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Aquatic Baseline Report for the Athabasca, Steepbank and Muskeg Rivers in the Vicinity of the Steepbank and Aurora Mines

APPENDICES

May, 1996

Prepared for:

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Prepared by:

Golder Associates

952-2307

APPENDIX I

GLOBAL POSITIONING SYSTEM (GPS)
AND NTS MAP COORDINATES
FOR SAMPLING SITES IN
THE STEEPBANK AURORA MINE STUDY AREAS

Global Positioning System (GPS) and NTS Map Coordinates for Sampling Sites in the Steepbank Aurora Mine Study Areas							
STATION			MAP UTM		GPS WAYPOINT		
ID NO.	TYPE	Km POST	EASTING	NORTHING	FILE	EASTING	NORTHING
AX001	Pt.	16.22	472192	6317191	R100620G	472129.2	6317403.7
AF001	Pt.	16.92	471950	6317645	R100620F	471857.1	6317867.9
AF002	Sec. (start)	16.92	471979	6317669	R100620E	471874.2	6317841.4
	(finish)	18.83	470781	6319022	R100620B	470850	6319156.4
AF002-GN1	Pt.	17.84	471399	6318201	R052216B		
AF002-SL1	Pt.	17.17	471920	6317760	R100620D	471863.3	6317956.3
AF002-SL2	Pt.	17.2	471890	6317805	R100620C	471823.7	6317961.5
AF003	Sec. (start)	18.6	471545	6319165	R100614A	471569.9	6319244.1
	(finish)	19.91	471298	6319925			
	(original start)	18.98	470950	6319341			
	(original finish)	19.56	470441	6319630	R100616A	470327.5	6320077.7
AF003-GN1	Pt.	19.18	470760	6319435	R052215A		
AF004	Sec. (start)	19.25	470489	6319271	R100620A	470531.4	6319427.3
	(finish)	20.96	469622	6320769	R100516B	469490.3	6321024.3
AF004-GN1	Pt.	20.8	469589	6320525	R052501A		
AF004-SL1	Pt.	20.37	469647	6320345	R100516E	469646.8	6320492.8
AF004-SL2	Pt.	20.4	469645	6320410	R100516C	469544.5	6320664.8
AF005	Sec. (start)	5.92	473469	6307521	R052222D		
	(finish)	8.8	473086	6310462	R100223A	473057.5	6310458
	(original finish)	7.62	472919	6309152	R052222C		
AF005-MT1/2/3	Pt.	6.96	473130	6308519	R052222A		
AF005-MT4/5/6	Pt.	7.4	473005	6308602	R052222B		
AF006	Sec. (start)	3.92	474625	6305809	R052223A		
	(finish)	4.98	474092	6306719	R052223B		
AF006-SL1	Pt.	4.64	474275	6306468	R100523A	474319.1	6306682
AF006-SL2	Pt.	4.7	474256	6306514	R100523B	474287.1	6306675.3
AF007	Sec. (start)	-0.2	474139	6301920	R052219B		
	(finish)	0	474115	6302097	R052219A		
AF008-SN1	Pt.	0	473925	6302160	R052220A		
AF009-GN1	Pt.	23.76	468624	6323635	R060117C		
AF010-SL1	Pt.	23.82	468667	6323719	R100516A	468564.9	6323941.5
AF011-PE1	Pt.	0.5	473930	6302150	R052423A		
AF012-PE1	Pt.	1	473440	6303135	R052423B		
AF013-GN1	Pt.	2.2	474260	6304160	R052500A		
AF015	Sec. (start)	20.6	469600	6320850	R060116A		
	(finish)	21.5	469050	6321600	R060116B		
AF016	Sec.(start)	21.6	469550	6321840	R060117A		
	(finish)	23.5	469340	6323705	R060117B		
AF018	Sec. (start)	14.08	473587	6315485	R101216A	473574.8	6315762
	(finish)	16.9	472526	6317658	R100621A	472500.5	6317799
AF018-SL1	Pt.	15.6	472805	6316831	R100621B	472700.7	6317107

