MUNICIPAL & COMMUNITY AFFAIRS

SEWAGE DISPOSAL IMPROVEMENTS
DESIGN AND OPERATIONS CONCEPT
CHESTERFIELD INLET, N.W.T.

M.M. DILLON LIMITED
CONSULTING ENGINEERS,
PLANNERS, AND ENVIRONMENTAL
SCIENTISTS

93-1477-01
May 1994

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Our File: 93-1477-01

May 24, 1994

Municipal and Community Affairs
Government of Northwest Territories
Rankin Inlet, N.W.T.
X0C 0G0

Attention: Don Forsyth

Sewage Disposal Improvements
Design and Operations Concept
Chesterfield Inlet, N.W.T.

Dear Mr. Forsyth;

Enclosed please find seven (7) copies of the final report for the above project. By copy of this letter, we have sent one copy directly to Mr. Al Shevkenek.

This report incorporates the comments we recieved from the review of the draft submission; trust you will find this report acceptable.

Yours truly,

M.M. DILLON LIMITED

Gary Strong, P.Eng.
Project Manager

GS:vw
Encls.
cc: Al Shevkenek

M.M. DILLON LIMITED — SUITE 201, 5102 - 51 STREET
YELLOWKNIFE, N.W.T. X1A 1S7

TELEPHONE (403) 920-4555
FAX (403) 873-3328

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1.0 INTRODUCTION

1.1 General

The Department of Public Works was retained in 1989 by the Department of Municipal and Community Affairs (MACA) to complete a Design and Operation Report for a new sewage and solid waste facility in Chesterfield Inlet, N.W.T. The report was completed in December 1989; however, construction of the facilities was deferred to 1992. The access road has been under construction since 1992. This report formed the basis for an application to obtain the Hamlet's first water licence from the Northwest Territories Water Board. The concepts developed in the 1989 report are as follows:

- Upgrade and widen approximately 160 m of road to the existing facility.
- Cap the existing bulky waste pits and develop new landfill trenches near the existing facility.
- Develop an annual storage sewage lagoon by constructing a berm between two rock ridges at the existing sewage disposal area. Discharge of the lagoon is to occur in September of each year.

During 1993, implementation of the above commenced with the construction of the road upgrading. The recommendation for the construction of a sewage lagoon was not adopted by Municipal and Community Affairs (MACA). In August 1993, M.M. Dillon was retained by MACA to develop the Design and Operation Concept for Sewage Treatment, based on a wetlands system.

The scope and objectives of this report are:

- To review the current literature and develop the design parameters for wetlands treatment at the proposed location.
- Develop the site design concepts for the selected treatment option.
- Develop the operational requirements for the treatment facility.

1.2 Terms of Reference

The "General Terms of Reference for a Community Water and Sanitation Services Study" are to be used for this project. Specific items for this study include:

- Complete a document collection and review to identify and develop design parameters for the sewage disposal facility. This will include:
  - Population projections to the 20 year design horizon.
  - Projected sewage generation volumes based on MACA Guidelines, and on Hamlet records of historic disposal volumes.
  - General geology and geophysical characteristics of the proposed site.
  - Provide recommendations on the sewage disposal method to be constructed in Chesterfield Inlet.

The above information will be provided at the conceptual level with sufficient detail provided for the Department of Public Works to complete design details, and prepare tenders to solicit construction bids, with minimal external involvement. It is not intended that details and plans provided in this report will be sufficient for contract tendering purposes.

Effluent testing is to be completed by the Department of Municipal and Community Affairs.

2.0 COMMUNITY INFORMATION

2.1 Location and Regional Setting

The Community of Chesterfield Inlet is located along the west shore of Hudson Bay at the northern end of Spurrel Harbour. The geographical setting is approximately latitude 63° 20'N, longitude 90° 42'W. Chesterfield Inlet is in the Keewatin Region with the Regional Administration Offices located in Rankin Inlet, approximately 10 kilometres to the southwest.

