in detail in Technical Memorandum 1 - Problem Definition. Sewer levels and CSO quality are discussed in this section.

6.1 SEWER LEVEL MONITORING

Sewer level monitoring has historically been carried out in two separate seasons. Winter monitoring is used to calculate average dry weather flow for use in sizing pumping station facilities and for setting weir elevations. This is typically done immediately upstream of the diversion weir, with the aid of a calibrated weir to gauge flows more accurately. This information is then compiled into a sewer gauging record for the district.

Summer sewer level monitoring has historically been carried out on a district basis, in conjunction with hydraulic basement flood relief studies. The level monitors are temporarily installed in several locations in the district's trunk system prior to the start of the engineering analysis. This data is used for model calibration for the district combined sewer relief studies.

The monitoring is carried out with Manning dipper type recorders. The City has approximately 30 of the recorders which are usually split among three districts per season. The recorders generally measure depth of flow, however some of the meters (7) can be converted to measure flow directly. The data provided by the recorders is often unreliable and can involve considerable effort to evaluate its applicability (IDE 1993[4]).

The combined sewers are, in most cases, in the centre of the right-of-way and under existing pavement. The recorders are placed in the sewer manholes as close as possible to the cover. This is done to facilitate maintenance and protect the unit from excessive surcharge. However this in turn may result in operational problems due to vibration from heavy traffic. In addition, there are the inherent problems related to instrumentation in sewer environments.

6.2 INTERCEPTOR SEWER

There is no available information on flow rates or water levels in any of the Interceptor tributaries to the NEWPCC. This information is vital to an assessment of operating conditions in the Main Interceptor.

6.3 NEWPCC PUMPING

Long-term records of flow pumped through the NEWPCC were restricted to daily totalized flows. Neither surge well levels nor actual pumping rates were recorded permanently. Such information is vital to analyzing the operating conditions in the Interceptor sewers and most particularly the Main Interceptor, which is the main element in the conveyance of combined sewage flows to the NEWPCC.

6.4 QUALITY MONITORING

The quality monitoring program has also been carried out for combined sewer overflows in conjunction with the basement flood relief program. The monitoring consists of a flow recorder that senses overflows and triggers the sampler. The sampling is done from the bottom end of the system, immediately downstream of the diversion weir. Details of the nature of the program and the extent of the data collected are discussed in the Technical Memorandum on Problem Definition.

6.5 INFORMATION GAPS

After review and synthesis of the considerable volume of infrastructure information, it was determined that some additional information was required to fill in the gaps. This was most notable in three areas, namely:

- NEWPCC pumping records;
- district interception rates; and
- interceptor hydraulics.

The levels in the surge tank at the plant govern the pumping protocol. This information would provide valuable end-of-pipe flow in the NEWPCC Interceptor system that could be used for understanding the operation of the Main Interceptor and in model calibration. While this information was monitored, it was not recorded. The City has recently begun recording both the surge tank levels and system pumping rates at 10 minute intervals.

The nominal district interception rate is 2.75 times dry weather flow. However, the interception rate can vary from district to district. In the case of the gravity flow diversions, the rate is dependent on the head imposed on the offtake piping and the hydraulic losses in the offtake system. This can be modelled once the piping configurations are clearly defined. In the districts that pump the wastewater to the interceptor the controlling factor can be the diversion hydraulics, or the pumping capacity. Pumping capacity at all pumped diversions will be reviewed. This will comprise a review of pump curves or actual drawdown tests.

The interceptor hydraulics were discussed above and, as indicated, are currently largely unknown. This is due in part to:

- the potentially large variation in interception rates for the various districts, especially the gravity flow connections without regulators;

- the potential for a major diversion of combined sewer flows directly to the Main Interceptor from "overflow" connections to the St. John's and the Jefferson combined sewer trunks;
- the lack of records on the manner in which the NEWPCC pumping (surge well and pumping rates) operates in WWF conditions (this is being rectified);
- the interceptor system proper is complex in that all three interceptors contribute flows to the NEWPCC.