STATION			MAP UTM		GPS WAYPOINT		
ID NO.	TYPE	Km POST	EASTING	NORTHING	FILE	EASTING	NORTHING
AF018-SL2	Pt.	15.66	472762	6316875	R100621C	472726.2	6317125
AF018-GN1	Pt.	14.7	473530	6316110	R060215B		
AF019	Sec.(start)	11	472184	6312510	R101219E	472185.6	6312537.8
	(finish)	13.3	472563	6314798	R101219F	472485.6	6314887.3
AF019-GN1	Pt.	11.5	472260	6313130	R060201C		
AF019-SL1/2	Pt.	11.5	472260	6313130	R060201C		
AF019-SL3	Pt.	12.4	472377	6313959	R101219E	472321	6314029.7
AF019-SL4	Pt.	12.28	472315	6313783	R101219C	472246.8	6313836.3
AF019-SL5	Pt.	12.35	472358	6313922	R101219D	472286.7	6314010.6
AF020	Sec.(start)	7.3	473725	6309590	R101218A	473745.1	6310133.3
	(finish)	10.9	472368	6312510	R101219A	472792.6	6312608.7
AF020-PE1	Pt.	10.42	472830	6311950	R060201A		
AF021-GN1	Pt.	10.61	472820	6312080	R060201B		
AF022-PE1	Pt.	11.9	472540	6313450	R060201E		
AF023-SN1	Pt.	12.03	472575	6313510	R060201F		
AF024-SN1	Pt.	12.2	472590	6313725	R060201D		
AF025-GN1	Pt.	5.44	473641	6307099	R060200A		
AF026-GN1	Pt.	5.61	473880	6307349	R060200D		
AF027-GN1	Pt.	5.85	473920	6307784	R060200C		
AF028-SL1	Pt.	5.77	473523	6307395	R060200B		
AF029-SL1/2/3	Pt.	4.9	474141	6306681	R060123B		
AF030-PE1	Pt.	6.54	473375	6308160	R100222C	473350.2	6308371.9
AF031-PE1	Pt.	7.92	472881	6309481	R060200E		
AF032-GN1	Pt.	1.81	474362	6303940	R060121A		
AF033	Sec.(start)	0	473390	6302085	R100219A	473874	6302135.5
	(finish)	2.4	473880	6304360	R100219B	473817.2	6304602.3
AF033-SL1	Pt.	0.25	473355	6302319	R060122E		
AF034	Sec. (start)	1.31	474035	6302721	R100220E	474006.1	6303023
	(finish)	2.78	474225	6304199	R100220C	474221.9	6304430
AF034-SL1	Pt.	0.64	473965	6303778	R060122B		
AF035-SN1	Pt.	0.58	474050	6302709	R060122C		
AF036	Sec. (start)	0.62	474213	6702765	R100220D	474211.9	6302921.3
	(finish)	2.86	474569	6304951	R100220A	474578.1	6305171.7
AF036-SL1	Pt.	1.48	474541	6303629	R060121B		
AF036-SL2	Pt.	3.05	474745	6304842	R100220B	474528.5	6305041.4
AF037-SN1	Pt.	0.2	473948	6302326	R060122D		
AF038-SN1	Pt.	0	473878	6302079	R052220A		
AF039-GN1	Pt.	0.94	474285	6303710	R060122A		
AF041	Sec. (start)	22.9	469073	6322815	R100516G	468997.5	6323061.2
	(finish)	25	468215	6324671	R060117E		
AF042	Sec. (start)	3.41	473966	6304710	R100221A	474002.9	6304934.1
	(finish)	6.82	473627	6306984	R100222B	473605.5	6307135.9
AF043	Sec. (start)		474000	6310141	R0812___?		

