APPENDIX E

HEAT LOSS AND BOILER SYSTEMS

Heat Loss Calcs:

Equations:

Static Heat Loss

Rate of heat loss per unit length q (W/m): $q = (Tw - Ta)/RT$ pg 18 Rankin

where Tw is water temp (C) and Ta is exterior ambient temp (C) and RT is total thermal resistance per length (Cm/W)

RT (total thermal resistance per length (Cm/W)) can be taken from TABLE 1 pg 19 Rankin

q can be read from TABLE 2 page 20 Rankin

Heat Loss & temp drop in a flowing pipe

Temperature at x location along watermain: $Tx = (Ti-Ta)e(-X/(m*C*Rt) + Ta$

where Ti is water temp (C) at input and Ta is exterior ambient temp (C) and RT is total thermal resistance per length (Cm/W)

and X is length of pipe in m

and m is the mass flow rate m = (V*Area)*d where area is m2 and V is velocity m/s and d is density of fluid 1000kg/m3

Tx can be read from TABLES 3-1 to 3-4 but must be calculated for 100 mm pipe.

Freeze up time in pipe in permafrost with no flow

$Tf = (pi * Dip^2 *d*C*(Tx-Tf)*Rt)/(2*(Tx-2*Ta+Tf))$ Time to drop to freezing temp

$Ts = (pi * Dip^2 *d*Hf*Rt)/(4*(Ti-Ta))$ Time to freeze solid

where Hf = 334720 J/kg

Knowns:

Dip Pipe Inside diameter 4"(100 mm) (m) :	0.092	m	
Flow Area 4" subtracting 1.5" heat pipe:	0.0055	m2	
Pipe Length:	3400	m	
C Fluid Specific heat (J/KgC):	4190	J/KgC	
TI Input water temp:	1	C	
Rule:	**Temp drop along pipe should be less than 2.5C**		
Hf Heat of fusion of fluid (J/kg):	334720	J/kg	
d density of fluid (kg/m3):	1000	kg/m3	
Tf Temp freezing	0	C	
Ta Ambiant Soil Temp:	-10	C	
Insulation thickness:	50	mm	
Depth of Bury:	1	m	
Velocity 2004 to 2014 (ft/s):	1.88	ft/s	
Velocity 2004 to 2014 (m/s):	0.57	m/s	
Flow 2004 to 2014 (m3/s):	0.0032	m3/s	0.00315473 check
Velocity 2015 to 2024 (ft/s):	3.60	ft/s	
Velocity 2015 to 2024 (m/s):	1.10	m/s	
Flow 2015 to 2024 (m3/s):	0.0060	m3/s	

Static Heat Loss

Rate of heat loss per unit length q (W/m): $q = (Tw - Ta)/RT$ pg 18 Rankin

where Tw is water temp (C) and Ta is exterior ambient temp (C) and RT is total thermal resistance per length (Cm/W)

RT (total thermal resistance per length (Cm/W)) can be taken from TABLE 1 pg 19 Rankin

q can be read from TABLE 2 page 20 Rankin

RT for 1 m bury, 50 mm insul, 100mm pipe:	**4.38735 Cm/W**	from TABLE 1
Rate of heat loss per unit length q (W/m):	**2.51 W/m**	q= (Tw - Ta)/RT
Rate of heat loss for pipeline:	**8524.51 W**	

Heat Loss & temp drop in a flowing pipe

Temperature at x location along watermain:

$Tx = (Ti-Ta)e(-X/(m^*C^*Rt)) + Ta$

where Ti is water temp (C) at input and Ta is exterior ambient temp (C) and RT is total thermal resistance per length (Cm/W)

and X is length of pipe in m

and m is the mass flow rate m = (V*Area)*d where area is m2 and V is velocity m/s and d is density of fluid 1000kg/m3

Tx can be read from TABLES 3-1 to 3-4 but must be calculated for 100 mm pipe.

2004 to 2014

Velocity 2004 to 2014 (m/s): 0.57 m/s

Flow 2004 to 2014 (m3/s): 0.0032 m3/s

X Distance along pipe (m):	Tx Temp at point along pipe (C):	check using other equation
0	1	
500	0.91	
1000	0.81	
1500	0.72	
2000	0.63	
2500	0.54	
3000	0.45	
3400	0.37	

2015 to 2024

Velocity 2015 to 2024 (m/s): 1.10 m/s

Flow 2015 to 2024 (m3/s): 0.0060 m3/s

X Distance along pipe (m):	Tx Temp at point along pipe (C):
0	1
500	0.95
1000	0.90
1500	0.85
2000	0.80
2500	0.75
3000	0.71
3400	0.67

Freeze up time in pipe in permafrost with no flow

t f = (pi * Dip^2 *d*C*(Tx-Tf)*Rt)/(2*(Tx-2*Ta+Tf)) Time to drop to freezing temp
or replace with actual flow area
t f = (A*d*C*(Tx-Tf)*Rt^2)/(Tx-2*Ta+Tf)

ts = (pi * Dip^2 *d*Hf*Rt)/(4*(Tf-Ta)) Time to freeze solid
or replace with actual flow area:
t s = (A*d*Hf*Rt)/((Tf-Ta))

2004 to 2014

Tf Time to drop from Tx to freeze:

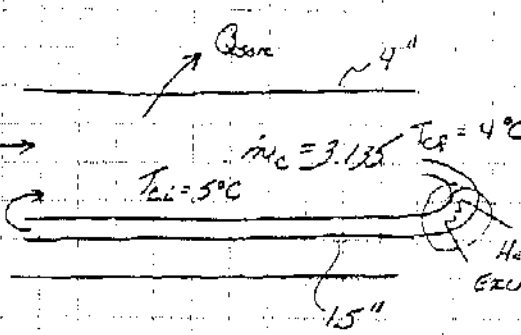
Tx=	0.37	C
Tf=	0.00	C
Time to drop to freeze from Tx:	**3713.52**	**sec**
	1.03	**hours**
Time to freeze solid from Tx:	808797.66	sec
	224.67	**hours**

2015 to 2024

Tf Time to drop from Tx to freeze:

Tx=	0.67	C
Tf=	0.00	C
Time to drop to freeze from Tx:	**6545.86**	**sec**
	1.82	**hours**
Time to freeze solid from Tx:	808797.66	sec
	224.67	**hours**

GOAT HAVEN - SUMMARY OF PRELIMINARY CALCULATIONS THE HEXCHANGERS / COILERS WERE BASED ON.



$\dot{m}_c + \dot{m}_h = \dot{m}_c$

$\dot{m}_c = 2.71$ kg/sec

ENERGY NEEDED TO HEAT CAKE WATER TO 5°C

$q_c = \dot{m}_c C_p (T_c - T_c)$

$= 2.71 \frac{kg}{sec} \cdot 4190 \frac{J}{kg \cdot °C} \cdot (5-1)°C$

$= 45\,420$ W

or 155 000 btu/hr

Heat exchanger at WTP

$q = 45\,420 = \dot{m}_h C_p (T_{hf} - T_{hi})$

$45\,420 = (.427)(4190)(T_{hf} - 4)$

$T_{hf} = 29.4°C$

30°C

$v = 410 \frac{US\ gal}{hr}$ $T_f = 30°C$ $T_i = 4°C$

$V_s = .57$ m/s at pipe K's velocity

$A_c = .0055\ m^2$ $\rho = 1000\ kg/m^3$

$\dot{m}_c = (.0055\ m^2)(.57\ m/s)(1000\ kg/m^3)$

$= 3.135$ kg/s

$V_h = .6096$ m/s (2 m/s)

using 4 mm wall thickness for 15" pipe

$A_h = .0007\ m^2$

$\dot{m}_h = (.0007)(.6096)(1000)$

$= .427$ kg/sec

$v = 40.6 \frac{US\ gal}{hr}$

Storage Tank

$q = 53\,000$ btu/hr

or 15 533 J/s

avg temp from above = 3°C

V_c 2 m/s (6.096 m/s) using 15" pipe

$q = \dot{m} C_p (T_f - T_i)$

$15\,533 = .427(4190)(T_f - 3)$

$T_f = 11.7°C$

$v = 410 \frac{US\ gal}{hr}$ $T_f = 12°C$ $T_i = 3°C$

By		Date		Project Name	GOAT HAVEN
Checked		Date			
Page		of		Project No.	020602

DILLON CONSULTING

121-97

APPENDIX F

COST ESTIMATES

From: Angela Saranchuk
To: Strong, Gary
Date: 10/17/02 3:11PM
Subject: exchanger info

Afternoon, Gary.

Another quote for both the main and tank recirc lines is coming - original quote was on single walled, not double walled construction.

'main' recirculating line -
- 2 quotes - $2,750 (shell & tube) - make - Armstrong
- $3,650 (plate) - make - Alfa Laval
- all double-wall construction
- assumed 50% ethylene glycol solution

tank recirc line
- 1 quote - $2,100 (shell & tube) - make - Armstrong
- waiting for a third to come in - forgot to ask them for this one as well as the 'main' one

boiler -
- 1 quote - $11,400 - make - Bryant
- CSA approved burners
* 2nd quote still to be in this afternoon (doubt it as it's already 4), sent info, but not price (make is Cleaver-Brooks)

I'll send off more info when I get it. I tried to get 3 quotes for all, but few boiler people listed in the yellow pages carry oil fired ones. Is there another brand you think I should be going for?

I'm faxing the calculations that I did to size the equipment. Please let me know if there are any errors. Thanks.

From: Angela Saranchuk
To: Strong, Gary
Date: 10/17/02 3:49PM
Subject: Re: exchanger info

Heat exchangers for based on glycol inlet temperatures of 170/180 F
main exchanger is for ~155,000 BTU/hr - come to think of it, I'll need to check into provisions for increasing this come 2014.
tank exchanger is for ~55,000 BTU/hr

The boiler
450,000 BTU/hr input
360,000 BTU/hr output (too high only need ~200, 000 initially)
10 Boiler Hp
we can't get a CSA approval on a smaller burner in this type of unit - but this will leave us room for when we increase the pump for 2014 and beyond (then we'll require 265,000 BTU/hr for the main as opposed to 155,000)

Hopefully this is what you meant.

>>> Gary Strong 10/17/02 04:15pm >>>
Can you also provide the info on what the unit sizs are so I can include them in the report.

thanks

g

Call to: Norm Dei - PW/S
Vincent Tam - PW/S

List of Quantities

Pump house - $300,000

100 mm Insulated pipe - $300/m

40 mm Uninsulated Pipe - $100/m

Access Vaults - $25,000

Concrete foundations - 2,000 /m^3

Pre-engineered Building - 240 /m^2 YK

Stick Built Buildings - 2,350/m^2

Steel tanks - Verticle tanks - $1.80/l

1 tank 280,000 l -
vert steel insulated cladding
- King hand on Both

Akalvik - Earth tech. -
John Bommer 77? - 1254
McPherson

Gjoa Haven Community factor 1.5

Annual Increase over Next 12 months 10%

Alberta Slowing down - but there is a back log

2006 might be the end of Spike

By ______ Date ______ Project Name ______
Checked ______ Date ______
Page ______ of ______ Project No. ______

DILLON CONSULTING

From: <John_Bulmer@gov.nt.ca>
To: <gstrong@dillon.ca>
Date: 10/21/02 2:25PM
Subject: RE: Tank estimates

Gary

The "reliable" computer is working again.

Actual Details

AKLAVIK

1999 - supply and install water tank (minimum 110 000 l size) $1.64/l
Total Cost: $ 180 453.00 (included small pipeline and connections to water plant).
Tank was insulated c/w metal cladding.
Contractor: Dowland Contracting

2001 - supply only one water tank
Total Cost: $ 169 383.00 including shipping charges from Hay River to Aklavik. $1.12/l.
Tank Size: H = 6.1 m, R = 2.8 m. Approximate Volume = 150 000 litres. no foundation
Foundation was already in place.
Tank was insulated c/w metal cladding.
Contractor: King Manufacturing

2001 - install second water tank and connections
Total Cost: $ 75 986.00
Contractor: Dowland Contracting

FORT MCPHERSON

2000 - supply two water tanks
Total Cost: $ 404 275.40
Tank Size: H = 7.0 m, R = 3.625 m. Approximate Volume = 290 000 litres (each). $1.39/l.
Tank was insulated c/w metal cladding.
Foundation was already in place.
Contractor: NTCL

1.63/l foundation only

2000 - construct Foundation
Total Cost: $ 67 800.00
Contractor: Terwood Industries (Fort McPherson).

That's about all the info I have for now.

If you have any additional questions please feel free to contact me.

jb

-----Original Message-----
From: gstrong /unix [mailto:gstrong@dillon.ca]
Sent: 21-Oct-02 01:57 PM
To: John Bulmer /IN /PWS

Cc: gstrong /unix
Subject: Tank estimates

Per our phone call, I'd appreciate knowing the construction costs for the installation of the water storage tanks in Aklavik and Fort MacPherson. Some other project details would help, such as tank size, and foundation cost, if that was separate.

Cheers

Gary Strong, P Eng

Dillon Consulting Limited

phone 867-920-4555
fax 867-873-3328

APPENDIX G
Microbiology Results

PSC

ANALYTICAL SERVICES

Client:	Dillon Consulting Ltd. 895 Waverley St. Suite 200 Winnipeg, MB, CANADA R3T 5P4	Date Received:	November 13/2002
		Date Reported:	December 2/2002
		Lab Ref#:	G227244
		Lab Quote#:	W021004
Fax:	204-452-4412	Client PO#:	02-0602-1000
		Client Ref#:	02-0602-1000
Attn:	Angela Saranchuk	Sampled By:	Gary Strong

Attached are your results for Microbiology

If you have any questions, please call Elaine Grant,
your Service Manager at Philip Analytical Services Corp.

