REPORT V4251/1
OCTOBER 1978

B.C. HYDRO AND POWER AUTHORITY

VANCOUVER B.C.

HAT CREEK PROJECT

COOLING WATER SUPPLY

PRELIMINARY DESIGN STUDY

SUPPLEMENTARY INVESTIGATIONS

SANDWELL

SANDWELL AND COMPANY LIMITED

SUITE 601 — 1550 ALBERNI STREET, VANCOUVER
B.C., CANADA V6G 1A4

31 October 1978

B. C. Hydro and Power Authority
Box 12121
555 West Hastings Street
Vancouver, B. C.
V6B 4T6

Attention: Mr. C. K. Harman, P. Eng.
Project Manager, Off-Site Facilities

Reference: V4251 Hat Creek Project
Cooling Water Supply
021.50 Preliminary Design Study
Supplementary Investigations

Dear Sirs:

We are pleased to present the attached copy of our Report V4251/1, Hat Creek Project, Cooling Water Supply, Preliminary Design Study, Supplementary Investigations, dated October 1978. Twenty copies have been sent to your attention under separate cover.

Yours truly

SANDWELL AND COMPANY LIMITED

A. Copeland, P. Eng.
Project Engineer

AC/jc
Attachment: Report V4251/1

SANDWELL

REPORT V4251/1
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
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SUMMARY

INTRODUCTION

In March 1978 Sandwell presented Report V4191/1, the Preliminary Design Study for the make-up water supply of B.C. Hydro's proposed 2000 MW* thermal power plant in the Hat Creek Valley near Ashcroft, B.C. Subsequent to that report, four supplementary investigations were carried out.

This report describes these investigations and also contains a breakdown of the Preliminary Design pipeline cost estimate. Investigations and cost breakdown are reported in five Project Memoranda, Appendix 2, a summary of which follows.

PIPELINE ROUTE REVIEW

In the Preliminary Design, a portion of the pipeline follows the 500 kV power transmission line planned to run due east from the power plant.

Project Memorandum V4251/1 reviews the pipeline route considering that the 500 kV transmission line would not be located in this area. In that case, the Preliminary Design scheme would change mainly as follows:

1. Routing: Section between Boston Flats and McLean Lake relocated.

2. Length: 22.4 km, 1.1 km shorter.

3. Waterhammer Protection:
   - One additional one-way surge tank.
   - Increased booster pump inertia at No. 2 Booster Station.

4. Direct Capital Cost: $33,980,000, $280,000 lower.

5. Minimum Energy Cost, Present Value: $20,861,000, $45,000 lower.

* Mega-watt. For this and other abbreviations, see Appendix 1, Glossary of Terms.

RESERVOIR RELOCATION

In the Preliminary Design the cooling water supply reservoir is located in close proximity to the power plant.

Project Memorandum V4251/4 reviews the water supply system considering that the reservoir would be located in upper Medicine Creek approximately 1 km further away from the power plant and approximately 125 m lower than the originally proposed reservoir. As for P.M. V4251/1, this study also assumes that the 500 kV transmission line is not a factor in route selection.

A scheme is recommended which differs mainly as follows from the Preliminary Design:

1.	Route:	- Section between Boston Flats and McLean Lake relocated (follows route recommended in P.M. V4191/1). - Last 2 km of pipeline relocated.
2.	Static Lift:	1013 m, 70 m lower.
3.	Length:	21.4 km, 2.1 km shorter.
4.	Pipeline Diameter:	7.3 km of 900 mm with the balance 800 mm, instead of 800 mm throughout.
5.	Waterhammer Protection:	- One additional simple surge tank. - Reduced booster pump inertia.
6.	Inlet to Reservoir:	Follows upstream end of reservoir valley instead of crossing under reservoir dam.
7.	Total Capital Cost:	\$46,000,000, \$1,400,000 lower.
8.	Minimum Energy Cost, Present Value:	\$15,699,000, \$5,207,000 lower, utilizing four million m^3 per annum of Medicine Creek run-off.
9.	Gravity Flow:	3.5 km of pipeline would flow by gravity, some of which partially full.

WATER TREATMENT BY MEANS OF SETTLING

Project Memorandum V4251/3 records and reviews water treatment proposals received during the Preliminary Design and recommends design parameters for a degritting clarifier. This method of treatment was selected during Preliminary Design to remove Thompson River water solids for the prevention of erosion in the high pressure pumps.

THOMPSON RIVER - WATER LEVEL DATA

Project Memorandum V4251/5 supplements water level data reported in the Preliminary Design Study for the proposed intake site. Water levels recorded here were taken at bimonthly intervals from 14 December 1977 until 1 July 1978.

PIPELINE - BREAKDOWN OF COST ESTIMATE

Project Memorandum V4251/2 records quantities, unit prices and breakdown of cost which were developed for the cost estimate of the water supply pipeline during Sandwell's Preliminary Design.

Prepared by ______________________
A. Copeland, P. Eng.

Approved by ______________________
Sandwell and Company Limited

APPENDIX 1

GLOSSARY OF TERMS

REPORT V4251/1
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

PRELIMINARY DESIGN STUDY
SUPPLEMENTARY INVESTIGATIONS

DATE OCTOBER 1978

APPENDIX 1 - GLOSSARY OF TERMS

Terms and Some Abbreviations

a	annum
^{o}C	degree Celcius
cm	centimetre
ft	foot
in	inch
kg	kilogram
km	kilometre
kWh	kilowatt hour
kPa	kilopascal
l/s	litre per second
m	metre
mm	millimetre
MW	mega-watt
m/s	metre per second
m^3/s	cubic metre per second
micron	one thousandth of a mm
mill	one thousandth of a dollar
pigs	Instrument packages which travel through a pipeline propelled by the flow for inspection or cleaning purposes.
psi	pounds per square inch
psig	pounds per square inch gauge
s	second
sq	square
USGPM	United States gallons per minute
waterhammer	The waves of pressure which travel in a pipeline when changes in flow occur.

Metric Units

Quantity	SI* Unit	Abbreviation	Equivalent	Imperial Unit
Length	millimetre	mm	0.03937	inch
	centimetre	cm	0.3937	inch
	metre	m	3.28	feet
			39.37	inches
	kilometre	km	0.6214	mile
			3280	feet
Area	square metre	m^2	10.87	square feet
	hectare	ha	2.471	acres
Volume	cubic metre	m^3	35.314	cubic feet
			264.17	US gallons
	litre	l	0.2642	US gallon
Discharge Rate	cubic metre per second	m^3/s	35.314	cubic feet per second
	litre per second	l/s	15.852	US gallons per minute
Force	newton	N	0.2248	pounds
Mass	tonne	t	2207	pounds
	kilogram	kg.	2.207	pounds
Pressure	pascal	Pa	0.000145	pounds per square inch
	kilopascal	kPa	0.145	pounds per square inch
	megapascal	mPa	145	pounds per square inch
Power	kilowatt	kW	1.34	horsepower
Velocity	metre per second	m/s	3.28	feet per second
Inertia	kilogram metre square	$kg.m^2$	0.737	slug.feet square

* International System of Units, as adopted by the Canadian Construction Industry.

APPENDIX 2

PROJECT MEMORANDA

PROJECT MEMORANDUM V4251/1

PIPELINE ROUTE REVIEW

SANDWELL

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

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PROJECT MEMORANDUM V4251/1
PIPELINE ROUTE REVIEW

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PROJECT V4251
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PROJECT MEMORANDUM V4251/1
PIPELINE ROUTE REVIEW

INTRODUCTION

In a letter to Mr. D. A. Brundrett of Sandwell, dated 22 February 1978, Mr. C. K. Harman of B.C. Hydro and Power Authority requested a review of the pipeline route described in Sandwell's Preliminary Design Study, Report V4191/1, March 1978. The reason for and extent of this review were given as follows:

> "Review and select optimum pipeline route between Boston Flats and McLean Lake on the assumption that the 500 kV transmission line would not be located in this area. If a new pipeline route is chosen, select a new location for No. 2 booster station. Revise the drawings and cost estimates to reflect the new locations."

This memorandum records the studies done to determine the optimum route and presents the results. The selection of the optimum route is based on capital and operating cost, and on other considerations.

Rather than revising the previous drawings, Sandwell has prepared new drawings to show the routes studied. Cost estimate revisions have been limited to a cursory identification of cost differences rather than an in-depth review of the entire project estimate.

ROUTES STUDIED

The routes studied are shown on Drawings B4251/1-1 and D4251/1-2, and their profiles on Drawing D4251/1-3, all in Appendix 2. The routes are:

- Preliminary Design Route as presented in Sandwell Report V4191/1, March 1978.
- Alternatives 1, 2 and 3, which, including the booster station locations, were developed using maps and air photos, but without a field visit.

Alternative 1 avoids the lake at Station 11+000 and much of the rock excavation of the Preliminary Design Route.

Alternative 2 follows a strip of favourable topography and also avoids the rock and lake mentioned.

Alternative 3 is basically the same as the Conceptual Design Route (Report V4007/2, January 1977), except that it has been shifted about 1 km north at the top of the hill above Boston Flats to avoid some difficult terrain which became apparent during the helicopter survey on 8 November 1977.

A combination utilizing the lower portion of Alternative 3 with the upper portion of Alternative 2, joining after the booster station, was considered to reduce clearing on the upper portion of Alternative 2 while avoiding the eroding zone on its lower portion. However, as this combination would require extensive sidehill construction and would increase the pipeline length with few offsetting advantages, it was not developed.

The Preliminary Design Route requires two one-way surge tanks and increased booster pump inertia to control waterhammer pressures in the pipeline. B.C. Hydro assessed waterhammer control facilities only for the most promising Scheme, Alternative 3, and found that it requires an additional one-way surge tank (total of three) as well as increased booster pump inertia at No. 2 Booster Station. Waterhammer control facilities for Alternatives 1 and 2 were assumed to be the same as for the Preliminary Design Route.

Geotechnical stability was not appraised for each route alternative owing to time and budget limitations. Previous studies have resulted in favourable assessments of the area so that the routes shown are expected to be geotechnically acceptable.

Cost differences and other considerations were determined using air photos (Reference 1*), topographic maps (Reference 2), photographs and impressions from previous field visits.

CAPITAL COST

Only those items in the Preliminary Design cost estimate which vary significantly from route to route were included in the cost analysis.

The direct costs shown in Table 1 are for the section of pipeline where the route is altered - that is, from Station 5 + 560 to Station 14 + 150, using the original stationing from Report V4191/1. Unit prices from the Preliminary Design estimate have been used, which were based on the fourth quarter of 1977.

* For references, see Appendix 1

Table 1 - Partial Cost Estimate, Station 5 + 560 to 14 + 150

Item		Preliminary Design	Alternative 1	Alternative 2	Alternative 3
Dept. 272.00 - Water Pipeline					
272.63	Grading	$ 105,000	$ 77,200	$ 100,500	$ 78,900
272.65	Pipe	1,693,400	1,688,600	1,502,700	1,430,200
272.67	Trenching	1,278,800	1,292,300	1,256,300	1,267,300
272.70	Line-up	217,300	213,500	191,700	187,500
272.71	Welding	160,800	160,100	143,000	135,000
272.74	Lower-in	248,600	245,500	220,300	215,600
272.75	Bedding	127,000	90,900	124,200	96,800
272.78	Backfill	148,600	144,300	133,000	128,000
272.83	Surge Tank Systems	-	*	*	250,000
272.86	Drainage Pipelines	231,500	87,600	118,300	75,700
Sub-Total		4,211,000	$ 4,000,000*	$ 3,790,000*	$ 3,865,000
Dept. 274.00 - No. 2 Booster Station					
274.86	Drainage Pipelines	$ 74,000	$ 74,000	$ 172,000	$ 240,000
274.93	Overflow Reservoir	890,000	890,000	690,000	620,000
274.94	Access Roads	35,000	43,000	108,000	155,000
Sub-Total		$ 999,000	$ 1,007,000	$ 970,000	$ 1,015,000
Dept. 291.00 Power Supply & Distribution					
291.51	69 kV Transmission Line	- Nil -	$ 3,000	$ 25,000	$ 50,000
Sub-Total		- Nil -	$ 3,000	$ 25,000	$ 50,000
Total of Partial Direct Cost		$5,210,000	$ 5,010,000*	$ 4,785,000*	$ 4,930,000

Notes on Capital Cost Estimate

1. Items 272.63, 67, 75 and 78, respectively grading, trenching, bedding and backfill are influenced by the depth of rock under the surface. The assumptions for rock depth are shown on Drawing D4251/1-3.

* Waterhammer analyses would be necessary to determine if additional surge tanks are required. The cost of an extra tank would be about $250,000.

2. Items 272.70, 71, and 74, respectively line-up, welding and lower-in, vary in accordance with the grade and wall thickness as shown on Drawing D4251/1-3.

3. Item 272.83, Surge Tank Systems, is based on analysis of the Preliminary Design Route and Alternative 3, but without analysis of Alternatives 1 and 2. Conceivably, 1 or 2 may require additional waterhammer control measures.

4. Item 272.86, drainage pipelines, is based on the drain points shown on Drawing D4251/1-2.

5. Items 274.86, the concrete-lined overflow trench at the second booster station, and 274.94, access roads, are as shown on Drawing D4251/1-2.

6. The overflow reservoir embankments, 274.93, are based on borrowed material as follows:

Alternative 1, as for Preliminary Design	97,000 m^3
Alternative 2	72,500 m^3
Alternative 3	63,000 m^3

7. B.C. Hydro and Power Authority was responsible for the design and cost estimate for the 69 kV transmission line during the Preliminary Design studies. Therefore, Item 291.51 was excluded from Report V4191/1, and only the extra length of line from the arc shown on Drawing D4191/2 is included here at $31,000/km.

OPERATING COST

Energy cost for pumping over the 35 year project lifetime due to the friction of the extra pipeline length compared to the shortest route, Alternative 3, is as shown in Table 2.

Table 2 - Present Value of Energy Cost Based On
20 Mills per Kwh and 8% Interest

Route	Extra Length (m)	Minimum (Pumping at 725 l/s continuously)	Maximum (Pumping at 1,580 l/s for 46% of the time)
Preliminary Design	1,090	$ 45,000	$ 210,000
Alternative 1	1,035	40,000	200,000
Alternative 2	140	5,000	30,000
Alternative 3	0	0	0

OTHER CONSIDERATIONS

The partial cost estimates in Table 1 do not reflect basic engineering design concepts and changes in unit prices which may be caused by differences in construction conditions. These aspects are shown and explained in Table 3, and each route is ranked from 1 (best) to 4 in each category.

Table 3 - Other Considerations of Pipeline Routings

Item	Why Considered	Distinguishing Characteristic	Ranking* Preliminary Design	Alternative 1	Alternative 2	Alternative 3
CONSTRUCTION						
Steepness	Partial cost estimate does not distinguish the degree of steepness.	Slope from Boston Flats to First summit, approximately at El. 1300.	1	2	4	3
Sidehill construction	Cost is more for sidehill, as it requires an excavated working road.	Based on topographic maps.	4	2	3	1
General access	Cost of upgrading or building construction roads.	Distance from existing forest road network.	1	2	3	4
DESIGN						
Spillage path	Potential for damage due to a pipeline breakage.	Worst - Highway junction at Boston Flats; Better-fields; hay fields at Boston Flats. Alternative 3 has a remote chance of flooding I.R.2.	3	4	1	2
Watercourse capacity for overflow from reservoir.	Affects size of outlet from overflow reservoir, therefore capacity of reservoir required.	Appearance on air photos and maps.	3	2	4	1
Crossing of Farmland	Disruption during construction, right-of-way cost.	Measured length.	4	3	2	1
Adjustability of route	Ease of making small route changes - flexibility.	Width of band in which route can be located.	4	3	2	1
Booster Station Location	Ease of construction and flexibility.	Adjustability of location and general site steepness.	2	1	4	3
Eroding Zones	Depth of bury of pipe may be increased.	Field photographs and air photos.	1	3	4	2
Overflow Reservoir	Adjustability in size and location.	Suitable alternative locations and capability for expansion.	1	1	4	3
		TOTAL	24	23	31	21

* Ranking is from 1 (best) to 4.

CONCLUSIONS

The capital and operating costs favour Alternatives 2 and 3 over Alternative 1 and the Preliminary Design Route. The cost differences are as follows:

Table 4 - Cost Differences

Item	Route: Preliminary Design	Alternative 1	Alternative 2	Alternative 3
Partial Capital Cost (Table 1)	$ 5,210,000	$ 5,010,000*	$ 4,785,000*	$ 4,930,000
Minimum Operating Cost (Table 2)	45,000	40,000	5,000	0
Total	$ 5,255,000	$ 5,050,000*	$ 4,790,000*	$ 4,930,000
Savings Relative to Preliminary Design	-	$ 205,000*	$ 465,000*	$ 325,000
Savings as % of Total Direct Cost of Preliminary Design	-	0.6%	1.4%	0.9%

The reasons why Alternatives 2 and 3 are more economical are mainly:

- Shorter pipe length.
- Fewer pipeline drainage facilities.
- Smaller overflow reservoir embankment.

The cost advantage of Alternative 3 over Alternative 2 would be reversed if Alternative 2 also needed an additional one-way surge tank. This difference is only 0.4 percent of the total direct cost.

Other considerations shown on Table 3 determine the selection of Alternative 3 rather than 2, as it ranks 10 points better. The superiority of Alternative 3 is mainly attributable to the categories sidehill construction, watercourse capacity for overflow, and passage through eroding zones, as well as slight advantages in five other categories. Alternative 2 has only slight advantages in two categories: general access and spillage path.

* Waterhammer analyses would be necessary to determine if additional surge tanks are required. The cost of an extra tank would be about $250,000.

In conclusion, Alternative 3 offers cost savings and is in other ways superior to the other routes, and thus is recommended by Sandwell.

The route selection and booster station location should be confirmed by geotechnical evaluation and field appraisal.

Prepared by

A. P. Basham, P. Eng.

Approved by

A. Copeland, P. Eng.

APPENDIX 1

REFERENCES

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 23 JUNE 1978

PROJECT MEMORANDUM V4251/1
PIPELINE ROUTE REVIEW

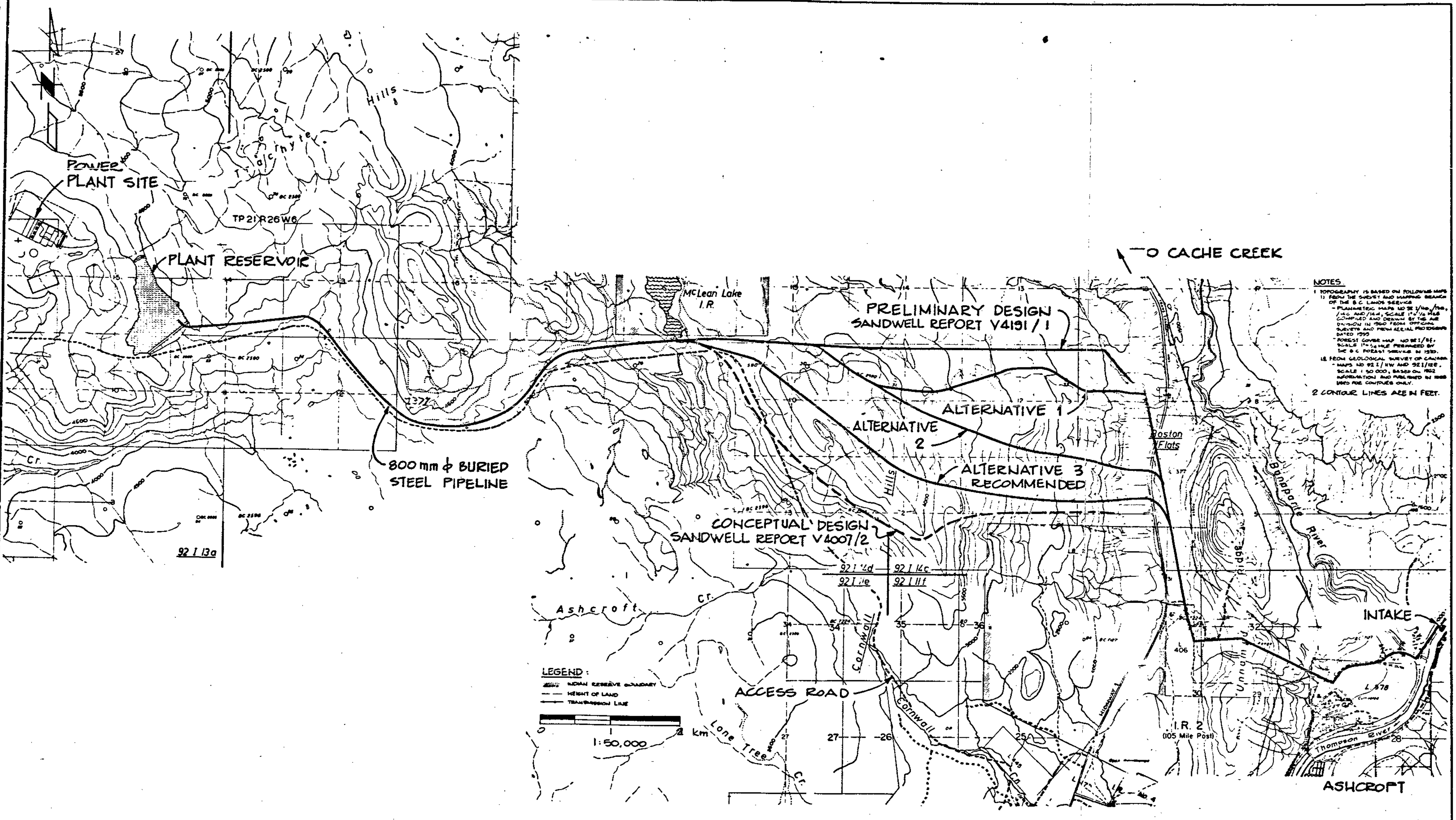
APPENDIX 1 - REFERENCES

1. Four McElhanney Air Photographs - MA 1044-06315-0-6660 through -6663 of September 1976 (Approximate Scale 1" = 2400 ft).

2. Integrated Resources Photography Limited, Topographic Mapping, Project 77-245, prepared from reference 1, Sheets 3, 4 and 5 of October 1977.

APPENDIX 2

ILLUSTRATIONS



DES	RECD
DWN SH	APPD
CHKD HB	APPD
INSP	APPD R.C.
SUBD	DATE JUNE 1978

SANDWELL DWG. NO.

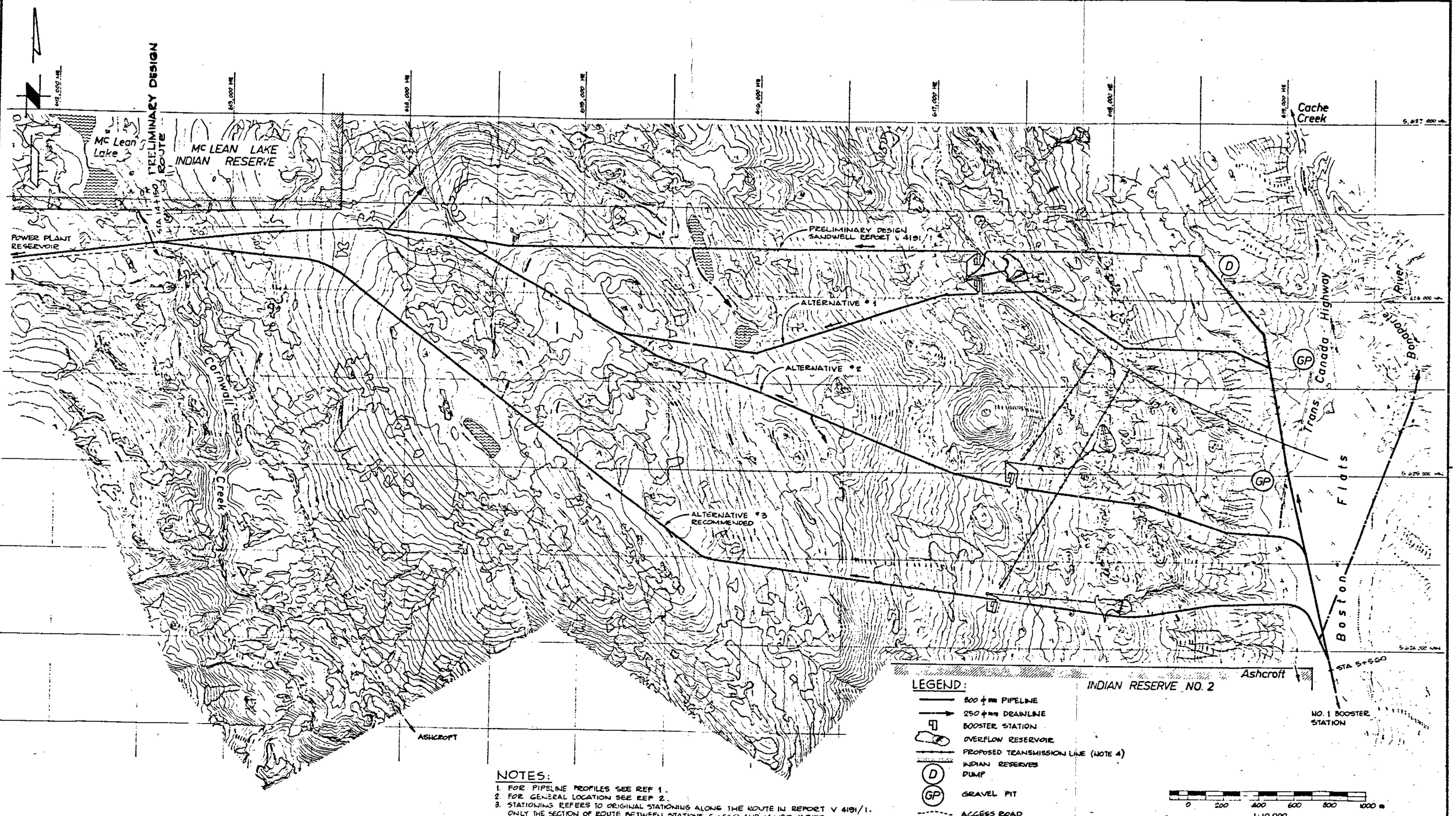
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
COOLING WATER SUPPLY
PIPELINE ROUTE REVIEW
PIPELINE ROUTES

SCALE AS SHOWN

DWG. No. B 4251 / 1-1 R

REFERENCE DRAWINGS | REFERENCE DRAWINGS | REVISIONS | REVISIONS



NOTES:

1. FOR PIPELINE PROFILES SEE REF 1.
2. FOR GENERAL LOCATION SEE REF 2.
3. STATIONING REFERS TO ORIGINAL STATIONING ALONG THE ROUTE IN REPORT V 4191/1. ONLY THE SECTION OF ROUTE BETWEEN STATIONS 5+560 AND 14+150 VARIES FROM THIS ROUTE.
4. THE TRANSMISSION LINES SHOWN ARE THE EXTRA LENGTH REQUIRED FOR SUPPLY FROM A NEW SUBSTATION NEAR CACHE CREEK. THE LINES STOP SHORT OF THE BOOSTER STATION FOR CLARITY, AND RUN TO AN ARC INDICATING APPROXIMATE EQUAL DISTANCE FROM THE SUBSTATION.

B 4251/1-1	PIPELINE ROUTES	2
D 4251/1-3	PIPELINE PROFILES	1
REFERENCE DRAWINGS		NO.