STATION			MAP UTM		GPS WAYPOINT		
ID NO.	TYPE	Km POST	EASTING	NORTHING	FILE	EASTING	NORTHING
	(finish)		473563	6310757	R0812___?		
AF044	Sec. (start)	11.58	472742	6313158	R101220A	472749.3	6313383.4
	(finish)	13.5	473237	6314884	No file		
AF045-SL1	Pt.	3.28	474683	6305240	R100220F	474677	6305579.6
AF046-GN1	Pt.		476420	630938	R081516A		
AF047	Trans. (LDB)	0.65	473370	6302790	R100522B	473455.1	6303061.4
	(RDB)		474245	6302880	R100522A	474213.1	6303117.4
AF048	Trans. (LDB)	3.28	474310	6305390	R100522C	474268.5	6305439.8
	(RDB)		474680	6305250	R101217A	474594.1	6305270.1
AF049	Trans. (LDB)	7.5	473071	6308640			
	(RDB)		473830	6308680	R101217D	473548.5	6308927.9
AF050	Trans. (LDB)	8.7	473040	6310330	R101217E	473091.1	6310614
	(RDB)		473360	6310325	R101217F	473248.8	6310545.2
AF051	Trans. (LDB)	14.2	473000	6315660	R101216C	473105.7	6316065.4
	(RDB)	14.45	473625	6315910	R101216B	473423.8	6315985.9
AF052	Sec. (start)	22.9	469040	6322800	R100517A	468931.3	6322796.2
	(finish)	22.7	469030	6322595	R100516H	468995.4	6323017.1
AF053-MT1	Pt.		468890	6325695	R101222A	468815.2	63325910.4
AF054-GN1	Pt.		468255	6326075	R101222B	468147.2	6326337.4
AF055-GN1	Pt.		468085	6326630	R101223A	468027.3	6326754.7
AF057	Trans. (LDB)	16.9	472000	6317520	R101317B	472104.8	6317589.5
	(RDB)		472560	6317595	R101317A	472432.7	6317712
AF058	Trans. (LDB)	11.4	472175	6312990	R101318A	472145.5	6313050.2
	(RDB)		472755	6312995	R101319A	472321.6	6313087.7
AF059	Trans. (LDB)	13.48	472928	6314920	R101320A	472989.5	6315145.6
	(RDB)	13.39	473175	6314795	R101320B	473211	6315029.8
SS1	Pt.	20	482392	6314357	R100722A	482339.8	6314560.6
SS2	Pt.	18.64	481345	6315229	R100723A	481360	6315480.5
SS3	Pt.	18.19	481010	6315570	R100723B	481037.5	6315798.2
SS4	Pt.	17.64	480455	6315710			
SS5	Pt.	17.5	480390	6315855			
SS6	Pt.	17.15	480010	6315885	R100815B	479970.9	6316076.4
SS7	Pt.	16.8	479765	6316180			
SS8	Pt.	16.51	479510	6316285	R100816A	479769.6	6316463.6
SS9	Pt.	16.22	479215	6316350	R100817A	479233.3	6316518.9
SS10	Pt.	15.27	478445	6316060	R100818A	478492.9	6316305.9
SS11	Pt.	14.27	477875	6316940	R100818B	477885.4	6316607.5
SS12	Pt.	14.14	477760	6316480	R100819A	477835.1	6316790.5
SS13	Pt.	13.29	477160	6316357	R100820A	477163.4	6316609.1
SS14	Pt.	12.25	476928	6316510	R100820B	476950	6316641.8
SS15	Pt.	2.1	474790	6318010	R100914A	474740.1	6318251.8
SS16	Pt.	5.1	473556	6318512	R100916A	473487.4	6318798
SS17	Pt.	25.2	485000	6309648	R101016A	485179.7	6309799