A detailed field inspection is needed to accurately assess the interception configuration and thus the hydraulics. Such an inspection program is proposed for Phase 2. This inspection will include an assessment of the performance of the regulator valves that control flow from the combined sewer to the Interceptor.

In accordance with all of the foregoing a number of activities need to be initiated:

- an inspection of the dry weather flow interception chambers, comminutor stations, overflow chambers, pumping stations, diversions and combined sewer outfalls, to provide sufficient information to determine current system operations and to permit modelling their performance, vis-a-vis diversions to the Interceptor;
- development of a coarse interceptor method in order to, eventually, model the Interceptor operation and, initially, to define locations for depths (and velocity) monitoring of all three NEWPCC interceptors;
- gather the information on the NEWPCC raw sewage pump WWF operations.

7.0 PRIORITY FIELD INSPECTIONS

7.1 OVERVIEW

The field inspections will focus on the combined sewer diversions to the interceptor sewer. The program will identify the flow path from the combined sewers to the interceptor (where they are conveyed to the treatment plant). The DWF and WWF are diverted from the sewer by a weir and offtake pipe arrangement (see Figure 5-2). The diverted flows are either conveyed by gravity sewer or pumped to the interceptor.

The requirement for the program is to ultimately provide the following information:

- determine hydraulic path from CS to interceptor;
- determine pumping station capacity;
- assess conditions that would affect hydraulics;
- determine potential monitoring sites;
- supply missing or confirm questionable information.

The inspections will cover the combined trunk sewers at the weir diversions, the various chambers, pumping stations and the interceptor sewer.

The combined sewer inspection will focus on the area immediately adjacent to the weir diversion. The inspection will note:

- invert depth of sewer;
- depth of sediment accumulation;
- structural condition of trunk, weir and offtake piping;
- weir type, height, location, freeboard, and any evidence of dry weather overflow;
- offtake piping location with respect to weir and CS invert.

The various chambers consist of comminutor, regulator and overflow chambers. In these structures we will review and record information relating to hydraulic and structural components. The review will include a comparison to the original drawing, whether gates exist or still function and any critical measurements.

The review of the pumping stations will include:

- an assessment of structural condition;
- pump and impeller inventory;
- reference to drawing dimensions;
- float control settings and type;
- valving;

- alarm type;
- wet well condition, i.e., amount of sedimentation;
- drawdown and pressure tests may be conducted at a later date, if necessary.

The final inspections will cover spot checks of the interceptor sewer. The inspections will:

- note flow depth and velocity;
- confirm pipe sizes;
- assess sediment build-up;
- review for potential flow monitoring sites;
- assess structural conditions;

The information gathered during the priority field inspections will be used to:

- identify districts with dry weather overflow potential;
- assess interception rates;
- identify potential flow monitoring sites;
- select the appropriate monitoring technology in view of the field conditions;
- prepare a preliminary condition report;
- gain an understanding of the hydraulic performance relationships for use in the Interceptor Model in Phase 2.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

1. The operation of the NEWPCC interceptor system during WWF is very complex. There is currently insufficient information to determine how the Main Interceptor functions during WWF events.

2. More information is needed on the details of the Interceptor chambers and their ancillaries (e.g., regulators, weirs) in order to be able to model the NEWPCC Interceptor system.

3. Flow monitoring of the NEWPCC Interceptor system is needed to be able to model the NEWPCC Interceptor system under WWF conditions.

4. The actual WWF diversion rate is uncertain. The "design" 2.75 times ADWF is probably a reasonable condition where the flows are pumped or are by gravity with a regulator. This is certainly not the case for gravity connections without regulators and for the two main "overflows".

8.2 RECOMMENDATIONS

1. More information is needed about the NEWPCC Interceptor System. To this end, the following actions are currently being initiated:

   a) The City of Winnipeg has begun to record the operations of the surge well (operating levels) and the pumping rate at the NEWPCC. This data will be recorded at 10 minute intervals and will be stored electronically.

   b) The Study Team, in conjunction with the City, have commenced inspections of all the CSO interceptor chambers.

2. A coarse interceptor model is needed to define locations for depth and flow monitoring of the NEWPCC Interceptor system and, eventually, to model the Interceptor operation.