2.2 Geology and Terrain

Chesterfield Inlet is situated in the Canadian shield. The area around the settlement consists of rock ridges and many scattered lakes. The bedrock is Precambrian granite and gneiss.

The region is in tundra and thus devoid of trees. Development has evolved around the areas of rock outcrops, small pond areas, and along the shoreline.

The surface material within the developed area consists of sand gravelly beach deposits with scattered boulders, section of muskeg, and bare rock.

Chesterfield Inlet is also located in a defined continuous permafrost zone. Thawing of the active layer in summer creates unstable surface and subsurface conditions. The depth of the active layer ranges from 0 to 1 metres and is dependent on subsurface composition. The area south of Police and Dog Lakes consists of alluvial till deposits which provides the subsurface medium to drain these lakes.

The terrain upon which the Community is situated slopes toward Spurrel Harbour. The average slope ranges from two to four percent (2-4%).

2.3 Climate

In January, the mean high temperature is -27.8°C. The mean low temperature for the same month is -35.2°C. In July the mean high temperature is +13.1°C and the low is +4.6°C.

The annual average wind velocities are 22.3 km/hr northwest. The average annual precipitation for the Community is 146 mm rainfall and 1,125 mm snowfall for a total of 259 mm water equivalent precipitation.

2.4 Population

Population projections are based on the "Population Counts and Population Projects" completed and published by the Northwest Territories Bureau of Statistics. The 1986 census indicated a population of 294 people and the 1991 census had 316 people. The Northwest Territories Bureau of Statistics projects the following increases:

		Annual Growth Rate
1991	316	
1996	374	3.43%
2001	420	2.35%
2006	474	2.45%

Based on the growth rate of 2.45%, we have extrapolated the population to the year 2015. The extrapolation and the population for interim years is shown in **Table 2.1**.

TABLE 2.1

POPULATION PROJECTIONS

YEAR		GROWTH RATE	POPULATION
1991		3.43%	316
1992			327
1993			338
1994			350
1995	Year 0	3.43%	362
1996		2.35%	374
1997			383
1998			392
1999			401
2000		2.35%	410
2001		2.45%	420
2002			430
2003			440
2004			451
2005	Year 10	2.45%	462
2006		2.45%	474
2007			486
2008			498
2009			510
2010			522
2011			535
2012			548
2013			561
2014			575
2015	Year 20	2.45%	589

These figures are illustrated in **Figure 4.1**.

3.0 EXISTING SEWAGE DISPOSAL AND WASTE MANAGEMENT PRACTICES

3.1 General

The economy of Chesterfield Inlet is primarily based on hunting, trapping and fishing in the surrounding areas. There is also a commercial based economy with retail sales, petroleum products, transportation and sales, and seasonal construction works. As a result, the Community is primarily residential in nature with minimal commercial activity and no heavy industrial activity. The sewage generation is, therefore, mainly domestic.

The majority of households have sewage holding tanks. A sewage collection truck hauls the raw sewage to the existing disposal facility approximately 2.5 kilometres from the Community.

