HYDROLOGY

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THE IMPACT OF THE PROPOSED COLD LAKE OIL SANDS PROJECT ON THE WATER QUALITY OF THE BEAVER RIVER AT THE ALBERTA-SASKATCHEWAN BOUNDARY

OCTOBER 5, 1979

PPWB REPORT 54

PRAIRIE PROVINCES WATER BOARD

CANADA ALBERTA SASKATCHEWAN MANITOBA

#54

THE IMPACT OF THE PROPOSED COLD LAKE OIL SANDS PROJECT ON THE WATER QUALITY OF THE BEAVER RIVER AT THE ALBERTA-SASKATCHEWAN BOUNDARY

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PRAIRIE PROVINCES WATER BOARD

SUMMARY

The Prairie Provinces Water Board has concluded that if effluent from the proposed Esso Resources Cold Lake Oil Sands Project is discharged to the Beaver River during periods of low flow, the interim PPWB water quality requirements for phenolics and total dissolved solids (notably sodium and sulphate) will be exceeded at the Alberta-Saskatchewan boundary in at least 10% of all annual low flow periods. This effluent will, however, improve the dissolved oxygen regime during periods of ice cover.

The Board has also concluded that, on the basis of existing treatment levels, major population increases at Cold Lake and Grand Centre associated with the proposed plant will cause the interim PPWB water quality requirements for total nitrogen and total phosphorus to be exceeded.

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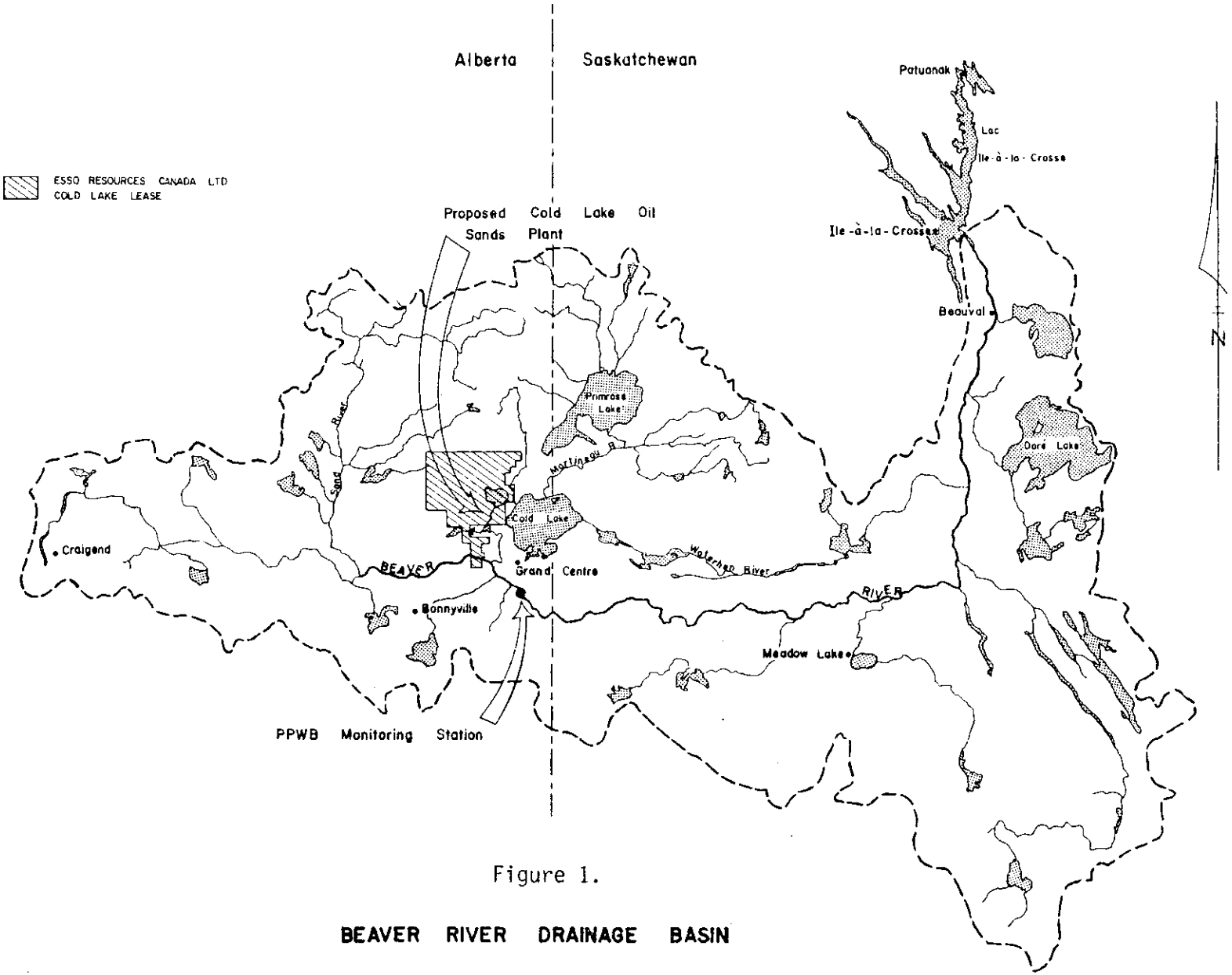