Post-it™ Fax Note 7671E | Date 2-Dec-02 | # of pages ▸ 7

To GARY STRONG	From ANGELA
Co./Dept.	Co. SARANCHUK
Phone #	Phone #
Fax #	Fax #

EPS Environmental Services

E-1420 Clarence Avenue
Winnipeg, MB R3T 1T6

Total Suspended Solids Analysis
Microscopic Identification
Three Water Samples

Job # PSC-4109

G227244.

Prepared for: Philip Analytical Services Corp.
5735 McAdam Road
Mississauga, ON
L4Z 1N9

28 November 2002

Total Suspended Solids Analysis
Microscopic Identification
Three Water Samples

Introduction

EPS Environmental Services received three 250 ml containers comprising three water samples on 18 November 2002. These samples were delivered to EPS by the client (Dillon Consulting LTD), and were received intact and in good condition. These samples were collected by the client on 3 November 2002, and have been identified as SL #1, SL #2 and WL #1. This project has been identified in the EPS internal records as Job# PSC-4109.

Results

Each sample was tested for Total Suspended Solids as per APHA Standard Methods[1]. All practices followed by EPS Environmental Services are detailed in an internal Manual of Laboratory Procedures[2]. Tests were run on 19 November 2002, and were done by Ainslie Hildebrand.

Test results of the TSS analysis are indicated in the Table 1.

Each water sample was poured into a petrie plate and was examined under a microscope for presence of microscopic organisms. Examinations were performed by Mima Wishart on 19 November 2002.

Results of the observations are detailed in Table 1.

Table 1: TSS Results and Microscopic observations for specified samples.

Sample identification	TSS (mg/L)	Microscopic Observations
SL #1	<1	Brown colour; Has appearance of minute plant debris present; A few rotifers observed; Water clear
SL #2	<1	Brown colour; Has appearance of minute plant debris and minute fibrous organic debris present; A few free-swimming rotifers observed
WL #1	<1	Very clear; No particles observed; No organisms observed

Test results have been reviewed and validated by Nancy Fuller.

---

1 Total Suspended Solids in *Standard Methods for the Examination of Water and Wastewater*, 18th edition, APHA 9221

2 Total Suspended Solids Determination, EPS Environmental Services of Laboratory Procedures. Test Method 15, Revision 1.0 February 2000

Prepared and Approved by:

Nancy Fuller
EPS Environmental Services

Reviewed by:

Carla Krueger
EPS Environmental Services

Philip Analytical Services Corp

5735 McAdam Road
Mississauga, Ontario, L4Z 1N9
tel:(905) 890-8566 fax:(905) 890-8575
Toll Free: 1-800-263-3040

Fax Cover Sheet

Pages: 3 (including cover sheet)

Please Deliver to: Angela Saranchuk

Dillon Consulting Ltd.
895 Waverley St.
Suite 200
Winnipeg MB
R3T 5P4

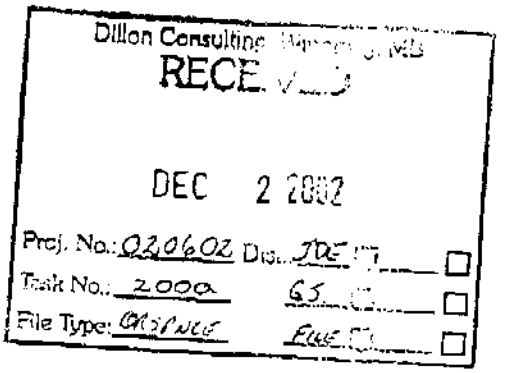
Fax #: 1-204-452-4412

Service Manager: Elaine Grant

Fax #: (905) 890-8575
Phone:

Final report will be mailed. If this fax is incomplete or unreadable, please call the above phone number.

REP227244INORGANIC WT



Philip Analytical Services Corp

Report of Analysis

Client : Dillon Consulting Ltd.
Contact: Angela Saranchuk

Report Date: December 2/2002
Lab Ref # : G227244
Lab Quote #: W021004
Client PO#: 02-0602-1000
Client Ref#: 02-0602-1000

Analysis of Water

Parameter	EQL	Units	SL 1 2002/11/03	SL 1 Replicate	SL 2 2002/11/03	WL 1 2002/11/03	
Mercury	.00005	mg/L	nd	nd	nd	nd	
Alkalinity(as CaCO3)	1.0	mg/L	120	116	120	107	
Nitrite(as N) and Nitrate(as N)	0.05	mg/L	nd	nd	nd	nd	
Chloride	0.5	mg/L	83.1	84.3	86.1	35.5	
Fluoride	0.1	mg/L	nd	nd	nd	0.1	
Nitrate(as N)	0.2	mg/L	nd	nd	nd	nd	
Sulphate	0.5	mg/L	8.1	7.8	7.9	22.1	
Ammonia(as N)	0.03	mg/L	0.03	0.05	0.03	nd	
Total Organic Carbon	0.2	mg/L	4.2	4.2	4.2	3.5	
Hardness(as CaCO3)	1	mg/L	141	146	139	134	
Aluminum	0.005	mg/L	0.007	0.007	0.010	0.019	
Antimony	0.0005	mg/L	nd	nd	nd	nd	
Arsenic	0.002	mg/L	nd	nd	nd	nd	
Barium	0.005	mg/L	nd	nd	nd	0.007	
Beryllium	0.001	mg/L	nd	nd	nd	nd	
Bismuth	0.001	mg/L	nd	nd	nd	nd	
Boron	0.005	mg/L	0.045	0.042	0.043	0.030	
Cadmium	0.0001	mg/L	nd	nd	0.0001	nd	
Calcium	0.5	mg/L	25.0	25.9	25.8	27.3	
Chromium	0.005	mg/L	nd	nd	nd	nd	
Cobalt	0.0001	mg/L	nd	nd	nd	nd	
Copper	0.0005	mg/L	0.0015	0.0016	0.0019	0.0016	
Iron	0.03	mg/L	nd	nd	0.03	0.04	
Lead	0.0025	mg/L	nd	nd	nd	nd	
Magnesium	0.05	mg/L	20.2	20.7	20.6	16.9	
Manganese	0.005	mg/L	nd	nd	nd	nd	
Molybdenum	0.001	mg/L	nd	nd	nd	0.003	

EQL Estimated Quantitation Limit = lowest level of the parameter that can be quantified with confidence.
nd parameters not detected ! = EQL higher than listed due to dilution ( ) Adjusted EQL

Philip Analytical Services Corp

Report of Analysis

Client : Dillon Consulting Ltd.
Contact: Angela Saranchuk

Report Date: December 2/2002
Lab Ref # : G227244
Lab Quote #: W021004
Client PO#: 02-0602-1000
Client Ref#: 02-0602-1000

Analysis of Water

Parameter	EQL	Units	SL 1 2002/11/03	SL 1 Replicate	SL 2 2002/11/03	WL 1 2002/11/03	
Nickel	0.001	mg/L	nd	nd	nd	nd	
Phosphorus	0.05	mg/L	nd	nd	nd	nd	
Potassium	0.1	mg/L	2.7	2.8	2.7	1.9	
Selenium	0.002	mg/L	nd	nd	nd	nd	
Silver	0.0001	mg/L	nd	nd	nd	nd	
Sodium	0.1	mg/L	46.8	47.6	47.5	19.4	
Strontium	0.001	mg/L	0.041	0.042	0.041	0.035	
Thallium	.00005	mg/L	nd	nd	nd	nd	
Tin	0.001	mg/L	nd	nd	nd	nd	
Titanium	0.005	mg/L	nd	nd	nd	nd	
Uranium	0.0001	mg/L	0.0004	0.0004	0.0004	0.0010	
Vanadium	0.0005	mg/L	nd	nd	nd	nd	
Zinc	0.005	mg/L	nd	nd	0.006	nd	
Bicarbonate(as CaCO3, calculated)	1	mg/L	119	115	119	106	
Conductivity - @25°C	1	uS/cm	493	491	502	339	
Total Dissolved Solids	2	mg/L	272	276	262	196	
Total Suspended Solids	1	mg/L	6	7	6	10	
Volatile Suspended Solids	1	mg/L	3	5	2	4	
pH	0.01	Units	8.04	8.06	8.00	7.88	
Colour	3	TCU	12	12	nd	12	
Turbidity	0.2	NTU	0.4	0.4	0.6	0.5	

EQL Estimated Quantitation Limit = lowest level of the parameter that can be quantified with confidence.
nd parameter not detected. ↑ = EQL higher than listed due to dilution. ( ) Adjusted EQL

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Nunavut: Community Population Estimates

Le Nunavut: Evaluation du nombre d'habitants par communautés

1997/1998/1999

Nunavut Bureau of Statistics
Bag 800
Iqaluit, Nunavut X0A 0H0
www.stats.gov.nu.ca

Nunavut: Community Population Estimates

	1997	1998	1999
Nunavut	25,947	26,429	27,039
Arctic Bay	703	709	716
Arviat	1,635	1,640	1,642
Baker Lake	1,427	1,445	1,439
Bathurst Inlet	X	X	X
Bay Chimo	53	51	X
Cambridge Bay	1,386	1,412	1,387
Cape Dorset	1,144	1,159	1,190
Chesterfield Inlet	357	363	363
Clyde River	726	733	752
Coral Harbour	794	823	822
Gjoa Haven	916	941	964
Grise Ford	149	154	145
Hall Beach	580	595	619
Igloolik	1,277	1,307	1,348
Iqaluit	4,352	4,368	4,627
Kimmirut	423	422	440
Kugaaruk	511	526	568
Kugluktuk	1,275	1,321	1,362
Nanisivik	219	243	228
Pangnirtung	1,384	1,429	1,475
Pond Inlet	1,208	1,237	1,276
Qikiqtarjuaq	499	495	508
Rankin Inlet	2,126	2,211	2,230
Repulse Bay	563	582	600
Resolute Bay	202	218	241
Sanikiluaq	680	682	680
Taloyoak	749	762	783
Whale Cove	317	317	308

Notes: Population estimates produced by Statistics Canada and the Nunavut Bureau of Statistics include people in the population who are residents of Nunavut and do NOT have a home elsewhere in Canada from which they are temporarily absent. Therefore, temporary residents such as construction crews, residents in mining camps, etc. are not included in the population estimates.

Data are suppressed for (a) communities with a population of 50 or less and (b) 'unorganized areas' -- but they are included in the Nunavut total.

Released by the Nunavut Bureau of Statistics

March 2000

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Nunavut: Community Population Projections

Le Nunavut: Projections pour la population par communautés

2000 – 2020

Nunavut Bureau of Statistics
Bag 800
Iqaluit, Nunavut X0A 0H0
www.stats.gov.nu.ca

Nunavut: Community Population Projections

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Nunavut	27,688	28,410	29,154	29,885	30,601	31,317	32,036	32,774	33,530	34,311	35,114
Arctic Bay	730	747	763	782	801	819	837	855	876	894	916
Arviat	1,690	1,736	1,784	1,833	1,883	1,929	1,982	2,033	2,088	2,142	2,198
Baker Lake	1,470	1,501	1,534	1,563	1,594	1,624	1,655	1,683	1,712	1,745	1,777
Bathurst Inlet	X	X	X	X	X	X	X	X	X	X	X
Bay Chimo	X	X	X	X	X	X	X	X	X	X	X
Cambridge Bay	1,418	1,449	1,484	1,517	1,550	1,581	1,609	1,642	1,679	1,715	1,752
Cape Dorset	1,213	1,240	1,268	1,298	1,327	1,354	1,382	1,412	1,441	1,471	1,501
Chesterfield Inlet	372	382	391	401	409	420	431	443	452	465	476
Clyde River	771	789	812	830	848	867	890	913	937	959	982
Coral Harbour	845	865	888	911	933	955	978	1,003	1,024	1,049	1,078
Gjoa Haven	984	1,005	1,023	1,045	1,063	1,084	1,102	1,117	1,136	1,154	1,173
Grise Fiord	145	146	147	146	148	147	149	151	151	153	155
Hall Beach	635	656	677	696	714	734	754	771	790	810	829
Igloolik	1,379	1,417	1,456	1,495	1,529	1,562	1,594	1,627	1,660	1,701	1,736
Iqaluit	4,762	4,930	5,108	5,278	5,438	5,606	5,768	5,936	6,108	6,289	6,477
Kimmirut	450	461	474	485	496	506	519	530	546	560	573
Kugaaruk	582	601	616	631	648	664	682	701	719	737	756
Kugluktuk	1,389	1,422	1,456	1,490	1,522	1,556	1,585	1,618	1,653	1,686	1,720
Nanisivik	230	225	224	226	225	223	222	220	221	221	220
Pangnirtung	1,506	1,539	1,575	1,613	1,651	1,687	1,722	1,756	1,792	1,831	1,870
Pond Inlet	1,314	1,361	1,405	1,443	1,489	1,532	1,574	1,624	1,668	1,714	1,761
Qikiqtarjuaq	522	537	551	566	582	599	614	629	641	654	668
Rankin Inlet	2,277	2,327	2,376	2,432	2,483	2,527	2,576	2,629	2,683	2,734	2,791
Repulse Bay	615	630	648	664	682	702	720	738	757	777	797
Resolute Bay	243	246	247	249	251	253	252	255	257	260	263
Sanikiluaq	702	722	740	758	776	796	816	834	853	873	896
Taloyoak	804	825	847	866	886	904	925	947	968	992	1,016
Whale Cove	312	321	328	336	344	351	358	367	378	388	397

Notes: Population projections produced by Statistics Canada and the Nunavut Bureau of Statistics include people in the population who are residents of Nunavut and do NOT have a home elsewhere in Canada from which they are temporarily absent. Therefore, temporary residents such as construction crews, residents in mining camps, etc. are not included in the population projections.

Data are suppressed for (a) communities with a population of 50 or less and (b) 'unorganized areas' -- but they are included in the Nunavut total.