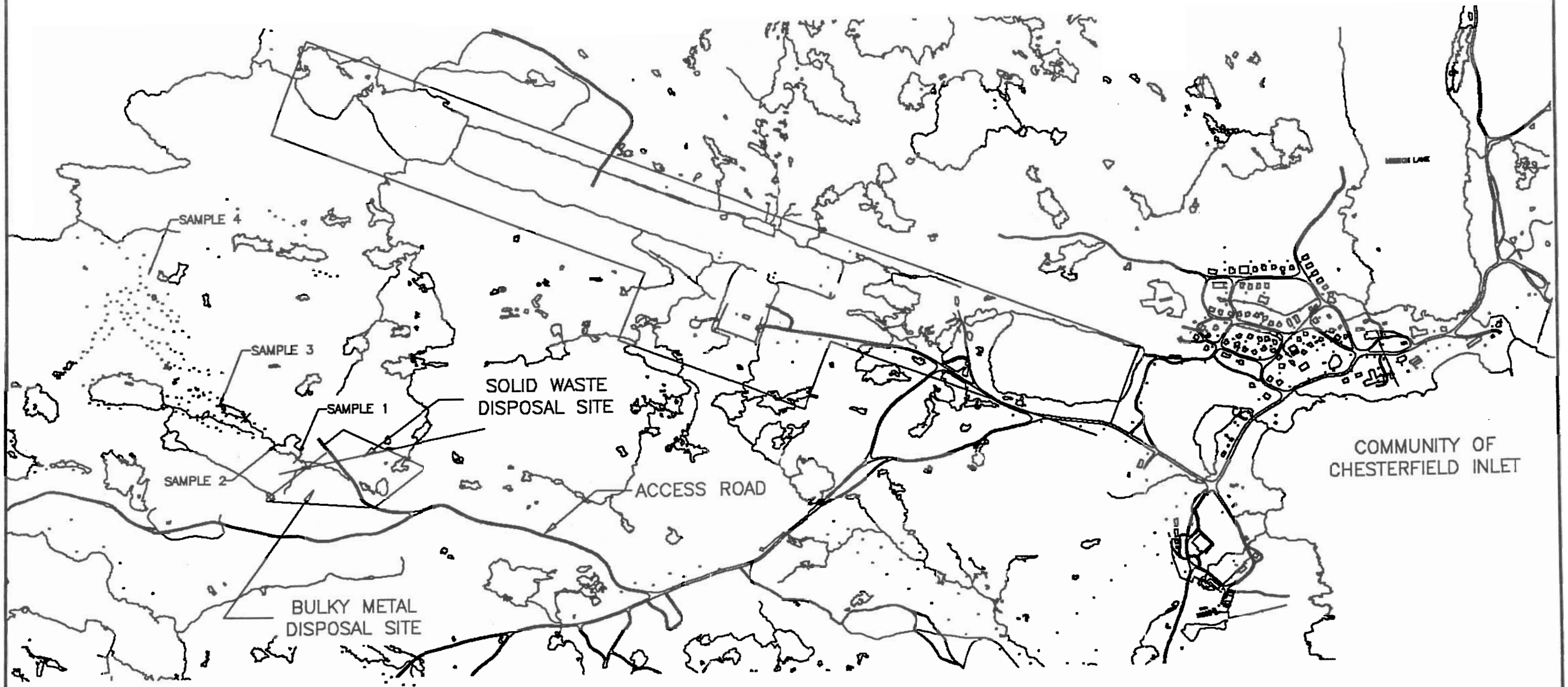
In 1992 it was reported that 13 of the 73 residences had bagged sewage disposal. The bagged sewage is collected and hauled to the solid waste disposal facility. The use of honeybags is expected to be phased out in the next five years, according to information received from MACA.

3.2 Existing Disposal Site

The existing sewage disposal area is located 2.5 kilometres west of the Community and 1.0 kilometre south of the airstrip. The sewage disposal facility is adjacent to the solid waste facility. **Figure 3.1** illustrates the existing roadway, solid waste and bulky metal disposal areas, and sewage discharge area in relation to the Community.

The sewage is currently discharged from the truck onto the side of the roadway. There is no discharge flume present. The sewage flows overland to a pond of approximately 2,400 m^2 in size ("P1"). The outlet of the pond flows through a series of wetland area for a distance of 900 m to discharge into Finger Bay.

During the site inspection in September 1993, it was noted the work was under way to develop a new access road and new solid waste facility. The discharge location of the sewage trucks is located adjacent to the access road. A small turnaround pad has been developed for the sewage trucks. It was reported that the sewage trucks have difficulty maneuvering in the winter and occasionally discharge the sewage directly on the truck access due to snow and icing problems on the truck pad.



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TITLE	COMMUNITY SITE PLAN
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DATE	JAN 94

Effluent samples were collected by Mr. Don Forsyth of MACA. The results of the samples taken during the site inspection and of previous samples, are shown in **Table 3.1**. The locations for the sample collections are illustrated in Figure 3.1.