Figure 1.

BEAVER RIVER DRAINAGE BASIN

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INTRODUCTION

The Beaver River is an eastward flowing interprovincial stream covered by the 1969 Prairie Provinces Water Board Master Agreement on Apportionment. It rises in Alberta near Craigend, (see Figure 1) and flows some 660 kilometres to the northeast where it is a major tributary to the Churchill River at Lake Ile-à-la Crosse. Routine water quality and water quantity monitoring for Board purposes has been conducted at the "Beaver River at Cold Lake Reserve" monitoring site at the request of the Board since 1974. This monitoring site is located at river kilometre 440 indicating that approximately one third of the Beaver River is in Alberta. At this point the river drains approximately 30% of the Beaver River Basin and contributes 30% of the average annual flow of the Beaver River at Ile-à-la Crosse.

As no major storage or diversion projects exist on the Beaver River in Alberta, the flow of the Beaver River is considered natural at the Alberta-Saskatchewan boundary. Flow data collected at the PPWB station shows large irregular seasonal variations typical of small unregulated parkland streams ranging from a spring maximum of 283 m^3/s to late winter flows as low as 0.37 m^3/s.

Water quality monitoring conducted at the interprovincial boundary since April 1974 has indicated that for the most part water crossing the boundary has been of satisfactory quality. However concern has been expressed regarding nitrogen, phosphorus, and dissolved oxygen data which have exceeded the 1973 PPWB Water Quality Objectives at this station.

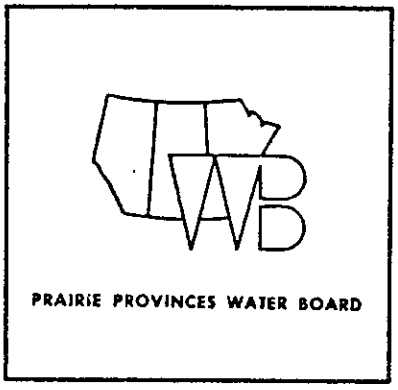
Water Uses

The principle economic activities currently being conducted in this basin are mixed farming, forestry, fishing and trapping. There are no existing large industrial or municipal water users in this basin.

Thus present beneficial water uses include: domestic water use, agricultural water use (stockwatering) and in stream uses (maintenance of aquatic life and wildlife). In addition to these beneficial uses the Beaver River is also used to assimilate intermittent municipal effluent discharges from lagoons in Bonnyville, Grand Centre, Cold Lake and a continuous effluent, via Marie Creek, from a mechanical treatment plant at the Cold Lake Canadian Forces Base.

Recent activities have proven that the Alberta portion of the Beaver River basin has large hydrocarbon resources and, as a result, a great potential for increased water use. At the present time seven oil companies are currently operating pilot oil sands extraction plants in this basin within twenty miles of Grand Centre.

In August 1978 Imperial Oil Limited applied to the Alberta Energy Resources Conservation Board for permission to build the Cold Lake Oil Sands plant near the Alberta-Saskatchewan boundary. As the development proposal presented by Imperial Oil proposed that 89,000 m^3/d (564,000 bpd) be extracted from Cold Lake, and that effluent from their plant be discharged to the Beaver River some 15 kilometres upstream of the PPWB station, the Board has become involved in assessing the effect that this project may have on the quality and quantity of waters crossing the boundary.



IMPACT ASSESSMENT

The following impact assessment has been prepared from information contained in a report of the Committee on Water Quality which was reviewed at a meeting of the Prairie Provinces Water Board on September 25, 1979. It deals with the impact of the proposed Esso Resources Canada plant on the water quality of the Beaver River at the interprovincial boundary but does not consider other possible industrial developments. It only considers effluent discharged directly into the Beaver River and does not address the atmospheric transport of contaminants to the Beaver River above the Alberta-Saskatchewan border or the effects of atmospheric pollution in Saskatchewan.