Released by the Nunavut Bureau of Statistics

March 2000

APPENDIX C – Inspection Reports
INAC
Health and Social Services

Nunavut Government
Department of Health and Social Services

Kitikmeot Regional Office

Box 83, Cambridge Bay, Nunavut, (NU) X0B 0C0 Tel: (867) 983-4076 Fax: (867) 983-4063

July 8, 2002

Raymond Kamookak
Senior Administrative Officer
Hamlet of Gjoa Haven
Gjoa Haven, NU

FAXED July 9/02

Re: Public Health Audit

In accordance with the Public Health Act of Nunavut, inspections were conducted of Gjoa Haven's public buildings and municipal services on June 17th to 21st, 2002. The following observations and recommendations are offered to assist in rectifying conditions that might impact on public health.

Airport Terminal Building

Continue to service the airport washrooms, and all public washrooms on a daily basis. Clean and sanitize the plumbing fixtures, and replenish the paper towels, toilet tissue, and dispensed soap container.

Sewage Lagoon

A large breach was noted in the berm wall of the sewage lagoon permitting the effluent to continually discharge. It is recommended that the breach be repaired to increase the retention and treatment time. The capacity of the lagoon should be such that winter storage is possible as very little treatment takes place during this period. It takes one to two months after spring breakup to achieve the required treatment. The sewage effluent might then be discharged in the fall.

Solid Waste Disposal

Domestic waste is strewn over a large area instead of being confined to a smaller, more manageable cell. The waste should be bull dozed to the rear of the site, compacted and covered with available cover material.

The hazardous waste disposal area also requires your attention. Several waste drums need to be uprighted, and waste batteries need to be stacked two high on wooden pallets.

Community Drinking Water

The free available chlorine was measured in the water trucks on June 18th at 0.65 mg/l. Although this concentration affords good protection of the water throughout the distribution system, the Public Water Supply Regulations specify 0.2 mg/l after twenty minutes of contact time.

The Regulations also specify that all chlorination equipment must be installed in duplicate in order to provide standby units for ensuring uninterrupted operation. Only one chlorinator was noted at the time of inspection.

Dog Control

In the event of a biting incident, the Nunavut protocol is to quarantine the dog away from other animals and people for 10 days to observe it for signs of rabies. This is difficult when a dog pen is not available. It is therefore recommended that the Hamlet construct a pound to accommodate two or three dogs for this purpose. The individual pens must be constructed so that one dog does not have direct contact with another.

Swimming Pool

I understand that the pool will not be used this season and that it will eventually be relocated and housed in its own building. Once plans are underway to construct this building, the design will need to be reviewed and approved by this office in accordance with the Public Pool Regulations.

Should you have any questions or comments regarding this matter or the environmental health program, please do not hesitate to contact me at (867) 983-4086.

Robert Phillips, CPHI(C)
Regional Environmental Health Officer

Indian and Northern Affairs Canada
www.inac.gc.ca

Affaires indiennes et du Nord Canada
www.ainc.gc.ca

INAC, Nunavut District Office
P.O. Box 100
Iqaluit, NU
X0A 0H0

Tel.: (867) 975-4298
Fax.:(867) 979-6445

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December 29, 2002

NWB3-GJO9904

Raymond Kamootak
Senior Administrative Officer
Hamlet of Gjoa Haven
General Delivery
Gjoa Haven, NU X0B 1J0

RE: August 22, 2002 Municipal Water Use Inspection - Report

The Water Resources Officer (WRO) appreciate the assistance provided during the tour of the Hamlet's water use and waste disposal facilities. Enclosed for your records is a copy of the Municipal Water Use Inspection Report performed on August 22, 2002. During the inspection the following observations were noted.

- **Water Supply**: The Water Lake Intake Facility requires some maintenance to the conveyance line (Photo 1 & 6). A motor boat was observed next to Water Lake Water Intake Facility (Photo 2). The filtration system at the Water Treatment Facility was not in use at the time of inspection. (Photo 3). Of major concern was the presents of Blood Worms in the potable water, given the filtration system at the Water Treatment Plant was not in use. The chlorination system located at the Water Treatment Plant was in use at the time of inspection(Photo 4 & 5). Enclosed analysis of samples taken at the Water Intake Facility (SNP) GJO-1 indicate that Nitrate + Nitrite (<0.008 mg/L vs 3.2 mg/L), pH (7.95 vs 6.5-8.5) and Colour (10 TCU vs 15 TCU) are within the *Guidelines for Canadian Drinking Water Quality.*

- **Sewage Disposal Facility**: The Sewage Lagoon had sufficient free board at the time of inspection (Photo 11). A large breach in the Sewage Lagoon berm allowed for continual sewage effluent to be discharged (Photo 12). The Lagoon effluent is discharged over land prior to entering the ocean. Enclosed analysis of samples taken from (SNP) GJO-3 the Sewage Lagoon discharge indicate that Total Suspended Solids (59 mg/L vs 120 mg/L) and pH (7.47 vs 6-9) meet the *Municipal Wastewater Effluent Quality Guidelines.* However analysis of Total Ammonia indicate that (101 mg/L vs 2.2 mg/L) is in excess of *Municipal Wastewater Effluent Quality Guidelines.*

Canada

- **Solid Waste Disposal Facility:** The Solid Waste Disposal Facility has a fence surrounding most of the dump. The dump has a large breach in the fence and the berm (Photo 7). Staining was noted indicating a seepage path. Waste oil storage at Solid Waste Disposal Facility. Enclosed analysis of samples taken of (SNP) GJO-2 dump seepage, indicate that Total Suspended Solids (405 mg/L vs 120 mg/L) Total Ammonia concentration of (40.2 mg/L vs 2.2 mg/L) *are in excess of Municipal Wastewater Effluent Quality Guidelines* . All waste oil is drummed and stored at the Solid Waste Disposal Facility (Photo 8). The Solid Waste Disposal Facility seemed well managed with segregation of waste and signs posted at the dump.

- **Bulky Metal Dump:** The bulky metal dump was partialy segregated diverting bulky waste from the general dump area (Photo 10). The creek alongside the bulky metal dump was sampled (Photo 9). Analysis of samples taken at the Bulky Metal Dump have not been rrecived by the WRO, these sample results will be made avayable once recived by the WRO.

Fuel Storage: At the time of inspection the berm surrounding the Tank Farm appeared to be in good condition with no breaches. The containment liner of the berm was not visible (Photo 14). There is a drainage hose that was left not unattended that should be removed (Photo 13).

- **Non-Compliance of Act or Licence:** The licencee has yet to provide Nunavut Water Board with Annual Reports from 1999, 2000, 2001. An Operational & Management (O&M) plan for the waste disposal facilities has yet to be submitted, so has an report detailing the Abandonment and Restoration (A&R) of municipal water and waste facilities.

If there are any concerns or questions in regards to this inspection, please contact me at (867) 975 4298 or bodykevichc@inac.gc.ca.

Sincerely,

Constantine Bodykevich
Water Resources Officer (WRO)
INAC, Nunavut District

cc. -Nunavut Water Board, Gjoa Haven (Jim Wall)
-CG&T, Rankin Inlet (Don Forsyth)
- Keewatin Health & Social Services, Rankin Inlet (Robert Phillips)
- EC Environmental Protection, Yellowknife (Anne Wilson)
- INAC Water Management, Iqaluit (Michelle Mc Christie)

Affairs Canada et du Nord Canada
www.inac.gc.ca www.ainc.gc.ca

MUNICIPAL WATER USE INSPECTION REPORT

Date: August 22 , 2002 **Licensee Rep. (Name/Title):** Rannond Kamookak/ SAO

Licensee: Hamlet of Gjoa Haven **Licence No.: NWB3-GJO9904**

WATER SUPPLY

Source(s): Water Lake / Swan Lake (source) **Quantity used:** recorded at truck

Owner:/Operator: Hamlet of Gjoa Haven

Indicate: **A** - Acceptable **U** - Unacceptable **NA** - Not Applicable **NI** - Not Inspected

Intake Facilities: U **Storage Structure:** A **Treatment Systems:** U **Chemical Storage:** A

Flow Meas. Device: NA **Conveyance Lines:** U **Pumping Stations:** U

Comments: Conveyance line from Water Lake **Water Intake** Facility to the Water Filtration Plant requires maintenance due to line damage at Water Intake Facility. Water Treatment Plant filter system presently not in use. Bloodworms present in potable water.

WASTE DISPOSAL

Sewage: **Sewage Treatment System** (Prim./Sec/Ter.): Secondary; over land to ocean.

Natural Water Body: **Continuous Discharge** (land or water): land

Seasonal Discharge: X **Wetlands Treatment:** limited **Trench:**

Solid Waste: **Owner/Operator:** Hamlet of Gjoa Haven

Landfill: **Burn & Landfill:** X **Other:**

Indicate: **A** - Acceptable **U** - Unacceptable **NA** - Not Applicable **NI** - Not Inspected

Discharge Quality: Sampled **Decant Structure:** NA **Erosion:** U

Discharge Meas. Device: NIL **Dyke Inspection:** U **Seepages:** U

Dams, Dykes: A **Freeboard:** A **Spills:** NIL

Construction: NA **O&M Plan:** U **A&R Plan:** NIL

Periods of Discharge: A **Effluent Discharge Rate:** Not Measured

Comments: There is adequate freeboard in the Sewage Lagoon. A breach in the berm is allowing considerable effluent seepage, causing accelerated erosion and exposure of the containment liner at the Sewage Lagoon discharge site. There is a large breach in the Solid Waste Disposal Facility fence and berm. Dump seepage has caused considerable staining along the discharge path. Waste oil is stored at the Solid Waste Disposal facility. Some segregation of waste is practices at the bulky metal dump. Waste batteries require spill protection in the current storage area.

FUEL STORAGE

Owner/Operator:

Indicate: **A** - Acceptable **U** - Unacceptable **NA** - Not Applicable **NI** - Not Inspected

Berms & Liners: A **Water within Berms:** A **Evidence of Leaks:** A

Drainage Pipes: U **Pump Station & Catchment Berm:** NA

Pipeline Condition: NI **Not Applicable:** **Condition of Tanks:** NI

SURVEILLANCE NETWORK PROGRAM (SNP)

Samples Collected **Hamlet:** NIL

INAC: GJO-1 potable water, sewage effluent GJO-3 and dump seepage GJO 2

Signs Posted **SNP:** NIL **Warning:**

Records & Reporting: No 1999, 2000, 2001 Annual Reports or Operational Maintenance plan.

Geotechnical Inspection: Not Applicable

Non-Compliance of Act or Licence: Operational & Management plan required for municipal waste disposal facilities since 1999/07/07. Annual Reports required for 1999, 2000 & 2001.

Constantine Bodykevich

Indian and Northern Affairs Canada
www.inac.gc.ca

Affaires indiennes et du Nord Canada
www.ainc.gc.ca

Global Positioning System Coordinates for the Municipality of Gjoa Haven

Gjoa Haven-01 Gjoa Haven Pot Water 01	N68.38037 W95.52088
Gjoa Haven-02 Gjoa Haven Dump-02	N68.37013 W95.50247
Gjoa Haven-3 Gjoa Haven Sewage Lagoon-3	N68.37235 W95.50236

Canada

Gjoa Haven Inspection pictures 2002

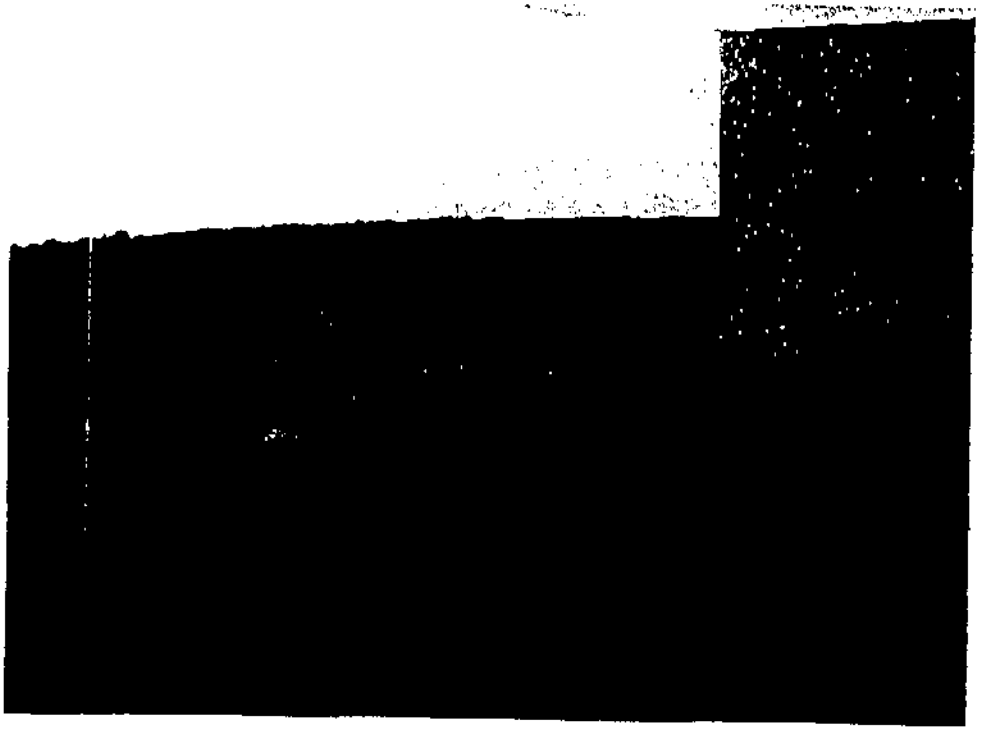


Photo # 1 Damaged section of conveyance line from Water Intake Facility

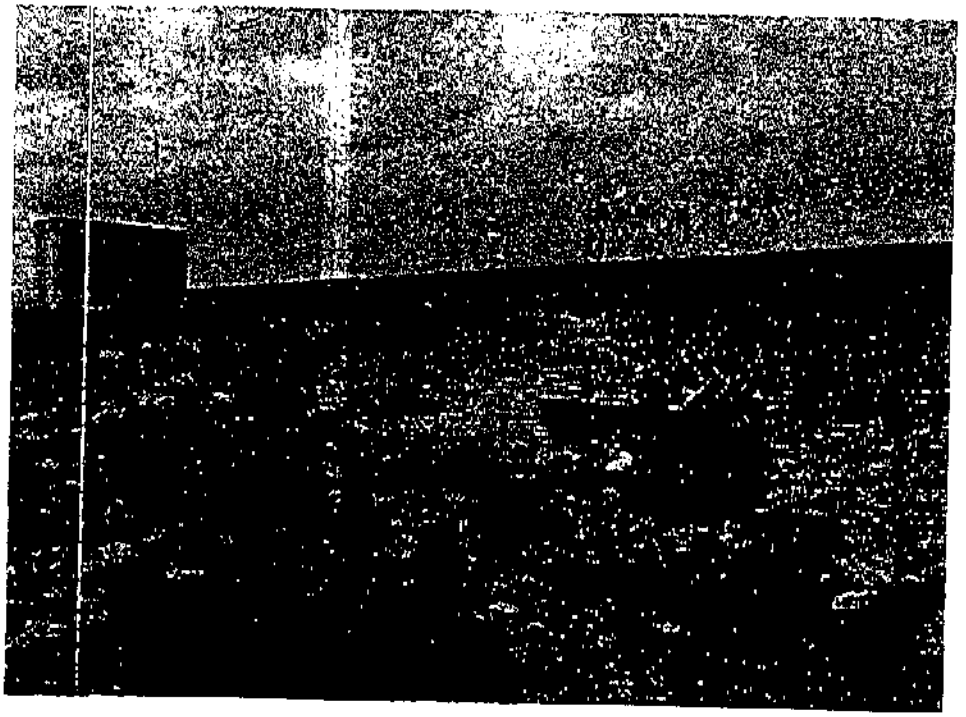


Photo # 2 Water reservoir with water intake facility in left of photo.