REFERENCE DRAWINGS

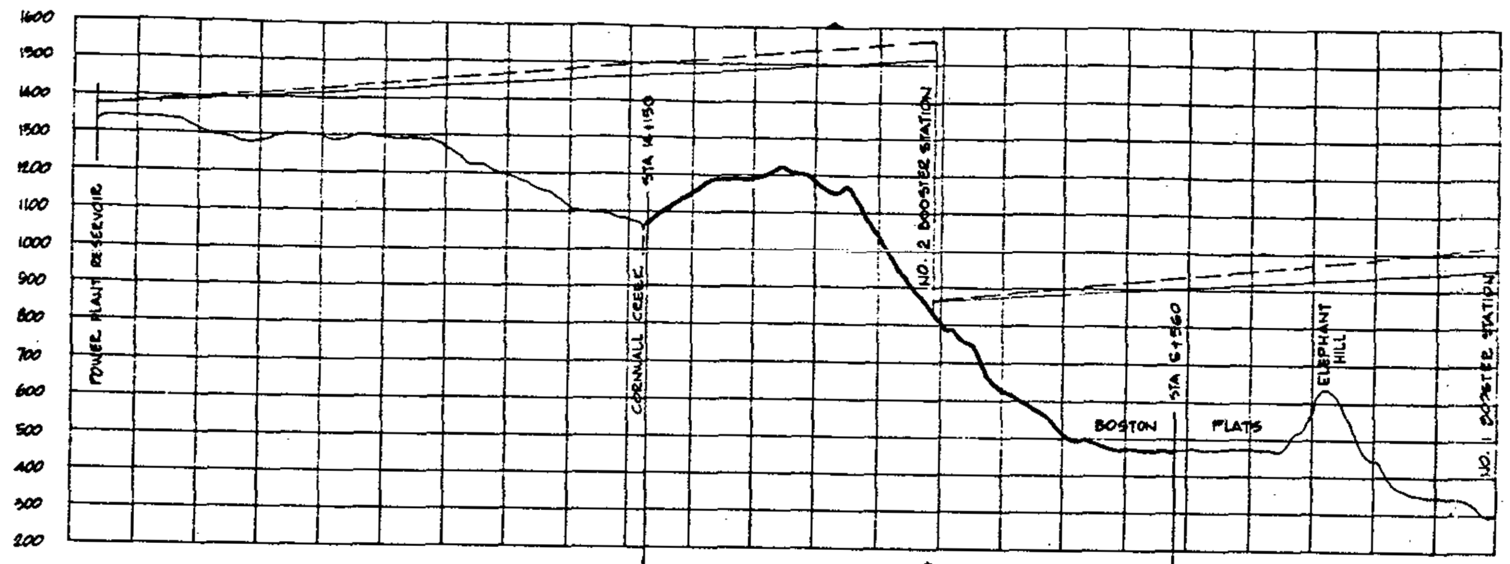
DES		RECD	
DWN	SH	APPD	
CHKD	LPB	APPD	
INSP		APPD	A.C.
SUBD		DATE	JUNE 1978
MICROFILMED		DIST'N CODE	

SANDWELL

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
COOLING WATER SUPPLY
PIPELINE ROUTE REVIEW
DETAILED PIPELINE ROUTES

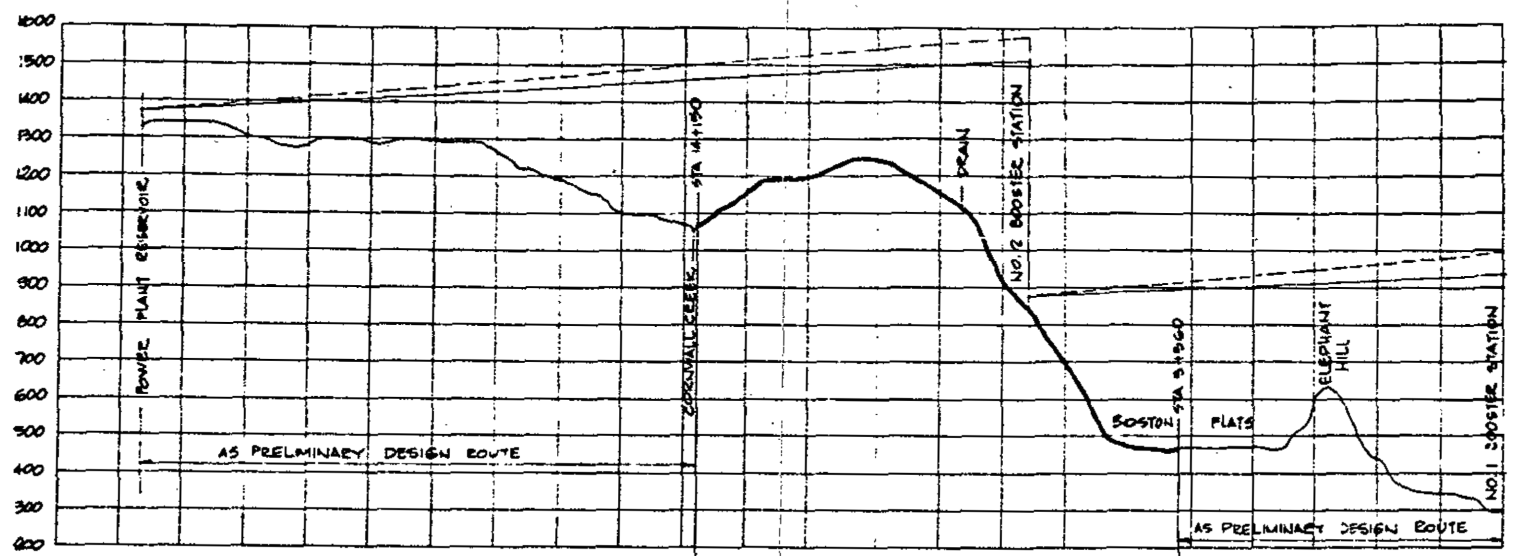
SCALE AS SHOWN | DWG No. D 4251/1-2 R



11	8	11	16	8	11	WALL THICKNESS
4.73	3,43	4,73	6.92	3.43	4.73	DESIGN PRESSURE
750	1880	880	870	2050	2060	LENGTH
STEEP	FLAT	STEEP	STEEP	STEEP	FLAT	STEEPNESS

2	0	2	1	0	1	0		> 3	DEPTH OF ROCK } ASSUMED
150	100	1700	1000	500	1700	300	500	2640	LENGTH } ASSUMED

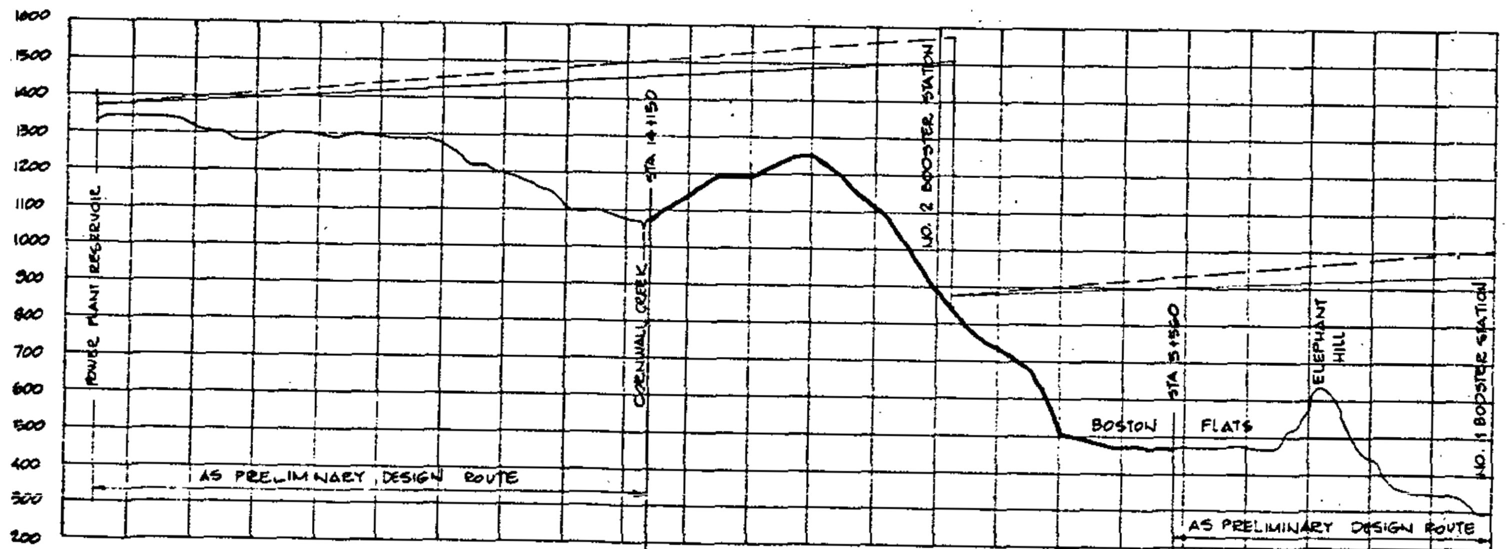
PRELIMINARY DESIGN ROUTE
SANDWELL REPORT V4191/1



11	8	11	16	8	11	WALL THICKNESS
4.73	3.43	4.73	6.92	3.43	4.73	DESIGN PRESSURE
800	2550	000	850	1250	90	LENGTH
STEEP	FLAT	STEEP	STEEP	STEEP	FLAT	STEEPNESS

2	0	2	1	0	0	> 3	DEPTH OF ROCK } ASSUMED
350	100	2240	2260	500	300	650	LENGTH } ASSUMED

ALTERNATIVE #2



11	8	11	16	8	11	WALL THICKNESS
4.73	3.43	4.73	6.92	3.43	4.73	DESIGN PRESSURE
750	2300	835	950	1750	1950	LENGTH
STEEP	FLAT	STEEP	STEEP	STEEP	FLAT	STEEPNESS

2	0	2	1	0	0	> 3	DEPTH OF ROCK } ASSUMED
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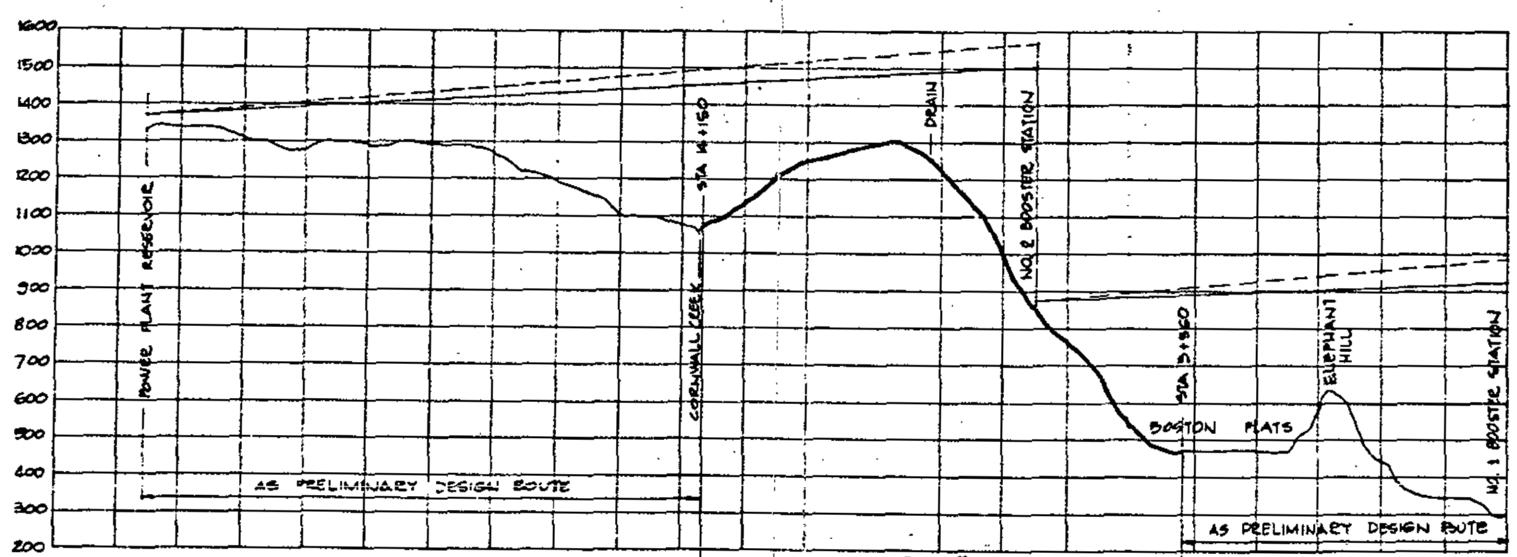
ALTERNATIVE #1



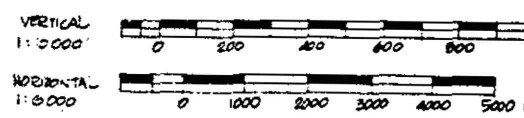
11	8	11	16	8	11	WALL THICKNESS
4.73	3.43	4.73	6.92	3.43	4.73	DESIGN PRESSURE
800	2550	600	750	400	600	LENGTH
STEEP	FLAT	STEEP	STEEP	STEEP	FLAT	STEEPNESS

2	0	2	1	0		> 3	DEPTH OF ROCK } ASSUMED
400	100	000	3800	500	400	500	LENGTH } ASSUMED

ALTERNATIVE #3
RECOMMENDED

NOTES:

1. FOR DETAILED PIPELINE ROUTES SEE REF 1.
2. STATIONING REFERS TO ORIGINAL STATIONING ALONG THE PRELIMINARY DESIGN ROUTE SANDWELL REPORT V4191/1.
3. ONLY THE SECTION OF PIPELINE ROUTE MARKED * FOR WHICH DETAILS ARE PROVIDED DIFFERS FROM ROUTE TO ROUTE. THE LENGTHS MARKED * AND THOSE IN THE TABLES BELOW ARE TAKEN ALONG THE SLOPE.
4. WALL THICKNESS IN mm
   DESIGN PRESSURE IN MPa
   OTHERS IN METRES



LEGEND

——— HYDRAULIC GRADE LINE
– – – – DESIGN GRADE LINE

DES		RECD	
DWN	SH	APPD	
CHKD	ARB	APPD	
INSP		APPD	A.C.
SCED		DATE	JUNE 1978
MICROFILMED		DIST'N CODE	

SANDWELL DWG. NO.
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
COOLING WATER SUPPLY
PIPELINE ROUTE REVIEW
PIPELINE PROFILES

SCALE: AS SHOWN
DWG No. D 4251 / 1-3 R

D 4251/1-2	DETAILED PIPELINE ROUTES	1
	REFERENCE DRAWINGS	NO

REFERENCE DRAWINGS

R	NO	REMARKS	DATE	MADE	CHKD	INSP	SUBD	RECD	APPD	APPD

REVISIONS

R	NO	REMARKS	DATE	MADE	CHKD	INSP	SUBD	RECD	APPD	APPD

REVISIONS

PROJECT MEMORANDUM V4251/2

PIPELINE - BREAKDOWN OF COST ESTIMATE

SANDWELL

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B. C. HYDRO AND POWER AUTHORITY
VANCOUVER B. C.

DATE 21 APRIL 1978

PROJECT MEMORANDUM V4251/2
PIPELINE
BREAKDOWN OF COST ESTIMATE

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PROJECT V4251
HAT CREEK PROJECT
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B. C. HYDRO AND POWER AUTHORITY
VANCOUVER B. C.

DATE 21 APRIL 1978

PROJECT MEMORANDUM V4251/2
PIPELINE
BREAKDOWN OF COST ESTIMATE

PURPOSE AND BACKGROUND

The purpose of this memorandum is to record quantities, unit prices and breakdown of cost which were developed for the cost estimate of the water supply pipeline, during Sandwell's Preliminary Design Study, Project V4191. The cost estimate recorded here comprises the pipeline from Thompson River intake to plant reservoir and is based on the Preliminary Design Study route proposed in Volume 1 of Sandwell's Report V4191/1 of March 1978. This route is also shown on Drawing B4251/2-1 in Appendix 2 of this memorandum.

To incorporate appropriate unit prices, the pipeline was divided into 14 sections. Appendix 1 contains a cost breakdown, quantities and unit prices for each of the 14 pipeline sections.

Table 1 on the following page is a summation of the pipeline costs broken down by sub accounts.

This table is identical to the one given on page 2 of Appendix 5, Details of Cost Estimate, Structures, contained in Volume 1 of Sandwell's Report V4191/1.

For a description of the basis of the estimates refer to Page 59, Volume 1, of Report V4191/1.

Table 1 - Details of Cost Estimate

Department 272 - Water Pipeline		Material	Labour	Total
272.62	Clearing	$ -	$ 115,000	$ 115,000
272.63	Grading	-	295,000	295,000
272.64	Stockpile	-	25,000	25,000
272.65	Pipe	4,880,000	-	4,880,000
272.66	Haul and String	25,000	315,000	340,000
272.67	Trenching	-	3,400 000	3,400 000
272.68	Dewatering	40,000	210,000	250,000
272.69	Bending	-	510,000	510,000
272.70	Line-up	-	525,000	525,000
272.71	Welding	-	450,000	450,000
272.72	Patch Joints	60,000	220,000	280,000
272.73	Anchors	10,000	20,000	30,000
272.74	Lower-in and Tie-in	-	640,000	640,000
272.75	Bedding	175,000	190,000	365,000
272.76	X-Rays	75,000	-	75,000
272.77	Testing - Hydro and Pig	-	120,000	120,000
272.78	Backfill	40,000	195,000	235,000
272.79	Crossings - Road and Gaslines	30,000	85,000	115,000
272.80	Crossings - Railroad	10,000	20,000	30,000
272.81	Crossings - Stream	80,000	175,000	255,000
272.82	Clean-up and Hydro-Seeding	-	195,000	195,000
272.86	Drainage Pipelines	335,000	970,000	1,305,000
272.87	Access Manholes	40,000	10,000	50,000
272.88	Pig Traps	745,000	180,000	925,000
272.90	Land Cost	120,000	5,000	125,000
Total, Department 272		$ 6,665,000	$ 8,870,000	$ 15,535,000

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APPENDIX 1

COST BREAKDOWN

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B. C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 21 APRIL 1978

PROJECT MEMORANDUM V4251/2
PIPELINE
BREAKDOWN OF COST ESTIMATE

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APPENDIX 1 - COST BREAKDOWN

The cost breakdown for the pipeline is given in the following 14 pages, each covering a section of the pipeline, as follows:

Section	Station From m	Station To m	Length m	Total Cost $(Rounded)	Average Cost $/m
1 - From intake to first booster pumping station.	-	-	697	450,000	645.6
2 - Starts at first booster pumping station.	0 + 300	2 + 000	1700	1,205,000	708.8
3 -	2 + 000	3 + 500	1500	1,305,000	870.0
4 -	3 + 500	8 + 000	4500	2,700,000	600.0
5 -	8 + 000	8 + 500	500	270,000	540.0
6 -	8 + 500	8 + 800	300	230,000	766.7
7 - Includes piping around second booster pumping station.	8 + 800	10 + 500	1700	1,700,000	1000.0
8 -	10 + 500	11 + 000	500	435,000	870.0
9 -	11 + 000	12 + 000	1000	775,000	775.0
10 -	12 + 000	13 + 700	1700	965,000	567.6
11 -	13 + 700	13 + 800	100	80,000	800.0
12 -	13 + 800	18 + 500	4700	2,640,000	561.7
13 -	18 + 500	20 + 500	2000	1,065,000	532.5
14 -	20 + 500	23 + 090	2590	1,715,000	662.2
Totals			23487 m	$15,535,000	$661.4

PIPELINE SECTION - 1

LENGTH: 697 m plus standpipe

FROM INTAKE
TO NO. 1 BOOSTER STATION

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	Nil	-	-	-	
.63	Grading - Earth	801 m	-	5.0/m	-	4,000	4,000	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	Nil	-	-	-	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	-	-	-	-	-	-	
	x 11 mm Wall Thickness	-	-	-	-	-	-	
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	734 m	193.48/m	-	142,015	-)	-	
	- 1200 Ø x 6.5 mm Wall Thickness	102 m	205.33/m	-	20,945	-)	182,960	
	Shop Bends and/or Tees	4	5,000	-	20,000	-)	-	
.66	Haul and String	-	1.00/m	13.12/m	840	11,000	11,840	
.67	Trenching - All Soil to 3 m Depth	80/m	-	72.00/m	-	57,675	57,675	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	801 m	1.65/m	9.85/m	1,320	7,890	9,210	
.69	Bending	801 m	-	21.35/m	-	17,100	17,100	
.70	Line-up	836 m	-	20.00/m	-	16,720	16,720	
.71	Welding	836 m	-	18.00/m	-	15,050	15,050	
.72	Patch Joints	836 m	2.50/m	9.15/m	2,090	7,650	9,740	
.73	Anchors	125 m @ 38%	2.00/m	3.60/m	250	450	700	
.74	Lower-in and Tie-in	801 m	-	25.50/m	-	20,425	20,425	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	801 m	0.65/m	4.60/m	480	3,725	4,205	
.76	X-rays	-	3.24/m	-	2,710	-	2,710	
.77	Testing - Hydro and Pig	836 m	-	5.00/m	-	4,180	4,180	
.78	Backfill	801 m	-	8.20/m	-	6,570	6,570	
.79	Crossings - Road and Gaslines - Open Cut	20 m	-	280.00/m	-	5,600	5,600	
	- Bore and Case	20 m	-	985.00/m	-	19,700	19,700	
.80	Crossings - Railroad - Bore and Case	20 m	-	1,315.00/m	9,000	20,400	29,400	
.81	Crossings - Stream	Bonaparte River - L.S.	-	-	4,000	16,000	20,000	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	6,570	6,570	
.86	Drainage Pipelines	-	-	-	-	-	-	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	300 m	5.20/m	0.21/m	1,560	65	1,625	
	Total						445,980	$639.9/m
	Total-Rounded						450,000	645.6/m

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PIPELINE SECTION - 2

LENGTH: 1700 m

FROM NO. 1 BOOSTER STATION
STATION 0 + 300
TO STATION 2 + 000

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	1,700 m	-	2.26/m	-	3,845	3,845	
.63	Grading - Earth	1,700 m	-	5.00/m	-	8,500	8,500	
	- Rock		-	-	-	-	-	
.64	Stockpile	1,700	-	1.15/m	-	1,955	1,955	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	-	-	-	-	-	-	
	x 11 mm Wall Thickness	-	-	-	-	-	-	
	x 17 mm Wall Thickness	1,700	309.71/m	-	526,510	-)	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-)	531,510	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-)		
	Shop Bends and/or Tees	1	5,000	-	5,000	-)		
.66	Haul and String	-	1.00/m	13.15/m	1,700	22,355	24,055	
.67	Trenching - All Soil to 3 m Depth	-	-	72.00/m	-	122,400	122,400	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	9.85/m	2,805	16,745	19,550	
.69	Bending	-	-	21.35/m	-	36,295	36,295	
.70	Line-up	-	-	20.00/m	-	34,000	34,000	
.71	Welding	-	-	18.00/m	-	30,600	30,600	
.72	Patch Joints	-	2.50/m	9.15/m	4,250	15,555	19,805	
.73	Anchors	-	-	-	-	-	-	
.74	Lower-in and Tie-in	-	-	25.50/m	-	43,350	43,350	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	4.60/m	1,105	7,820	8,925	
.76	X-rays	-	3.24/m	-	5,510	-	5,510	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	8,500	8,500	
.78	Backfill	-	-	8.20/m	-	13,940	13,940	
.79	Crossings - Road and Gaslines - Open Cut	-	135 m	280/m	-	37,800	37,800	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	13,940	13,940	
.86	Drainage Pipelines	-	-	-	-	-	-	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	1 - L.S.	-	185,960	44,740	230,700	
.90	Land Costs	-	5.20/m	0.21	8,840	335	9,195	
	Total						1,204,375	$708.5/m
	Total-Rounded						1,205,000	708.8/m

(P.M. V4251/2, App. 1)

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PIPELINE SECTION - 3

LENGTH: 1500 m

FROM STATION 2 + 000

TO STATION 3 + 500

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Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	2.26/m	-	3,390	3,390	
.63	Grading - Earth	-	-	-	-	-	-	
	- Rock	-	-	74.00/m	-	111,000	111,000	
.64	Stockpile	-	-	-	-	-	-	
.65	Pipe - 800 ∅ x 8 mm Wall Thickness	-	-	-	-	-	-	
	x 11 mm Wall Thickness	640 m	210.87/m	-	177,130	-)	381,540	
	x 17 mm Wall Thickness	660 m	309.71/m	-	204,410	-)		
	- 900 ∅ x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 ∅ x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	1,500 m	1.00/m	13/15/m	1,500	19,725	21,225	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	250.00/m	-	375,000	375,000	
.68	Dewatering	-	-	-	-	-	-	
.69	Bending	-	-	21.35/m	-	32,025	32,025	
.70	Line-up	-	-	30.00/m	-	45,000	45,000	
.71	Welding	-	-	21.60/m	-	32,400	32,400	
.72	Patch Joints	-	2.50/m	9.15/m	3,750	13,725	17,475	
.73	Anchors	1,500 m - 25%	1.65/m	3.15/m	2,475	4,725	7,200	
.74	Lower-in and Tie-in	-	-	32.00/m	-	48,000	48,000	
.75	Bedding - Concrete	-	60.00/m	35.00/m	90,000	52,500	142,500	
	- Mulch	-	-	-	-	-	-	
.76	X-rays	-	3.24/m		4,860	-	4,860	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	7,500	7,500	
.78	Backfill	-	6.80/m	8.00/m	10,200	12,300	22,500	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	20 m		985.00/m	7,880	11,820	19,700	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20	-	12,300	12,300	
.86	Drainage Pipelines	-	-	-				
.87	Access Manholes	-	L.S.	-	9,200	2,000	11,200	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	7,800	315	8,115	
	Total						1,302,930	$868.6/m
	Total-Rounded						1,305,000	870.0/m

(P.M. V4251, App. 1)

PIPELINE SECTION -4 FROM STATION 3 + 500

LENGTH: 4500 m TO STATION 8 + 000

			Unit Price		Cost			Average
Account	Description	Amount	Material	Labour	Material	Labour	Total	Cost $/m
272.62	Clearing	-	-	2.26/m	-	10,170	10,170	
.63	Grading - Earth	-	-	5.00/m	-	22,500	22,500	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	1.15	-	5,175	5,175	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	400 m	160.24/m	-	64,095	-)	-	
	x 11 mm Wall Thickness	3,420 m	210/87 m	-	721,175	-)	-	
	x 17 mm Wall Thickness	680 m	309.71/m	-	210,605	-)	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-)	1,005,875	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-)	-	
	Shop Bends and/or Tees	2	5,000	-	10,000	-	-	
.66	Haul and String	-	1.00/m	13.15/m	4,500	59,175	63,675	
.67	Trenching - All Soil to 3 m Depth	-	-	72.00/m		324,000	324,000	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	9.85/m	7,425	44,325	51,750	
.69	Bending	-	-	21.35/m	-	96,075	96,075	
.70	Line-up	-	-	20.00/m	-	90,000	90,000	
.71	Welding	-	-	18.00/m	-	81,000	81,000	
.72	Patch Joints	-	2.50/m	9.15/m	11,250	41,175	52,425	
.73	Anchors	1,500 m - 10%	0.50/m	1.00/m	750	1,500	2,250	
.74	Lower-in and Tie-in	-	-	25.50/m	-	114,750	114,750	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	4.60/m	2,925	20,700	23,625	
.76	X-rays	-	3.24/m	-	14,580	-	14,580	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	22,500	22,500	
.78	Backfill	-	-	8.20/m	-	36,900	36,900	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	50 m	-	985.00/m	19,700	29,550	49,250	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	36,900	36,900	
.86	Drainage Pipelines	1 - 1,600 m	L.S.	-	116,210	454,890	571,100	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	23,400	945	24,345	
	Total						2,698,845	$599.7/m
	Total-Rounded						2,700,000	600.0/m

(P.M. V4251/2, App. 1)

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PIPELINE SECTION - 5

LENGTH: 500 m

FROM STATION 8 + 000

TO STATION 8 + 500

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	2.26/m	-	1,130	1,130	
.63	Grading - Earth	-	-	6.50/m	-	3,250	3,250	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	1.15/m	-	575	575	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	500 m	160.24/m	-	80,120	-	80,120	
	x 11 mm Wall Thickness	-	-	-	-	-	-	
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	-	1.00/m	13.15/m	500	6,575	7,075	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	181.50/m	-	90,750	90,750	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	9.85/m	825	4,925	5,750	
.69	Bending	-	-	21.35/m	-	10,675	10,675	
.70	Line-up	-	-	30.00/m	-	15,000	15,000	
.71	Welding	-	-	21.60/m	-	10,800	10,800	
.72	Patch Joints	-	2.50/m	9.15/m	1,250	4,575	5,825	
.73	Anchors	-	0.50	1.00	250	500	750	
.74	Lower-in and Tie-in	-	-	32.00/m	-	16,000	16,000	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	5.60/m	325	2,300	2,625	
.76	X-rays	-	3.24/m	-	1,620	-	1,620	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	2,500	2,500	
.78	Backfill	-	8.40/m	8.20/m	4,200	4,100	8,300	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	4,100	4,100	
.86	Drainage Pipelines	-	-	-	-	-	-	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	2,600	105	2,705	
	Total						269,550	$539.1/m
	Total-Rounded						270,000	540.0/m