PREDEVELOPMENT CONDITIONS

Based on an examination of the PPWB Beaver River water quality data collected since April 1974 the Board has concluded that, for the most part, the water crossing the interprovincial boundary has been of satisfactory quality. However, the 1973 PPWB Water Quality Objectives for total nitrogen and total phosphorus have, on occasion, been exceeded on the Beaver River since 1974. These exceedences, and their relationship to existing municipal discharges, are discussed separately below.

As no total nitrogen values and only 4 of the 55 total phosphorus values collected from April 1974 to December 31, 1978 have exceeded the revised interim requirements adopted by the Board for the Beaver River at their September 25, 1979 meeting, the Board has concluded that nutrients are not a problem at the present level of development.

During open water the dissolved oxygen concentrations exceed the PPWB requirement. However from December to April dissolved oxygen concentrations have been reduced by natural processes below 3.0 mg/l.

TABLE 1

PROJECTED CONSTITUENT CONCENTRATIONS AT PPWB BEAVER RIVER STATION

(all units in mg/l unless otherwise specified)

Proposed Cold Lake Oil Sands Project Effluent Discharged to Beaver River				
PARAMETER	DEFINED NATURAL 90th PERCENTILE	MAXIMUM EFFLUENT = 0.309 m^3/s	INTERIM PPWB REQUIREMENT	MINIMUM EFFLUENT = 0.124 m^3/s
Alkalinity (HCO_3)	300	300	360	293
Calcium	60	81	80	86 ? <81 ?
Chloride	5	95	30	28
Magnesium	25	59	40	48
Potassium	5	5	10	6 ? <5
Sodium	25	270	40	110
Sulphate	30	625	50	362
Total Dissolved Solids	450	1280	525	652
pH (in pH units)	7.0-8.5	>7.0 <8.5	6.5-9.0	>7.0 <8.5
Silica (Reactive)	10	17	30	19 ? <17
Chromium (Total)	<0.02	0.014 NB	0.05	0.018 ? <.014
Copper (Total)	0.002	0.02 ? 0.002	0.003	0.002
Phenolics	0.004	0.009	0.005	0.020 ? <.009
Dissolved Oxygen				
April to December	7.0	>6.0	≥6.0 or 50% saturation	>6.0
December to March	3.0	>5.0	3.0	≥5.0
Total Phosphorus	0.15	0.12	0.22	0.13 ? <.12
Total Nitrogen	1.72	1.4	2.6	1.9 ? <1.4
Sulphides	no data	-	0.002	-
Dissolved Iron	no data	-	0.3	-
Suspended Solids	30	22	40	26
Temperature	ambient 0-25°C	3°C above ambient	ΔT<3°C from ambient	3°C above ambient

Assumptions made for Calculations

i) normal plant operation results in a continuous discharge of effluent of the quality and quantity shown in Table 5, Esso Resources Cold Lake Project Beaver River Assimilation Study,

ii) the effluent is completely mixed at the Beaver River PPWB station,

iii) the streamflow equals 0.77 m^3/s (1:10 seven day consecutive low flows).

iv) the defined natural concentration of parameters equals the ninetieth percentile of data collected at this station from 1974-04-01 to 1978-12-31.

PROJECT ASSESSMENTS

The Board has concluded that both the effects of the effluent discharged from the proposed Cold Lake Oil Sands Plant and the effects of increased municipal effluents discharged from growth centers upstream of the boundary must be included in assessments of impacts this project may have on waters crossing the boundary. Thus the industrial and related municipal impact assessments are discussed separately below.

For the purposes of determining a low flow frequency to be used in calculating continuous effluent loadings, a minimum seven-day low flow with a probability of occurrence of once in ten years was selected. This choice is consistent with criteria used by the provinces of Saskatchewan and Manitoba, and by a majority of similar agencies in the United States. It is estimated that the once in ten years seven day minimum low flow at the PPWB Beaver River monitoring station is 0.77 m3/s. This estimate is based on 23 years of recorded flow data collected at the Beaver River at Cold Lake Reserve hydrometric monitoring site.

Impact of Proposed Industrial Effluent

Estimates of the range of concentrations of constituents which would exist in waters of the Beaver River at the PPWB station if the proposed effluent was discharged during periods of low flow are listed in Table 1. These results are based on best estimates of effluent characteristics listed in Table 5, Section 3, May 1979 Draft, Cold Lake Project Beaver River Assimilation Study, prepared for Esso Resources Canada by Stanley Associates (Appendix One) and the assumptions footnoted in Table 1.