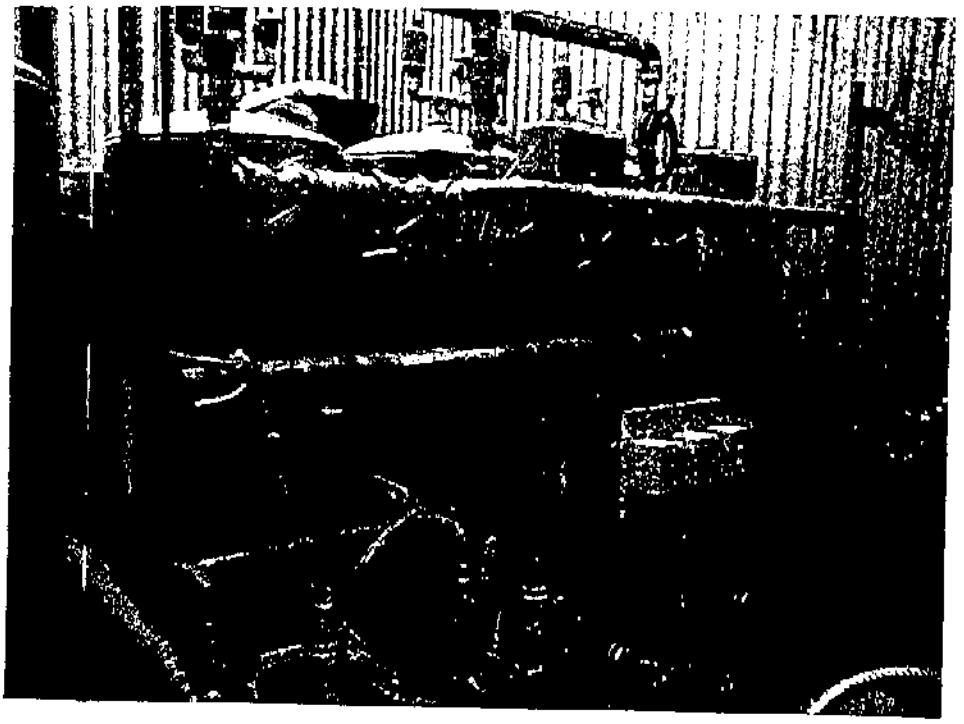


Photo # 3 Sand filters at Gjoa Haven Water Treatment Facility. Not in use at the time of this inspection.

Photo # 4 Chlorination system in place at Gjoa Haven Water Treatment Facility.

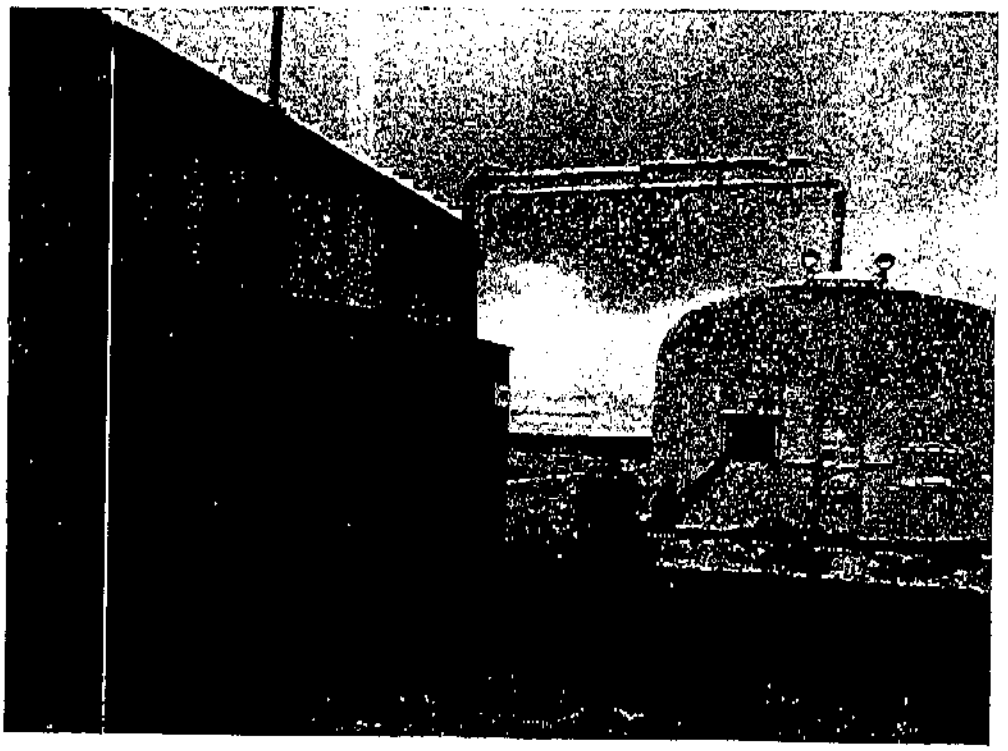


Photo # 5 Water Treatment Facility and truck fill station.

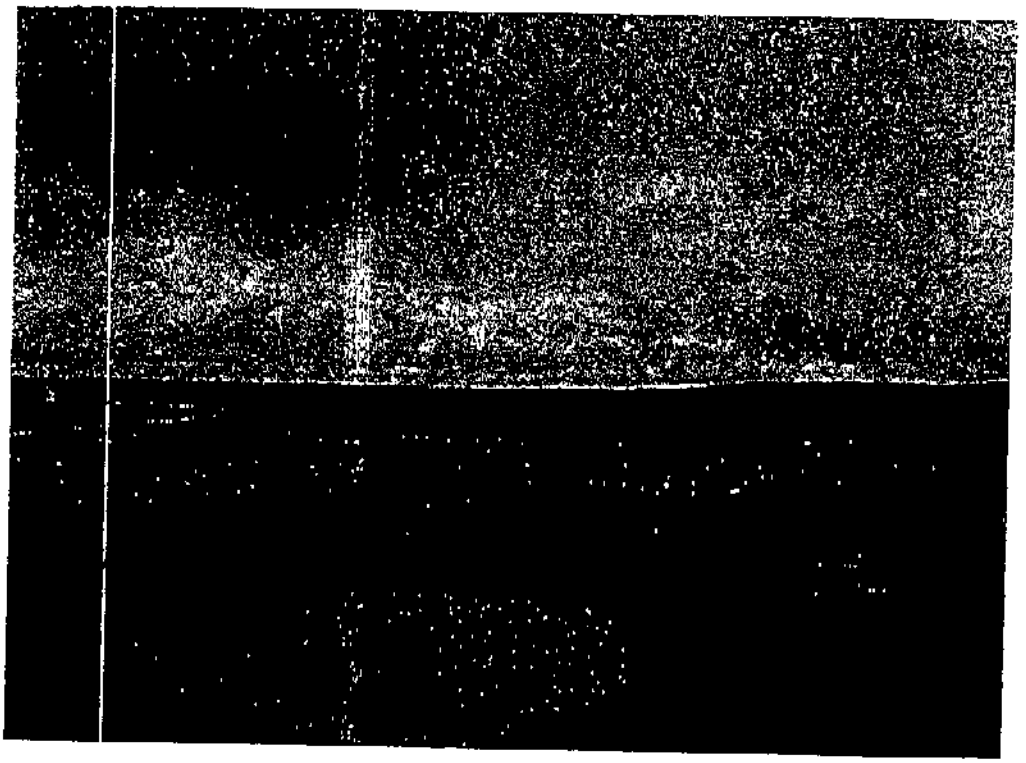


Photo # 6 Water Lake with Water Intake Facility and convayance line seen to the left of the picture.

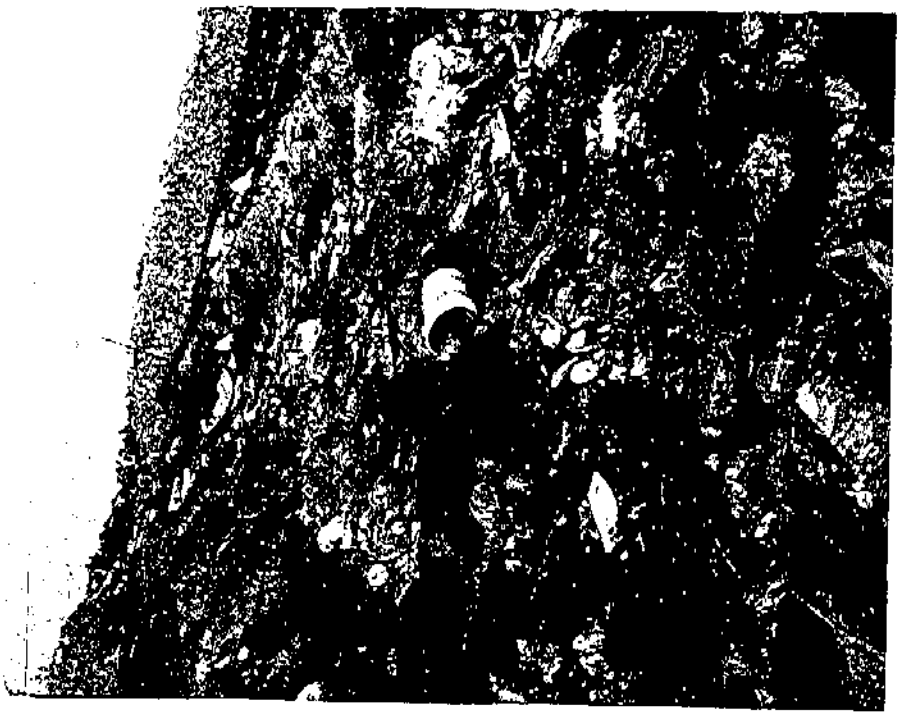


Photo # 7 Seepage from Solid Waste Disposal Facility; note a breach in the landfill berm and fencing, location of landfill seepage sample.

Photo # 8 Waste oil storage area in Solid Waste Disposal Facility.

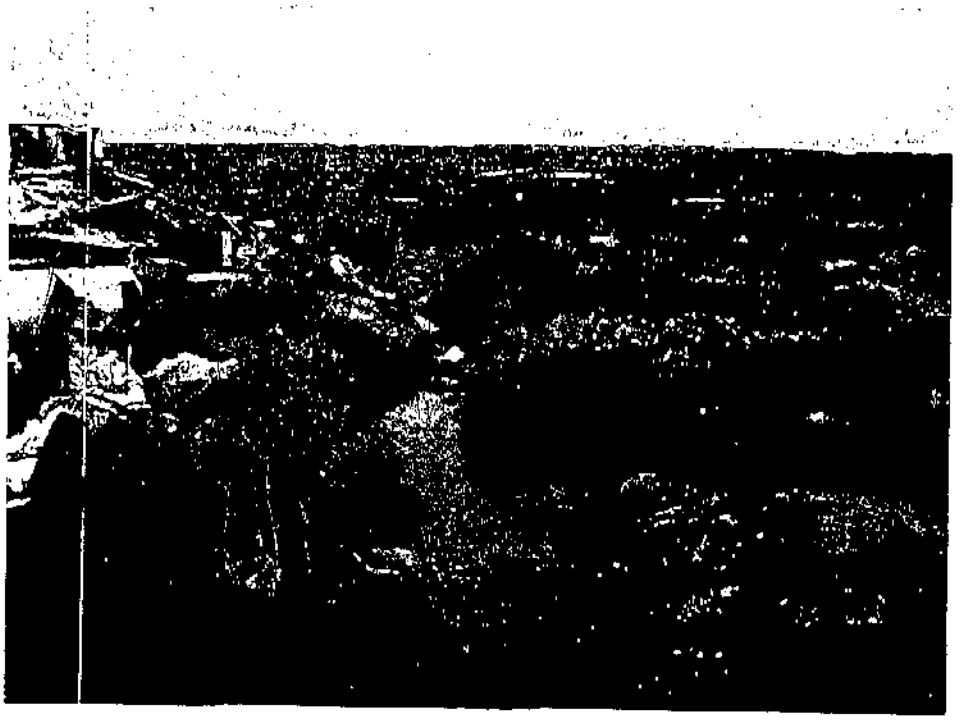


Photo # 9 Creek by bulky metal waste dump; location of metal dump sample.