(P.M. V4251/2, App. 1)

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PIPELINE SECTION - 6

LENGTH: 300 m

FROM STATION 8 + 500

TO STATION 8 + 800

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	6.80/m	-	2,040	2,040	
.63	Grading - Earth	-	-	-	-	-	-	
	- Rock	-	-	74.00/m	-	22,200	22,200	
.64	Stockpile	-	-	-	-	-	-	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	300 m	160.24/m	-	48,075	-	48,075	
	x 11 mm Wall Thickness	-	-	-	-	-	-	
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	-	1.00/m	13.15/m	300	3,945	4,245	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	250.00/m	-	75,000	75,000	
.68	Dewatering	-	-	-	-	-	-	
.69	Bending	-	-	21.35/m	-	6,405	6,405	
.70	Line-up	-	-	30.00/m	-	9,000	9,000	
.71	Welding	-	-	21.60/m	-	6,480	6,480	
.72	Patch Joints	-	2.50/m	9.15/m	750	2,745	3,495	
.73	Anchors	300 m - 25%	1.65/m	3.15/m	495	945	1,440	
.74	Lower-in and Tie-in	-	-	32.00/m	-	9,600	9,600	
.75	Bedding - Concrete	-	60.00/m	35.00/m	18,000	10,500	28,500	
	- Mulch	-	-	-	-	-	-	
.76	X-rays	-	3.24/m	-	970	-	970	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	1,500	1,500	
.78	Backfill	-	6.80/m	8.20/m	2,040	2,460	4,500	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	2,460	2,460	
.86	Drainage Pipelines	-	-	-	-	-	-	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	1,560	65	1,625	
	Total						227,535	$758.5/m
	Total-Rounded						230,000	766.7/m

SANDWELL

PIPELINE SECTION - 7

LENGTH: 1700 m

FROM STATION 8 + 800

TO STATION 10 + 500

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	7.05/m	-	13,925	13,925	
.63	Grading - Earth	-	-	6.50/m	-	12,840	12,840	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	1.15/m	-	2,275	2,275	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	955 m	160.24/m	-	153,030	-)	-	
	x 11 mm Wall Thickness	-	-	-	-	-)	-	
	x 17 mm Wall Thickness	870 m	309.71/m	-	269,450	-)	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-)	458,280	
	- 1200 Ø x 6.5 mm Wall Thickness	150 m	205.33/m	-	30,800	-)	-	
	Shop Bends and/or Tees	1	5,000 ea	-	5,000	-)	-	
.66	Haul and String	-	1.00/m	13.15/m	1,975	25,975	27,950	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	181.50/m	-	358,465	358,465	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	9.85/m	3,260	19,455	22,715	
.69	Bending	-	-	21.35/m	-	42,170	42,170	
.70	Line-up	-	-	30.00/m	-	59,250	59,250	
.71	Welding	-	-	21.60/m	-	42,660	42,660	
.72	Patch Joints	-	2.50/m	9.15/m	4,940	18,070	23,010	
.73	Anchors	1,700 m - 15%	1.00/m	1.80/m	1,975	3,555	5,530	
.74	Lower-in and Tie-in	-	-	32.00/m	-	63,200	63,200	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	4.60/m	1,285	9,085	10,370	
.76	X-rays	-	3.24	-	5,510	-	5,510	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	9,875	9,875	
.78	Backfill	-	-	8.20/m	-	16,195	16,195	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	16,195	16,195	
.86	Drainage Pipelines	#2-	L.S.	L.S.	21,230	13,650	34,880	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	2	L.S.	L.S.	371,920	89,480	461,400	
.90	Land Costs	-	5.20/m	0.21/m	8,840	355	9,195	
	Total						1,695,890	$997.6/m
	Total-Rounded						1,700,000	1000.0/m

PIPELINE SECTION 8

LENGTH: 500 m

FROM STATION 10 + 500

TO STATION 11 + 000

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	9.05/m	-	4,525	4,525	
.63	Grading - Earth	-	-	-	-	-	-	
	- Rock	-	-	74.00/m	-	37,000	37,000	
.64	Stockpile	-	-	-	-	-	-	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	-	-	-	-	-	-	
	x 11 mm Wall Thickness	500 m	210.87	-	105,435)			
	x 17 mm Wall Thickness	-	-	-	-)			
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-)		115,435	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-)			
	Shop Bends and/or Tees	2	5,000	-	10,000)			
.66	Haul and String	-	1.00/m	13.15/m	500	6,575	7,075	
.67	*Trenching - All Soil to 3 m Depth*	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	250.00/m	-	125,000	125,000	
.68	Dewatering	Plus Pump Out Lake-Allow	1.65/m	9.85/m	3,000	12,000	15,000	
.69	Bending	-	-	21.35/m	-	10,675	10,675	
.70	Line-up	-	-	30.00/m	-	15,000	15,000	
.71	Welding	-	-	21.60/m	-	10,800	10,800	
.72	Patch Joints	-	2.50/m	9.15/m	1,250	4,575	5,825	
.73	Anchors	25%	1.65	3.15	825	1,575	2,400	
.74	Lower-in and Tie-in	-	-	32.00/m	-	16,000	16,000	
.75	Bedding - Concrete	-	60.00/m	35.00/m	30,000	17,500	47,500	
	- Mulch	-	-	-	-	-	-	
.76	X-rays	-	3.24/m	-	1,620	-	1,620	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	2,500	2,500	
.78	Backfill	-	6.80/m	8.20/m	3,400	4,100	7,500	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	4,100	4,100	
.86	*Drainage Pipelines*	-	-	-	-	-	-	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	2,600	105	2,705	
	Total						430,660	$861.3/m
	Total-Rounded						435,000	870.0/m

(P.M. V4251/2, App. 1)

SANDWELL

PIPELINE SECTION 9

LENGTH: 1000 m

FROM STATION 11 + 000

TO STATION 12 + 000

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	–	–	9.05/m	–	9,050	9,050	
.63	Grading – Earth	–	–	5.00/m	–	5,000	5,000	
	– Rock	–	–	–	–	–	–	
.64	Stockpile	–	–	1.15/m	–	1,150	1,150	
.65	Pipe – 800 Ø x 8 mm Wall Thickness	600 m	160.24/m	–	96,145	–)	180,495	
	x 11 mm Wall Thickness	400 m	210.87/m	–	84,350	–)		
	x 17 mm Wall Thickness	–	–	–	–	–	–	
	– 900 Ø x 9 mm Wall Thickness	–	–	–	–	–	–	
	– 1200 Ø x 6.5 mm Wall Thickness	–	–	–	–	–	–	
	Shop Bends and/or Tees	–	–	–	–	–	–	
.66	Haul and String	–	1.00/m	13.15/m	1,000	13,150	14,150	
.67	Trenching – All Soil to 3 m Depth	–	–	–	–	–	–	
	– 2 m Soil + 1 m Rock	–	–	–	–	–	–	
	– 1 m Soil + 2 m Rock	–	–	181.50/m	–	181,500	181,500	
	– All Rock to 3 m Depth	–	–	–	–	–	–	
.68	Dewatering	–	1.65/m	9.85/m	1,650	9,850	11,500	
.69	Bending	–	–	21.35/m	–	21,350	21,350	
.70	Line-up	–	–	20.00/m	–	20,000	20,000	
.71	Welding	–	–	18.00/m	–	18,000	18,000	
.72	Patch Joints	–	2.50/m	9.15/m	2,500	9,150	11,650	
.73	Anchors	–	0.50/m	1.00/m	500	1,000	1,500	
.74	Lower-in and Tie-in	–	–	25.50/m	–	25,500	25,500	
.75	Bedding – Concrete	–	–	–	–	–	–	
	– Mulch	–	0.65/m	4.60/m	650	4,600	5,250	
.76	X-rays	–	3.24/m	–	3,240	–	3,240	
.77	Testing – Hydro and Pig	–	–	5.00/m	–	5,000	5,000	
.78	Backfill	–	–	8.20/m	–	8,200	8,200	
.79	Crossings – Road and Gaslines – Open Cut	–	–	–	–	–	–	
	– Bore and Case	–	–	–	–	–	–	
.80	Crossings – Railroad – Bore and Case	–	–	–	–	–	–	
.81	Crossings – Stream	–	–	–	–	–	–	
.82	Clean-up and Hydro-Seeding	–	–	8.20/m	–	8,200	8,200	
.86	Drainage Pipelines	#3 – 500 m L.S.	–	–	53,160	170,955	224,115	
.87	Access Manholes	1 – L.S.	–	–	9,200	2,000	11,200	
.88	Pig Traps	–	–	–	–	–	–	
.90	Land Costs	–	5.20/m	0.21/m	5,200	210	5,410	
	Total						771,460	$771.5/m
	Total-Rounded						775,000	775.0/m

(P.M. V4251/2, App. 1)

SANDWELL

PIPELINE SECTION 10

LENGTH: 1700 m

FROM STATION 12 + 000

TO STATION 13 + 700

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	6.92/m	-	11,765	11,765	
.63	Grading - Earth	-	-	5.50/m	-	9,350	9,350	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	1.15/m	-	1,955	1,955	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	1,380 m	160.24/m	-	221,135	-)	288,615	
	x 11 mm Wall Thickness	320 m	210.87	-	67,480	-)		
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	-	1.00/m	13.15/m	1,700	22,355	24,055	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	145.00/m	-	-	246,500	246,500	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	9.85/m	2,805	16,745	19,550	
.69	Bending	-	-	21.35/m	-	36,295	36,295	
.70	Line-up	-	-	20.00/m	-	34,000	34,000	
.71	Welding	-	-	18.00/m	-	30,600	30,600	
.72	Patch Joints	-	2.50/m	9.15/m	4,250	15,555	19,805	
.73	Anchors	-	0.50/m	1.00/m	850	1,700	2,550	
.74	Lower-in and Tie-in	-	-	25.50/m	-	43,350	43,350	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	4.60/m	1,105	7,820	8,925	
.76	X-rays	-	3.24/m	-	5,510	-	5,510	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	8,500	8,500	
.78	Backfill	-	-	8.20/m	-	13,940	13,940	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	13,940	13,940	
.86	Drainage Pipelines	#4 - 300 m L.S.	-	-	38,350	93,710	132,060	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	8,840	355	9,195	
	Total						960,460	$565.0/m
	Total-Rounded						965,000	567.6/m

SANDWELL

PIPELINE SECTION 11

LENGTH: 100 m

FROM STATION 13 + 700

TO STATION 13 + 800

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	-	-	-	-	
.63	Grading - Earth	-	-	-	-	-	-	
	- Rock	-	-	74.00/m	-	7,400	7,400	
.64	Stockpile	-	-	-	-	-	-	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	-	-	-	-	-	-	
	x 11 mm Wall Thickness	100 m	210.87/m	-	21,090	-	21,090	
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	-	1.00/m	13.15/m	100	1,315	1,415	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	250.00/m	-	25,000	25,000	
.68	Dewatering	-	1.65/m	9.85/m	165	985	1,150	
.69	Bending	-	-	21.35/m	-	2,135	2,135	
.70	Line-up	-	-	20.00/m	-	2,000	2,000	
.71	Welding	-	-	18.00/m	-	1,800	1,800	
.72	Patch Joints	-	2.50/m	9.15/m	250	915	1,165	
.73	Anchors	-	-	-	-	-	-	
.74	Lower-in and Tie-in	-	-	25.50/m	-	2,550	2,550	
.75	Bedding - Concrete	-	60.00/m	35.00/m	6,000	3,500	9,500	
	- Mulch	-	-	-	-	-	-	
.76	X-rays	-	3.24/m	-	325	-	325	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	500	500	
.78	Backfill	-	6.80/m	8.20/m	680	820	1,500	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	820	820	
.86	Drainage Pipelines	-	-	-	-	-	-	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	520	20	540	
	Total						78,890	$788.9/m
	Total-Rounded						80.000	800.0/m

SANDWELL

PIPELINE SECTION 12

LENGTH: 4700 m

FROM STATION 13 + 800

TO STATION 18 + 500

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	6.22/m	-	29,235	29,235	
.63	Grading - Earth	-	-	5.50/m	-	25,850	25,850	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	1.15/m	-	5,405	5,405	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	2,890 m	160.24/m	-	463,095	-)	844,770	
	x 11 mm Wall Thickness	1,810 m	210.87/m	-	381,675	-)		
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	-	1.00/m	13.15/m	4,700	61,805	66,505	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	145.00/m	-	681,500	681,500	
	- 1 m Soil + 2 m Rock	-	-	-	-	-	-	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	9.85/m	7,755	46,295	54,050	
.69	Bending	-	-	21.35/m	-	100,345	100,345	
.70	Line-up	-	-	20.00/m	-	94,000	94,000	
.71	Welding	-	-	18.00/m	-	84,600	84,600	
.72	Patch Joints	-	2.50/m	9.15/m	11,750	43,005	54,755	
.73	Anchors	-	0.50/m	1.00/m	2,350	4,700	7,050	
.74	Lower-in and Tie-in	-	-	25.50/m	-	119,850	119,850	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	4.60/m	3,055	21,620	24,675	
.76	X-rays	-	3.24/m	-	15,230	-	15,230	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	23,500	23,500	
.78	Backfill	-	-	8.20/m	-	38,540	38,540	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	Cornwall Creek L.S.	-	-	74,415	159,505	233,920	
.82	Clean-up and Hydro-Seeding	-	-	8.20	-	38,540	38,540	
.86	Drainage Pipelines	#5 - 20 m + #6 - 20 m L.S.	-	-	38,900	28,480	67,380	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	24,440	985	25,425	
	Total						2,635,125	$560.7/m
	Total-Rounded						2,640,000	561.7/m

(P.M. V4251/2, App. 1)

SANDWELL

PIPELINE SECTION 13 | FROM STATION 18 + 500

LENGTH: 2000 m | TO STATION 20 + 500

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	-	-	4.08/m	-	8,160	8,160	
.63	Grading - Earth	-	-	5.00/m	-	10,000	10,000	
	- Rock	-	-	-	-	-	-	
.64	Stockpile	-	-	1.15/m	-	2,300	2,300	
.65	Pipe - 800 Ø x 8 mm Wall Thickness	2,000 m	160.24/m	-	320,480	-	320,480	
	x 11 mm Wall Thickness	-	-	-	-	-	-	
	x 17 mm Wall Thickness	-	-	-	-	-	-	
	- 900 Ø x 9 mm Wall Thickness	-	-	-	-	-	-	
	- 1200 Ø x 6.5 mm Wall Thickness	-	-	-	-	-	-	
	Shop Bends and/or Tees	-	-	-	-	-	-	
.66	Haul and String	-	1.00/m	13.15/m	2,000	26,300	28,300	
.67	Trenching - All Soil to 3 m Depth	-	-	-	-	-	-	
	- 2 m Soil + 1 m Rock	-	-	-	-	-	-	
	- 1 m Soil + 2 m Rock	-	-	181.50	-	363,000	363,000	
	- All Rock to 3 m Depth	-	-	-	-	-	-	
.68	Dewatering	-	1.65/m	1.85/m	3,300	3,700	7,000	
.69	Bending	-	-	21.35/m	-	42,700	42,700	
.70	Line-up	-	-	20.00/m	-	40,000	40,000	
.71	Welding	-	-	18.00/m	-	36,000	36,000	
.72	Patch Joints	-	2.50/m	9.15/m	5,000	18,300	23,300	
.73	Anchors	-	-	-	-	-	-	
.74	Lower-in and Tie-in	-	-	25.50/m	-	51,000	51,000	
.75	Bedding - Concrete	-	-	-	-	-	-	
	- Mulch	-	0.65/m	4.60/m	1,300	9,200	10,500	
.76	X-rays	-	3.24/m	-	6,480	-	6,480	
.77	Testing - Hydro and Pig	-	-	5.00/m	-	10,000	10,000	
.78	Backfill	-	-	8.20/m	-	16,400	16,400	
.79	Crossings - Road and Gaslines - Open Cut	-	-	-	-	-	-	
	- Bore and Case	-	-	-	-	-	-	
.80	Crossings - Railroad - Bore and Case	-	-	-	-	-	-	
.81	Crossings - Stream	-	-	-	-	-	-	
.82	Clean-up and Hydro-Seeding	-	-	8.20/m	-	16,400	16,400	
.86	Drainage Pipelines	#7 - 100 m L.S.	-	-	21,695	40,300	61,995	
.87	Access Manholes	-	-	-	-	-	-	
.88	Pig Traps	-	-	-	-	-	-	
.90	Land Costs	-	5.20/m	0.21/m	10,400	420	10,820	
	Total						1,064,835	$532.4/m
	Total-Rounded						1,065,000	532.5/m

(P.M. V4251/2, App. 1)

SANDWELL

PIPELINE SECTION 14

LENGTH: 2590 m

FROM STATION 20 + 500

TO STATION 23 + 090

Account	Description	Amount	Unit Price Material	Unit Price Labour	Cost Material	Cost Labour	Cost Total	Average Cost $/m
272.62	Clearing	–	–	5.50/m	–	14,245	14,245	
.63	Grading – Earth	–	–	5.00/m	–	12,950	12,950	
	– Rock			–	–	–	–	
.64	Stockpile	–	–	1.15/m	–	2,980	2,980	
.65	Pipe – 800 ø x 8 mm Wall Thickness	2,590 m	160.24	–	415,025	–)		
	x 11 mm Wall Thickness	–	–	–	–	–)		
	x 17 mm Wall Thickness	–	–	–	–	–)	420,025	
	– 900 ø x 9 mm Wall Thickness	–	–	–	–	–)		
	– 1200 ø x 6.5 mm Wall Thickness	–	–	–	–	–)		
	Shop Bends and/or Tees	1	5,000	–	5,000	–)		
.66	Haul and String	–	1.00/m	13.15/m	2,590	34,060	36,650	
.67	Trenching – All Soil to 3 m Depth	–		–	–	–	–	
	– 2 m Soil + 1 m Rock	–	–	145.00/m	–	375,550	375,550	
	– 1 m Soil + 2 m Rock	–	–	–	–	–	–	
	– All Rock to 3 m Depth	–	–	–	–	–	–	
.68	Dewatering	–	1.65/m	9.85/m	4,275	25,515	29,790	
.69	Bending	–	–	21.35/m	–	55,300	55,300	
.70	Line-up	–	–	20.00/m	–	51,800	51,800	
.71	Welding	–	–	18.00/m	–	46,620	46,620	
.72	Patch Joints	–	2.50/m	9.15/m	6,475	23,700	30,175	
.73	Anchors	–	–	–	–	–	–	
.74	Lower-in and Tie-in	–	–	25.50/m	–	66,045	66,045	
.75	Bedding – Concrete	250 m	60.00	35.00	15,000	8,750	23,750	
	– Mulch	2,590 m	0.65/m	4.60/m	1,685	11,915	13,600	
.76	X-rays	–	3.24/m	–	8,390	–	8,390	
.77	Testing – Hydro and Pig	–	–	5.00/m	–	12,950	12,950	
.78	Backfill	–	–	8.20/m	–	21,240	21,240	
.79	Crossings – Road and Gaslines – Open Cut	–	–	–	–	–	–	
	– Bore and Case	–	–	–	–	–	–	
.80	Crossings – Railroad – Bore and Case	–	–	–	–	–	–	
.81	Crossings – Stream	–	–	–	–	–	–	
.82	Clean-up and Hydro-Seeding	–	–	8.20/m	–	21,240	21,240	
.86	Drainage Pipelines	#8 – 500 m L.S.	–	–	46,155	167,415	213,570	
.87	Access Manholes	1 L.S.	–	–	9,200	2,000	11,200	
.88	Pig Traps	1 L.S.	–	–	185,960	44,740	230,700	
.90	Land Costs	–	5.20/m	0.21/m	13,470	545	14,015	
	Total						1,712,785	$661.3/m
	Total-Rounded						1,715,000	662.2/m

(V4251/2, App. 1)

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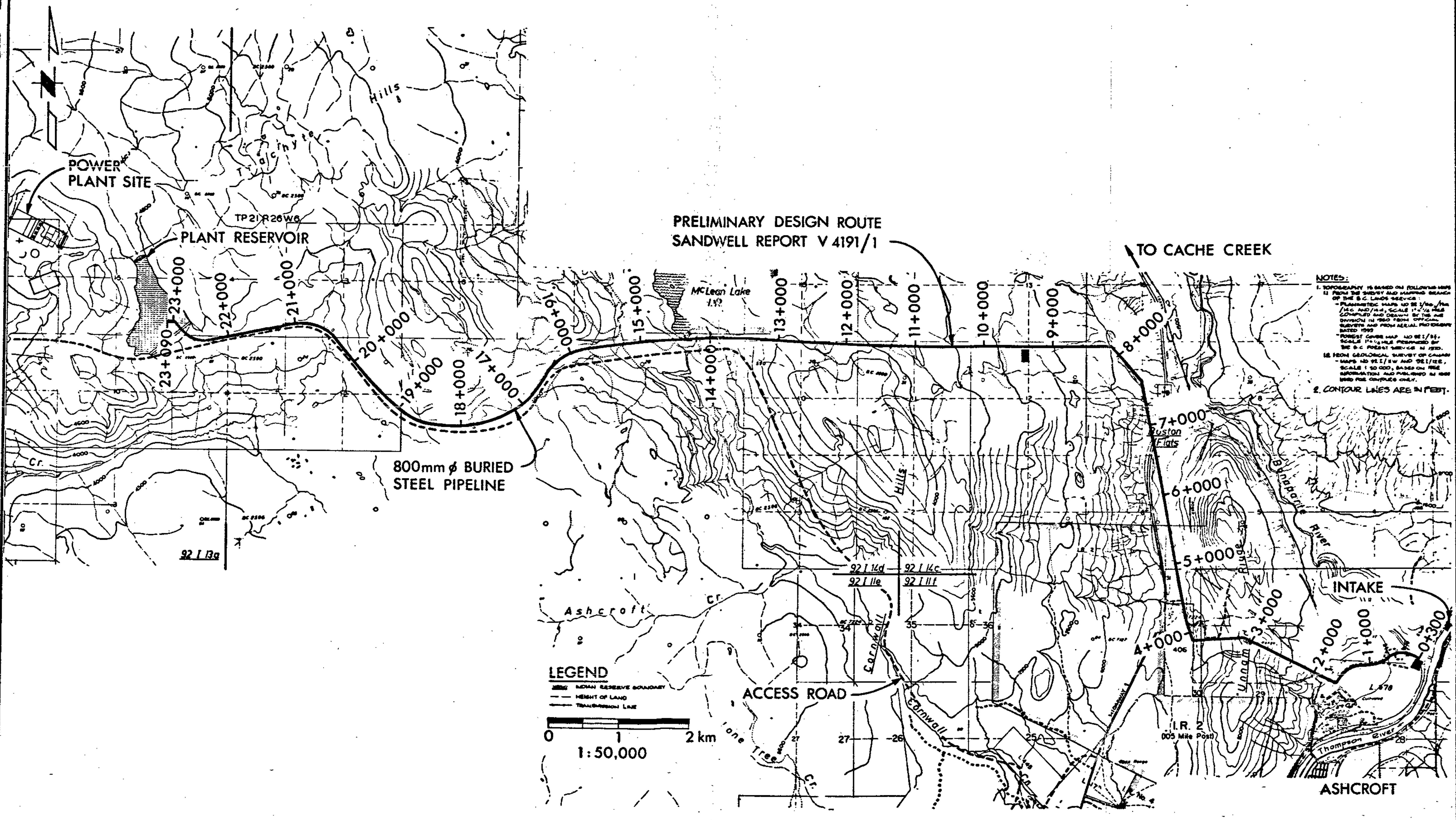
APPENDIX 2

ILLUSTRATIONS



DES		RECO	
DWN	SH	APPD	
CHKD	A.C.	APPD	
MEP		APPD	R.C.
SUBD		DATE	APRIL '78
MICROFILMED		DIST'N CODE	

SANDWELL DWG. NO.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
COOLING WATER SUPPLY
BREAKDOWN OF COST ESTIMATE
PIPELINE ROUTE

SCALE AS SHOWN — DWG No B 4251/2-1 R

REFERENCE DRAWINGS — REFERENCE DRAWINGS — REVISIONS — REVISIONS

SANDWELL

PROJECT MEMORANDUM V4251/3

WATER TREATMENT BY MEANS OF SETTLING

(V4251/1)

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

PROJECT MEMORANDUM V4251/3
WATER TREATMENT BY MEANS OF SETTLING

DATE 25 AUGUST 1978

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PROJECT V4251
HAT CREEK PROJECT
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VANCOUVER B.C.

PROJECT MEMORANDUM V4251/3
WATER TREATMENT BY MEANS OF SETTLING

DATE 25 AUGUST 1978

INTRODUCTION

The purpose of this Project Memorandum is to record and review water treatment proposals received during the Preliminary Design Study, Project V4191, and to recommend design parameters for a degritting clarifier. This method of treatment was selected by Sandwell in Report V4191/1 (Reference 1.1)*, to remove Thompson River water solids for the prevention of erosion in the high pressure pumps.

PROPOSALS

Water treatment proposals were received in answer to Sandwell's letter of inquiry, dated 7 October 1977, Appendix 2. To obtain the widest possible response from water treatment suppliers, this inquiry did not specify the type of treatment system except for excluding large settling basins and prohibiting the use of chemicals. Table 1 on page 2 lists the proposals.

* For references see Appendix 1

Table 1 - Proposed Water Treatment Systems

Treatment System	Make or Name	Units Required	Supplier
1. Settling			
1.1	Hydroseparator	1	Dorr-Oliver-Long Ltd.
1.2	Degritting Clarifier	1	Envirotech Canada Ltd.
1.3	Aerated Degritter	1	Degremont-Infilco Ltd.
1.4	Detritor	1	Dorr-Oliver-Long Ltd.
1.5	Grit Collector	1	Rexnord (Canada) Ltd.
2. Centrifugal Cleaner			
2.1	FR Dorrclone	6	Dorr-Oliver-Long Ltd.
2.2	Desanding Dorrclone	7 or 12	Dorr-Oliver-Long Ltd.
2.3	Desanding Dorrclone	5	US Filter Fluid Systems Corporation
2.4	Celleco Cleaner	2	Bancroft Western Sales Limited
2.5	Smith and Loveless Pista Grit Trap	Model 30:2 or Model 30:1	Ecodyne Ltd.
3. Media Filter			
3.1	Neptune Microfloc Filter	8	Neptune Microfloc
3.2	Peacock Immedium Upflow Filter	Not Given	Peacock Brothers Ltd.
3.3	Graver Filter	6	Ecodyne Limited
3.4	Graver Monovalve Filter	17	Ecodyne Limited
4. Micro Filter			
4.1	Cuno Automatic Flo-Klean Filter	2	Peacock Brothers Ltd.
4.2	North Water Filter	8	H.D. Fowler Co. Ltd.

The majority of particles anticipated in the proposed Thompson River intake would range from 2.5 mm, the gap between the wires of the travelling screens, to 0.1 mm (Reference 1.3, Table 4). Particle sizes acceptable to the booster pumps are in the order of 0.2 mm and smaller (Reference 1.2).

For the required river solids removal system to work properly and efficiently, it must be able to:

1. Remove solids ranging from 2.5 mm to at least 0.2 mm.

2. Absorb shock loadings and avoid blinding.

3. Minimize land requirements, energy, supervision, water waste and wear.

4. Operate continuously, even under freezing conditions.

5. Operate without chemicals and without treatment of waste prior to discharge.

6. Dispose of removed solids.

7. Have proven technology.

8. Operate without enhancing algal growth.

The settling proposals, System 1, are acceptable in principle since they satisfy the above requirements. These proposals are examined in depth in this Project Memorandum in order to establish specific design parameters for use during final design. Resumes of these proposals are given in Appendix 3.