These results show that the proposed PPWB Water Quality Requirements would be exceeded for five of the major ions associated with total dissolved solids (notably sulphate and sodium), phenolic compounds, and total copper. In addition, Table 1 shows that the proposed effluent would increase late winter low flow dissolved oxygen concentrations. The impact that these exceedences would have on downstream water uses are discussed briefly below.

Total Dissolved Solids[1]

If the total dissolved solids were allowed to range from 600 to 1200 mg/l Saskatchewan's use of waters for domestic or municipal purposes would be impaired. Concentrations of sulphate ranging from 350 to 625 mg/l could cause laxative effects in domestic consumers. In addition, concentrations of sodium ranging from 110 to 270 in combination with other constituents added to the river by this effluent could result in an unpalatable mineral taste.

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(1) *Total dissolved solids are defined as the sum of the following ions: calcium, magnesium, sodium, potassium, bicarbonate, chloride, and sulphate determined by individual analyses.*

Phenolics

Concentrations of phenolic compounds as low as 0.005 mg/l have been found to cause taste and odour problems in chlorinated domestic and municipal supplies and cause tainting of edible fish flesh. Thus, if the concentration of phenolics were to approach 0.01 to 0.02 mg/l it is possible that Saskatchewan's recreational sport fishery on the Beaver River could be impaired and that taste and odour problems might be encountered in waters withdrawn for human consumption.

The Board recognizes that both Ontario and the United States Environmental Protection Agency have recommended that concentrations of phenols not be allowed to exceed 0.001 mg/l to protect chlorinated domestic water supplies from taste and odour problems and prevent fish flesh tainting. As some phenolic compounds may not cause taste and odour problems, and as the analytical method now used detects phenolic compounds as opposed to phenols, it has been agreed, for the purposes of this assessment, that municipal uses and aquatic life would be protected if phenolic compounds detected by the 4-amino Antipyrene Method do not exceed 0.005 mg/l.

Copper

Preliminary analysis by Imperial Oil's Consultants indicate high levels of copper in plant effluent. These high readings, however, are suspect and the Committee on Water Quality concluded that the level of copper in the effluent will probably not be a threat to downstream aquatic life.

Dissolved Oxygen

The discharge of the proposed effluent, saturated with oxygen, would increase dissolved oxygen concentrations in the river at the inter-provincial boundary. The most significant increase would occur during late winter when low flows exist and natural dissolved oxygen values fall below 3.0 mg/l. Under these conditions it is estimated that the effluent would increase the dissolved oxygen concentration in the river to levels greater than 5.0 mg/l. Thus the dissolved oxygen present in the effluent would significantly increase late winter dissolved oxygen concentrations at the PPWB station thereby enhancing the stream's ability to support aquatic life during late winter.

IMPACT OF EXISTING MUNICIPAL EFFLUENTS

The Beaver River currently receives semi-annual discharges from municipal lagoons located at Bonnyville (population 3,135), Grand Centre (population 2,780), and Cold Lake (population 1,317). In addition, a continuous effluent from a mechanical sewage treatment plant from the

Canadian Forces Base at Cold Lake is discharged to the Beaver River via Marie Creek. As the effluent from Bonnyville is discharged through a series of lakes and creeks to the Beaver River the impact of this effluent on water crossing the interprovincial boundary is considered negligible. The assessment of dissolved oxygen and nutrient concentrations collected during periods of municipal effluent discharge (spring and fall) indicate that, at the present level of development, dissolved oxygen concentrations are above the PPWB requirements and that occasional exceedences of the phosphorus requirement have occurred.

POTENTIAL MUNICIPAL EFFLUENT IMPACT

At this time it is not possible to accurately determine the impact that increased municipal development in the Cold Lake-Grand Centre area will have on interprovincial water quality or the impact that additional municipal loadings will have on the increased oxygen concentrations caused by the discharge of the proposed industrial effluent. However, preliminary municipal effluent discharge projections indicate that PPWB nutrient requirements will be exceeded in the future if lagoons are discharged during the fall. These projections are based on the following information.