Photo # 10 Bulky metal dump showing segregation of waste streams.

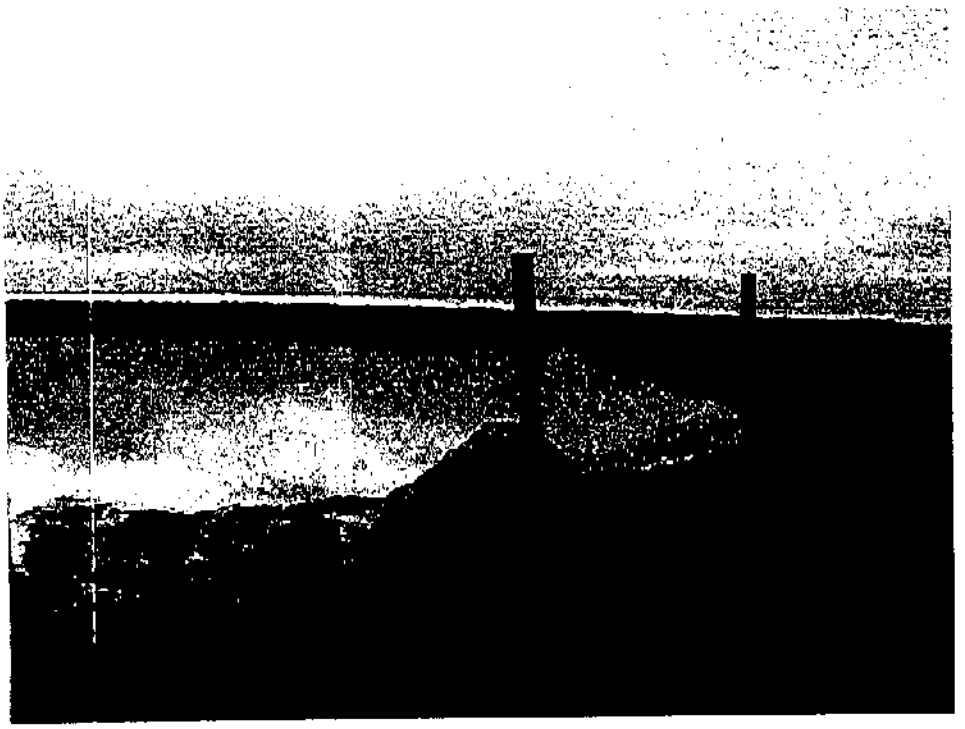


Photo # 11 Sewage truck discharge structure at Sewage Treatment Facility.

Photo # 12 ewage seepage noted at partial breach in Sewage Treatment Facility berm; location of sewage effluent sample.

Photo # 13 Tank Farm, showing drainage hose in berm area.

Photo # 14 Drum storage area at Tank Farm.

Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: DIAND Nunavut District Office *Attn:* Constantine Bodykevi

Sample ID: Gjoa Haven pot water GJO-1 **Taiga Sample ID:** 222515

Client Project: **Sample Type:** potable **Received Date:** 26-Aug-02

Location: Gjoa Haven pot water **Sampling Date:** 19-Aug-02

Report Status: Final *Approved by:* _____

Test Parameter	Result	Units	Detection Limit	Analysis Date	Data Qualifier
Physicals					
Alkalinity	77.9	mg/L	0.3	16-Sep-02	
Colour	10		5	16-Sep-02	
Conductivity, Specific	246	µS/cm	0.3	16-Sep-02	
pH	7.95	pH units	0.05	16-Sep-02	
Solids, Total Dissolved	178	mg/L	10	16-Sep-02	
Solids, Total Suspended	<3	mg/L	3	16-Sep-02	
Turbidity		NTU	0.1	17-Sep-02	14
Nutrients					
Ammonia as N	0.010	mg/L	0.005	02-Sep-02	
Nitrate+Nitrite as N	<0.008	mg/L	0.008	05-Sep-02	
Organic Carbon, Total	3.4	mg/L	0.5	07-Oct-02	
Phosphorous, Dissolved	0.066	mg/L	0.004	04-Sep-02	
Phosphorous, Total	0.071	mg/L	0.004	04-Sep-02	
Major Ions					
Calcium	19.1	mg/L	0.05	29-Aug-02	

Report Date: Wednesday, January 22, 2003

Taiga Environmental Laboratory
1601 52nd Ave., Box 1500, Yellowknife, NT. X1A 2P3
Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: DIAND Nunavut District Office

Attn: Constantine Bodykevi

Sample ID: Gjoa Haven pot water GJO-1

Taiga Sample ID: 222515

Chloride	19.7	mg/L	0.2	06-Sep-02
Hardness as CaCO3	96.9	mg/L	0.17	29-Aug-02
Magnesium	12.0	mg/L	0.02	29-Aug-02
Potassium	1.50	mg/L	0.03	28-Aug-02
Sodium	11.2	mg/L	0.02	28-Aug-02
Sulphate	18	mg/L	3	04-Sep-02

Data Qualifier Descriptions:

14 Insufficient sample to perform analysis

Report Date: Wednesday, January 22, 2003

Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: DIAND Nunavut District Office

Attn: Constantine Bodykevi

Sample ID: Gjoa Haven GJO-3

Taiga Sample ID: 222516

Client Project:

Sample Type: sewage

Received Date: 26-Aug-02

Location: Gjoa Haven sewage

Sampling Date: 19-Aug-02

Report Status: Final

Approved by: _____

Test: Parameter	Result	Units	Detection Limit	Analysis Date	Data Qualifier
Physicals					
Alkalinity	777	mg/L	0.3	19-Sep-02	
Colour	300		5	16-Sep-02	
Conductivity, Specific	1950	µS/cm	0.3	16-Sep-02	
pH	7.47	pH units	0.05	16-Sep-02	
Solids, Total Dissolved	1000	mg/L	10	16-Sep-02	
Solids, Total Suspended	59	mg/L	3	16-Sep-02	
Turbidity	42.4	NTU	0.1	17-Sep-02	
Nutrients					
Ammonia as N	104	mg/L	0.005	02-Sep-02	
Nitrate+Nitrite as N	0.017	mg/L	0.008	05-Sep-02	
Organic Carbon, Total	84	mg/L	0.5	07-Oct-02	
Phosphorous, Dissolved	14.9	mg/L	0.004	04-Sep-02	
Phosphorous, Total	15.4	mg/L	0.004	04-Sep-02	
Major Ions					
Calcium	43.8	mg/L	0.05	29-Aug-02	

Report Date: Wednesday, January 22, 2003

Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: DIAND Nunavut District Office

Attn: Constantine Bodykevi

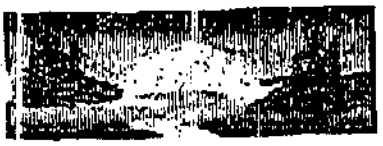
Sample ID: Ojon Haven G-50-3

Taiga Sample ID: 222514

Chloride	133	mg/L	0.2	06-Sep-02
Hardness as CaCO3	262	mg/L	0.17	29-Aug-02
Magnesium	37.0	mg/L	0.02	28-Aug-02
Potassium	45.5	mg/L	0.03	28-Aug-02
Sodium	175	mg/L	0.02	28-Aug-02
Sulphate	11	mg/L	3	04-Sep-02

Data Qualifier Descriptions:

Report Date: Wednesday, January 22, 2003



Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867) 669 2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: DIAND Nunavut District Office

Attn: Constantine Bodykevl

Sample ID: GJO-2

Taiga Sample ID: 222517

Client Project:

Sample Type: dump

Received Date: 26-Aug-02

Location: Gjoa Haven

Sampling Date: 19-Aug-02

Report Status: Final

Approved by:

Test Parameter	Result	Units	Detection Limit	Analysis Date	Data Qualifier
Physicals					
Solids, Total Dissolved	2300	mg/L	10	16-Sep-02	
Solids, Total Suspended	405	mg/L	3	16-Sep-02	
Turbidity	682	NTU	0.1	17-Sep-02	
Nutrients					
Ammonia as N	40.2	mg/L	0.005	02-Sep-02	
Nitrate+Nitrite as N	0.036	mg/L	0.008	05-Sep-02	
Organic Carbon, Total	72	mg/L	0.5	07-Oct-02	
Phosphorous, Dissolved	0.128	mg/L	0.004	04-Sep-02	
Phosphorous, Total	1.73	mg/L	0.004	04-Sep-02	

Data Qualifier Descriptions:

Report Date: Wednesday, January 22, 2003

Indian and Northern Affairs Canada / Affaires Indiennes et du Nord Canada

MUNICIPAL WATER USE INSPECTION FORM

Date: 2001/08/13 Licensee Rep. (Name/Title): Jacob Keanik / Foreman

Licensee: Hamlet of Gjoa Haven Licence No.: NWB3GJO9904

WATER SUPPLY

Source(s): Water Lake / Swan Lake (recharge) Quantity used: recorded @ truck delivery

Owner:/Operator: Hamlet

Indicate: A - Acceptable U - Unacceptable NA - Not Applicable NI - Not Inspected

Intake Facilities: U Storage Structure: NA Treatment Systems: A Chemical Storage: A

Flow Meas. Device: NA Convey. Lines: U Pumping Stations: U

Comments: No appreciable improvement noted in regards to the derelict status of the water intake and supply facilities; renewed conveyance line freeze up problems and bloodworm complications. Water Lake to be recharged from Swan Lake in late summer and/or early fall. Chlorination in use. Filtration system still bypassed.

WASTE DISPOSAL

Sewage: Sewage Treatment System (Prim./Sec/Ter.): primary; discharge overland to ocean

Natural Water Body: Continuous Discharge (land or water):

Seasonal Discharge: x Wetlands Treatment: limited Trench:

Solid Waste: Owner/Operator: Hamlet

Landfill: Burn & Landfill: x Other:

Indicate: A - Acceptable U - Unacceptable NA - Not Applicable NI - Not Inspected

Discharge Quality: sampled	Decant Structure: U	Erosion: U
Discharge Meas. Device: none	Dyke Inspection: NA	Seepages: A
Dams, Dykes: A	Freeboard: U	Spills: none reported
Construction: NA	O&M Plan: U	A&R Plan: none
Periods of Discharge: A	Effluent Discharge Rate: not measured	

Comments: Significant cleavage, and signs of erosion, of the sewage lagoon berm in the decanting area; slight flow from one of the two notches in the berm. Lack of freeboard in decanting area abridges retention time. Solid waste disposal facility is now fenced, although a gap in the section where the berm lowers creates a decant/runoff channel; no flow noted but an obviously stained path of leachate could be observed. Pooled water still lies in the middle of the wastepile. Household waste is regularly burnt and compacted towards the toe of the facility, but not covered; exposed waste covers an extensive area. Bulky metal wastes, hazardous materials and waste oil segregated; notable ground contamination in the waste oil storage area. Outstanding O&M plan.

FUEL STORAGE

Owner/Operator:

Indicate: A - Acceptable U - Unacceptable NA - Not Applicable NI - Not Inspected

Berms & Liners:	Water within Berms:	Evidence of Leaks:
Drainage Pipes:	Pump Station & Catchment Berm:	
Pipeline Condition:	Not Applicable: x	Condition of Tanks:

SURVEILLANCE NETWORK PROGRAM (SNP)

Samples Collected Hamlet: none

INAC: raw water @ Water Lake(GJO-1); sewage discharge @ 10 m below decant

Signs Posted SNP: no Warning: yes

Records & Reporting: No 1999, 2000 Annual Reports; no O&M plan

Geotechnical Inspection: not applicable

Non-Compliance of Act or Licence: 1999 and 2000 Annual Reports not submitted; respectively due by 2000/03/31 and 2001/03/31. Operation and Management (O&M) plan for the municipal waste disposal facilities overdue since 1999/07/07.

Philippe Lavallée

Inspector's Name

Inspector's Signature

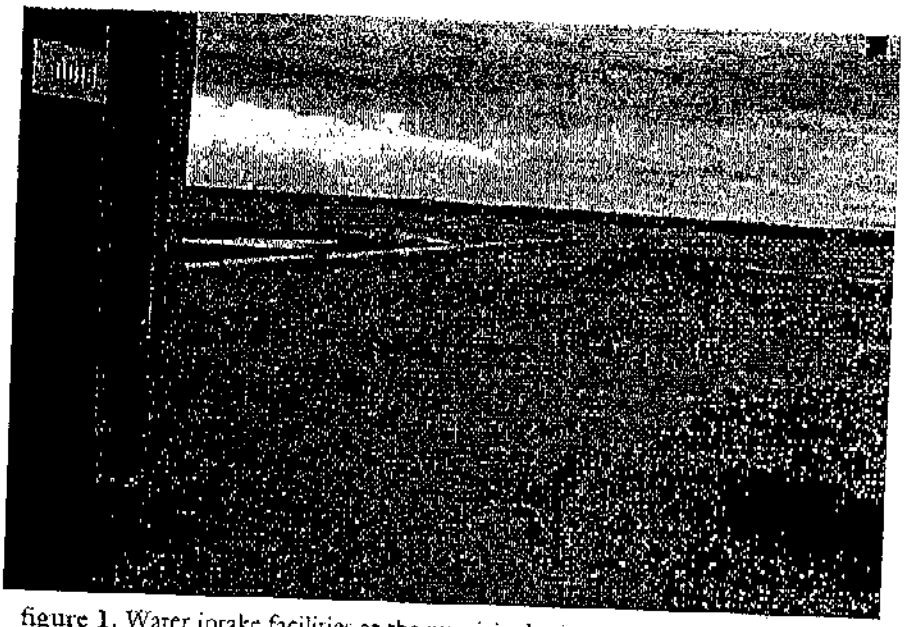


figure 1. Water intake facilities at the municipal water supply; 2001/08/13.