All other proposals in Table 1, Systems 2, 3 and 4, were rejected for the following reasons:

- Centrifugal cleaners (System 2) waste approximately 10 percent of inflow water, require energy (a head of 3 to 15m), are subject to wear and are generally used for removing solids ranging from 500 to 3 microns. Not only from an operational viewpoint are centrifugal cleaners less attractive than a settling system such as a degritting clarifier, but also from capital cost considerations, as shown below:

  Degritting Clarifier Capital Cost

  Based on Preliminary Design Study, Report V4191/1, Volume 1, Appendix 5, Details of Cost Estimate, page 5, Item 273.64:

Concrete vat, 30m diameter	$ 75,000
Rake, including erection	170,000
Dome, to prevent freezing	105,000
Total	$350,000

  Centrifugal Cleaning Capital Cost

  Based on Dorr-Oliver-Long's telex proposal of 28 June 1978, for twelve 76cm (30 in.) diameter Desanding Dorrclone centrifugal cleaners with a pressure drop of 5.3m (7.5 psig), see Appendix 4, Item 2.2. A proposal in the same telex for 7 identical units but operating with a pressure drop of 14.1m (20 psig) was found to be less economical because of higher energy cost. Present value of energy cost was based on 35 years, 20 mills per Kwh, 8 percent interest, intake pump efficiency of 80 percent, and motor efficiency of 90 percent:

12 Dorrclones	$144,000
Taxes, piping, fittings and erection of Dorrclones	108,000
Housing	50,000
Increased capacity at intake (allowance)	100,000
Present value of energy	112,000
Total	$514,000

- Media filters (System 3) would collect the majority of particles between 2.5mm and 0.1mm, but since they are cleaned by means of a reversed flow whereby only particles smaller than 0.5 to 0.1mm (depending on media sizes) can be back washed, most of the river solids would be trapped permanently. These solids could be back washed by increasing the reversed flow but this would also remove filter media - an unacceptable condition. A media filter is, therefore, not suitable in this application as it would gradually fill up with solids.

- Micro filters (System 4) are designed to operate at a high rate of 20 to 50 l/s per m^2 (30 to 70 USGPM per ft^2) and are primarily used where solids concentrations are consistently low. Because of the danger of blinding in the case of Thompson River water, micro filters are not recommended.

Details of Systems 2, 3 and 4 are given in resumes contained in Appendix 4.

THEORY OF SETTLING

Data on the theory of settling were obtained from sources in Reference 2.

The rate of settling of a discrete particle in a fluid is a function of the viscosity, density and temperature of the fluid, of the size, shape, and specific gravity of the particle and of the Reynolds number.

Drawing A4251/3-1* shows the rate of settling in still water of 20°C, for particles varying from 10 microns to 1 cm and having specific gravities varying from 2.65 (discrete sand particles) to 1.05 (flocculated mud particles). Reynolds numbers differentiate three settling zones: the eddying resistance, the Stokes Law and the transition zone.

- The eddying resistance zone is for Reynolds numbers greater than 2000. This is the turbulent zone where eddying resistance slows the settling rate. As it applies to particles larger than 5mm, it is outside the range of particles considered here.

* For drawings, see Appendix 6 - Illustrations

- The Stokes Law is for Reynolds numbers less than 1. Particles in this zone are in a laminar flow region where viscous resistance from the water particles slows the settling rate, expressed as follows:

$$V = \frac{1}{18} \frac{g}{\eta} \left(\frac{Sp}{Sf} - 1\right) \cdot d^2 \text{ - (Stokes Law)}$$

in which V = settling rate in cm/s
g = acceleration due to gravity in cm/s^2
η = kinematic viscosity of the fluid in cm^2/s
Sp = specific gravity of the particle
Sf = specific gravity of the fluid
d = diameter of the particle in cm

Viscosity is influenced by temperature. Thompson River water temperatures range from 0°C to 19.5°C at Spences Bridge, over the period of record commencing in 1952 (Reference 3). Drawing A4251/3-2 shows that, over this temperature range, the viscosity of water increases significantly, from 0.95 at 19.5°C to 1.65 at 0°C (Reference 4). As the settling rate varies inversely with the viscosity, this rate decreases with lower temperatures. Therefore, at 0°C it is 0.95/1.65 = 0.6 of that at 19.5°C. This illustrates the significant influence of temperature in the design of settling systems.

- The transition zone is for Reynolds numbers from 1 to 2000. This zone includes most of the particles relevant to the Hat Creek application.

A mathematical expression for the settling rate in this zone is not available and these rates are, therefore, based on experiments such as carried out by Hazen (Reference 2.1) for particles from 10 mm to 0.1 mm. Settling rates are listed in Table 2 (Reference 5), which also gives settling rates in the Stokes Law zone, for particles from 60 micron to 4 micron.

In addition to "Settling rate", Table 2 also lists "overflow rate". The former is expressed as length per unit time, whereas the latter is expressed as flow per unit area. Water treatment suppliers commonly use the overflow rate as it can be equated directly to a tank size.

Table 2 - Settling Rates

Diameter of Particle Micron	mm	Classification	Settling Rate mm/s	Overflow Rate or Rise Rate l/s/m²	USGPM/ft²	
	10.0)		1 000	1 000	1 475	
	1.0)	Gravel	100	100	148	
600	0.6		63	63	93	Hazen
400	0.4)		42	42	62	
200	0.2)	Coarse Sand	21	21	31	
100	0.1)		8	8	11.8	
60	)		3.8	3.8	5.6	
40	)		2.1	2.1	3.1	
20	)	Fine Sand	0.62	0.62	0.91	Stokes
10	)		0.154	0.154	0.227	
4	)	Silt	0.025	0.025	0.036	

Note: These settling rates are in still water of 10°C for discrete particles with a specific gravity of 2.65

The settling rates in Table 2 apply to discrete particles with a specific gravity of 2.65. This is for sand and silt as given in Reference 5. For soil in general, the specific gravity varies from 2.0 to 3.0, however it is usually between 2.6 and 2.7 (Reference 6).

APPLICATION OF SETTLING

To evaluate the proposed settling systems listed in Table 1, installation lists were obtained from suppliers. In addition, overflow rates were established based on 1580 l/s (25,000 USGPM), the flow given in the letter of inquiry. These overflow rates together with other system parameters are given in Table 3.

Table 3 - Comparison of Parameters of Proposed Settling Systems

Item		1.1 Dorr-Oliver -Long	1.2 Envirotech	1.3 Degremont-Infilco	1.4 Dorr-Oliver -Long	1.5 Rexnord
		System Number and Supplier				
Name		Hydroseparator	Degritting Clarifier	Aerated Degritter	Detritor	Grit Collector
Tank Size	- m	24 diameter	29 diameter	10 x 16	12 diameter	5 x 21
	- ft	80 diameter	95 diameter	33 x 52	40 diameter	15 x 70
Tank Area	- m^2	430	540	140	120	100
excluding feedwell	- ft^2	4640	5830	1450	1260	1050
Minimum Operating Temperature	- ^oC	2	0	Not given	Not given	Not given
Specific Gravity of Settled Particle		2.65	2.65	Not given	Not given	Not given
Safety Factor		1.43	2	1	1	1
Overflow Rate after applying safety factor	- $l/s/m^2$	3.6	2.9	11.7	13.5	16.1
	- $USGPM/ft^2$	5.4	4.3	17.2	19.9	23.8
Minimum Settled Particle Size	- Microns	100	100	200	150	200

Note: Data in this table are based on an inflow of 1580 l/s (25,000 USGPM).

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The safety factor is an important system parameter. It allows for discrepancies between actual and theoretical overflow rates, because of actual particle densities, turbulence, wind action, short circuiting, thermal currents and flocculating effects.

The diversity of overflow rates, safety factors and minimum particle size used by water treatment suppliers indicates that final design inquiries should be based on specific parameters.

Of the five proposed settling systems listed in Table 3, following are the two which satisfy the requirements for the Hat Creek Project.

Hydroseparator By Dorr-Oliver-Long (1.1)

This separator is a circular clarifier with rake mechanism and operates without the addition of chemicals in many industrial plants to recover solids.

Design is based on Table 2, adjusted for minimum operating temperature and safety factor. Dorr-Oliver-Long lists 24 installations, five in Canada and the balance in the USA. For details see Appendix 5.

Degritting Clarifier by Envirotech Canada Limited (1.2)

This circular clarifier with rake mechanism is custom designed on the basis of Table 2, adjusted for minimum operating temperature and safety factor. Although not backed up by installations, this system is acceptable as it is similar to Dorr-Oliver-Long's Hydroseparator.

The other proposed settling systems, 1.3, 1.4 and 1.5, would be unsuitable for the Hat Creek Project, because these systems do not apply to raw water, as elaborated below.

Aerated Degritter by Degremont-Infilco (1.3)

This aerated degritter is only used in sewage treatment plants, where entrained air aids the separation of organic material from sand particles. Although Degremont-Infilco claimed that entrained air would also be of value in raw water degritting, experience records to substantiate this were not provided.

Detritor by Dorr-Oliver-Long (1.4)

The Detritor is similar to a circular clarifier with rake mechanism, except that the liquid flows across the clarifier rather than from the centre. The Detritor is commonly used for degritting sewage, prior to treatment (Reference 7). Subsequent to Sandwell's request for installations on raw river water, Dorr-Oliver-Long withdrew the Detritor in favour of their Hydroseparator.

Grit Collector by Rexnord (1.5)

This system consists of a rectangular settling tank with a V-bottom. Solids collected in the bottom are removed by means of a pump mounted on a travelling bridge. Its main application appears for sludge removal in water and waste treatment plants. Applications for the treatment of raw water were not supplied.

CONCLUSIONS

On the basis of both theory and application of settling it can be concluded that:

1. A clarifier provides a reliable method for the removal of Thompson River water solids by means of settling.

2. Clarifier design can be based on overflow rates given in Table 2, provided these are adjusted for temperature, safety factor and, if necessary, specific gravity of particle.

DESIGN PARAMETERS

General

Drawing A4251/3-3, prepared on the basis of overflow rates in Table 2, shows the relationship between minimum settled particle size and clarifier diameter at 0°C and 20°C, with a safety factor of 2 and for a capacity of 1,660 l/s. This capacity is 5 percent more than the cooling water supply design capacity of 1,580 l/s, to allow for clarifier underflow and process losses. On the basis of this drawing the following design parameters are discussed.

Feedwell

Although the feedwell adds considerably to the overall clarifier diameter, it is important that it be large enough to avoid high entrance velocities into the clarifier. The assumed diameter of 12 m would provide a weir rate of 44 l/s.

Minimum Operating Temperature

A clarifier designed to remove particles down to 200 microns would have a diameter of 17.5 m at 20°C, and 20.5 m at 0°C, an increase of 17 percent. Similarly for 100 microns, 23.5 m at 20°C and 30 m at 0°C, an increase of 28 percent. Therefore, there would be significant savings if a higher design temperature than 0°C could be selected. This, however, is not recommended as the most critical condition occurs in winter when water temperatures are 0°C and suspended solids can be present in the intake due to its proximity to the eroding Ashcroft bluffs (Reference 1.4).

Drawing A4251/3-4 shows the relationship between a typical Thompson River hydrograph and the river water temperature curve, both at Spences Bridge. This indicates that the freshet peaks when the river water temperature is only 14°C, 6 degrees below its maximum of 20°C. Although the freshet peak may give the highest solids concentration in the river, reliable solids removal must already take place when solids first appear in the river. This occurs when the river starts to rise in April when water temperatures are approximately 2 to 4°C. As protection of the high pressures pumps is the sole objective of the clarifier, it is recommended that it be provided all year round and, therefore, that 0°C be selected as the minimum operating temperature.

Specific Gravity of Thompson River Solids

Overflow rates in Table 2 are based on sand and silt particles; these have a specific gravity of 2.65. For the purpose of comparison, specific gravities for materials similar to sand and silt and for organic and mud particles are given in Table 4.

Table 4 - Specific Gravities

Material	Amount
Mica	2.8
Granite	2.7
Shale, Limestone and Quartz	2.6
Asbestos and Gypsum	2.4
Sandstone	2.3
Concrete	2.2
Suspended organic matter	1.0-1.4
Flocculated mud particles	1.05

Water treatment handbooks, Dorr-Oliver-Long and Envirotech all use 2.65 as the specific gravity for river solids. It appears reasonable to assume that this same value can be used for Thompson River solids, because:

- Thompson River solids settle in the sump of the municipal intake at Ashcroft (Reference 8).

- Ashcroft municipal water is not treated which is indicative of the absence of lightweight particles.

- Specific gravities of materials similar to sand and silt, listed in Table 4, are in the 2.65 ranges.

Therefore, it is recommended that 2.65 be used as the specific gravity for Thompson River solids, but that this value be confirmed during final design, on the basis of laboratory analyses.

Minimum Settled Particle Size

A clarifier operating at 0°C would require a diameter of 20.5 m for a minimum particle size removal of 200 microns, and 30 m for that of 100 microns, an increase of 46 percent. From a pump protection point of view, report V4191/1 recommends a minimum particle size removal of only 200 microns (Reference 1.3), whereas the clarifier recommended in this same report is for 100 microns with a diameter of 30 m. This conservative approach was followed for two reasons:

- To provide the best possible protection which can be obtained by means of a degritting clarifier at reasonable cost.

- To assure that the pump manufacturer will not be able to use water quality as an excuse to revoke his performance guarantee, in the event of failure of performance.

For final design, it is recommended that the minimum settled particle size be confirmed based on requirements for the selected equipment and a cost benefit study for clarifier diameters of 30 m and 20.5 m.

Safety Factor

The safety factor allows for discrepancies between actual and theoretical overflow rates. A factor of 2 is recommended.

Summary of Design Parameter Recommendations

Overflow Rate	:	Use Table 2, adjusted for temperature.
Feedwell	:	To be sized for a low clarifier entrance velocity.
Minimum Operating Temperature	:	0°C
Specific Gravity of Settled Particle	:	2.65. To be confirmed in Final Design.
Minimum Settled Particle Size	:	At least 200 microns, preferably 100 microns. To be confirmed in final design on the basis of pump requirements and cost benefit study.
Safety Factor	:	2

Prepared by: John WC Boyle
J. W. C. Boyle

Approved by: [signature]
A. Copeland, P. Eng.

APPENDIX 1

REFERENCES

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

PROJECT MEMORANDUM V4251/3
WATER TREATMENT BY MEANS OF SETTLING

DATE 25 AUGUST 1978

APPENDIX 1 - REFERENCES

1. Sandwell and Company Limited, Report V4191/1, Hat Creek Project, Cooling Water Supply, Preliminary Design Study. Report to B.C. Hydro and Power Authority, March 1978

1.1 Volume 1, p. 23.

1.2 Volume 1, p. 30.

1.3 Volume 2, Appendix 8, Project Memorandum V4191/5, Water Treatment, p.3.

1.4 Volume 2, Appendix 8, Project Memorandum V4191/5, Water Treatment, p.2.

2. Theory of Settling.

2.1 Allen Hazen, "On Sedimentation", American Society of Civil Engineers, paper no. 980, 1 June 1904.

2.2 Skeat and Dangerfield, "Manual of British Water Engineering Practice, Volume III, Water Quality and Treatment", pp. 208 to 211.

2.3 Tebbutt, "Principles of Water Quality Control", pp. 82 to 90.

2.4 Fair, Geyer and Okun, "Water and Waste Water Engineering", pp. 25.2 to 25.5.

2.5 Linsley and Franzini, "Water Resources Engineering", pp. 444 to 445.

3. Environment Canada "Water Temperatures, British Columbia and the Yukon Territories", Volume 4, 1977.

4. Data on Viscosity of Water.

4.1 American Water Works Association, "Water Treatment Plant Design", p. 90.

4.2 Perry, Chilton and Kirkpatrick, "Perry's Chemical Engineers' Handbook", p. 3.201.

4.3 Davis, "Handbook of Applied Hydraulics", p. 960.

5. American Water Works Association, "Water Treatment Plant Design", p.91, Table 2.

6. P. N. Khanna, "Soil Mechanics", p. 6/9.

7. Solids removal.

8.1 Dorr-Oliver-Long "Detritor", bulletin No. 64411C.

8.2 The Institute of Water Pollution Control U.K., "Preliminary Processes", pp. 26 to 31.

8. Sandwell and Company Limited, "Field Visit Report V4191, Hat Creek Project, Cooling Water Supply, Ashcroft Pumping Station", Report of 13 June 1977.

APPENDIX 2

LETTER OF INQUIRY FOR WATER TREATMENT, DATED 7 OCTOBER 1977

Copies of this letter also sent to the following:

Envirotech Canada Ltd., Eimco Division,
Calgary, Alberta
Passavant, Vancouver, B.C.
Permutit, Vancouver, B.C.
Crane Cochrane, North Vancouver, B.C.
Peacock Brothers Ltd., Vancouver, B.C.
Neptune Microfloc, Calgary, Alberta
Degremont (Canada) Limited, Montreal, P.Q.
Dorr-Oliver-Long Limited, Vancouver, B.C.
Graver Water Div. of Ecodyne,
Oakville, Ontario

SANDWELL AND COMPANY LIMITED
SUITE 601 — 1550 ALBERNI STREET, VANCOUVER
B.C., CANADA V6G 1A4
TELEPHONE: 684-8151 AREA CODE: 604
CABLE ADDRESS: SANCONSULT • TELEX: 04 508736

7 October 1977

Rexnord (Canada) Ltd.
1955 West Broadway
Vancouver, B.C.

Attention: Sales Manager

Reference: V4191 B.C. Hydro and Power Authority
273.60 Pumping Station - Water Treatment

Dear Sir:

B. C. Hydro and Power Authority are planning a 2000 MW coal-fired generating station to utilize the coal deposits of the Hat Creek Valley, near the town of Ashcroft, in the Province of British Columbia, Canada. Our firm has been retained for the preliminary design of the cooling water make-up system for this project.

Introduction

The design capacity of the make-up system will be 1580 l/s (25,000 USGPM), which will be drawn from the Thompson River by means of a direct intake in the vicinity of Ashcroft, B.C.

The intake structure will house vertical travelling screens with a maximum mesh size of 2.5 mm (0.1 inch), and five low head vertical turbine pumps. These pumps will pass raw river water to a grit removal plant, after which four high pressure pumps will pump to a second stage high pressure station. From there, the water will be pumped to the plant reservoir in the Hat Creek Valley. The total head from the treatment plant to the plant reservoir will be 1255 m (4115 ft).

Budget Proposal

To assist us in obtaining technical input and a budget price for this project, we request you to submit a preliminary proposal with budget prices, on a system to take out grit, in order to prevent wear on the costly high pressure pumps. The system will require to operate all year round in view of the chance of high solids loading from eroding cliffs nearby (see section on water quality for further details). A settling basin cannot be considered for the degritting system due to real estate restrictions, and because a dome will be required over the unit to prevent it from freezing, (since allowance will have to be made for intermittent pumping to suit electrical load requirements).

Background

We enclose some data on several characteristics of the Thompson River to enable you to decide on the optimum type of grit removal mechanism which you would propose for this project.

1. Water Quality Summary

The data presented in Appendix 1 was obtained from B. C. Hydro and was collected at Savona, approximately 32 kilometers (20 miles) upstream of Ashcroft.

Although the suspended solids load in the vicinity of the proposed intake is not known, we would expect it to be much higher than the maximum value of 7.6 mg/l indicated in the table in this Appendix. The reason for this is the presence of the Ashcroft Cliffs, which are upstream of the intake site. The erosion of these cliffs introduces solids all year round. This introduction is expected to be at its highest during the freshet when rising water elevations erode recent shore deposits from slides. Further introduction of solids takes place all year round when minor slides fall into the river.

2. Solids from Thompson River Bank

On 15 June 1977, a solids sample was taken from a bar on the left river bank opposite the Ashcroft Cliffs. Sieve analysis on this sample was carried out only on particles passing No. 8 sieve, 2.36 mm (0.93 inch). This sieve approximates most closely the maximum particle size which will pass the proposed intake travelling screens with stipulated maximum mesh opening of 2.5 mm (0.10 inch). The sieve analysis curve is shown in Figure 1, Appendix 2.

3. Solids from Ashcroft Municipal Intake

The Municipality of Ashcroft operates an intake on the left bank of the Thompson River just downstream of the road bridge and 4 km (2.5 miles) downstream of the Ashcroft Cliffs. The intake consists of a pump well which is connected to the river by means of a 0.30 m (1 ft) diameter buried pipe which protrudes approximately 0.9 m (3 ft) above the river bottom; the entrance to this pipe is protected with a 40 mm (1.5 inch) square mesh screen. Apart from some chlorination no other treatment is given to this potable water supply.

As some river solids collect in the bottom of the pump well, Sandwell obtained 12 samples from different locations in the well and sieve analyses were carried out on sample numbers 2 and 10. These sieve analyses were only carried out on particles passing No. 8 sieve, 2.36 mm (0.93 inch). This sieve approximates most closely the maximum particle size which will pass the proposed intake travelling screens with stipulated maximum mesh opening of 2.5 mm (0.10 inch). For sieve curves see Figure 2 and 3, Appendix 2.

Sieve Analysis Results

The data presented in the table below has been abstracted from the sieve analyses of samples 1, 2 and 10.

Thompson River Solid
Particle Size Distribution in % of Dry Weight

Particle Size		Origin of Sample		
		River Bar	Ashcroft Intake	
mm	inch	Sample #1	Sample #2	Sample #10
2.36 - 1.00	.093 - .039	20	27	20
1.00 - 0.50	.039 - .020	34	31	46
0.50 - 0.30	.020 - .012	29	26	24
0.30 - 0.10	.012 - .004	14	14	9
< 0.10	< .004	3	2	1
2.36 - 0.30	.093 - .012	83	84	90
0.30 - 0.10	.093 - .004	14	14	9
< 0.10	< .004	3	2	1

4. Solids Anticipated in Proposed Hat Creek Intake

The proposed Hat Creek intake would withdraw water directly from the river before solids have had a chance to settle out and from a zone rich in suspended solids. Although this zone of water withdrawal would on the average be less deep than that of the Ashcroft intake, it is considered very unlikely that the size distribution of particles smaller than 2.5 mm (0.10 inch) to be anticipated in the Hat Creek intake would be much different than those found in the Ashcroft intake. It is interesting to note the striking resemblance between the size distribution of the sieve analysis of the sample taken near the Ashcroft Cliffs and those taken from the Ashcroft intake well (distance between sampling points is approximately 4 kilometers (2.5 miles).

5. Algae

Some data is included for your information in Appendix 3 on algal growth in the Thompson River.

Degritting System

We request you to submit typical arrangement drawings indicating the method(s) which you would propose to remove grit from the raw water, together with budget costs for the structures (excluding housings) and mechanical plant. Delivery should be quoted on an F.O.B. plant price, together with the plant weight and the place where it will be transported from. The system can be designed such that the grit can be returned to the river. We emphasize that the only objective of this system is to remove solids from the flow to prevent pump impeller wear. Although we do not know the anticipated solids concentration in the river, your system must be conservatively designed to cope with, at times, concentrations of at least 100 - 500 mg/l; the anticipated minimum particle size that your system will be capable of removing must be given, (chemical addition must not be considered, so that waste can be returned to the river without causing environmental concern). Details of completed projects of similar installations which process raw water without the addition of chemicals are required together with all predicted head and water losses associated with your proposed system. The desirability of pilot plant studies should be indicated.

Filters

Once the degritting system is in operation, experience could indicate that this system alone would not be adequate to prevent wear on the pump impellers and an additional gravity filter system would then be required to further remove solids. We therefore also request your proposal for such a filter (no cost estimates are necessary), and to what extent this filter would be able to remove solids carried over from the degritting system. The only objective for the gravity filter would be to remove solids to prevent pump impeller wear. Back wash water would be returned to the river and, therefore, chemical addition would not be allowed in this process. All predicted head and water losses are required as are examples of similar installations that remove solids without the addition of chemicals. The desirability of pilot plant studies should be indicated.

Shock Loading

Because of the anticipated intensities of river solids concentrations, the degritting system and filters shall have a high capacity to absorb shock loadings. Systems which could become blinded, such as micro screens and micro strainers, are, therefore, considered undesirable.

Alternatives

In addition to supplying us the information requested in this letter, we would welcome any alternative proposals which you may wish to present.

Should you have any questions on the contents of this letter do not hesitate to contact the undersigned. We would appreciate your proposal being submitted on or before the 4th of November 1977.

Yours truly

SANDWELL AND COMPANY LIMITED

A. Copeland, P.Eng.

JWCB/vw
Attachments
cc: Mr. C. K. Harman, B. C. Hydro, Vancouver
bcc: A. Copeland
J. Boyle

SANDWELL

APPENDIX 1

WATER QUALITY DATA

APPENDIX 1 - WATER QUALITY DATA

THOMPSON RIVER (SAVONA) WATER QUALITY SUMMARY

PARAMETER[1]	AVERAGE	MAXIMUM
Total Dissolved Solids[2]	57.4	72.0
Total Solids[2]	60.4	74.0
Suspended Solids[2]	3.1	7.6
Turbidity (JTU)[2]	1.8	8.5
Specific Conductance (μmho/cm)[2]	98	225
Oil & Grease[2]	< 1.0	2.0
pH (units)[2]	7.5	8.6
Alkalinity ($CaCO_3$)[2]	35.1	44.8
Hardness ($CaCO_3$)[2]	38.2	47.6
Calcium (dissolved)[2]	12.1	14.6
Magnesium (dissolved)[2]	1.9	2.6
Chloride[2]	1.5	3.1
Sulphate[2]	7.2	10.0
Silica[2] (as SiO_2)	4.8	6.5
Colloidal Silica	--	2.1
Nitrate-Nitrogen[2]	0.09	0.22
Nitrite-Nitrogen	< 0.005	< 0.005
Ammonia-Nitrogen	0.012	0.03
Total Kjedahl Nitrogen	0.1	0.24
Nitrogen, Organic	0.08	0.15
Phosphorous as p[2]	0.007	0.021
Organic Carbon[2]	3.12	10.0
Inorganic Carbon[2]	7.4	10.0
Phenol	0.002	0.003

THOMPSON RIVER (SAVONA) WATER QUALITY SUMMARY

PARAMETER[1]	AVERAGE	MAXIMUM
Arsenic, Dissolved	< 0.005	< 0.005
Chromium, Dissolved	< 0.005	< 0.005
Chromium, Total	< 0.005	< 0.005
Copper, Dissolved	< 0.006	0.06
Iron, Dissolved	< 0.09	0.10
Lead, Dissolved	< 0.0015	< 0.003
Lead, Total	< 0.0019	< 0.003
Mercury, Total (µg/l)	< 0.05	0.25
Manganese, Total	< 0.01	0.01
Molybdenum, Dissolved (µg/l)	< 0.5	0.7
Potassium	0.85	0.9
Sodium	2.24	3.2
Zinc, Dissolved	0.02	0.12

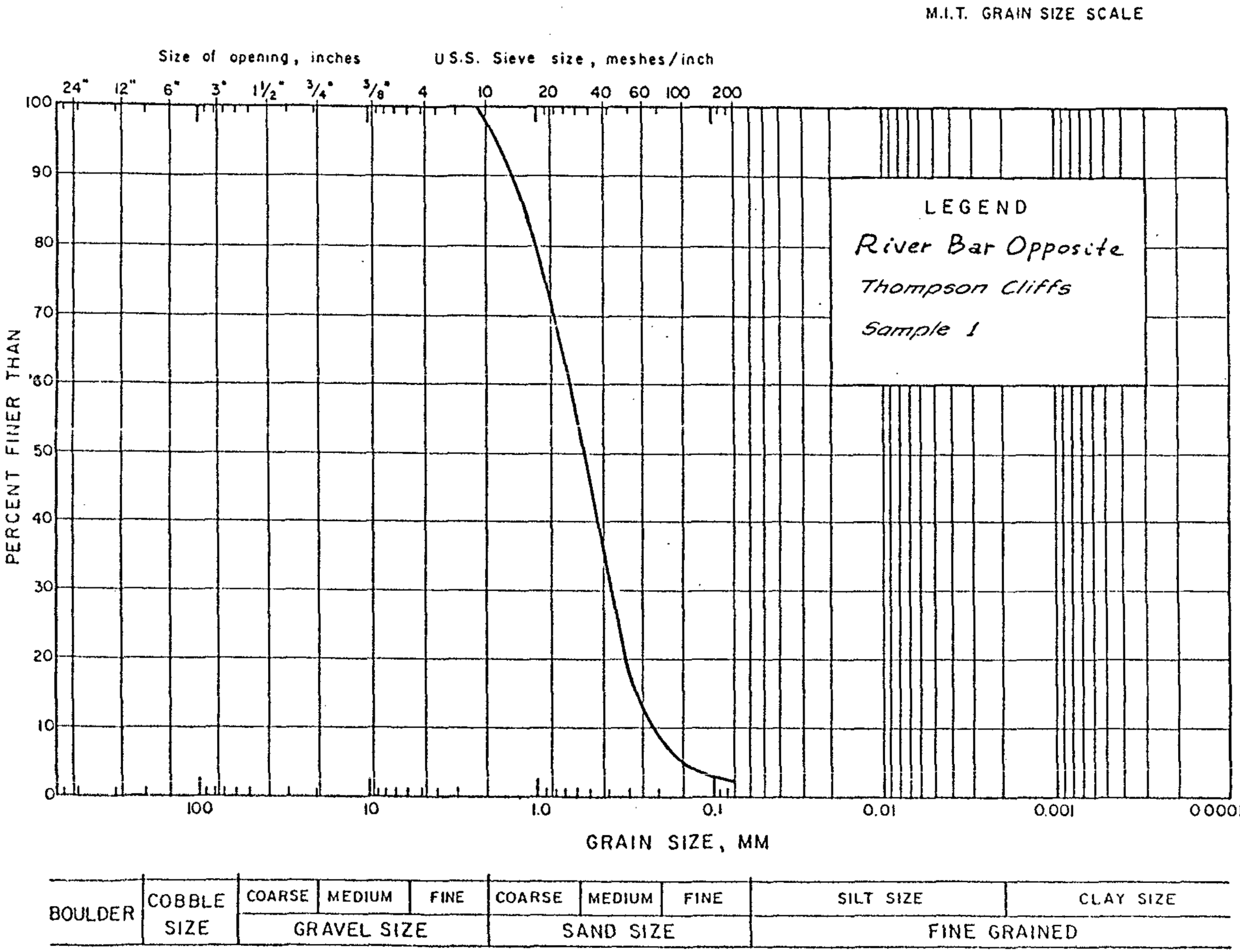
Notes:

1. All parameters expressed in mg/l unless otherwise noted.
2. Average values represent monthly annual averages, all other parameters represent total sample averages.