STATION			MAP UTM		GPS WAYPOINT		
ID NO.	TYPE	Km POST	EASTING	NORTHING	FILE	EASTING	NORTHING
SS18	Pt.	24.75	484652	6309930	R100716A	484630.3	6310225.6
SS19	Pt.	24.6	484580	6310044			
SS20	Pt.	24.35	484458	6310276	R100716B	484417.2	6310466.9
SS21	Pt.	24.13	484440	6310490	R100717A	484465.9	6310730.9
SS22	Pt.	23.06	484440	6311316	R100718B	484413.4	6311441.1
SS23	Pt.	21.54	483219	6313075	R100721A	483216.5	6313282.4
AF014	Sect. (start)		474759	6318069			
	(finish)	0	471768	6320156	R052520A		
	(original start)	2.41	472120	6319912	R052516A		
AF017	Sect. (start)	25	485000	6309648	R080417A		
					R052618A		
	(finish)	22.8	483868	6312512	R080422A		
AF040	Sect. (start)	17.1	479945	6315848	R052816A		
	(finish)	13.93	477580	6316407	R052823A		
?	Sect. (dis)	23.41	484416	6310956	R100717B	484377.6	6311136
?	(dis)	23.21	484448	6311160	R100718A	484388.8	6311381.1
AF060	Trans. (LDB)	19.6	482008	6314597	R101414A	481986.1	6314942.1
	(RDB)		482053	6314618	R101414B	481967.6	6315037.6
AF061	Trans. (LDB)	18.25	481030	6315555	R101416A	481077	6315742
	(RDB)		481045	6315566	R101416B	481114.5	6315769.2
AF062	Trans. (LDB)	16.76	479873	6316200	R101418A	479860.3	6316448.4
	(RDB)		489915	6316230	R101418B	479881.8	6316469.8
AF063	Trans. (LDB)	12.45	477038	6316486	R101514A	477006.2	6316616
	(RDB)		477012	6316518	R101514B	476920.3	6316748.1
AF064	Trans. (LDB)	10.3	475912	6316960	R101516A	475861.7	6317124.1
	(RDB)		475900	6316980	R101516B	475879.7	6317209.4
AW001	Pt.	25.8	485650	6309288	R080416A		
					R052616A		
AW002	Pt.	25.9	485620	6309248	R052617A		
AW003	Pt.	13.94	477599	6316428	R052914A		
AW004	Trans. (LDB)	-0.71	473720	6301421	R060122F		
	(RDB)		474242	6301420	R060122G		
AW005	Pt.		474684	6305821	R060123A		
AW006	Pt.		424033	6307018	R060123C		
AW007	Pt.		473635	6315820	R060215C		
AW008	Pt.		473036	6308569	R052222B		
AW009	Trans. (LDB)	25	468159	6324702	R060117E		
	(RDB)		468473	6324926	R060117D		
AW010	Pt.	0.13	470919	6319565	R060118B		
AW011	Pt.	0.13	470881	6319574	R060119A		
AW012	Pt.	0.19	470989	6319569	R060118A		
AW013	Unnamed Creek						
AW014	Pt.		473686	6310747	R081221A	473794.8	6310824.6

STATION			MAP UTM		GPS WAYPOINT		
ID NO.	TYPE	Km POST	EASTING	NORTHING	FILE	EASTING	NORTHING
AW015					R100621D	473069.9	6316893.5
AW016					R100621F	473033.5	6315514
AW017					R100623B	472213.3	6313690.4
AW018	Trans. North		467768	6326985	R101314A	467745.2	6327199.8
	South		468520	6325843	R101314B	468452	6326082.7

Map and U.T.M Coordinates of Sampling Sites for the Aurora Mine Study Area

STATION		MAP U.T.M		GPS WAYPOINT						
SITE ID	TYPE	EASTING	NORTHING	FILE	EASTING	NORTHING	LONGITUDE (N)	LATITUDE (W)	ELEVATION (m)	DATE
Muskeg (Site 30)	Pt.	466550	6338750	R092323A	-	-	-	-	-	8-May-95
Jackpine (S-4)	Pt.	475300	6343850	R092319A	-	-	-	-	-	18-May-95
N. Muskeg (Site 9)	Pt.	483700	6346600	R081022A	484076.6	6346815.3	111.264	57.266	302.573	21-May-95
Muskeg R. (Site 18)	Pt.	469971	6345620	R092421A	-	-	-	-	-	21-May-95
Jackpine Cr. (Site 17)	Pt.	471642	6346605	R081020A	476440.2	6350971	111.391	57.303	255.601	22-May-95
Khahago Cr.(Site 14)	Pt.	480440	6342451	R092120A	480435.4	6342155.5	111.324	57.224	302.241	27-May-95
Muskeg R. (Site 4)	Pt.	476194	6351411	-	-	-	-	-	-	28-May-95
Stanley Cr. (Site 60)	Pt.	479000	6355800	R080919A	478875.6	6355856.1	111.351	57.347	257.646	28-May-95
Blackfly Cr. (Site 55)	Pt.	-	-	R092119B	484413.2	6340134.7	111.258	57.206	316.799	11-Aug-95
Iynimin Cr. (Site 8)	Pt.	-	-	R081116A	489379.8	6345017	111.176	57.25	336.129	16-Aug-95
Kearl Lk. (Site 80)	Pt.	-	-	-	-	-	-	-	-	13-Aug-95