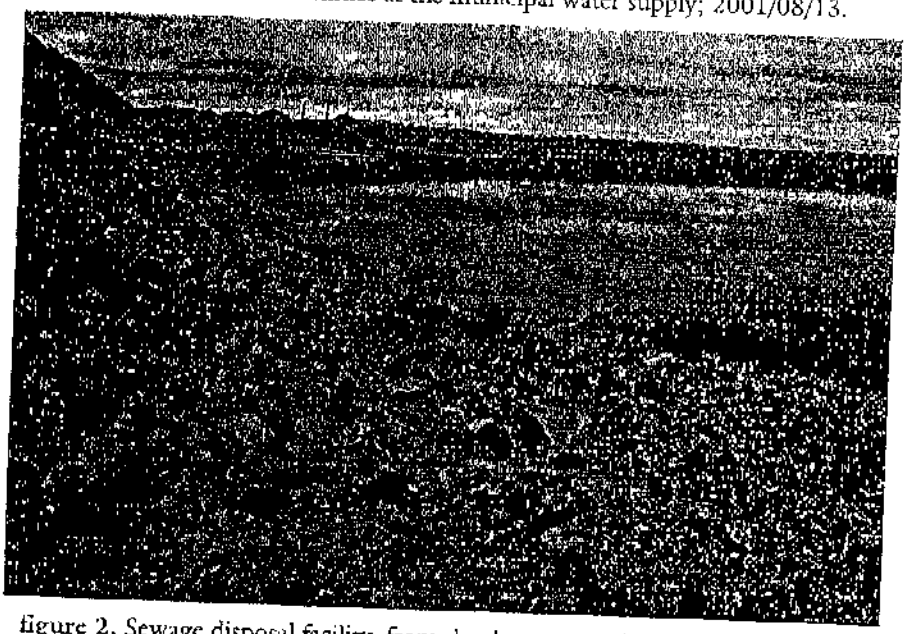


figure 2. Sewage disposal facility, from the decant area; 2001/08/13.

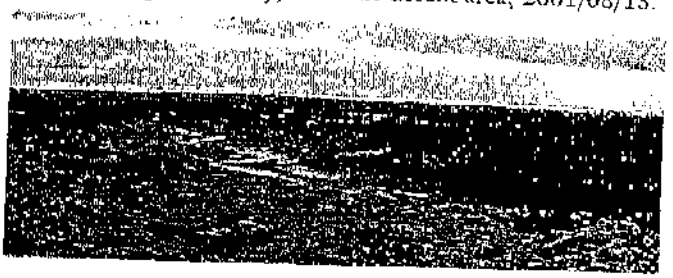


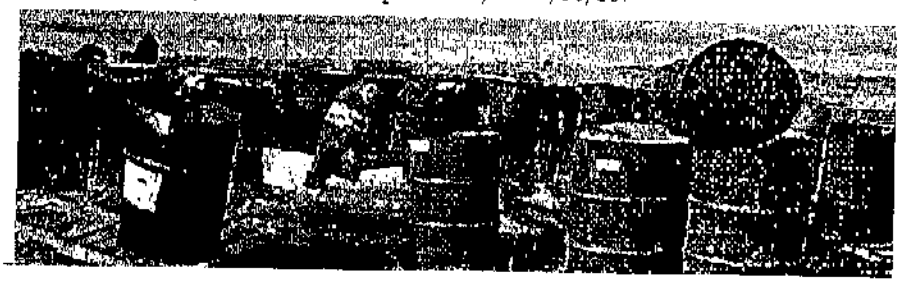
figure 4. Solid waste disposal facility; 2001/08/13.

figure 5. Pooled water along the toe of the solid waste disposal facility; 2001/08/13.

figure 6. Leachate from the toe of the solid waste disposal facility; 2001/08/13.

figure 7. Path of runoff from the solid waste disposal facility; 2001/08/13.

figure 8. Bulky metal wastes disposal site; 2001/08/13.



Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: Nunavut District Office DIAND, Operations *Attn:* Philippe Lavalllee

Sample ID: raw water GJO-1 **Taiga Sample ID:** 212061

Client Project: **Sample Type:** raw water **Received Date:** 14-Aug-01

Location: Ghoa Haven **Sampling Date:** 13-Aug-01

Report Status: **Final** ***Approved by:***

Lab Section	Test Parameter	Result	Units	Detection Limit	Analysis Date
Major Ions	Sodium	10.3	mg/L	0.02	15-Aug-01
Microbiology	Coliforms, Fecal	<1	CFU/100mL	1	14-Aug-01
Nutrients	Ammonia as N	0.013	mg/L	0.005	30-Aug-01
	Biological Oxygen Demand	<2	mg/L	2	14-Aug-01
	Nitrate+Nitrite as N	0.016	mg/L	0.008	21-Aug-01
Physicals	Colour	5		5	15-Aug-01
	Solids, Total Dissolved	139	mg/L	10	04-Sep-01
	Turbidity	1.0	NTU	0.1	15-Aug-01
Subcontract	Chloride	16.0	mg/L	0.1	30-Aug-01
	Sulphate	18.0	mg/L	0.3	30-Aug-01
Total Metals	Arsenic	<1.0	µg/L	1	07-Sep-01
	Cadmium	<0.3	µg/L	0.3	21-Aug-01
	Chromium	<3	µg/L	3	21-Aug-01
	Cobalt	<1	µg/L	1	21-Aug-01
	Copper	<2	µg/L	2	21-Aug-01
	Iron	<30	µg/L	30	20-Aug-01

RECEIVED SEP 2 2001

Report Date: Monday, September 24, 2001

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Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

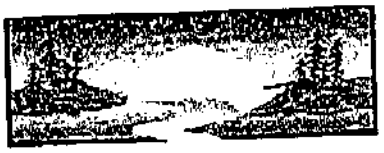
Prepared For: Nunavut District Office DIAND, Operations *Attn:* Philippe Lavalllee

Sample ID: raw water GJO-1 **Taiga Sample ID:** 212061

Total Metals	Lead	< 1	µg/L	1	21-Aug-01
	Manganese	10	µg/L	1	21-Aug-01
	Mercury	< 0.01	µg/L	0.01	13-Sep-01
	Nickel	2	µg/L	1	21-Aug-01
	Zinc	15	µg/L	10	21-Aug-01

Field Data (01/08/13) GJO-1
Temperature: 14.5 °C
Conductivity: 245 µS/cm
pH: 8.4 **Time:** 13:26

Report Date: Monday, September 24, 2001



Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788
Fax: (867)-669-2718

- CERTIFICATE OF ANALYSIS -

Prepared For: Nunavut District Office DIAND, Operations *Attn:* Philippe Lavallee

Sample ID: Sewage Discharge GJO-3 **Taiga Sample ID:** 212062

Client Project: **Sample Type:** sewage **Received Date:** 14-Aug-01

Location: Ghoa Havan **Sampling Date:** 13-Aug-01

Report Status: **Amended** ***Approved by:***

Lab Section	Test Parameter	Result	Units	Detection Limit	Analysis Date
Microbiology	Coliforms, Fecal	3000	CFU/100mL	1	14-Aug-01
Nutrients	Ammonia as N	2.66	mg/L	0.005	30-Aug-01
	Biological Oxygen Demand	326	mg/L	2	14-Aug-01
	Nitrate+Nitrite as N	0.017	mg/L	0.008	21-Aug-01
	Phosphorous, Total	12.2	mg/L	0.004	16-Aug-01
Physicals	Solids, Total Suspended	271	mg/L	3	04-Sep-01
Subcontract	Phenols	1.0	µg/L	0.5	22-Aug-01

Field Data (01/08/13) GJO-3
Temperature: 12.5 °C
Conductivity: 838 µS/cm
pH: 10.4 Time: 13:43

Report Date: Monday, September 17,

REPORT OF TOXICITY USING MICROTOX

COMPANY/LOCATION: GJO-3 Lagoon Discharge, 212062

Sample Collected By: Philippe Lavallee

Date/Time Sampled: August 13, 2001 13:43

Date/Time Received: August 15, 2001

Date/Time Test Start: August 15, 2001

Sample Type: Elutriate
Sampling Method: Grab

Method: *Environment Canada Laboratories SOP#830.0 Revision 1, for Microtox Testing in Compliance W*
November 1992: Biological Test Method: Toxicity Test Using Luminescent Bacteria Photobacteri
phosphoreum), November 1992, EPS 1/RM/24.

Environment Canada has conducted testing on the material sampled according to its own Microtox standards
procedures. The data proceeding from that testing is intended as a preliminary screening tool only, and canno
used for any other purpose. This data is provided on the condition that it not be used in any report that is inten
for public or official use.

RESULTS: **TOXIC - IC_{50} Concentration: 53.2%** **(Toxic 0 to 50%)**

TEST ORGANISMS:
Species: Vibrio fisheri (Photobacterium phosphoreum)
Test Apparatus: Model 500 Analyzer

TEST SUBSTANCE/CONDITIONS

pH of Sample: (No pH adjustment)

Sample Appearance: no colour adjustment

Lot # of Osmotic Adjusting Solution: OAS007

Lot # of Reconstitution Solution: RSN099Y

Lot # of Diluent: DIL034L

TEST METHODS AND CONDITIONS

Test Start Date/Time: August 15, 2001 / 02:10 PM

Test Method: Basic 45% Test, 15 minute incubation.

QUALITY CONTROL

Reference Toxicant: Zinc Sulfate Standard

Reagent Lot #: ACV026-6

IC_{50} - 15 minutes mg/L: 2.4 mg/L

IC_{50} Confidence Range: 1.6 to 3.6 mg/L

TEST ANALYST: Ron Bujold **INITIAL:** RB

APPENDIX D
Geotechnical Evaluation Report

GJOA HAVEN SEWAGE LAGOON
AND
SOLID WASTE DISPOSAL FACILITY
PRELIMINARY GEOTECHNICAL EVALUATION

Submitted

to

STANLEY ASSOCIATES ENGINEERING LTD.

Thurber Consultants Ltd.
Calgary, Alberta

M.C. Harris, P.Eng.
Review Principal

L.B. Smith, P.Eng.
Project Engineer

April, 1985
File: 17-308-14

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

1.1 General

This report presents a geotechnical evaluation of a proposed sewage lagoon and solid waste disposal facility to be constructed in Gjoa Haven, N.W.T. The evaluation is based on a description of the proposed facilities as presented in the following pre-design reports, which were prepared by Stanley Associates Engineering Ltd. and submitted to the Department of Public Works, Government of the Northwest Territories:

- Sewage Disposal Facilities, Gjoa Haven, N.W.T.
- Design and Operation Concept Report, Gjoa Haven Solid Waste Disposal

1.2 Project Background

The proposed facilites are located adjacent to one another about 1.5 km southeast of the settlement. A field investigation for the solid waste facility was carried out by project personnel from Stanley Associates in August, 1984. The site investigation included the excavation of 4 test pits at the proposed site for the waste disposal facility. The test pit logs are presented in Appendix A. Disturbed soil samples from the test pits were submitted to Thurber Consultants for grain size analyses and permeability testing.

Subsequent to the field investigation it was decided to locate the sewage lagoon adjacent to the solid waste disposal facility. It is understood that no test pits or test holes have been drilled at the location for the proposed sewage lagoon. An examination of the airphotographs indicates that the near surface soils at the lagoon site are similar to those encountered at the site for the solid waste facility.

A more complete description of the proposed sewage lagoon, solid waste disposal facility and access road is presented in the pre-design reports prepared by Stanley Associates.

SECTION 2

SITE CONDITIONS

The near surface soils at Gjoa Haven consist primarily of sands and gravel. These materials are underlain by limestone bedrock. The depth to bedrock at the location for the proposed sewage lagoon and solid waste disposal facility are not known.

Gjoa Haven is located within the continuous permafrost zone. The depth of the active layer ranges from 1 to 1.5 m, depending primarily on the water content of the near surface soils.

Sand and gravel and occasional cobbles were encountered in the test pits excavated at the site for the solid waste disposal facility. Permafrost was encountered at a depth of 1.2 m below grade and it was not possible to excavate below this depth with the available equipment.

In the vicinity of Gjoa Haven, groundwater is usually present within the active layer, depending on local topography. Groundwater is generally contained by the impervious permafrost below the active layer. Groundwater was encountered in two of the test pits excavated at the site for the solid waste facility at depths of 1.0 and 0.8 m below ground surface.

The near surface sands and gravels are relativey clean and therefore pervious. A permeability of 1×10^{-2} cm/sec was measured in a laboratory falling head test on a disturbed sample of sand taken from Test Pit 4. This value for permeability is consistent with the grain size distribution of the sample.

SECTION 3

SOLID WASTE DISPOSAL FACILITY

3.1 Landfill Construction

It is understood that the operation of the landfill will require the excavation of a cell about 2.2 m deep, 5 m wide and 50 m long. The cells would have to be excavated progressively as the ground thaws over the summer. The excavated material would be used to bury the waste from the previous year. It is considered practical to progressively excavate the permafrost to a depth of 2.2 m over one summer, provided excavations were commenced early in each thaw season.

3.2 Site Drainage

Site drainage is a major concern in the operation of the landfill site. Water will enter the landfill area through the active layer from the area upslope from the landfill. Surface runoff can also be expected to collect in the operating disposal trench. The proposed layout for the facility, as described in the pre-design report, appears to ensure that the water will be collected and drained away from the landfill. It should be recognized, however, that leachate from the solid waste disposal facility will flow into the proposed drainage system.

Annual maintainance of permanent drainage ditches may be required, depending on the volume of water which flows in the ditches. Rip rap armour protection may be required in locations where severe erosion occurs.