As shown in Table 3.1, after passing through the wetlands area, the effluent contaminant levels appear to be within acceptable limits (sample station No.4). This station is located approximately halfway between the inlet to the wetlands area, and the discharge point in Finger Bay. Therefore, it appears that the area is capable of providing adequate treatment within the scope of a wetlands treatment system.

It should be noted that the BOD_5 concentration at sample locations No.1 & 2 are lower than would generally be expected, given the sampling location (primary settling pond). These results can be attributed to the following:

- The overland flow regime provides some measure of settling/biological treatment, as sewage makes its way from the existing dumping location (road) to the settling pond. The mechanism of overland flow, coupled with nutrient uptake by any plant life on the slope, would tend to decrease all contaminant levels, particularly BOD_5 and SS.

- Samples were collected during late August and September nearing the end of summer. The summer period with extended periods of daylight tend to reduce BOD_5 concentrations through the active biological process which is generally enhanced in summer in northern communities, where sunlight can be present twenty-three (23) hours per day.

- Samples were typically collected from the surface of the pond. Undissolved BOD_5 and SS are removed rapidly through settling, and reduced through microbial digestion in oxygenated (aerobic) zones. It would, therefore, be expected that the surface waters of a settling pond exposed to re-aeration by wind, would be lower in total BOD_5 concentrations.

TABLE 3.1

EFFLUENT SAMPLE RESULTS

	Sampled August 25/93				Sampled September 9/93				Guideline
Parameter	**#1**	**#2**	**#3**	**#4**	**#1**	**#2**	**#3**	**#4**	
pH	8.06	8.1	7.82	7.55	7.58	7.40	7.57	7.45	6.5-9.0 *
Fecal Coliforms (CFU/dl)	21,000	110,000	230	0	41,000	46,000	150	0	100,000 **
Biological Oxygen Demand (mg/l)	7.0	8.0	<5	<5	8.0	14.0	<5	<5	100 **
Ammonia (mg/l)	12	12.5	6.76	<0.02	20.2	20.2	8.30	<0.02	2.0 *
Total Kjeldahl Nitrogen (mg/l)					22.5	28.0	9.87	<0.20	2.2 *
Oil and Grease (mg/l)								<10	<5 **

* Canadian Water Quality Guidelines for Freshwater Aquatic Life (CCME, 1987)

** Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories (1992).

4.0 SEWAGE GENERATION

Sewage generation in a trucked water supply and trucked sewage collection system is generally equivalent to the water consumption for that Community. Based on the Government of the Northwest Territories Guidelines, water consumption and, therefore, sewage generation can be estimated by the following:

Residential per capita water consumption = 90 lcd.

Commercial component of water consumption is accounted for by factoring the residential rate as shown in the following formula.

Annual sewage volume = Population x 90 x (1 + 0.00023 x population) x 365 = l/year.

Guidelines for the calculation of waste generation from bagged sewage is 0.0014 m^3/c.d. Based on the reported thirteen (13) houses using bagged sewage, and estimating four (4) people per household, the total volume of bagged sewage in 1993 will be:

$$13 \times 4 \times 0.0014 \times 365 = 26.6\ m^3/year$$

For projecting the sewage generation over the 20-year design horizon, MACA Guidelines recommend assuming that the bagged sewage systems will be phased out over the next five (5) years.