APPENDIX 2

SIEVE ANALYSIS CURVES

V77047 NAS Sept '77

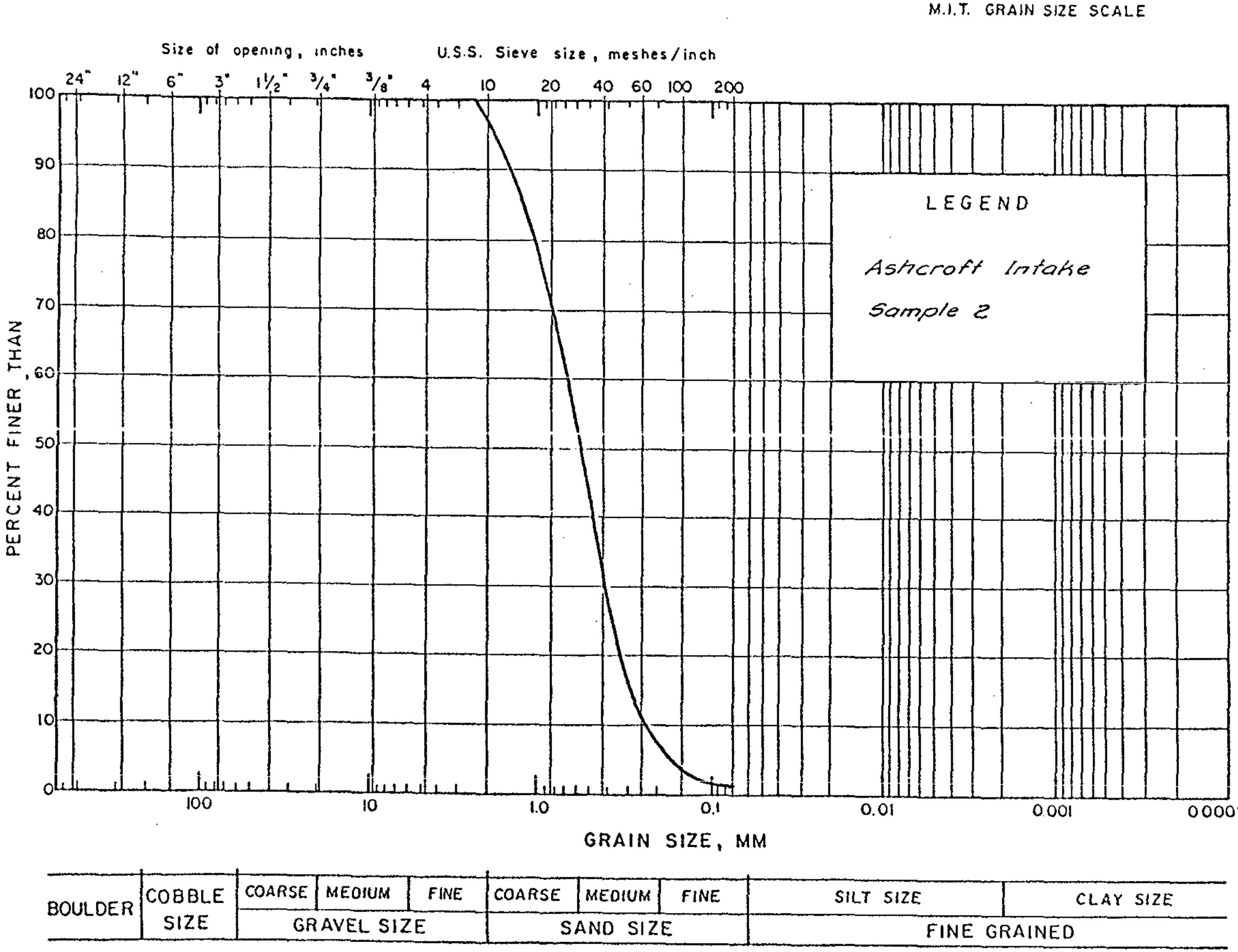


Golder Associates

GRAIN SIZE DISTRIBUTION
HAT CREEK WATER SUPPLY
THOMPSON RIVER

Figure 1.

Y77047 AA HAS Sept '77

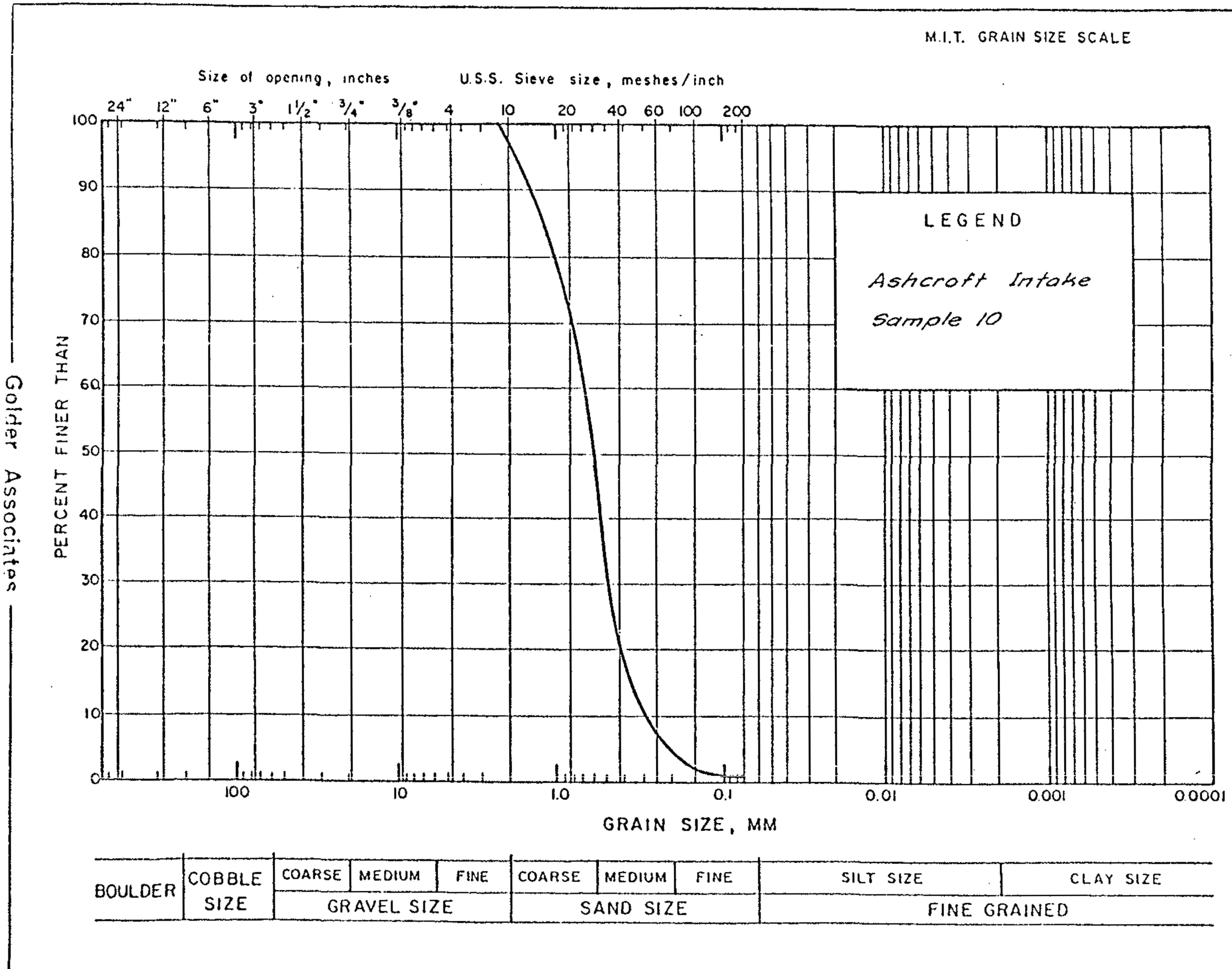


Golder Associates

GRAIN SIZE DISTRIBUTION
HAT CREEK WATER SUPPLY
THOMPSON RIVER

Figure 2.

V77047 ... HAS Sept '77



GRAIN SIZE DISTRIBUTION
HAT CREEK WATER SUPPLY
THOMPSON RIVER

Figure 5.

APPENDIX 3

ALGAL GROWTH IN THE THOMPSON RIVER

APPENDIX 3 - ALGAL GROWTH IN THE THOMPSON RIVER

ALGAE

Tables 1,2, and 3 (attached) summarize phytoplankton data for three sample periods at the Walachin Bridge, 23 February, 17 March and 2 June, 1977, 22 kilometers (14 miles) upstream of Ashcroft.

Phytoplankton densities increased from 262,871 to 383,332 to 695,265 units per litre over the sampling period. It is considered that maximum productivity will not be achieved in the Thompson River system until late August.

The data from this program indicated a preponderance of diatom species within each sample. Servici (1976) and BEAK (1973) have similarly indicated a dominance of diatoms in periphyton samples collected in the Thompson system and the Pollution Control Branch and Environment Canada (1973) also indicated a dominating effect of diatoms on the south Thompson system near Walachin. Diatoms generally range in size from 5 µ to 75 µ.

Langer and Nassichuk (1975) indicated that there exists a proliferation of periphytic algae downstream of Kamloops Lake due to nutrient input from domestic and industrial discharges into the system. Langer and Nassichuk (1975) also indicated that with the water currents found in the Thompson River, periphytic filamentous growths may become dislodged and form mat-like rafts of algae. They also speculate that this phenomenon occurs relatively frequently.

In summary, it is evident that those algal groups prevalent within the phytoplankton community of the Thompson River near Walachin are comparable to the periphytic associations reported in other studies. A dominant group within these two life systems were the diatom species. The most significant factors in terms of an intake structure would be diatoms, which appear to achieve maximum concentration in August, and upstream periphytic colonies that exhibit a potential to dislodge in large mats.

APPENDIX 4

COMPUTER PRINT OUT OF PHYTOPLANKTON DATA FROM THE THOMPSON RIVER STUDY

TABLE 1: PHYTOPLANKTON DATA THOMPSON RIVER STUDY DATE: 23 FEBRUARY 1977

TAXA	UNITS/LITER	%
RHODOMONAS MINUTA	53519	20.4
CHLORELLA-LIKE #1	41686	15.9
ACNANTHES MINUTISSIMA	35032	13.3
SYNEDRA VAUCHERIAE	20987	8.0
ACNANTHES LINEARIS	13569	5.2
GOMPHONEMA OLIVACEOIDES	12701	4.8
RHODOMONAS LACUSTRIS	12224	4.7
TABELLARIA FENESTRATA	10558	4.0
FRAGILARIA CROTONENSIS	6542	2.5
CYCLOTELLA STELLIGERA	5249	2.0
CYMBELLA MINUTA	4798	1.8
ASTERIONELLA FORMOSA	3973	1.5
CRYPTOMONAS OVATA	3514	1.3
TETRASELMIS #1	2203	.8
RHIZOLENIA ERIENSIS	2195	.8
GOMPHONEMA DICHOTOMUM	2195	.8
STEPHANODISCUS ASTRAEA	2186	.8
ARTHROSPIRA JENNERI	2178	.8
FRAGILARIA CONSTRUENS	1761	.7
AMPHORA PERPUSILLA	1752	.7
CHRYSOPHYTE STATOSPORE #11	1752	.7
NAVICULA CRYPTOCEPHALA V. VENET	1744	.7
MELOSIRA DISTANS V. ALPIGENA	1735	.7
GOMPHONEMA SUBCLAVATUM	1319	.5
NITZSCHIA RECTA	885	.3
ACNANTHES LANCEOLATA	885	.3
NITZSCHIA SILICA	885	.3
TREUBARIA TRIAPPENDICULATA	885	.3
CYCLOTELLA KUTZINGIANA	876	.3
SCENEDEDMUS DENTICULATUS	876	.3
MELOSIRA ITALICA	868	.3
OCHROMONAS-LIKE	868	.3
DIATOMA TENUE	868	.3
NITZSCHIA FRUSTULUM	868	.3
STEPHANODISCUS ASTRAEA V. MIN	442	.2
NITZSCHIA LINEARIS	442	.2
NITZSCHIA GRACILIS	442	.2
HANNAEA ARCUS	442	.2
CHROMULINA-LIKE	442	.2

TABLE 1: PHYTOPLANKTON DATA (CONTINUED)

TAXA	STATION 346 UNITS/LITER	%
ULOTHRIX ZONATA	442	.2
CALONEIS HYALINA	442	.2
COSCINODISCUS ROTHII	434	.2
NITZSCHIA ACICULARIS	434	.2
NAVICULA #13	434	.2
CYMBELLA CISTULA	434	.2
NAVICULA MINIMA	434	.2
ACNANTHES HAUCKIANA	434	.2
ACNANTHES PERGALLI	434	.2
CYMBELLA SINUATA	434	.2
NITZSCHIA DISSIPATA	434	.2
SYNEDRA DELICATISSIMA	434	.2
NITZSCHIA PALEA	434	.2
CYMBELLA AFFINIS	434	.2
CHLAMYDOMONAS-LIKE	434	.2

TOTAL MEAN DENSITY (UNITS/LITER)	262871
STANDARD ERROR OF MEAN DENSITY	2576
COEFF. OF VARIATION OF REPLICATES(%)	1.39
TOTAL TAXA/STATION	54
MEAN UNITS COUNTED/REPLICATE	300.00
NUMBER OF REPLICATES	2

**** = LESS THAN .1%

TABLE 2: PHYTOPLANKTON DATA DATE: 17 MARCH 1977
THOMPSON RIVER STUDY

TAXA	UNITS/LITER	%
ACNANTHES MINUTISSIMA	98039	25.6
CHLORELLA-LIKE #1	46023	12.0
SYNEDRA VAUCHERIAE	45567	11.9
GOMPHONEMA OLIVACEOIDES	30818	8.0
RHODOMONAS MINUTA	27375	7.1
CYMBELLA MINUTA	17304	4.5
HANNAEA ARCUS	13666	3.6
RHODOMONAS LACUSTRIS	11153	2.9
ACNANTHES LINEARIS	10612	2.8
NITZSCHIA RECTA	5458	1.4
ASTERIONELLA FORMOSA	5068	1.3
CHLAMYDOMONAS-LIKE	4721	1.2
CYCLOTELLA KUTZINGIANA	4028	1.1
SYNEDRA RUMPENS	4028	1.1
NITZSCHIA PALEA	3682	1.0
GOMPHONEMA OLIVACEUM	3444	.9
CYCLOTELLA STELLIGERA	3292	.9
TABELLARIA FENESTRATA	3097	.8
FRAGILARIA CROTONENSIS	2945	.8
TETRASELMIS #1	2902	.8
GOMPHONEMA SUBCLAVATUM	2902	.8
CYMBELLA AFFINIS	2556	.7
OCHROMONAS-LIKE	2209	.6
CYMBELLA CISTULA	2209	.6
NITZSCHIA FRUSTULUM	2014	.5
NITZSCHIA ACICULARIS	2014	.5
GOMPHONEMA HEDINII	1819	.5
NITZSCHIA SILICA	1819	.5
FRAGILARIA LEPTOSTAURON	1624	.4
MELOSIRA ITALICA	1473	.4
CHROOMONAS NORDSTEDII	1473	.4
CRYPTOMONAS OVATA	1278	.3
SYNEDRA RADIANS	1278	.3
ARTHROSPIRA JENNERI	1278	.3
AULOMONAS PURDYI	1083	.3
RHIZOLENIA ERIENSIS	1083	.3
DIATOMA VULGARE	1083	.3
NITZSCHIA BREVIROSTRIS	736	.2
ACNANTHES FLEXELLA	736	.2

TABLE 2: PHYTOPLANKTON DATA (CONTINUED)

TAXA	STATION 401 UNITS/LITER	%
SCENEDEDMUS DENTICULATUS	736	.2
AMPHIPLEURA PELLUCIDA	736	.2
OSCILLATORIA LIMNETICA	736	.2
FRAGILARIA CONSTRUENS	736	.2
ANKISTRODESMUS FALCATUS	541	.1
NITZSCHIA SUBACICULARIS	541	.1
CHROMULINA-LIKE	541	.1
STAURONEIS ANCEPS	541	.1
NITZSCHIA FONTICOLA	541	.1
NITZSCHIA DISSIPATA	541	.1
TREUBARIA TRIAPPENDICULATA	541	.1
NITZSCHIA LINEARIS	541	.1
SYNEDRA MAZAMAENSIS	541	.1
ACNANTHES LANCEOLATA	541	.1
SYNEDRA ULNA	541	.1
GOMPHONEMA PARVULUM	541	.1

TOTAL MEAN DENSITY (UNITS/LITER)	383332
STANDARD ERROR OF MEAN DENSITY	58449
COEFF. OF VARIATION OF REPLICATES(%)	21.56
TOTAL TAXA/STATION	55
MEAN UNITS COUNTED/REPLICATE	300.00
NUMBER OF REPLICATES	2

**** = LESS THAN .1%

TABLE 3: PHYTOPLANKTON DATA DATE: 2 JUNE 1977
THOMPSON RIVER STUDY

TAXA	UNITS/LITER	%
RHODOMONAS MINUTA	232468	33.4
RHIZOLENIA ERIENSIS	111991	16.1
ACNANTHES MINUTISSIMA	39684	5.7
ASTERIONELLA FORMOSA	35138	5.1
CYCLOTELLA KUTZINGIANA	34104	4.9
CYCLOTELLA STELLIGERA	29843	4.3
RHODOMONAS LACUSTRIS	29754	4.3
OCHROMONAS-LIKE	18968	2.7
CRYPTOMONAS OVATA	17310	2.5
SYNEDRA VAUCHERIAE	16508	2.4
SYNEDRA RUMPENS	14191	2.0
CHROMULINA-LIKE	10875	1.6
NITZSCHIA ACICULARIS	10500	1.5
CHLORELLA-LIKE #1	9413	1.4
SYNEDRA RADIANS	9270	1.3
CYMBELLA MINUTA	6953	1.0
SCENEDEDMUS DENTICULATUS	5865	.8
DINOBRYON SERTULARIA	5723	.8
ACNANTHES LINEARIS	5723	.8
FRAGILARIA CONSTRUENS	4492	.6
NITZSCHIA PALEA	3690	.5
MELOSIRA ITALICA	3548	.5
STEPHANODISCUS ASTRAEA	3405	.5
NITZSCHIA RECTA	3262	.5
CRUCIGENIA QUADRATA	2460	.4
DIATOMA TENUE	2460	.4
ARTHROSPIRA JENNERI	2318	.3
NITZSCHIA FRUSTULUM	2175	.3
GOMPHONEMA OLIVACEOIDES	2175	.3
FRAGILARIA CAPUCINA	2175	.3
NITZSCHIA SILICA	1230	.2
DINOBRYON BAVARICUM	1230	.2
TETRASELMIS #1	1230	.2
CLADOPHORA	1230	.2
OSCILLATORIA LIMNETICA	1230	.2
NITZSCHIA GRACILIS	1230	.2
OOCYSTIS PUSILLA	1230	.2
CHLAMYDOMONAS-LIKE	1230	.2
RHIZOCHRISIS #1	1230	.2

TABLE 3: PHYTOPLANKTON DATA (CONTINUED)

TAXA	STATION 450 UNITS/LITER	%
SYNURA UVELLA	1230	.2
NAVICULA PUPULA	1087	.2
HANNAEA ARCUS	1087	.2
MALLOMONAS PSEUDOCORONATA	1087	.2
NAVICULA #8	1087	.2
NAVICULA CRYPTOCEPHALA V. VENET	1087	.2
ACNANTHES LANCEOLATA	1087	.2

TOTAL MEAN DENSITY (UNITS/LITER)	695265
STANDARD ERROR OF MEAN DENSITY	42786
COEFF. OF VARIATION OF REPLICATES(%)	8.70
TOTAL TAXA/STATION	46
MEAN UNITS COUNTED/REPLICATE	300.00
NUMBER OF REPLICATES	2

**** = LESS THAN .1%

APPENDIX 3

RESUMES OF PROPOSALS FOR SETTLING SYSTEMS

APPENDIX 3 - RESUMES OF PROPOSALS FOR SETTLING SYSTEMS

In this Appendix, resumes are given of solids removal systems which were accepted in principle from the proposals received in response to Sandwell's letter of inquiry for water treatment (Appendix 2). Numbers used for these resumes correspond to those in Table 1 in the Introduction of this Project Memorandum.

1. SETTLING

1.1 Hydroseparator

Dorr-Oliver-Long Ltd. of Orillia, Ontario, proposed one 24 m (80 ft) diameter Hydroseparator, which is basically a circular clarifier with rake mechanism. This unit would remove at least 95 percent of 100 microns. Budget prices were not submitted.

1.2 Degritting Clarifier

Envirotech Canada Ltd. of Calgary, Alberta, proposed one 29 m (95 ft) diameter clarifier with a 12.2 m (40) ft diameter feedwell and a 4 m (13 ft) depth at the perimeter. This depth includes a 0.6 m (2 ft) allowance for ice buildup. The clarifier would be equipped with a rake for solids removal. Minimum particle size removal would be approximately 100 microns.

The quoted budget price was as follows:

Concrete base and design	$ 75,000
Mechanism and tank shell	110,000
Erection and painting	60,000
Total	$245,000

1.3 Aerated Degritter

Degremont-Infilco of Montreal, proposed one 10 x 15.7 m (33 x 51.5 ft) aerated solids removal system. Solids would collect in two bottom troughs located in the centre of the tank and parallel to its short side. Removal of solids would be by means of two travelling submerged pumps. Minimum particle size removal would be 200 microns. The quoted budget price was $100,000, for the mechanical equipment consisting of air diffusion system and travelling solids removal pumps.

1.4 Detritor

Dorr-Oliver-Long Ltd. of Orillia, Ontario, proposed one 12.2 m (40 ft) diameter x 1.5 m (5 ft) deep Detritor, which is similar to a circular clarifier with rake mechanism, except that the liquid flows across the clarifier rather than from the centre.

The quoted budget price for rake mechanism only was $22,600, FOB Orillia, Ontario.

1.5 Grit Collector

Rexnord (Canada) Ltd. of Willowdale, Ontario, Proposed one 4.6 m (15 ft) wide, 21.3 m (70 ft) long and 3.8 m (12.5 ft) deep settling tank with V-bottom. Solids collected at the bottom would be removed by a submerged pump mounted on a travelling bridge. Minimum particle size removal would be 200 microns.

The quoted budget price, FOB Willowdale, Ontario, for the travelling bridge complete with drive, pump, reel, electric controls and running rails was $75,000, excluding sales taxes.

APPENDIX 4

RESUMES OF REJECTED PROPOSALS: CENTRIFUGAL CLEANERS, MEDIA FILTERS AND MICRO FILTERS

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

PROJECT MEMORANDUM V4251/3
WATER TREATMENT BY MEANS OF SETTLING

DATE 25 AUGUST 1978

APPENDIX 4 - RESUMES OF REJECTED PROPOSALS: CENTRIFUGAL CLEANERS, MEDIA FILTERS AND MICRO FILTERS

In this Appendix, resumes are given of solids removal systems which were rejected from the proposals received in response to Sandwell's letter of inquiry for water treatment (Appendix 2). Numbers used for the resumes correspond to those in Table 1 in the Introduction of this Project Memorandum.

2. CENTRIFUGAL CLEANER

2.1 FR Dorrclone

Dorr-Oliver-Long Ltd. of Orillia, Ontario, proposed six 122 cm (48 in.) diameter FR Dorrclones which would operate with a pressure drop of 69 kPa (10 psig) and would remove particles down to 100 microns. The quoted budget price was $72,000 FOB Vancouver, and would include housings, liners, Vortex finders and apex valves.

2.2 Desanding Dorrclone

In a telex of 28 June 1978, Dorr-Oliver-Long Ltd., proposed either seven or twelve 76 cm (30 in.) diameter Desanding Dorrclones operating with a pressure drop of respectively 138 kPa (20 psig) and 52 kPa (7.5 psig). The quoted budget price was $12,000 per unit, FOB Vancouver. This telex proposal superseded Dorr-Oliver-Long's original letter proposal of 7 November 1977 for six 122 (48 in.) diameter F.R. Dorrclones, see item 2.1 above.

2.3 Desanding Dorrclone

P.J. Hannah and Associates Ltd. of Vancouver, agents for U.S. Filter Fluid Systems Corporation, proposed five 76 cm (30 in.) diameter, Desanding Dorrclones each with a capacity of 330 l/s (5,200 USGPM). Each unit, requiring a pressure drop of 28 kPa (4 psig), would remove at least 95 percent of particles of 110 microns. The quoted budget price was $250,000 and this would include the Dorrclones, valving, instrumentation and interconnecting piping within the system limits.

2.4 Celleco Cleaner

Bancroft Western Sales Ltd. of Vancouver, agents for Celleco, proposed two Celleco Cleanpac 130 Canister assemblies requiring a pressure drop of 97 kPa (14 psi). There would be a continuous reject flow of 140 l/s (2,200 USGPM). The quoted budget price for two canisters FOB Vancouver was $136,000, excluding taxes.

Pilot study apparatus would be freely available for testing at the treatment plant site.

2.5 Smith and Loveless Pista Grit Trap

Ecodyne Ltd. of Edmonton, Alberta, proposed following two alternative Smith and Loveless grit traps:

Two Smith and Loveless Pista Grit Traps, Model No. 30, operating in parallel, each unit rated for 880 - 1320 l/s (14,000-21,000 USGPM). The quoted budget price for rotating mechanism only was $50,000 total, FOB plant Oakville, Ontario, with freight and applicable taxes extra.

or

One Smith and Loveless Pista Grit Trap, Model No. 50, rated for 1320-2200 l/s (21,000-35,000 USGPM). The quoted budget price for rotating mechanism only was $30,000 and conditions of sale would be as for Model No. 30 above.