It is recommended that all permanent sideslopes for berms and ditches be constructed at a slope of 3 horizontal to 1 vertical in order to minimize surface erosion of the sideslopes. Temporary sideslopes for the disposal trenches could be constructed at 2 horizontal to 1 vertical, however some erosion and sloughing may occur.

SECTION 4

SEWAGE LAGOON

4.1 Lagoon Construction

It is understood that the lagoon will be constructed using a bulldozer to excavate the material as it thaws. It should be possible to excavate the full depth of the lagoon (about 2 to 3 metres) over a single thaw season using this approach. It would be essential, however, to commence excavation in early July. The lagoon berms would be formed from the excavated sand. Care will be required to ensure that the sand is adequately drained so that it can be compacted properly as the berms are formed. It is not known what equipment will be available in the community for compaction and this aspect should be investigated further.

Water from the active layer will probably flow into the excavation as the work proceeds. This water will have to be removed either by pumping from sumps or by excavating a temporary drainage ditch through the lagoon berms.

The depth to bedrock on the lagoon site is not known. There is a risk that bedrock will be encountered within the depth of excavation. If this is the case, it may be necessary to blast the bedrock, or alternatively set the design base of excavation higher and import material for the construction of the lagoon berms. In order to reduce the risk of encountering bedrock within the excavation it is recommended that test holes or test pits be excavated at the site. If neither of these alternatives is possible, it is recommended that contingency plans be made to cover the possibility of encountering bedrock.

4.2 Lagoon Watertightness

Watertightness of the lagoon is a major concern for two reasons:

- It is important to prevent water from the surface and within the active layer from flowing into the lagoon and filling it.
- It is important to prevent sewage effluent from leaking out of the lagoon in an uncontrolled manner.

It is understood that 3 alternatives are being considered in order to make the lagoon watertight.

- permafrost
- berm cutoff
- full membrane liner

4.2.1 Permafrost

If the lagoon were constructed so that the permafrost around the lagoon was higher than the maximum water level in the lagoon, then the permafrost would render the lagoon watertight. There are a number of concerns with this approach which should be addressed:

1) Depending on the configuration of the lagoon, water from the active layer could still flow into the lagoon during the summer months.

   While permafrost will aggrade upwards into the reservoir berms, it is doubtful that the berms will become impervious. This is because the above grade portion of the berms will not be fully saturated, and will therefore be pervious. Water from the lagoon will leak through the berms and will form preferred seepage paths through the berm which will probably pipe and result in failure of the berm. It is unlikely that the seepage from the lagoon will freeze in the berms and make them impervious.

2) In view of the foregoing, the only feasible method of using the permafrost to make the lagoon impervious would be to make the excavation deep enough, such that full service level in the lagoon will be below the maximum depth of the active layer in the surrounding natural ground (about 1 m). This would mean that a significantly deeper excavation would be required than would be the case if the lagoon were constructed by balanced cut and fill. Moreover, depending on the configuration of the lagoon, water from the active layer could still fill the lagoon during the summer months.

3) There is concern that an unsaturated zone may be encountered within the natural permafrost at this site. If such a zone were present, the lagoon could leak even if the full service level were kept below the active layer of the surrounding area. The occurance of such an unsaturated zone is unlikely but possible. Its presence would only be revealed during construction.

4.2.2 Berm Cutoff

A second alternative would be to install an impervious cutoff through the berm around the entire perimeter of the lagoon as shown on Figure 3.2 of the pre-design report. There are a number of concerns with this approach:

1) In order to be effective, the cutoff would have to extend at least 1 m into the native soil below the berm. If the bottom of the cutoff were placed within the fill, as shown on the bottom half of Figure 3.2, it is probable that seepage underneath the cutoff would occur which could result in piping failure of the berm.

2) A number of construction difficulties are anticipated if the cutoff is extended into the natural permafrost below the berm. The excavation for the cutoff would be fairly deep and the trench sideslopes would have to be cut back to a slope of 1 to 1 in order to make the slopes stable. In addition, excavation of the permafrost would be required in order to anchor the cutoff into the permafrost. It is probable that the permafrost could only be excavated by blasting. Finally, there may be difficulties with water from the active layer flowing into the trench excavation.

3) There is a risk that sewage effluent could flow below the cutoff, either because the cutoff was installed to insufficient depth, or because of the presence of unsaturated pervious zones within the natural soil. It would be difficult to locate the exact location of such seepage zones, if they occur, so that repairs could be made.

4.2.3 Full Membrane Liner

A third alternative to make the lagoon watertight would be to line the entire lagoon with a suitable membrane liner. While this alternative would be effective, it is, as pointed out in the pre-design report, extremely expensive.

If a full membrane liner is used, it is recommended that a subdrainage system be incorporated into the design in order to prevent heaving of the liner due to groundwater from the active layer flowing below the liner when the lagoon is emptied during the late summer. The installation of a subdrainage system will increase the cost of this alternative significantly. The use of weight placed on the liner can be considered further, however, a relatively substantial depth of soil cover (1 to 2 m) would be required to prevent heaving of the liner and therefore this approach may not be cost effective.

4.2.4 Conclusion

It is clear that the watertightness of the lagoon will be a major concern and that there are unresolved difficulties associated with the available alternatives. This aspect of the design should be reviewed further before proceeding with the preparation of the detailed design drawings and specifications .

4.3 Lagoon Sideslopes

It is propsed to construct the lagoon sideslopes at 4 horizontal to 1 vertical. Deep seated failure of the lagoon berms is not a concern in view of the granular nature of the soils to be used in construction. However, the native soils are highly susceptible to wave erosion and for this reason it is recommended that sideslopes be constructed at 4 horizontal to 1 vertical. The sideslopes could be constructed steeper than this, however, wave erosion would increase and significant annual regrading of the slopes would be required.

4.4 Freeboard and Crest Width

The present design allows for 0.5 m of freeboard at full service level. It is recommended that the freeboard be increased to 1.0 m in order to account for possible

settlement of poorly compacted berms, as well as to provide an extra margin of safety in the event that wave erosion is more severe than currently anticipated.

It is also recommended that an overflow culvert be installed above full service level to prevent accidental overtopping of the lagoon berms.

A berm crest width of 5 m has been proposed. This width should be adequate to permit construction equipment to travel around the crest of the berms to carry out maintenance of the berms as required.

4.5 Discharge Ditch

Erosion of the discharge ditch which carries effluent from the end of the discharge pipe to the ocean is a concern, because of the large flows which will be discharged from the outlet over a short period of time when the lagoon is emptied. This aspect should be examined in more detail during the detailed design phase. It is probable that rip rap and possibly some check structures may be required, depending on the maximum flows and gradient of the ditch. It is recommended that the design of the ditch be reviewed by a qualified hydrological engineer.

4.6 Truck Discharge

A sketch of the proposed truck discharge system is shown in Figure 3.1 of the pre-design report. It is understood that the outlet from the discharge pipe will be placed below about 0.8 m of water in the fall, in order to prevent the outlet from freezing up. This depth of water may not be sufficient to prevent the outlet from freezing.

4.7 Wind Erosion

The near surface soils in the vicinity of the sewage lagoon which contain more than 70 percent sand and silt size particles will be moderately susceptible to erosion, particularly when they dry out and are exposed near the top of the lagoon berms. It is recommended that a minimum thickness of 150 mm of gravel, which contains not more than 50 percent passing the #4 sieve (5 mm size) be placed on the inside and outside slopes of the lagoon berms in order to minimize possible wind erosion.

4.8 Fence Design

It is understood that a chain link fence will be installed around the lagoon.

Frost jacking of the fence posts will occur as a result of annual thawing and freezing of the active layer. Frost jacking can be reduced by placing fence posts in cone shaped concrete pedestals, with the large end of the cone placed down, and the base of the cone not less than 1.5 m below finished grade. Alternatively, fence posts could be placed to a depth of 3 m below finished grade, with the upper 1 m greased to reduce adfreeze forces in the active layer. If this arrangement is selected, it is also recommended that a wide flange or bar be welded onto the bottom of the post to anchor the post into the permafrost.

SECTION 5

ROAD DESIGN AND CONSTRUCTION

The pre-design report recommends that the access road to the facilities be constructed in the late summer in order to prevent excessive permafrost degradation. The method of road construction and the rational for this recommendation is not clear.

The road could be constructed by placing a minimum of 1 m of granular fill over the existing ground surface. Care should be taken not to disturb the existing surface vegetation prior to placing the fill. In poorly drained areas, additional fill may be required in order to achieve a satisfactory road surface. If this method of construction is used, it is preferable to place fill during the early summer, before the active layer reaches its maximum depth.

An alternative method of constucting the road would be to borrow native materials from the ditches in order to build up the road surface. If this approach is used, it would be preferable to construct the road in mid to late summer, when the active layer is deeper. This approach will not work where fine grained silts or clays are present near the ground surface because it will not be possible to drain such soils to the point where they will provide adequate bearing capacity.

Fill sideslopes for roads should be trimmed at 3 horizontal to 1 vertical in order to reduce erosion of the sideslopes as well as to provide a more stable shoulder.

It is recommended that past experience with road construction in the community be reviewed before a final decision is made as to the optimum method of road construction in this case.

SECTION 6

GEOTECHNICAL REVIEW

It is recommended that the design drawings and specifications for the access road, sewage lagoon and solid waste disposal facility be reviewed in detail by a qualified geotechnical engineer once the tender documents are 80 to 90 percent complete, and before they are submitted to prospective bidders.

APPENDIX A

Test Pit Logs

Grain Size Analyses

23 August 1984
File: (2577)52-89-01-01

GJOA HAVEN SOLID WASTES SITE
TEST PIT RECORD

Test Pit #1

0 to 0.1 m	organics with lichens
0.1 to 0.2 m	cobbles and sand
0.2 to 1.1	coarse sand SAMPLE

Test Pit #2

0 to 0.7 m	coarse sand
0.7 to 1.2 m	sand and gravel; W.T. @ 0.8; 0.75 after 20 min; SAMPLE

Test Pit #3

0 to 0.2 m	organics
0.2 to 1.0 m	cobbles and sand
1.0 to 1.1 m	sand and gravel SAMPLE

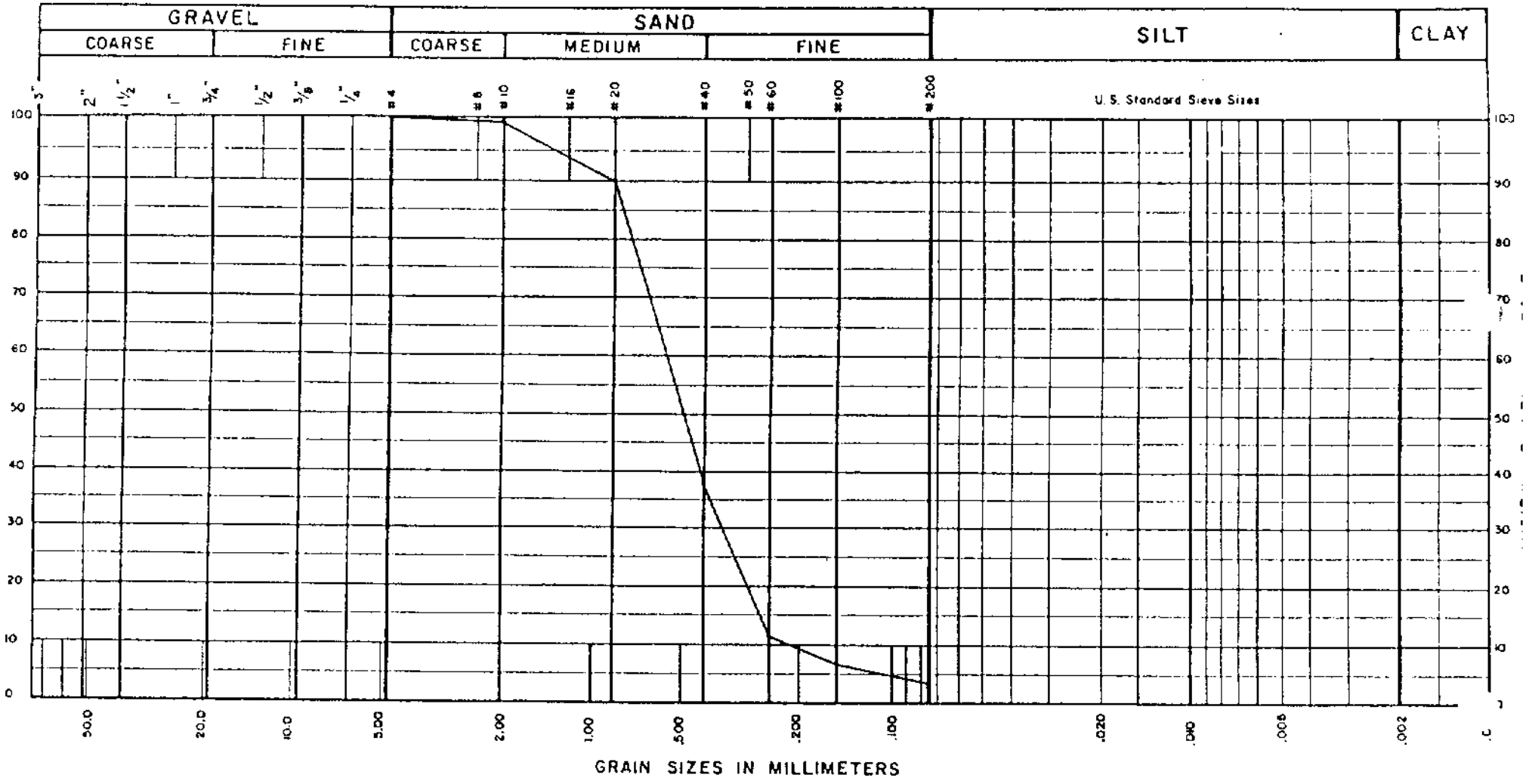
Test Pit #4

0 to 0.1 m	organics
0.1 to 1.0 m	coarse sand SAMPLE
1.0 to 1.2 m	sand and gravel; W.T. @ 1.0 m