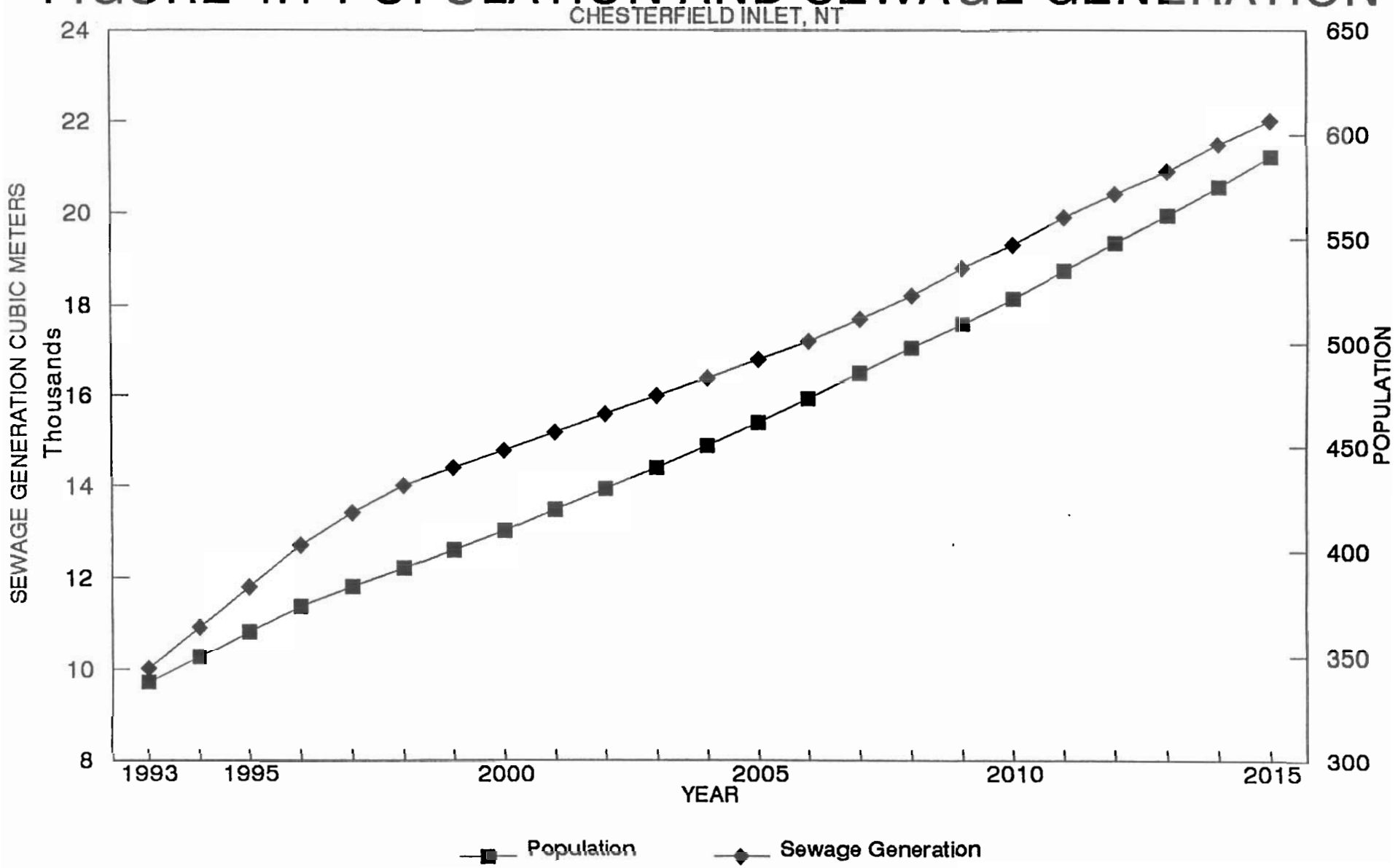
Table 4.1 illustrates the sewage generation volumes for the design horizon, and **Figure 4.1** graphically illustrates these volumes.

TABLE 4.1

SEWAGE GENERATION VOLUMES

	Total Population	Annual Bagged Sewage Volume (m^3)	Annual Trucked Sewage Volume (m^3	Annual Total Sewage Volume (m^3)
1993	338	26.6	10,003	10,040
1994	350	21.4	10,900	10,920
1995	362	14.3	11,800	11,800
1996	374	8.2	12,700	12,700
1997	383	4.1	13,400	13,400
1998	392	0	14,000	14,000
1999	401	0	14,400	14,400
2000	410	0	14,800	14,800
2001	420	0	15,700	15,200
2002	430	0	15,600	15,600
2003	440	0	16,000	16,000
2004	451	0	16,400	16,400
2005	462	0	16,800	16,800
2006	474	0	17,200	17,200
2007	486	0	17,700	17,700
2008	498	0	18,200	18,200
2009	510	0	18,800	18,800
2010	522	0	19,300	19,300
2011	535	0	19,900	19,900
2012	548	0	20,400	20,400
2013	561	0	20,900	20,900
2014	575	0	21,500	21,500
2015	589	0	22,000	22,000