3. MEDIA FILTER

3.1 Neptune Microfloc Filter

Neptune Microfloc of Corvallis, Oregon, U. S. A., proposed four twin bay gravity filters, with a total filter area of 470 m^2 (5000 sq ft) The backwash rate for this size of filter would be approximately 630 l/s (10,000 USGPM) and would normally run from five to eight minutes. A storage volume of 320 m^3 (85,000 USG) would be required. Budget prices were not submitted.

3.2 Peacock Immedium Upflow Filter

Peacock Brothers Ltd. of Vancouver proposed their Peacock Immedium Upflow Filter which would require an area of 370-470 sq m (4,000-5,000 sq ft). Other details were not given.

3.3 Graver Filter

Ecodyne Ltd. of Edmonton, Alberta, proposed six 18.9 m (62 ft) x 6.7 m (22 ft) concrete Graver filters, operating in parallel, with air scour. The quoted budget price was $250,000, FOB shipping points, for the supply of dual media 46 cm (18 in) anthrafilt and 30 cm (12 in) sand, together with Graver Partilock underdrain strainers, air distribution in plenum chamber, backwash troughs, gate valves and air blowers. Freight and sales taxes would be extra as would all concrete work.

3.4 Graver Monovalve Filter

Ecodyne proposed as an alternative to 3.3 seventeen 7.6 m (25 ft) diameter by 4.6 m (15 ft) high, single compartment, all steel construction, Graver Monovalve Filters, complete with frontal piping, controls, dual media 30 cm (12 in) anthrafilt and 30 cm (12 in) sand. Units would be shipped knocked down, for field assembly by others.

The quoted budget price was $1.02 million, FOB plant Oakville, Ontario, with freight included to B.C., but all taxes extra.

4. MICRO FILTER

4.1 Cuno Automatic Flo-klean Filter

Peacock Brothers Ltd. of Vancouver proposed two AMF Cuno Automatic Flo Klean Filters - Model No. FKR16-4, each capable of filtering 790 l/s (12,500 USGPM) on heavy duty service with element spacing of 250 microns. Each filter unit would be supplied with a 5 HP backwash nozzle drive motor and a 40 HP backwash water supply pump set.

The quoted budget price was $300,000 total, FOB Hat Creek Site.

3.2 North Water Filter

H.D. Fowler Co. Ltd. of Vancouver proposed eight North water filters, each 1.5 m (5 ft) diameter by 3.7 m (12 ft) long. 'North' water filters are manufactured by Green Bay Foundry and Machine Works. Five of these rotating units would be equipped with 75 micron retentive cloth and be able to cope with normal operating sediment conditions and the three remaining rotating filters would only be required during periods of relatively high solids loading and would be equipped with 246 micron retentive cloth. For approximately $500, 'North' would carry out laboratory tests to determine the exact number and size of the filters required. Budget prices were not submitted.

APPENDIX 5

DORR-OLIVER-LONG HYDROSEPARATORS:

INSTALLATION LIST AND DATA

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 25 AUGUST 1978

PROJECT MEMORANDUM V4251/3
WATER TREATMENT BY MEANS OF SETTLING

APPENDIX 5 - DORR-OLIVER-LONG HYDROSEPARATORS: INSTALLATION LIST AND DATA

Dorr-Oliver-Long Hydroseparator installations are listed in Table 1. On the basis of this list, a telephone survey was conducted in order to locate installations most resembling operating conditions anticipated for the Hat Creek Project (see Table 2).

As shown in Table 2, the Eveleth Taconite Mining Company at Forbes, Minnesota, operates five Hydroseparators (Installations 14.2 and 14.4) which remove solids comparable to the proposed Hat Creek Project. These installations could be used as a reference during Final Design.

The telephone survey was limited to the companies listed in Table 2 and terminated when a representative installation had been located.

Table 1 - Installation List of Dorr-Oliver-Long Hydroseparators

Installation No.	Company	Country	Year	Hydroseparator Amount	Diameter (m)	Centre Depth (m)	Inflow l/s	Additional Data in Table 2	Comments
1	Iron Ore Co. of Canada	Canada	62	1	9.8	-	-		Located in Labrador.
2	Jones & Laughlin	Canada	63	1	9.8	3.1	-	x	
3.1	Potash Co. of America	Canada	64	1	15.2	-	140	x	
3.2			64	1	3.7	-	140	x	
4	International Minerals and Chemical	Canada	65	2	13.7	3.6	45	x	
5	Great Canadian Oil-Sands Ltd.	Canada	66	2	9.1	2.4	-		Used for separation of foaming grease, not comparable to Hat Creek Project.
6.1	U.S. Steel	U.S.A.	65	1	4.9	2.2	160	x	
6.2			70	6	11.0	3.1	-	x	
6.3			76	1	9.8	-	-	x	
7.1	Hanna	U.S.A.	65	5	9.1	3.4	-	x	
7.2			65	6	9.1	3.4	-	x	
8.1	J. M. Huber	U.S.A.	65	1	3.7	1.5	-		
8.2			65	1	7.3	2.1	-		
8.3			73	1	3.7	1.5	-		
8.4			73	1	7.3	2.1	-		
9	Erie Mining	U.S.A.	65	2	5.5	3.1	-	x	
10	Swift and Co.	U.S.A.	66	1	15.2	3.1	-		
11.1	Jackson Co.	U.S.A.	67	2	7.9	3.3	130		
11.2			67	1	4.9	1.5	270		
12	Fria	U.S.A.	69	1	9.8	2.4	140		
13	Unisil Corporation	U.S.A.	72	1	4.9	2.4	-		
14.1	Eveleth Taconite Mining Company	U.S.A.	74	3	12.8	4.7	310	x	
14.2			74	3	13.7	3.0	1130	x	
15	Mississippi Chemical	U.S.A.	76	1	19.8	1.8	-		

Note: Dash (-) means information not given.

Table 2 - Additional Data on Some Dorr-Oliver-Long Hydroseparators from Table 1

Installation No.	Company	Place	Contact	Telephone No	Hydroseparator No. of Units	Hydroseparator Tank Dia. (m)	Hydroseparator Feedwell Dia. (m)	Flow Through Each Tank Inflow l/s	Flow Through Each Tank Intermittent Underflow l/s	Material Settled Out	Particle Specific Gravity	Minimum Particle Size Settled Out (Microns)	Comments
2	Jones & Laughlin	Adams Mine, Kirkland Lake, Ontario, Canada	N. Coats	705-567-3321	1	9.8	-	-	-	Coarse sand	-	-	Tank mechanism no longer used.
3	Potash Company of America	Saskatoon, Saskatchewan Canada	R. Smith	306-374-4806									
3.1					1	15.2	5	140	25	Clay	-	50	Material settled out not comparable to Hat Creek project. Also relatively low flow rate compared with Hat Creek flow of 1660 l/s.
3.2					1	3.7	-	140	25	-	-	-	Tank mechanism no longer used.
4	International Minerals and Chemical, K2 Mine	Esterhazy, Saskatchewan, Canada	R. Bomboir	306-745-3911	2	13.7	-	45	-	Carnallite	1.62	-	Liquid temperature (82°C) not comparable to Hat Creek project.
6	U.S. Steel Minnesota Ore Operations	Mt. Iron, Minnesota, USA 55768	C.W. Niemi Robertson	218-741-9020	-	-	-	-	-	-	-	-	Written request required before data given.
7	Hanna	Cooley, Minnesota, USA	P. Koskinen R. Jensen	218-885-1020 218-262-3451	-	-	-	-	-	Silica	-	-	Written request required before additional data given.
9	Erie Mining Company	Box 847 Hoyt Lakes, Minnesota, USA 55750	C. Keith	218-225-2171	-	-	-	-	-	-	-	-	Written request required before data given.
14	Eveleth Taconite Mining Company	Forbes, Minnesota, USA	D. Wilson D. Coyle	218-749-1460									
14.1					3	12.8	4	310	60	Magnetite	4.9-5.2	40	Material settled out not comparable to Hat Creek Project.
14.2					3	13.7	6	1130	20	Silica	2.6-2.7	150	Application similar to Hat Creek Project.
14.3					4	8	2	240	50	Magnetite	4.9-5.2	40	Material settled out not comparable to Hat Creek project.
14.4					2	12	5	1080	25	Silica	2.6-2.7	150	Application similar to Hat Creek Project.

Notes: 1. Dash (-) means information not given
2. All above installations are inside process buildings and operate with a liquid temperature equal to that of the ambient air, except for No. 4 (see comment).
3. Installation Nos. 14.1 and 14.2 are extensions to the original installations, Nos. 14.3 and 14.4. The original installations were not by D.O.L.

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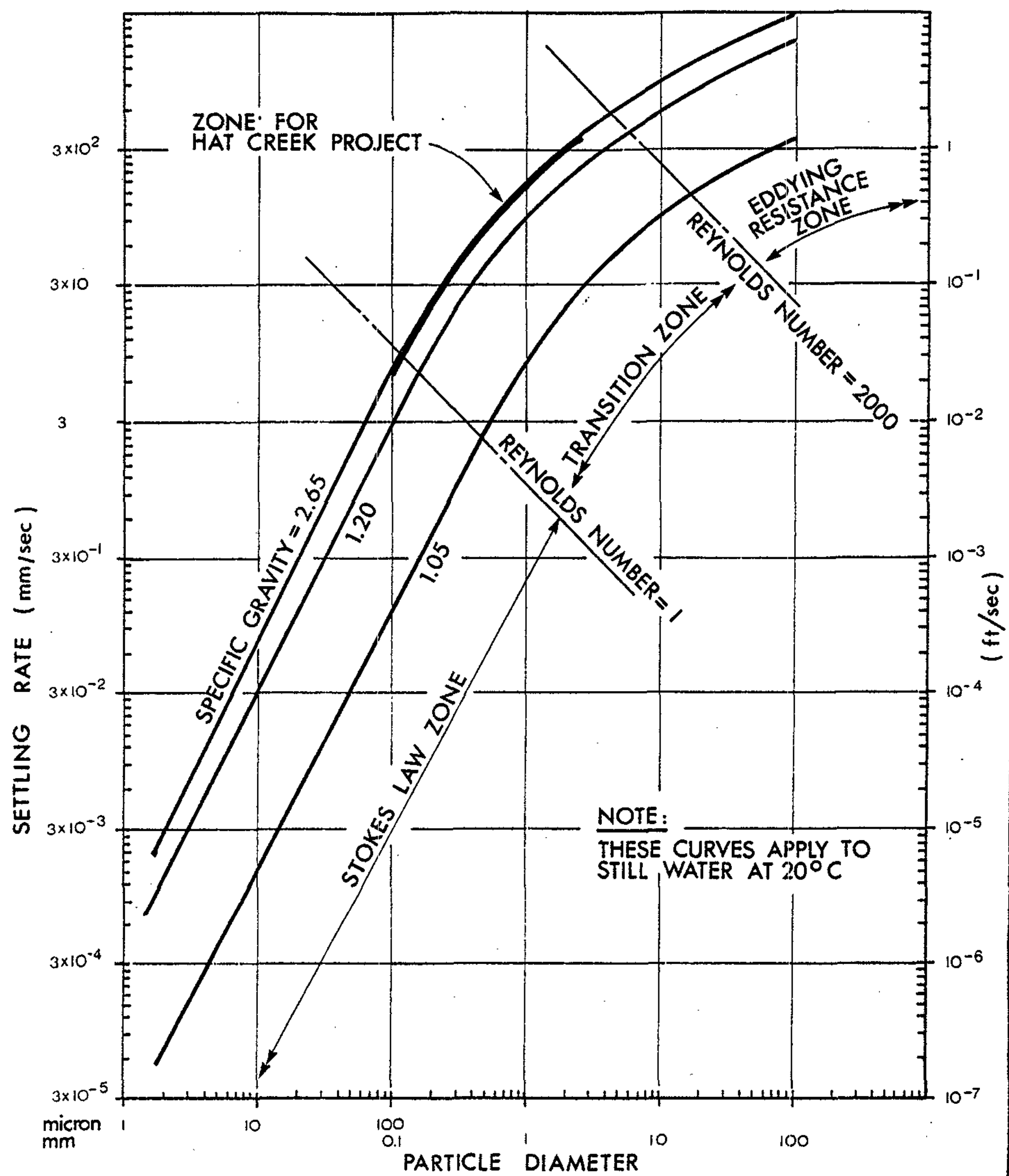
APPENDIX 6

ILLUSTRATIONS

(PM V4251/3)



			DAY	MO.	YR.	
APPROVED						HAT CREEK PROJECT
DATE	DR'N.	SH				COOLING WATER SUPPLY
	CH'K'D.					WATER TREATMENT BY MEANS OF SETTLING
A	APP'D.					
	APP'D.	A. C.	25	8	78	SETTLING RATE / PARTICLE DIAMETER CURVES

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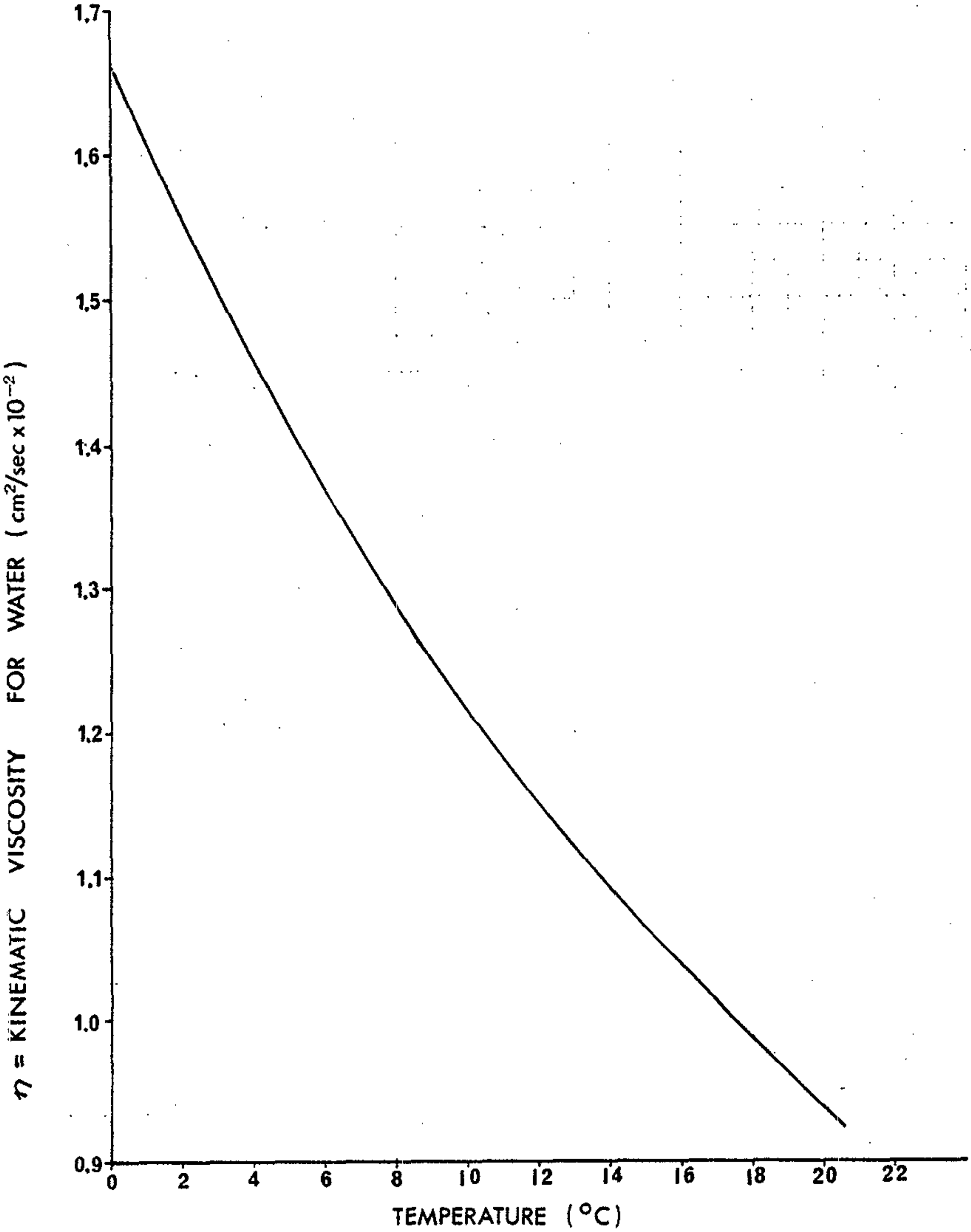
DWG. A 4251/3-1 REV



APPROVED			DAY	MO.	YR.
DATE	DR'N.	SH			
	CH'K'D.				
A	APP'D.				
	APP'D.	A.C.	25	8	78

HAT CREEK PROJECT
COOLING WATER SUPPLY
WATER TREATMENT BY MEANS OF SETTLING
KINEMATIC VISCOSITY / TEMPERATURE CURVE

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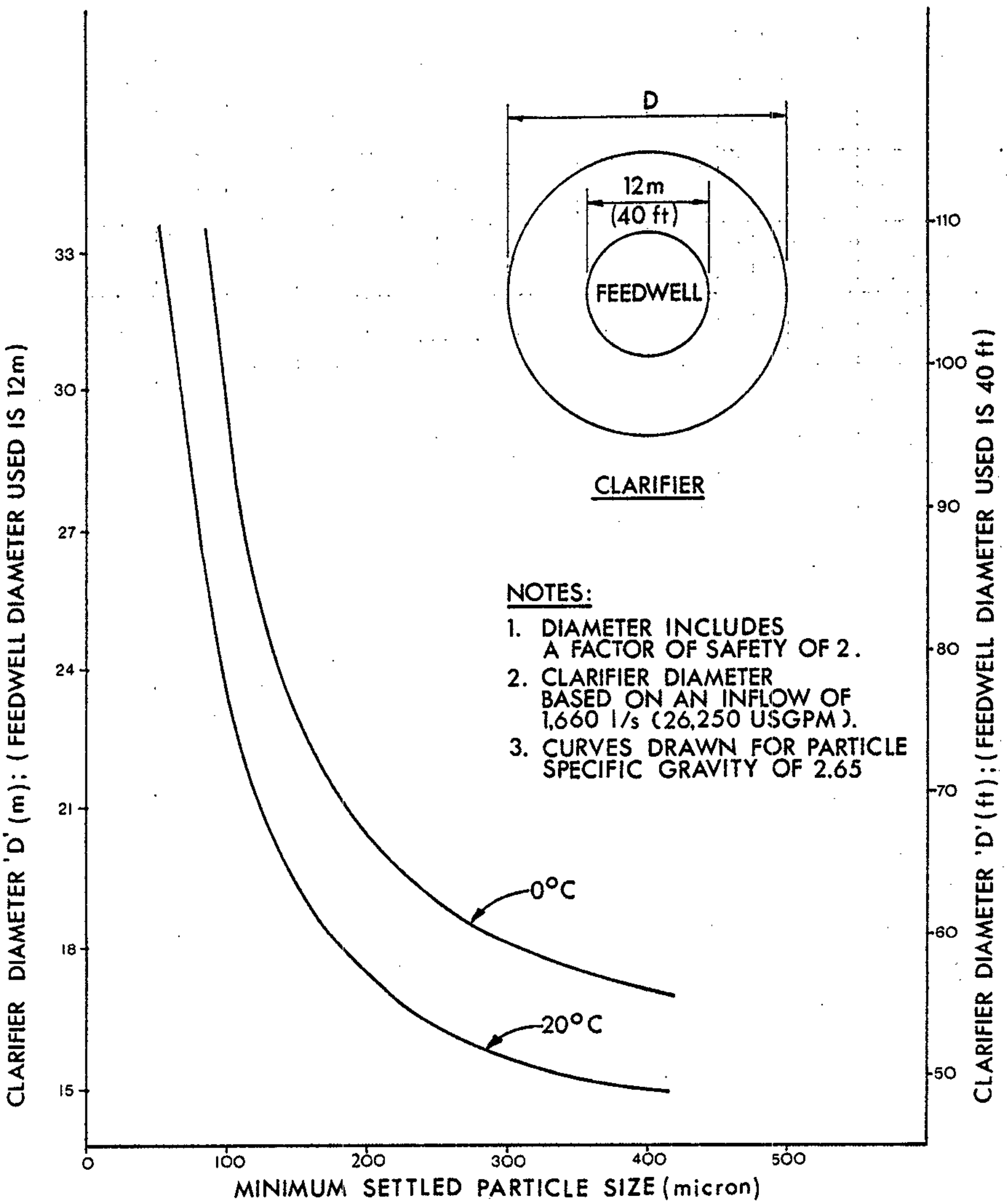

NOTES:

1. DIAMETER INCLUDES A FACTOR OF SAFETY OF 2.
2. CLARIFIER DIAMETER BASED ON AN INFLOW OF 1,660 l/s (26,250 USGPM).
3. CURVES DRAWN FOR PARTICLE SPECIFIC GRAVITY OF 2.65

APPROVED			DAY	MO.	YR.
DATE	DR'N.	SH			
	CH'K'D.				
A	APP'D.				
	APP'D.	A.C.	25	8	78

HAT CREEK PROJECT
COOLING WATER SUPPLY
WATER TREATMENT BY MEANS OF SETTLING
CLARIFIER DIAM./PARTICLE SIZE & TEMPERATURE

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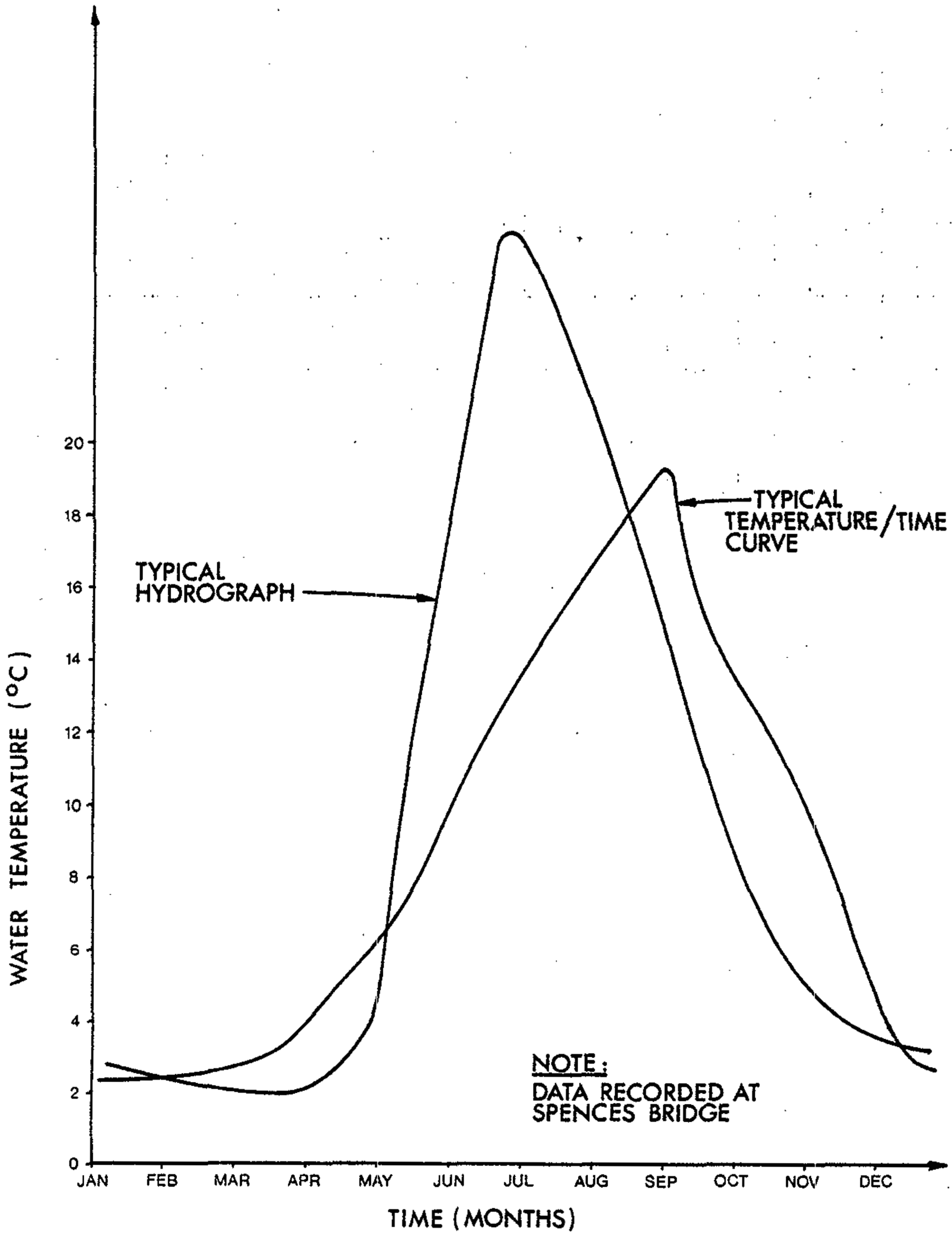
SANDWELL 550 A



APPROVED			DAY	NO.	YR.
DATE	DR'N.	SH			
	CH'K'D.				
A	APP'D.				
	APP'D.	R.G.	25	8	78

HAT CREEK PROJECT

COOLING WATER SUPPLY

WATER TREATMENT BY MEANS OF SETTLING

THOMPSON RIVER HYDROGRAPH & TEMP/TIME CURVE

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PROJECT MEMORANDUM V4251/4

RESERVOIR RELOCATION

(V4251/1)

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B. C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 8 SEPTEMBER 1978

PROJECT MEMORANDUM V4251/4
RESERVOIR RELOCATION

CONTENTS

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B. C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 8 SEPTEMBER 1978

PROJECT MEMORANDUM V4251/4
RESERVOIR RELOCATION

INTRODUCTION

Mr. C.K. Harman of B.C. Hydro and Power Authority, in a letter dated 25 April 1978 to Mr. A. Copeland of Sandwell, asked what effect relocating the power plant water reservoir would have on the cooling water supply scheme and on the preliminary engineering cost estimate. The reservoir would be relocated to upper Medicine Creek, as shown on Drawing B4251/4 - 1*.

The Scope of Work was defined in correspondence dated 2 and 12 May 1978, quoted in Appendix 1. The work includes choosing a compatible combination of pipeline route, reservoir discharge arrangement, and with B.C. Hydro assistance, waterhammer control scheme. The cost estimate was prepared by determining the cost of items which are different from the Preliminary Design estimate, and then adjusting the estimate accordingly.

PIPELINE ROUTE

The route selected as being most compatible with overall economy and with the relocated reservoir location is shown on Drawing B4251/4 - 1, and in profile on Drawing D4251/4 - 2. The route is that of Alternative 3 from Project Memorandum V4251/1, Pipeline Route Review, except that it is shorter by 1 km because it has been revised between Station 18 + 500 and the relocated power plant reservoir. This route was selected for the reservoir relocation because it offers the advantage of a high point near Station 10 + 100 suitable for a simple surge tank, from which flow would be by gravity to the plant reservoir. This arrangement simplifies waterhammer control, and also provides the cost and other benefits of Alternative 3 which were identified in Project Memorandum V4251/1.

FLOW CONTROL

Drawing D4251/4 - 2, Pipeline Profile, shows that along the selected route, the pipeline has two summits about 8.5 km apart and at nearly the same elevation, and that from the second summit the pipeline descends to the plant reservoir. This profile creates special problems for flow control, and invalidates the one-way surge tank** configuration proposed for the Preliminary Design route.

---

* For Drawings see Appendix 3, Illustrations.

** A one-way surge tank is a tank filled with water, isolated from the pipeline by check valves, so that when the piezometric head at the tank drops below the water level in the tank the check valves open and water from the tank flows into the pipeline to reduce waterhammer.