H. J. Bourque, P. Eng.

THURBER

Unified Soil Classification System & N.R.C. Field Description (Modified with clay size at 0.002 mm)



		%
Nat. Water Content		
Liquid Limit		
Plastic Limit		
Plastic Index		

		%
Clay		
Silt	3	
Sand	97	
Gravel	0	

Classification

Clean Poorly Graded Soil (SP)

THURBER CONSULTANTS LTD., Geotechnical Engineers

CLIENT Stanley Associates

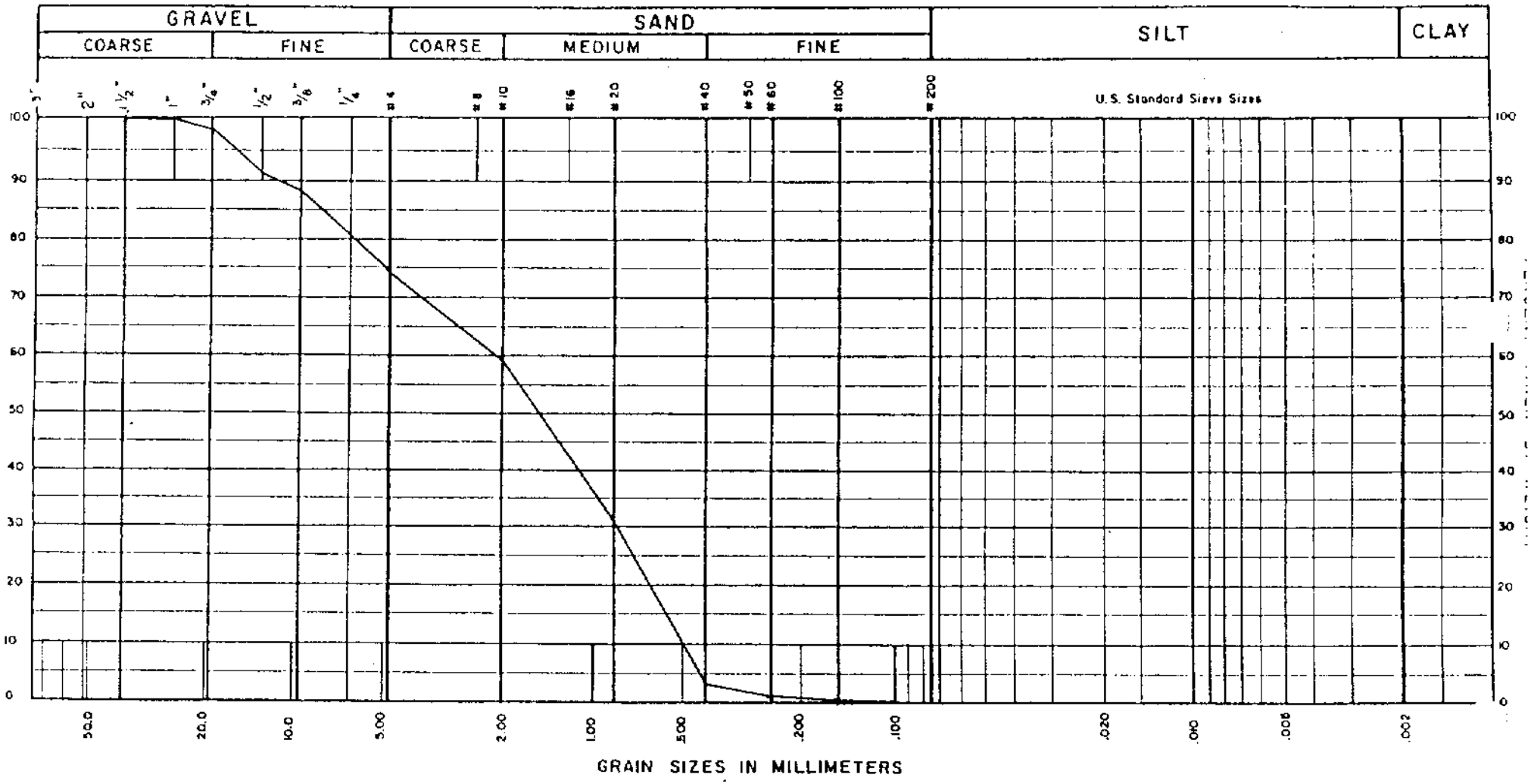
PROJECT Gjoa Haven Landfill

LOCATION Test Pit #1

SAMPLE

TEST DATE Aug 29/84 FILE Nº 17-308-14

Unified Soil Classification System & N.R.C. Field Description (Modified with clay size at 0.002 mm)



Nat. Water Content		%
Liquid Limit		
Plastic Limit		
Plastic Index		

Clay		%
Silt	0	
Sand	75	
Gravel	25	

Classification

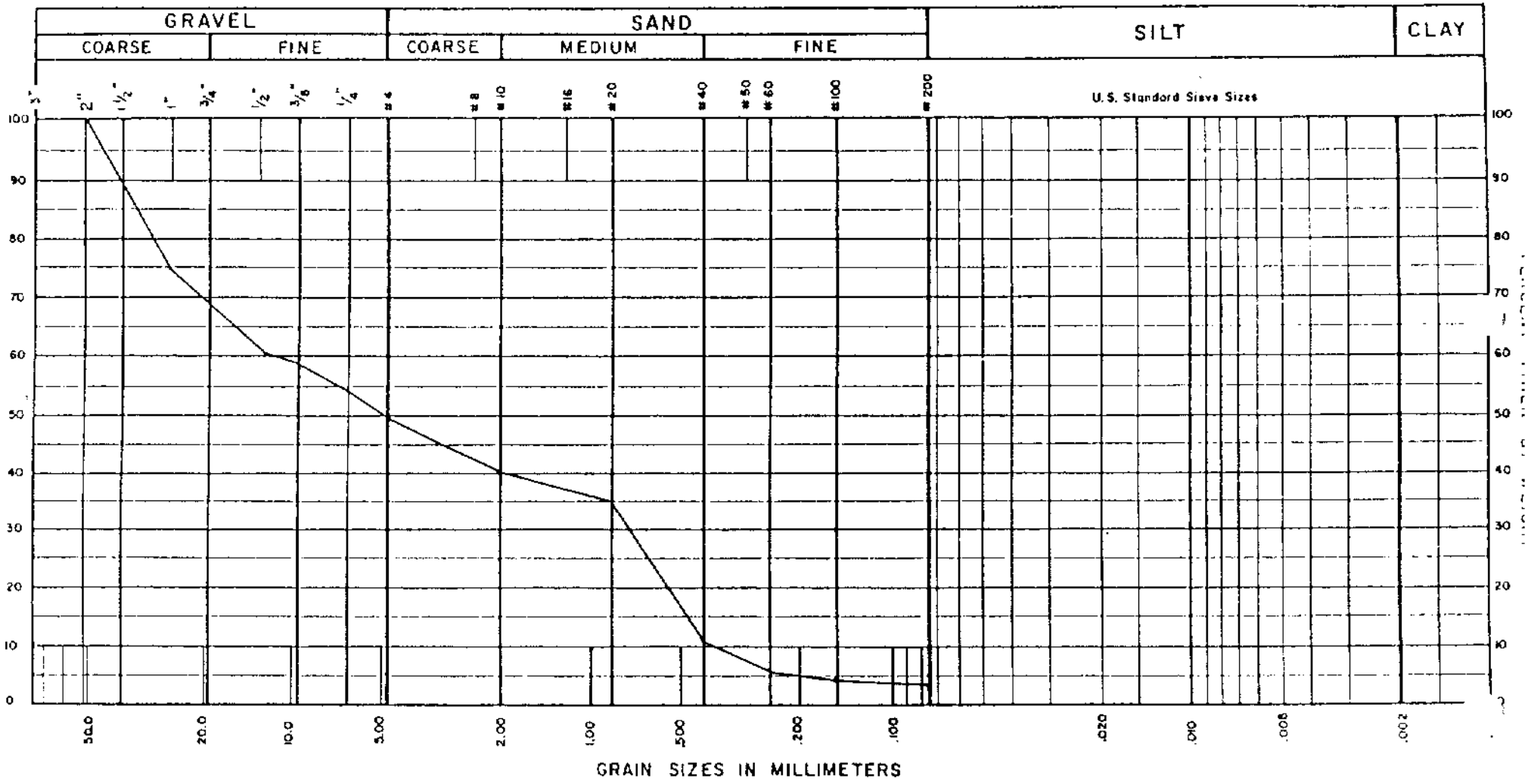
Clean Poorly Graded Sand (SP)

CLIENT	Stanley Associates
PROJECT	Gjoa Haven Landfill
LOCATION	Test Pit #2
SAMPLE	
TEST DATE	Aug 29/84

FILE No 17-308-14

THURBER CONSULTANTS LTD., Geotechnical Engineers

Unified Soil Classification System & N.R.C. Field Description (Modified with clay size at 0.002 mm)



Nat. Water Content		%
Liquid Limit		
Plastic Limit		
Plastic Index		

Clay		%
Silt	3	
Sand	46.8	
Gravel	51.1	

Classification

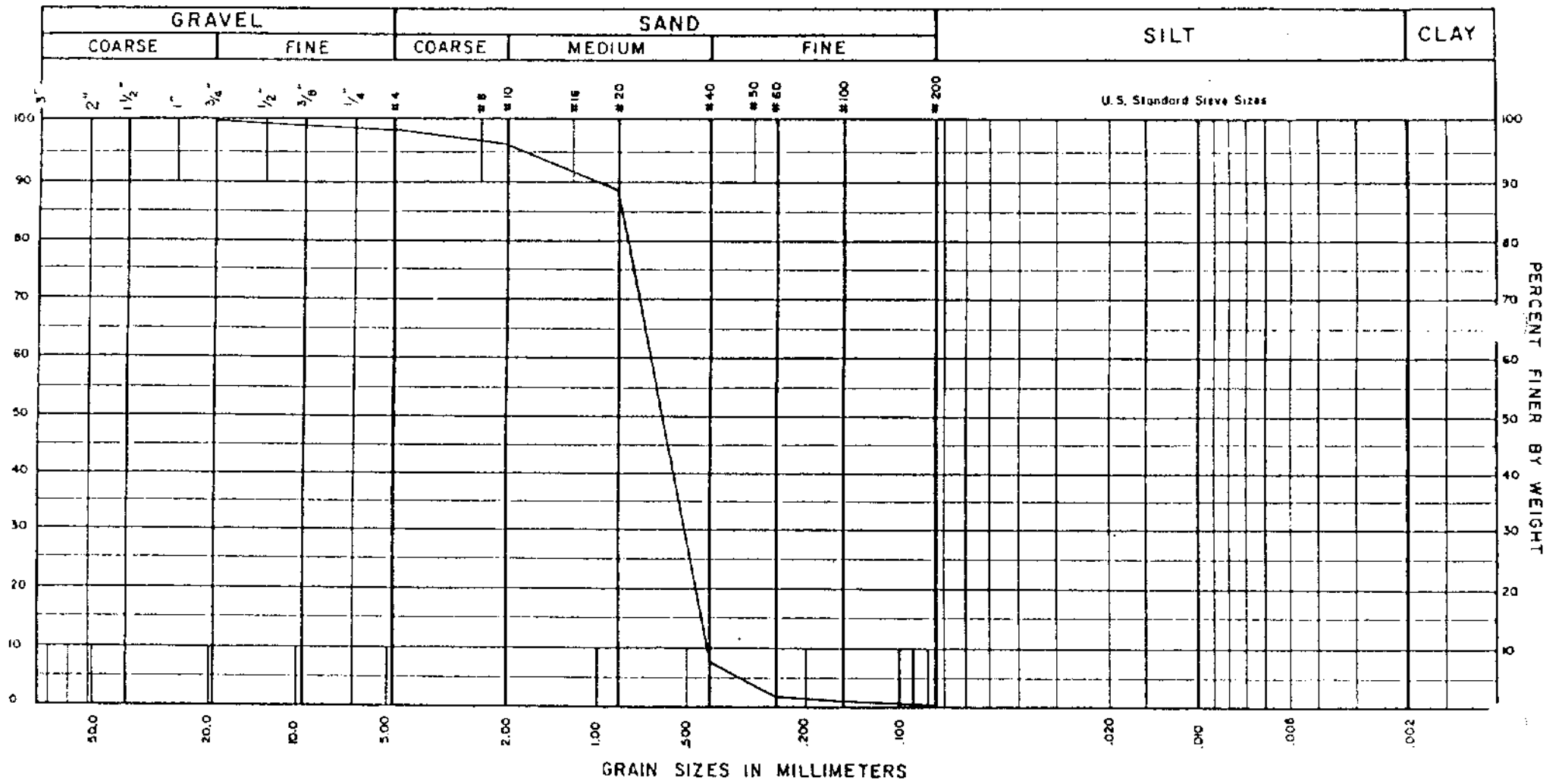
Clean Poorly Graded Gravel (GP)

CLIENT	Stanley Associates
PROJECT	Gjoa Haven Landfill
LOCATION	Test Pit #3
SAMPLE	0.5 m
TEST DATE	Aug 29/84

FILE Nº 17-308-14

THURBER CONSULTANTS LTD., Geotechnical Engineers

Unified Soil Classification System & N.R.C. Field Description (Modified with clay size at 0.002 mm)



Nat. Water Content			%
Liquid Limit			
Plastic Limit			
Plastic Index			

Clay		%
Silt	1	
Sand	97	
Gravel	2	

Classification

Clean Poorly Graded Sand (SP)

CLIENT	Stanley Associates
PROJECT	Gloa Haven Landfill
LOCATION	Test Pit #4
SAMPLE	1.0 m
TEST DATE	Aug 29/84
FILE Nº	17-308-14

THURBER CONSULTANTS LTD., Geotechnical Engineers