FIGURE 4.1 POPULATION AND SEWAGE GENERATION



5.0 PROPOSED SITE

5.1 Background

The existing facility has been in use for a number of years. A report entitled "Chesterfield Inlet Predesign Study Water, Sewer and Solid Waste" by I.D. Engineering completed in 1982, recommended the use of this area. The site is used for the disposal of solid waste and sewage waste.

In 1992 the Department of Public Works completed a Design and Operations Report for improvements to this facility.

In October of 1992, the access road to the existing landfill was upgraded by widening 160 metres of road to a 10 metre width. Additional roadway improvements were identified in 1992, which include the extension of the road by approximately 400 metres. The new road accesses both the landfill and sewage disposal areas.

The Department of Public Works Report recommended the construction of a sewage lagoon. The lagoon design required hydraulic retention of all sewage throughout the freezing season. The discharge of the lagoon was to be exfiltrated through the berms, augmented by pumping or siphoning if necessary on an annual basis. A truck turnaround and sewage discharge flume were to be constructed.

MACA did not implement the recommendation for the lagoon construction. The intent is to investigate the use of wetlands treatment for sewage disposal, and to construct an engineered wetlands facility.

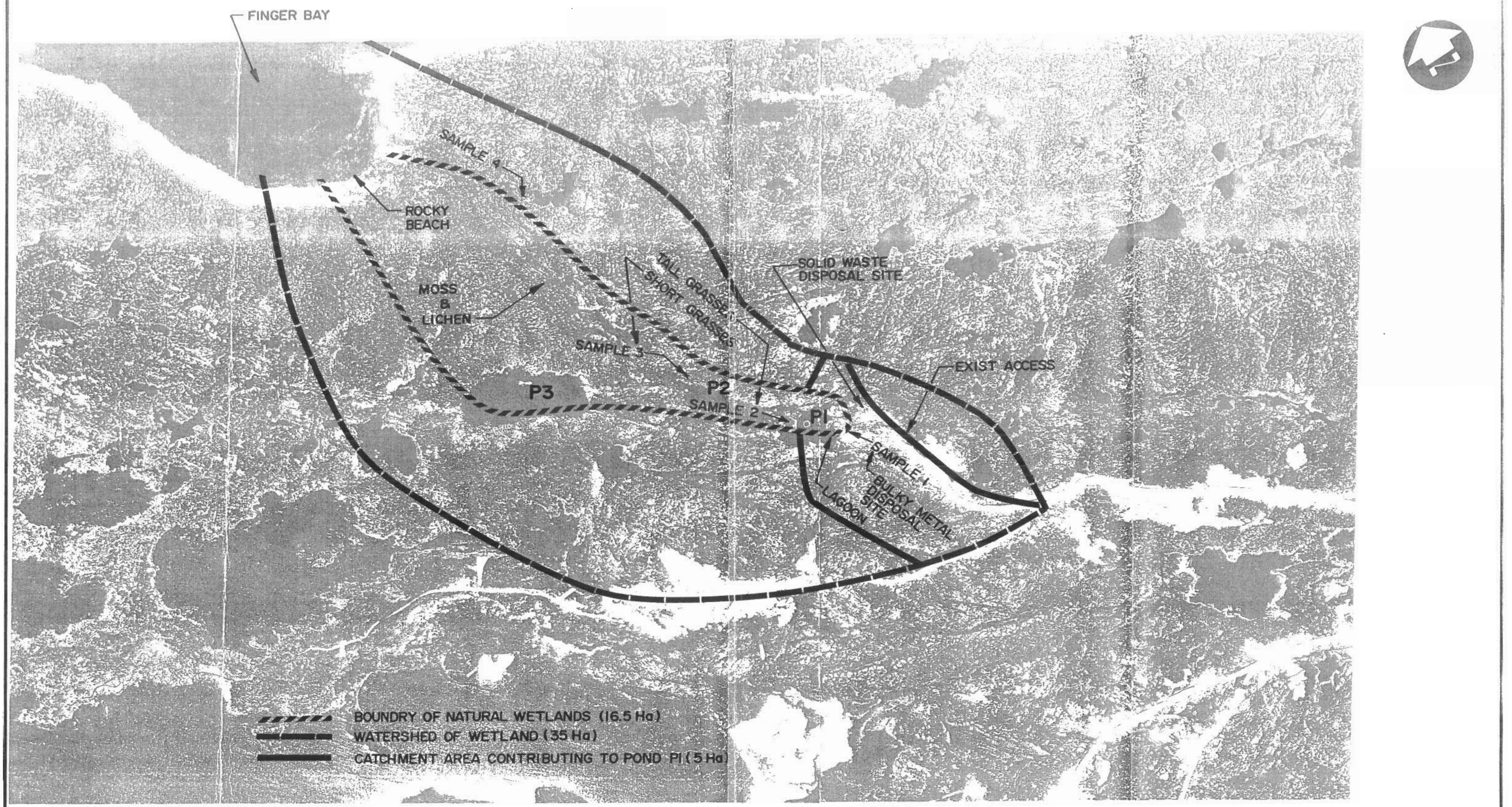
5.2 General Setting

The proposed site has a small pond ("P1") with an approximate surface area of approximately 2,000 m^2. The depth of the pond is not known. The pond is encompassed by a rock outcrop on the north, east and south sides. The east side is part of the old solid waste facility that is to be capped as part of the development of the new solid waste facility. The west end of the pond is a low lying area that is heavily vegetated with tall grasses and moss. During the site visit, this area was noted to be a feeding ground for numerous Canada geese.

The tall grasses cover an area of approximately 100 metres long by 40 metres in width downstream of pond ("P1"). Another pond ("P2") of approximately 1,000 m^2 is in this area. Down gradient of the tall grasses is an area of shorter grasses, moss and some lichen. This area is approximately 100 m in length and 50 to 70 m in width. Small ponds exist in this area. These areas are bordered on the north and south by rock ridges with sparse vegetation.