In the early stages of this study, it was desirable to develop a scheme using a one-way surge tank on the first summit to enable comparison between similar schemes for the relocated reservoir and for the Preliminary Design reservoir. However, such a scheme was not developed because a one-way tank there would not protect the pipeline for the following reason: the one-way tank, being higher than the second summit, would drain when pumping stopped. When pumping resumed, the tank would refill slowly through a control valve, and it is possible that maximum pipeline discharge could be reached with very little water in the tank. Should power fail at this time, the tank would not protect the pipeline.

This problem did not exist with the Preliminary Design arrangement because the one-way tanks were located below the pipeline summit; thus they would refill during the time pumping was stopped.

There are perhaps ways to avoid this problem with the one-way tank, such as lowering the pipeline profile and tank elevation, interlocking pump start-up with tank level, or even changing the pipeline route. However, the best way to avoid the problem is to use a simple surge tank* instead of a one-way surge tank. The simple tank requires no valves and is therefore more reliable. This tank would be located on the first summit, with maximum water level at about elevation 1340. The discharge throughout the pipeline cannot reach maximum until the simple tank is full, because the head in the tank is needed to drive the water downstream. Therefore, the pipeline is protected for the maximum flow condition.

The flow from the simple tank to the plant reservoir would be by gravity since the tank becomes the high point in the profile. Two cases for controlling this flow have been developed, as shown on Drawing D4251/4 - 2, and as described below:

<u>Case 1</u>: Control Valve at Maximum Reservoir Level

The valve, with an energy-dissipating fitting to prevent cavitation** damage, keeps the pipe full and maintains the water level in the simple tank on the first summit. To reduce the height of tank required, a 900mm diameter pipeline is necessary between the tank and the valve.

<u>Case 2</u>: Weir at Second Summit

The weir, at elevation 1302 in a tank at the second summit, keeps the water level at that elevation when pumping stops. At the first summit, the pipeline is buried below elevation 1302, but the simple tank drains when pumping stops. The tank would refill when flow resumes. Again, a 900mm diameter pipeline is needed between the summits.

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* A simple surge tank is a tank filled with water, connected directly to the pipeline. This tank controls waterhammer by accepting or supplying water when flow conditions change.

** Cavitation is caused by the collapse of cavities of vapour which tend to form in the flow when absolute pressure drops to the fluid vapour pressure. The collapse causes serious problems of noise, vibration, and pitting of surfaces.

PARTIALLY-FULL FLOW SECTION

The pipeline section from the control valve to the plant reservoir in Case 1, and from the weir on the second summit to the plant reservoir in Case 2, is designed to carry the maximum discharge in a buried partially-full pipe. The partially-full system simplifies flow control. Full flow, on the other hand, would require a submerged control valve on the downstream end of the pipeline. This concept was rejected, as the submerged control valve would be troublesome for operation and maintenance.

Breather pipes rather than air release valves would allow air exchange. The pipeline would end at a small concrete stilling basin below low water level. Transition from partially-full to full flow would occur inside the pipe at the reservoir level.

A canal or open channel along the surface would be possible with either case, but was rejected as it would be susceptible to freezing. In the selected arrangement, the pipe would be buried below the depth of frost penetration in the ground; thus the water in the pipe would not freeze if the pipe were full. However, as there would be an air-water interface, and as the air could escape through the breather pipes, there could be heat lost from the water and ultimately from the surrounding soil. Remedies which may include heat tracing, heating the air in the pipe, or deeper burial of the pipe, should be examined during Final Design if the heat loss were too great.

As the water in the partially-full flow section of the pipeline drops as much as 87 m with Case 2, the design must ensure that the water velocity does not become so high as to cause severe damage to the pipeline. The maximum velocity in the pipeline would be 7.9 m/s under uniform flow conditions. (The calculations for non-uniform flow are not warranted at this time as the actual profile of the field-bent pipe will not be known until Final Design.)

B.C. Hydro advised that coal tar epoxy or other thin film linings, as were proposed in the Preliminary Design for the pipeline interior, have an excellent operating record with water velocities up to 18 - 21 m/s. As the calculated maximum velocity of 7.9 m/s is well below that level, the design is acceptable for this portion of the pipeline.

LOCATION OF Nº 2 BOOSTER STATION

The total dynamic head for Cases 1 and 2 being about 150 m less than for Alternative 3 of Project Memorandum V4251/1, it was necessary to relocate the Nº 2 Booster Station to elevation 775 m from elevation 835 m. On topographic maps and air photos, ground conditions appear about the same. This location is closer to the overflow reservoir, thus the overflow trench required is shorter. Geotechnical evaluation and field appraisal, as were recommended in Project Memorandum V4251/1, are still necessary to confirm this location.

PIPELINE INSPECTION

The concept of inspecting the pipeline using "smart pigs" is discussed in Report V4191/1. In order to use pigs with the Case 1 and Case 2 arrangements, two extra pig traps are needed each side of the simple surge tank. These traps are necessary because the pipe diameter changes at the tank from 800mm to 900mm, too great a change to use the same pig without modifying the driving cups.

The partially-full portion of pipeline to the reservoir from the control valve in Case 1, and from the weir tank in Case 2, could not be inspected the same way because of the breather pipes which would release pressure needed to drive the pigs. However, this portion could be visually inspected as it would drain freely. Moreover, the consequences of leakage are insignificant here compared to pressurized portions of the pipeline.

PIPELINE FRICTION

In any pumping system, the delivery of the design discharge depends on the pipeline friction being as expected at the time of design. In Preliminary Design, pipeline friction was calculated for coal tar epoxy lining and for the 35 year project lifetime, and the pumps were rated accordingly. However, in the unlikely event that the pipeline interior became badly corroded, so that the pumps could no longer supply the design discharge, a booster pump could be added to each booster station to regain the full discharge capability.

For Cases 1 and 2, a substantial increase in friction would cause the simple surge tank to overflow, and a possible remedy would be to make the tank higher. During Final Design, it may be decided to avoid this problem by increasing the pipe diameter between the simple surge tank and the control valve (Case 1) or weir tank (Case 2).

WATERHAMMER STUDIES

The results of B.C. Hydro's waterhammer studies of the two cases are contained in a letter dated 30 June 1978 from Mr. I.C. Dirom of B.C. Hydro to Mr. A.P. Basham of Sandwell. The following measures are sufficient to control the design pressure rise to less than 10% of the rated head, and to prevent water-column separation:

Case 1

a. Nº 1 to Nº 2 Booster Station

- Nº 1 Booster Pump - Motor inertia = 175kg.m^2 each
- One-way surge tank required at summit of Elephant Hill, 4m in diameter
- Pump discharge valve closing time = 70 s

b. Nº 2 Booster Station to Control Valve

- Nº 2 Booster Pump - Motor inertia = 175 kg.m^2 each
- Pump discharge valve closing time = 55 s
- Simple surge tank at Station 10 + 100 to be 5m in diameter. Design upsurge to be 5m above maximum steady water level

Case 2

a. Nº 1 to Nº 2 Booster Station

- All as Case 1

b. Nº 2 Booster Station to Plant Reservoir

- Nº 2 Booster Pump inertia as Case 1
- Pump discharge valve closing time = 55 s
- Simple surge tank as Case 1
- Tank with weir at Station 18 + 500 to be 8m in diameter.

The variations from the waterhammer control measures appropriate to the Preliminary Design are notably the simple rather than one-way surge tank on the summit of Cornwall Hill and the necessity of a one-way surge tank on Elephant Hill. These result from the lower total head and altered profile. It is also notable that the booster pump inertia requirement, less than half of that for Preliminary Design, attests to the superior waterhammer behaviour of this configuration.

The B.C. Hydro waterhammer study group prefers Case 2 because the control valve in the Case 1 arrangement could cavitate at low discharges. It could, therefore, require expensive maintenance if the energy dissipator did not function properly.

CAPITAL COST

In accordance with Item 8 of Appendix 2, the following cost estimate has been prepared. This estimate is not a complete re-examination of the Preliminary Design estimate, rather it reflects adjustments to the various categories because of the selection of Alternative 3 (Project Memorandum V4251/1) and because of the relocated water reservoir. For ease of comparison, the Preliminary Design estimate and the estimate for Alternative 3 are also given.

A detailed breakdown of the items in the estimate which have been changed is provided in Appendix 2 for Case 1 and Case 2, and in Project Memorandum V4251/1 for Alternative 3.

Table 1 - Cost Estimate

Account	Item	Preliminary Design (Report V4191/1)	Adjusted For Alternative 3 (PM V4251/1)	Adjusted For Case 1	Adjusted For Case 2
	STRUCTURES				
271.00	Thompson River Intake	$ 2,640,000	$ 2,640,000	$ 2,640,000	$ 2,640,000
272.00	Water Pipeline	15,535,000	14,940,000	14,885,000	14,925,000
273.00	No. 1 Booster Station	950,000	950,000	950,000	950,000
274.00	No. 2 Booster Station	1,755,000	1,770,000	1,620,000	1,620,000
	Total Structures	$20,880,000	$20,300,000	$20,095,000	$20,135,000
	EQUIPMENT				
271.00	Thompson River Intake	$ 1,780,000	$ 1,780,000	$ 1,780,000	$ 1,780,000
272.00	Water Pipeline	2,385,000	2,635,000	2,185,000	2,370,000
273.00	No. 1 Booster Station	3,430,000	3,430,000	3,370,000	3,370,000
274.00	No. 2 Booster Station	3,445,000	3,445,000	3,385,000	3,385,000
291.00	Power Supply and Distribution	2,345,000	2,395,000	2,295,000	2,195,000
	Total Equipment	$13,385,000	$13,685,000	$13,015,000	$13,100,000
	Total Direct Cost	$34,265,000	$33,985,000	$33,110,000	$33,235,000
	Owner's Construction Overhead	$ 2,740,000	$ 2,715,000	$ 2,660,000	$ 2,660,000
	Engineering	3,500,000	3,500,000	3,500,000	3,500,000
	Contingencies	5,245,000	5,100,000	4,980,000	5,005,000
	Total Construction Cost	$45,750,000	$45,300,000	$44,250,000	$44,400,000
	Corporate Overhead	2,250,000	2,250,000	2,200,000	2,200,000
	Total Capital Cost	$48,000,000	$47,550,000	$46,450,000	$46,600,000

SANDWELL

(P.M. V4251/4)

ENERGY COST

Energy cost for pumping from the clearwell at elevation 325 m to the plant reservoir over the 35 year project lifetime is shown on Table 2.

Table 2 - Present Value of Energy Cost
Based on 20 Mills per kWh and 8% Interest
(Total volume: 22.9 million m^3/a)

	Preliminary Design (Report V4191/1)	Alternative 3 (P.M. V4251/1)	Case 1	Case 2
Minimum (Pumping at 725 l/s continuously)	$20,906,000	$20,861,000	$19,774,000	$19,213,000
Maximum (Pumping at 1580 l/s for 46% of the time)	$24,343,000	$24,133,000	$21,252,000	$21,301,000

As mentioned in Project Memorandum V4251/1, Alternative 3 benefits from a shorter pipeline route than the Preliminary Design. Cases 1 and 2 benefit from a pipeline route which is shorter yet, from the use of 900 m diameter pipe, and from a lower elevation of the plant reservoir. Case 2 saves about $0.5 million over Case 1 for the continuous pumping condition because the weir control allows a lower water level in the simple surge tank. In Case 1, this water level would be constant regardless of discharge.

As the relocated reservoir would be located on Medicine Creek, it could be designed to collect run-off from this stream and thus reduce the amount needed from the Thompson River by 4 million cubic metres per year (from 22.9 to 18.9 million cubic metres per year).

Additional cost data for the relocated reservoir utilizing Medicine Creek water are given on Table 3 in two groups: the first group where the full 4 million cubic metres is taken, and the second group where 2.5 million cubic metres is taken and the balance is diverted for irrigation.

Table 3 - Present Value of Energy Cost Where
Medicine Creek Water Collected (basis as Table 2)

	Volume used from Medicine Creek (million m^3/a)	Case 1	Case 2
Minimum (Pumping at 598 l/s continuously)	4.0	$16,206,000	$15,699,000
Maximum (Pumping at 1580 l/s for 38% of the time)	4.0	$17,528,000	$17,575,000
Minimum (Pumping at 646 l/s continuously)	2.5	$17,548,000	$17,017,000
Maximum (Pumping at 1580 l/s for 41% of the time)	2.5	$18,936,000	$18,972,000

Cases 1 and 2 thus can save up to $3.7 million by collecting 4 million m^3/a of Medicine Creek run-off. ($21,301,000 - $17,575,000 = $3,726,000)

COMPARISON OF CASE 1 AND CASE 2

The advantages of Case 1 over Case 2 are:

- The capital cost is $150,000 less
- A greater length of pipeline can be pigged

The advantages of Case 2 over Case 1 are:

- The energy cost for continuous discharge is $560,000 less
- The simple surge tank drains when pumping stops, therefore Case 1 requires less energy to prevent freezing in the tank
- The control valve and energy dissipator at the plant reservoir, which would be potentially troublesome maintenance items, are avoided

As the advantages of Case 2 over Case 1 outweigh those of Case 1 over Case 2, Sandwell recommends Case 2 for further consideration should B.C. Hydro decide to relocate the plant reservoir to Upper Medicine Creek.

CONCLUSIONS

The implications of relocating the power plant reservoir to Upper Medicine Creek, using Case 2, would be as shown on Table 4. Since the Preliminary Design route is no longer appropriate to either reservoir location, it is excluded from the comparison.

Table 4 - Implications of Reservoir Relocation

Item	Plant Reservoir Preliminary Design	Plant Reservoir Relocated - Case 2
Route	Alternative 3 (P.M. V4251/1)	Altered beyond Sta 18 + 500 Shorter by 1 km
Pipe Size	Uniform 800mm diameter	7.3 km of 900mm diameter
Flow Controls	Self-regulating at booster stations	Self-regulating at booster stations
Waterhammer Controls	3 one-way surge tanks	1 one-way surge tank (Elephant Hill) 1 simple surge tank 1 weir tank
	400 $kg.m^2$ flywheel inertia	175 $kg.m^2$ flywheel inertia
Capital Cost	$47.6 million	$46.6 million
Energy Cost	$20.9-$24.1 million	$15.7*-$21.3 million

These implications can be incorporated into B.C. Hydro's considerations of other costs and benefits which would accrue from relocating the power plant reservoir.

*Using 4 million m^3/a of Medicine Creek water

Prepared by [signature]
A. P. Basham, M. Eng., P. Eng.

Approved by [signature]
A. Copeland, P. Eng.
Project Engineer

APPENDIX 1

SCOPE OF WORK

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 8 SEPTEMBER 1978

PROJECT MEMORANDUM V4251/4
RESERVOIR RELOCATION

APPENDIX 1 - SCOPE OF WORK

In letters to Mr. C.K. Harman of B.C. Hydro and Power Authority dated 2 May 1978 and 12 May 1978 from Mr. D.A. Brundrett of Sandwell, the following Scope of Work was defined for determining the effects on the cooling water supply scheme of relocating the power plant water reservoir to Upper Medicine Creek:

1. (2 May) Since a power line corridor will not be required, the pipeline route downstream of Boston Flats will be reviewed. Data in Project Memorandum V4251/1 will be used for the pipeline routing between Boston Flats and McLean Lake. Alternative 3, recommended in this Project Memorandum, may have to be reconsidered as this route may not be compatible with a lower plant reservoir.

   B.C. Hydro is to advise whether or not the proposed power plant access road is to be considered when selecting a new pipeline route.

2. (12 May) The selection of a suitable location for the second booster pumping station: this work will be carried out with the same level of effort as was done for Project Memorandum V4251/1, Pipeline Route Review.

3. (2 May) Pipe wall thickness requirements will be reviewed, because of a lower total discharge head.

4. (2 May) Since the divide between Cornwall Creek and Medicine Creek is approximately at elevation 1290 m, or 65 m above the minimum reservoir level, we will review the discharge into the reservoir. The result may be different from the solution recommended in Report V4191/1 where the entire pipeline profile was below minimum reservoir level.

5. (2 May) Although the total pump discharge head will be slightly lower and the total annual water demands will be slightly less because of Medicine Creek flows, we will assume that the following water supply parameters and components will remain unchanged:

   5.1 Design capacity of 1580 l/s
   5.2 Entire system from intake to the point where the high pressure pipeline commences at the Nº 1 Booster Station
   5.3 Pipeline diameter of 800mm
   5.4 Basic selection and cost of booster pumps and motors
   5.5 System configuration of two booster pumping stations
   5.6 Arrangement and size of booster pumping stations

6. (2 May) Dr. M.H. Chaudhry of B.C. Hydro will be responsible for waterhammer protection. Sandwell's work will be carried out in close consultation with Dr. Chaudhry so that specific portions of this review, such as the location of the second booster station and the cost estimate, will not commence until the proposed route has been found acceptable from a waterhammer protection point of view.

7. (12 May) The following drawings will be prepared:

   7.1 Overall pipeline route similar to Drawing B4251/1 - 1, Project Memorandum V4251/1
   7.2 A new profile similar to Drawing D4191 - 15, Report V4191/1

8. (12 May) We will prepare a cost estimate with the same level of effort as that for our Project Memorandum V4251/1. This would be reported in the form of a "Summary of Cost Estimate" similar to Table 8, page 58, Volume 1, Report V4191/1, except that no breakdown of material and labour will be provided. Only total costs will be given for each item.

9. (2 May) The results will be presented in the form of a Project Memorandum.

The following items should be noted, referring to the numbers above:

1. B.C. Hydro has advised that, from about Station 18 + 500, the new pipeline route need not include consideration of the proposed power plant access road.

5.3 Pipeline diameters were modified in some areas for hydraulic reasons.

APPENDIX 2

DETAILS OF COST ESTIMATE

PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B.C. HYDRO AND POWER AUTHORITY
VANCOUVER B.C.

DATE 8 SEPTEMBER 1978

PROJECT MEMORANDUM V4251/4
RESERVOIR RELOCATION

APPENDIX 2 - DETAILS OF COST ESTIMATE (Showing all altered items.)

Account	Item	Preliminary Design	Alternative 3	Case 1	Case 2	Notes
	STRUCTURES					
272.00	Pipeline					
272.63	Grading	$ 295,000	$ 268,900	$ 263,600	$ 263,600	1
272.65	Pipe	4,880,000	4,616,800	4,418,000	4,369,800	1,2,3
272.66	Haul and String	340,000	340,000	325,100	325,100	1
272.67	Trenching	3,400,000	3,388,500	3,378,900	3,471,600	1,3,4,6
272.69	Bending	510,000	510,000	520,000	520,000	5
272.70	Line-up	525,000	495,200	474,200	474,200	1
272.71	Welding	450,000	424,200	426,400	421,400	1,2,3
272.74	Lower-in and tie-in	640,000	607,000	607,000	607,000	1
272.75	Bedding	365,000	334,800	329,300	329,300	1,3
272.77	Testing - Hydro and pig	120,000	120,000	140,000	140,000	5
272.78	Backfill	235,000	214,400	197,200	197,200	6
272.86	Drainage pipelines	1,305,000	1,149,200	873,600	873,600	7
272.88	Pig traps	925,000	925,000	1,387,000	1,387,000	8
	All other pipeline	1,545,000	1,545,000	1,545,000	1,545,000	
	Total (rounded)	$15,535,000	$14,940,000	$14,885,000	$14,925,000	

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Account	Item	Preliminary Design	Alternative 3	Case 1	Case 2	Notes
274.00	No. 2 Booster Station					
274.86	Drainage pipelines	$ 80,000	$ 246,000	$ 96,000	$ 96,000	9
274.93	Overflow reservoir	890,000	620,000	620,000	620,000	10
274.94	Access roads	35,000	155,000	155,000	155,000	10
	All other No. 2 Booster Station	750,000	750,000	750,000	750,000	
	Total (rounded)	$ 1,755,000	$ 1,770,000	$ 1,620,000	$ 1,620,000	
	EQUIPMENT					
272.00	Pipeline					
272.38	Process controls	$ 370,000	$ 370,000	$ 445,000	$ 370,000	11
272.43	Starters and MCC	40,000	40,000	31,100	31,100	12
272.44	Power wiring	260,000	260,000	202,200	202,200	12
272.48	Telemetering system wiring	440,000	440,000	411,300	411,300	1
272.83	Surge tank systems	750,000	1,000,000	603,300	860,900	13
272.89	Air/vacuum valves	365,000	365,000	332,800	332,800	14
	All other pipeline	160,000	160,000	160,000	160,000	
	Total (rounded)	$ 2,385,000	$ 2,635,000	$ 2,185,000	$ 2,370,000	
273.00	No. 1 Booster Station					
273.31	Pumps	$ 935,000	$ 935,000	$ 875,000	$ 875,000	15
	All other No. 1 Booster Station	2,495,000	2,495,000	2,495,000	2,495,000	
	Total (rounded)	$ 3,430,000	$ 3,430,000	$ 3,370,000	$ 3,370,000	

Account	Item	Preliminary Design	Alternative 3	Case 1	Case 2	Notes
274.00	No. 2 Booster Station					
274.31	Pumps	$ 935,000	$ 935,000	$ 875,000	$ 875,000	15
	All other No. 2 Booster Station	2,510,000	2,510,000	2,510,000	2,510,000	
	Total (rounded)	$ 3,445,000	$ 3,445,000	$ 3,385,000	$ 3,385,000	
291.00	Power Supply and Distribution					
291.51	69 kV transmission lines	$ Excluded	$ 50,000	$ 50,000	$ 50,000	10
291.54	Pipeline sub-stations	895,000	895,000	795,600	696,000	12,16
	All other power supply and distribution	1,450,000	1,450,000	1,450,000	1,450,000	
	Total (rounded)	$ 2,345,000	$ 2,395,000	$ 2,295,000	$ 2,195,000	

Notes

Total 27,865,000

1. Differences in length.
2. Differences in wall thickness distribution.
3. Difference in pipe diameter.
4. Extra depth at first summit included for Case 2.
5. Includes an allowance for the extra difficulty caused by changing pipe diameter.
6. Differences in depth to rock.
7. Two drainage pipelines no longer needed.
8. Two extra pig traps.
9. Shorter length of overflow pipeline.
10. See Project Memorandum V4251/1.
11. Includes control valve for Case 1.
12. Electrical equipment at 2 drainage pipelines deleted.
13. Case 2 includes weir tank.
14. Two fewer air/vacuum valves needed.
15. Booster pump flywheel inertia reduced.
16. Includes sub-station for control valve, Case 1.

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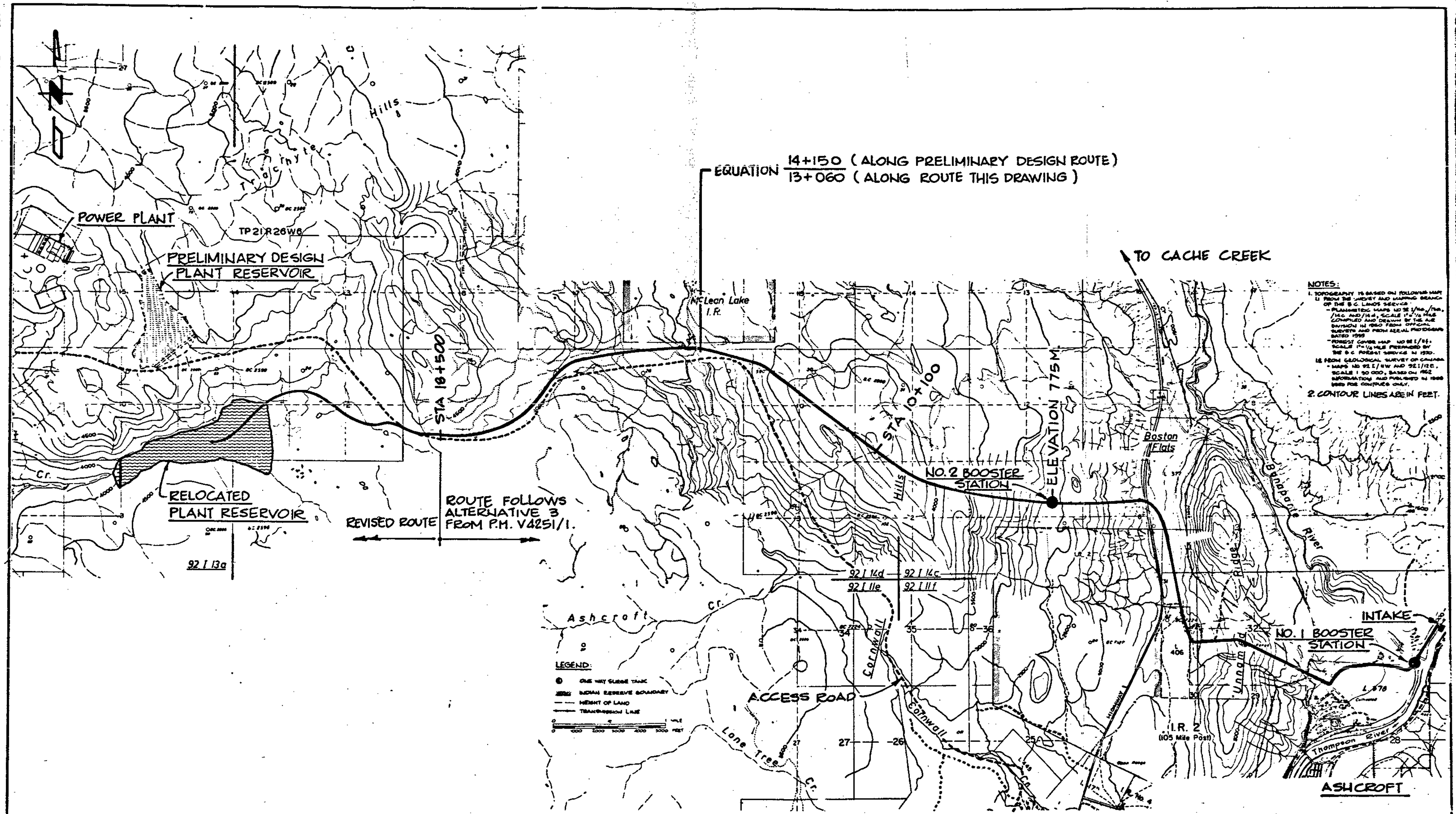
APPENDIX 3

ILLUSTRATIONS

(P.M. V4251/4)