It is estimated that the population of the Cold Lake-Grand Centre area will rise from 4,000 to 18,000 by 1989, and that it will stabilize at about 35,000 by 2000. Based on the assumption that a population of 18,000 would be served by a proposed regional sewerage system (aerated lagoon) and that estimated contaminant loads would be as documented in Table 11 Cold Lake-Grand Centre Sewerage Study* flows of approximately 7.1 m^3/s and 19.8 m^3/s would be required for a 60 day period to meet the proposed PPWB Requirements for nitrogen and phosphorus respectively. These calculations assume that no steps are taken to remove excess nitrogen or phosphorus from lagoons prior to discharging to the Beaver River. A preliminary examination of 23 years of hydrometric data collected at this site showed that nutrients discharged from the lagoon would cause the proposed PPWB Requirements at the border to be exceeded in the fall in some years. Table 2 indicates the number of years that fall flows were less than these required levels in the last 23 years.

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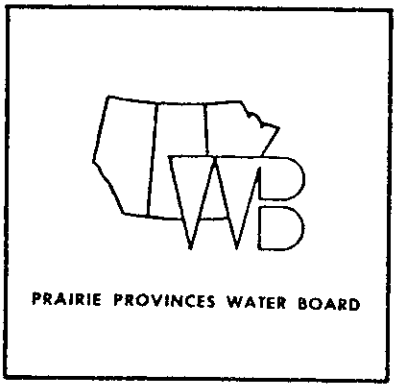
*Page 65, Table 11, Cold Lake-Grand Centre Sewerage Study, W.J. Francl and Associates, July 1979.

TABLE 2

NUMBER OF YEARS MONTHLY FLOW IS NOT ADEQUATE TO DILUTE NUTRIENTS
(Based on a Population of 18,000)

Parameter	PPWB Requirement	Flow Needed to meet PPWB Requirement	Years Monthly Flow less than Needed		
			Sept.	Oct.	Nov.
Nitrogen	2.6 ~~1.72~~ mg/l.	7.1 m^3/s	2 of 23	3 of 23	6 of 23
Phosphorus	0.22 mg/l.	19.8 m^3/s	10 of 23	11 of 23	17 of 23



CONCLUSIONS

The following conclusions are based on information supplied to the Board by Esso Resources through the Alberta government and on the present flow regime of the Beaver River.

The Board has concluded that if effluent from the proposed Esso Resources Cold Lake Oil Sands Project is discharged to the Beaver River during periods of low flow, the interim PPWB water quality requirements for phenolics and total dissolved solids (notably sodium and sulphate) will be exceeded at the Alberta-Saskatchewan boundary in at least 10% of all annual low flow periods. This effluent will, however, improve the dissolved oxygen regime during periods of ice cover.

The Board has also concluded that, on the basis of existing treatment levels, major population increases at Cold Lake and Grand Centre associated with the proposed plant will cause the interim PPWB water quality requirements for total nitrogen and total phosphorus to be exceeded.

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APPENDIX ONE

CHARACTERISTICS OF PROPOSED EFFLUENT BEAVER RIVER ASSIMILATION STUDY

Parameter	Maximum Effluent Discharge*		Minimum Effluent Discharge		Effluent Guidelines for Alberta Petroleum Refineries (mg/l)
	Kg/d	mg/l	Kg/d	mg/l	
Temperature (^{o}C)		3^{o} above ambient			
Dissolved Oxygen		Saturated at its Temperature			
pH		8.1		8.0	6.0 - 9.5
Chemical Oxygen Demand	735	28	824	77	200
Biochemical Oxygen Demand	70	3.0	39	3.6	
Oil	35	1.3	31	2.9	10
Suspended Solids	78	2.9	61	5.7	25
Phenols	.66	.02	1.27	.12	1
Sulfide	.84	.03	.92	.09	0.35
Total Nitrogen	17.4	.65	31	2.9	
Total Phosphorus (as P)	1.1	.04	2.6	.24	
Total Dissolved Solids	117 597	4 404	48 283	4 512	
Calcium	3 553	133	2 658	248	
Magnesium	3 810	143	2 047	191	
Sodium	23 529	881	6 910	646	
Sulfate	56 450	2 114	26 039	2 434	
Chloride	8 480	318	1 780	166	
Potassium	79	3.0	78	7.3	
Bicarbonate	11 117	416	5 818	544	
Hydroxide	10 033	376	2 291	214	
Silica	824	31	655	61	
Iron (total)	7	.26	0	0	
Copper (total)	1.9	.07	0	0	
Chromium (total)	.29	.01	.42	.04	0.30 (Hexavalent)
Discharge Rate (cms)	.309		.124		

* Represents the quality of effluent associated with the water balance shown in Esso's submission to Alberta Energy Resources Conservation Board on December 4, 1978 as Exhibit 2, Table 6.8 and Exhibit 4, Table 1.3.