The remaining land to the bay is covered in moss, lichen and other low lying vegetation, with numerous boulders and small areas of rock outcrops. This area becomes a rocky beach at the waterfront.

Figure 5.1 illustrates the general site area.



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APR 94	WETLANDS AREA SITE PLAN	FIG. NO. 5.1

6.0 DESIGN

6.1 General Approach

It is proposed to take advantage of the natural wetland setting downstream of the existing sewage disposal site, incorporating it into an engineered wetlands treatment facility. The design of the facility must minimize the required construction effort, and therefore, capital cost, while still allowing the facility to meet the discharge guidelines for municipal wastewater, set by the NWT Water Board. The design and operation of a wetland treatment system at the proposed site is constrained by climate, topography, and geologic conditions. Scheduling of system construction details must, therefore, coincide with the most favourable climatic conditions, (i.e. summer) minimizing impacts to the natural drainage scheme, while taking into account the contribution of runoff to the system. The following specific issues must be addressed by the design:

- Sewage treatment process/specific configuration.
- Sewage treatment efficiency (with respect to regulations).
- Site access requirements.
- Sewage discharge means (to and from system).
- Control of runoff and site drainage.

These elements of the design and operation are discussed in the following sections.

6.2 Site Characteristics and Drainage

Chesterfield Inlet is located in a zone of continuous, non-ice rich permafrost. The natural wetland area proposed for incorporation into the sewage treatment system is devoid of any tree stands or large bushes, but supports a healthy growth of sedge grasses, moss and lichens, interspersed with clumps of dwarf willow. Numerous surface water impoundments exist, with the three largest being "P1" (2,000 m^2), "P2" (1,000 m^2), and "P3" (11,500 m^2), as shown on **Figure 5.1**.