DES		RECD	
DWN	SH	APPD	
CHKD	APB	APPD	
INSP		APPD	G.C.
SUBD		DATE	SEPT. '78

SANDWELL

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
COOLING WATER SUPPLY
RESERVOIR RELOCATION
PIPELINE ROUTE

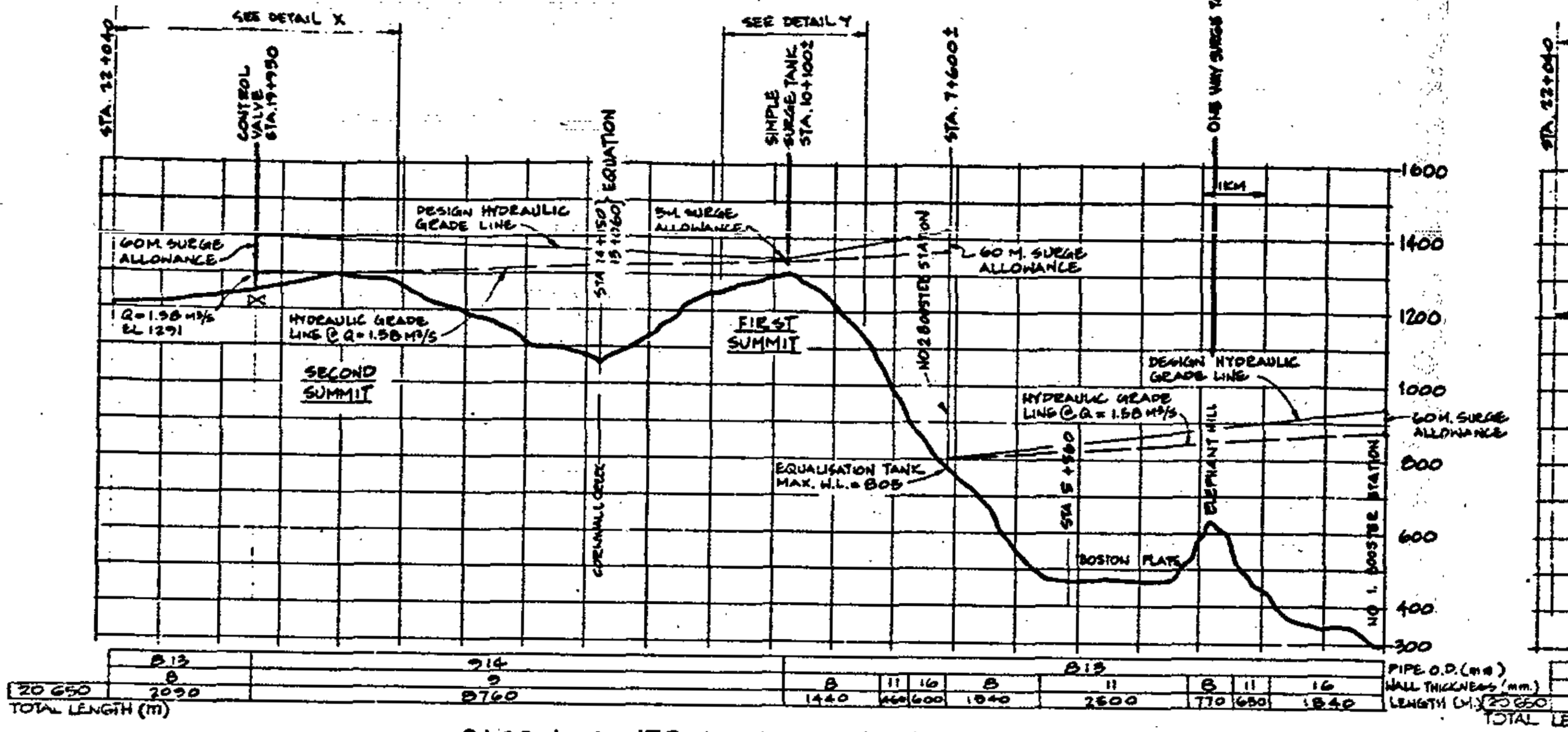
SCALE AS SHOWN

DWG No. B 4251/4-1 R

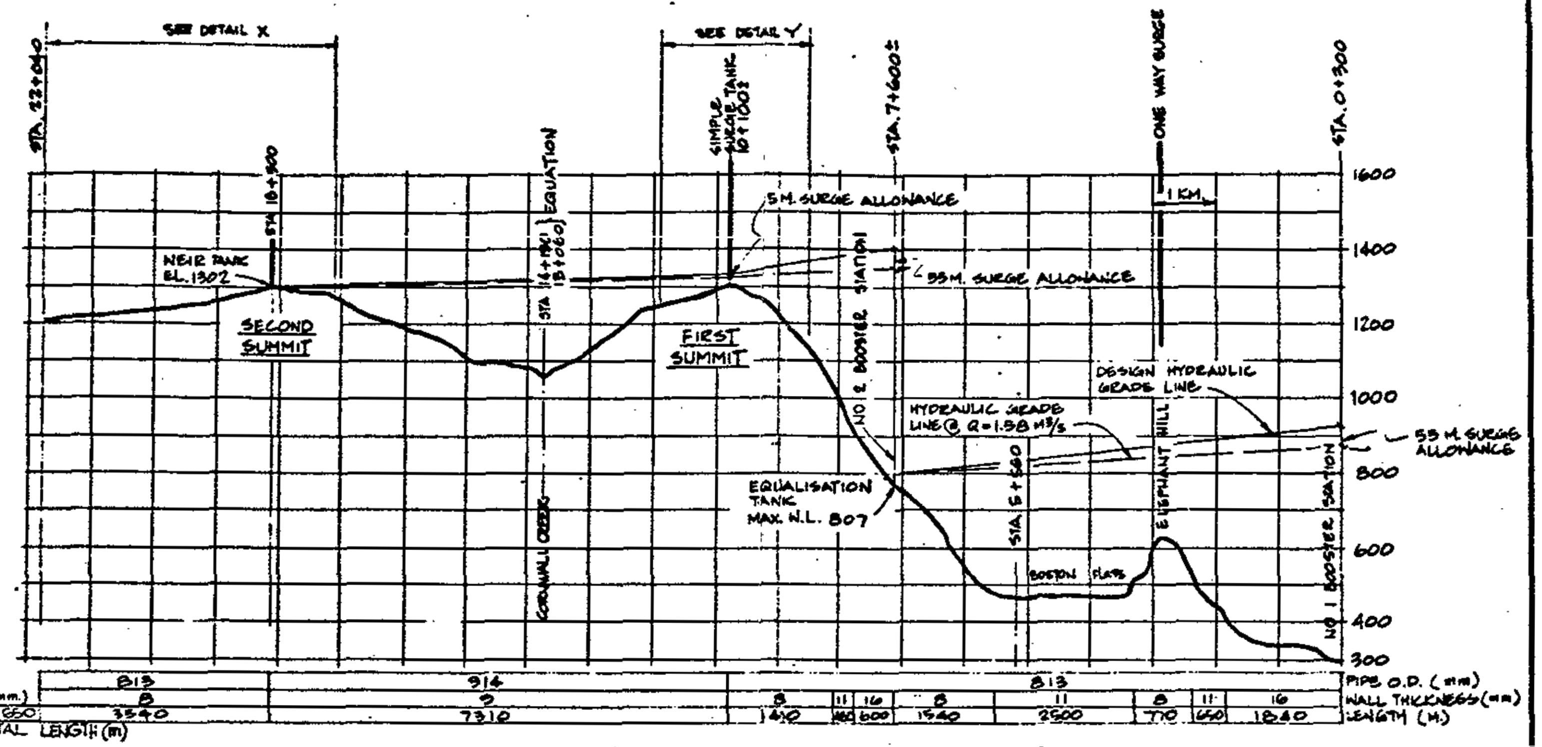
REVISIONS

REFERENCE DRAWINGS

B 4251/4-2 PIPELINE PROFILE



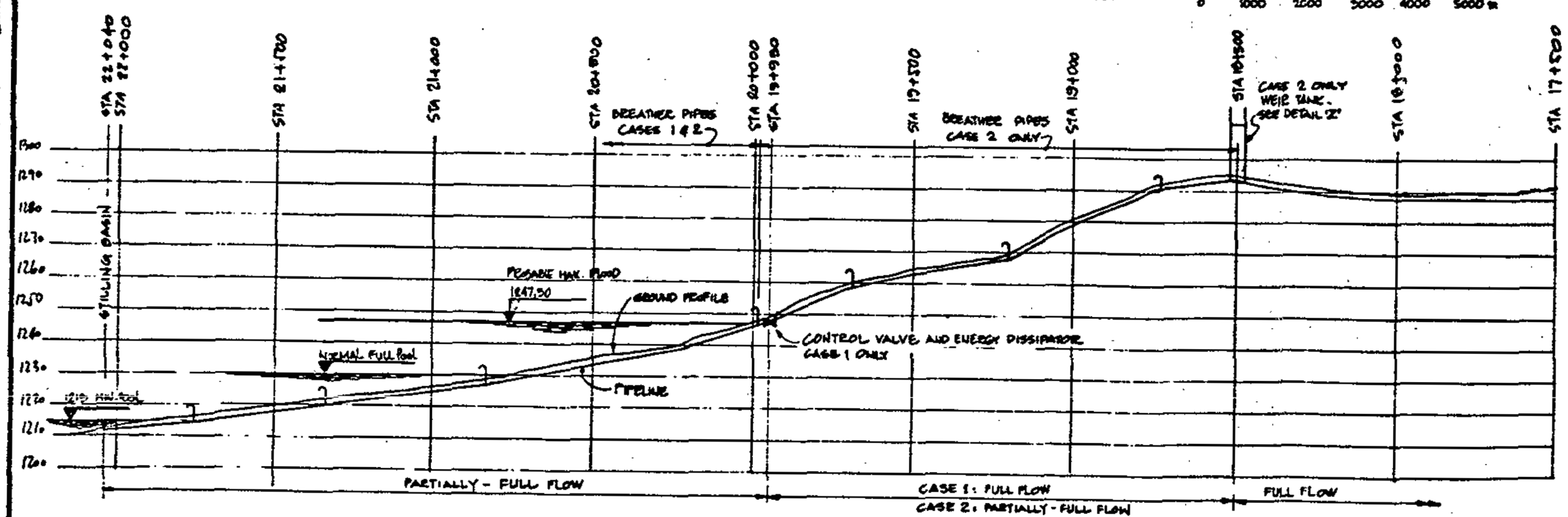
CASE 1: CONTROL VALVE AT RESERVOIR



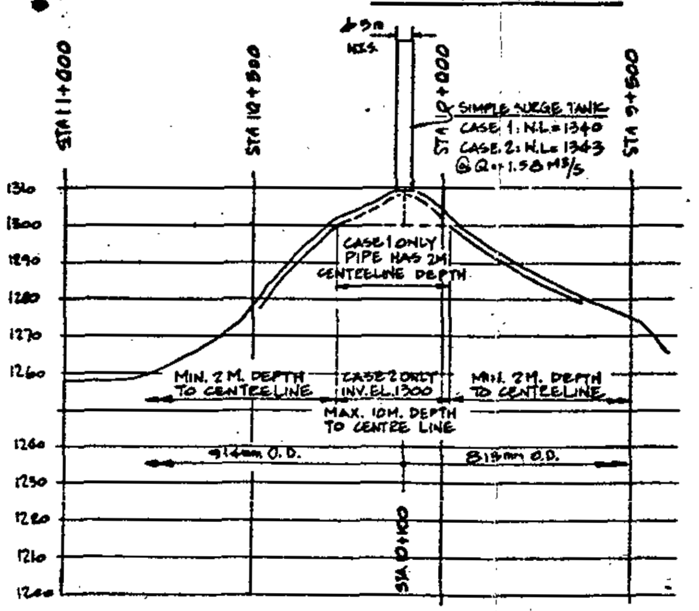
CASE 2: WEIR AT SECOND SUMMIT RECOMMENDED

VERTICAL 1:10 000 — 0 200 400 600 800 1000 m

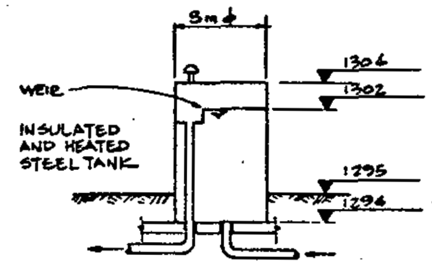
HORIZONTAL 1:60 000 — 0 1000 2000 3000 4000 5000 m



SECOND SUMMIT DETAIL X



FIRST SUMMIT DETAIL Y



SECOND SUMMIT WEIR TANK DETAIL Z

VERTICAL 1:1000 — 0 20 40 60 80 100 m

HORIZONTAL 1:10 000 — 0 200 400 600 800 1000 m

NOTES:

1. FOR PIPELINE ROUTE SEE REF 1.
2. RATED HEAD OF PUMPS CASE 1. 556.5 M. CASE 2: 558 M.
3. LENGTHS AND STATIONS HAVE BEEN DETERMINED APPROXIMATELY.

Scales as drawn

SANDWELL DWG. NO. D4251 /4-2

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
COOLING WATER SUPPLY
RESERVOIR RELOCATION
PIPELINE PROFILE

DES		RECO	
DWN	GJ	APPD	
CHKD	MB	APPD	
INSP		APPD	R.C.
SUBD		DATE	SEPT. 1978
MICROFILMED		DIST N CODE	

SCALE AS SHOWN — DWG No D4251/ 4-2 — R

1 B4251/4-1 PIPELINE ROUTE — REFERENCE DRAWINGS

REFERENCE DRAWINGS — REVISIONS — REMARKS — DATE — MADE — CHKD — INSP — SUBD — RECO — APPD — APPD

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PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B. C. HYDRO AND POWER AUTHORITY
VANCOUVER B. C.

PROJECT MEMORANDUM V4251/5
THOMPSON RIVER - WATER LEVEL DATA

DATE 31 JULY 1978

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PROJECT V4251
HAT CREEK PROJECT
COOLING WATER SUPPLY

B. C. HYDRO AND POWER AUTHORITY
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PROJECT MEMORANDUM V4251/5
THOMPSON RIVER - WATER LEVEL DATA

DATE 31 JULY 1978

PURPOSE

This Project Memorandum supplements water level data for intake Site 10 contained in Volume 2 of Sandwell's Report V4191/1 of March 1978, "Preliminary Design Study", Hat Creek Project, Appendix 8, Project Memorandum V4191/3, "Thompson River - Water Level Data". The water levels in PM V4191/3 were taken at bimonthly intervals from 6 December 1976 until 15 July 1977, during low winter flows and spring freshet.

Water level readings reported here were resumed on 14 December 1977 on a bimonthly basis until 1 July 1978, for following reasons:

1. To obtain readings during the winter of 1977-1978 as these were anticipated to be exceptionally low as a result of the 1977 drought.

2. To obtain readings during the 1978 freshet as these were anticipated to be higher than those taken during the 1977 freshet, which was exceptionally low.

3. To obtain readings at Site 10-D, the intake site selected during the Preliminary Design Study. These readings were required to confirm the stage discharge curve developed during the Preliminary Design Study on the basis of water levels taken 180 m downstream of 10-D.

STATIONS

Readings were taken at the following stations, see Drawing A4251/5-1*:

1. Station 10-D: The selected intake site, 225 m (750 ft) upstream of Site 10 (Station 0).

2. Station 45 m (150 ft) Upstream: This station, 45 m upstream of Site 10 (Station 0), is for correlation of readings taken during 1976 - 1977 and 1977 - 1978.

3. Station 10-G: A potential backup site for 10-D, identified during the Preliminary Design Study. This station is 1220 m (4000 ft) downstream of Site 10 (Station 0).

* For drawings see Appendix 1.

4. Station 1939 m (6360 ft) Downstream: This station serves as downstream control for hydraulic computations with a submerged condition of the Thompson River rapids, located at the confluence with the Bonaparte River. Therefore, these readings were taken during the freshet only.

DATA

To obtain the water levels, Sandwell retained McElhanney Surveying and Engineering Ltd. who engaged Paul Genton, Land Surveyor of Clinton, to carry out the readings. Table 1 in Appendix 1 lists the readings together with mean daily flow rates at Spences Bridge, obtained from the Department of the Environment, Water Survey of Canada, Vancouver.

The hydrograph on Drawing D4251/5-2 illustrates how the water level readings cover the 1977 - 1978 low water period and the 1978 freshet, and also how these readings relate to both the hydrographs for 1976 and 1977, and the minimum and maximum flows on record.

Prepared by
J. W. C. Boyle

Approved by
A. Copeland, P. Eng.

APPENDIX 1

TABLE 1 AND ILLUSTRATIONS

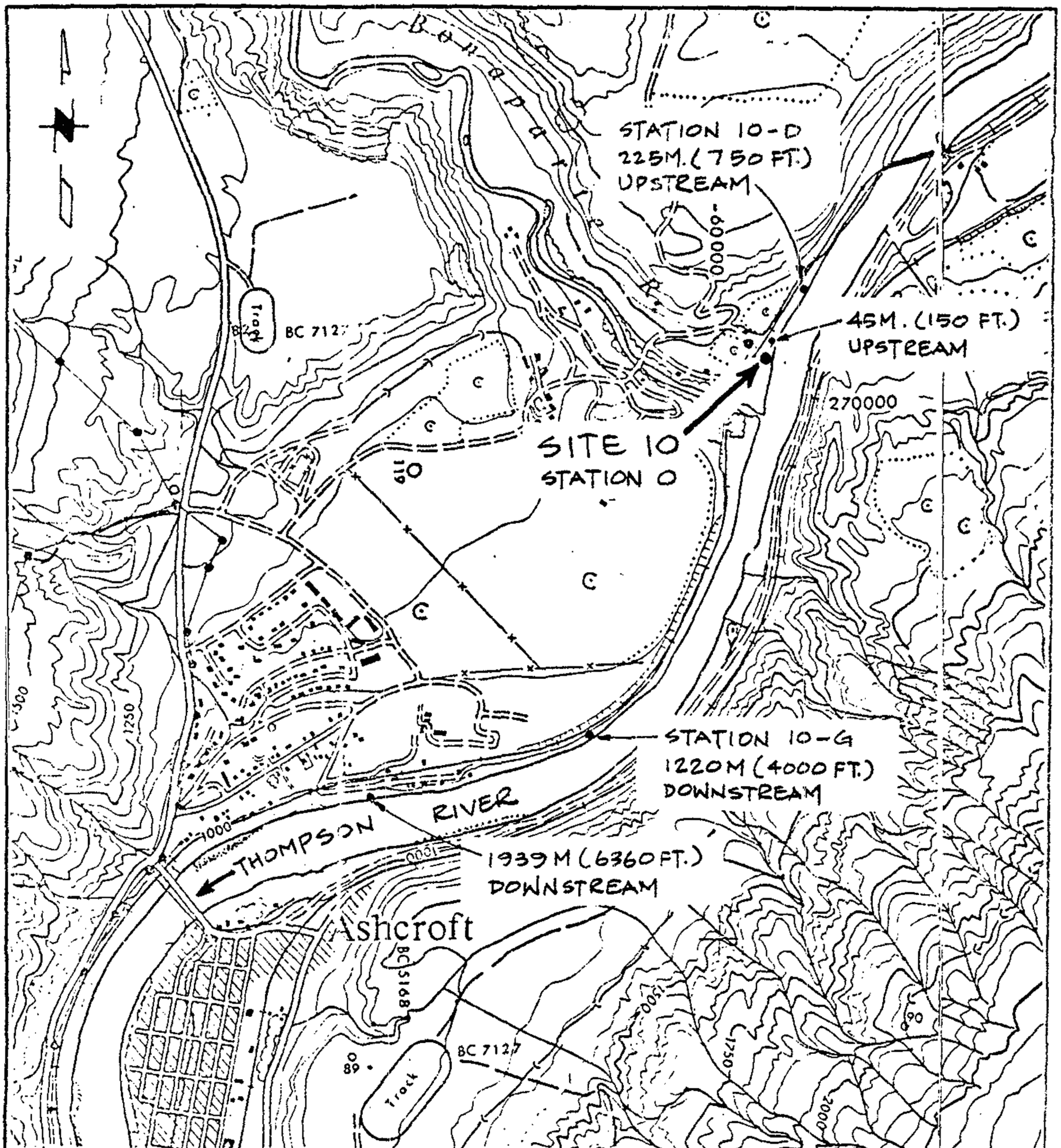
Table 1 - Water Surface Elevations

Date	6360 Ft Downstream Elevation m	6360 Ft Downstream Change m	Station 10-G 4000 Ft Downstream Elevation m	Station 10-G 4000 Ft Downstream Change m	150 Ft Upstream Elevation m	150 Ft Upstream Change m	Station 10-D 750 Ft Upstream Elevation m	Station 10-D 750 Ft Upstream Change m	Thompson River (see note 2) Discharge m³/s	Thompson River (see note 2) Change In Discharge m³/s
77 Dec 14	-	-	288.50	- 0.17	289.87	- 0.20	289.93	- 0.19	218	- 26
Dec 31	-	-	288.33	0	289.67	- 0.01	289.74	- 0.01	192	- 21
78 Jan 15	-	-	288.33	- 0.14	289.66	- 0.13	289.73	- 0.14	171	- 25
Feb 1	-	-	288.19	+ 0.06	289.53	+ 0.02	289.59	+ 0.02	146	+ 19
Feb 14	-	-	288.25	- 0.06	289.55	- 0.05	289.61	- 0.05	165	- 9
Feb 28	-	-	288.19	- 0.01	289.50	- 0.01	289.56	- 0.02	156	- 3
Mar 16	-	-	288.18	+ 0.31	289.49	+ 0.35	289.54	+ 0.36	153	+ 79
Mar 31	-	-	288.49	+ 0.53	289.84	+ 0.62	289.90	+ 0.64	232	+ 119
Apr 15	-	-	289.02	+ 1.65	290.46	+ 2.13	290.54	+2.18	351	+ 659
May 15	289.63	+ 0.56	290.67	+ 0.51	292.59	+ 0.74	292.72	+ 0.72	1,010	+ 310
May 31	290.19	+ 0.84	291.18	+ 1.03	293.33	+ 1.49	293.44	+ 1.46	1,320	+ 730
June 15	291.03	- 0.35	292.21	- 0.36	294.82	- 0.51	294.90	- 0.46	2,050	- 260
July 1	290.68		291.85		294.31		294.44		1,790	

Note: 1. This program of recording water levels was terminated on 1 July 1978 because the peak of the freshet had passed the intake site.

2. Discharges were obtained by subtracting Bonaparte and Nicola River flows (Stations 8LF02 and 8LG06) from Thompson River flow at Spences Bridge (Station 8LF51).

3. Low water level readings were terminated on 15 April 1978 and freshet water level readings were commenced on 15 May 1978.



DWG. No.	REFERENCE	REF. No.	REV.	BY	DATE	REVISION	APP'D

APPROVED

DATE

A 4251/5-1

		DAY	MO.	YR.
SCALE	1:16,000			
DR'N.	D. TUNG	5	6	78
CH'K'D.				
APP'D.				
APP'D.	A. C.	31	7	78

HAT CREEK PROJECT
COOLING WATER SUPPLY
THOMPSON RIVER – WATER LEVEL DATA
SITE 10 — STATIONS

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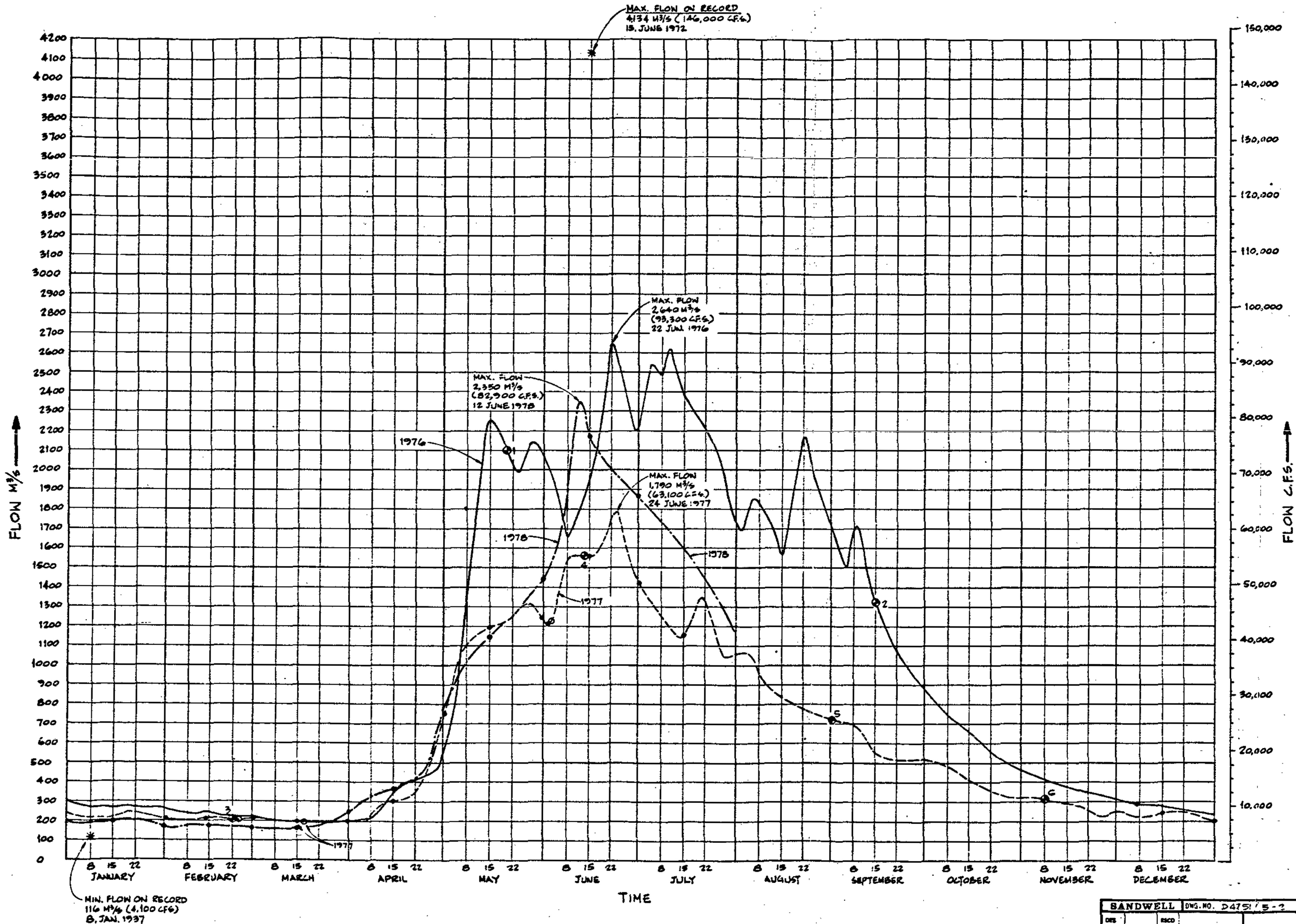
VANCOUVER B.C.

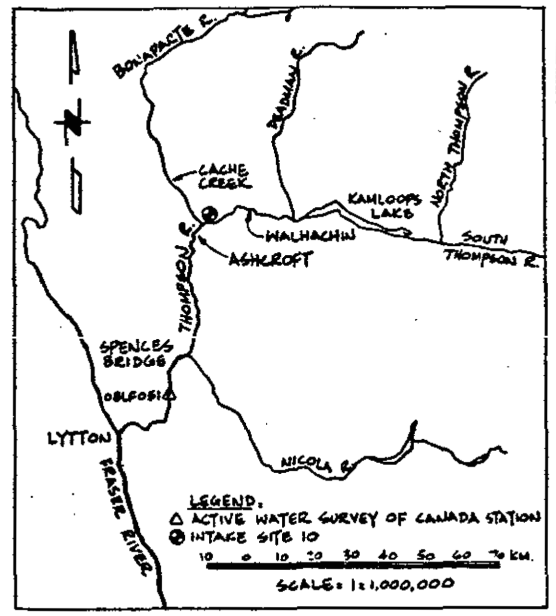
DWG. A 4251/5-1 REV

PROJECT MEMORANDUM V4251/5

THOMPSON RIVER - WATER LEVEL DATA

(V4251/1)





KEY PLAN

LEGEND.

- ● WATER LEVELS TAKEN AT INTAKE SITE 10.
- ⊗ FIELD VISITS MADE AT INTAKE SITE 10.
- ○ WATER SAMPLES TAKEN AT WALHACHIN BRIDGE.

NOTES.

1. THE DATA USED TO PLOT THESE HYDROGRAPHS FOR THE THOMPSON RIVER NEAR SPENCES BRIDGE WAS SUPPLIED BY THE WATER SURVEY OF CANADA.
2. THE 1977 & 1978 CURVES ARE BASED ON INCOMPLETE DATA AND, THEREFORE, THE PEAKS MAY NOT BE EXACTLY IN THE CORRECT POSITIONS.

⊗ RECORD OF FIELD VISITS AT INTAKE SITE 10

NO.	DATE	REMARK
1	20 MAY 1976	FIRIST HELICOPTER VISIT
2	15 SEPT. 1976	SECOND HELICOPTER VISIT
3	22 FEB. 1977	THIRD HELICOPTER VISIT
4	13 & 14 JUNE 1977	GROUND VISIT
5	1 SEPT. 1977	GROUND VISIT
6	8 NOV. 1977	FOURTH HELICOPTER VISIT

SANDWELL DWG. NO. D4751 / 5-2

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

DES		RECD	
DWN	D. TUNG	APPD (TECH)	
CHKD	JWRB	APPD	
INSP		APPD	A.C.
SUBD		DATE	31 JULY '78

HAT CREEK PROJECT
COOLING WATER SUPPLY
THOMPSON RIVER - WATER LEVEL DATA
HYDROGRAPHS - 1976 THROUGH JULY 1978

MICROFILMED | JOB No. V4251 | CONTRACT No. | SCALE AS NOTED | DWG No. D 4251 / 5 - 2 | R

REFERENCE DRAWINGS | REFERENCE DRAWINGS | REVISIONS | REVISIONS