Notes
- data not available

APPENDIX II

RATIONALE FOR SELECTION OF WATER QUALITY PARAMETERS

Naphthenic Acids - Oil sands wastewater and fine tailings originate from extracting bitumen from oil sands, so it is not surprising that the predominant issues identified to date are related to organic compounds. The most important issue with respect to acute toxicity to aquatic organisms is elevated concentrations of naphthenic acids in oil sands tailings recycle and pore waters. Naphthenic acids, which are a complex group of naturally-occurring organic acids/surfactants leached from the oil sands during the hot water extraction process, account for nearly all of the acute toxicity to aquatic organisms of tailings pond water and porewater from Suncor's and Syncrude's wastewater ponds. These compounds naturally detoxify in aerobic environments due to biodegradation, however, it is not known whether significant detoxification occurs within anaerobic groundwater. In addition, these compounds are highly soluble and it is unlikely that they readily partition to solid-phase material. Hence, they are likely persistent and mobile in groundwater, so seepage of naphthenic acids to surface waters is of potential concern.

Benthic invertebrates (small, bottom-dwelling animals) and fish are the primary organisms at risk with respect to exposure to these compounds. The mode of toxicity may be related to adherence of the compounds to organism membranes, thus disrupting oxygen transfer and resulting in suffocation.

Limited naphthenic acids data exists because of the difficulty in measuring naphthenic acid concentrations. However, Syncrude Canada Ltd. has developed a promising method for quantifying total naphthenic acid concentrations using Fourier Transform Infra-Red Spectroscopy (FTIR) and absorbance at two wave numbers present in the 1700-1800 cm^{-1} range. Typical naphthenic aids concentrations based on the FTIR method range from 1-2 mg/L in the Athabasca River to over 100 mg/L in fresh tailings water.

Substituted PAHs and PASHs - While concentrations of unsubstituted polycyclic aromatic hydrocarbons (PAHs) are generally low or below detection limits even in tailings pond recycle water, the presence of alkyl-substituted PAHs is an emerging issue. In many oil sands waste samples, concentrations of alkyl-substituted PAHs are considerably higher than the parent compounds. The lower molecular weight PAHs (2-3 rings such as naphthalene and phenanthrene)

are generally more acutely toxic to aquatic organisms than the higher molecular weight PAHs. However, the higher weight PAHs have a greater affinity to lipids and therefore bioconcentrate more in animal tissue. Hence, they are a potential issue with respect to food chain biomagnification. Further, alkyl-substituted PAHs are a particular concern because alkyl substituents may enhance both the carcinogenic potency and the persistence of these compounds.

Another issue is the potential for tainting of fish flesh, primarily associated with polycyclic aromatic sulphur heterocycles (PASHs) such as dibenzothiophene and alkyl-substituted dibenzothiophenes. These compounds have been detected in oil sands wastewater and in the Athabasca River downstream of Suncor's lease. PASHs are generally more persistent and more toxic than other PAHs. In addition, they readily bioaccumulate in animal tissues .

PANHs - Polycyclic aromatic nitrogen heterocycles (PANHs) such as quinoline and alkyl-substituted quinolines have been identified in both natural and synthetic crude oils. These compounds have been detected in oil sands wastewater and in the Athabasca River downstream of Suncor's lease. PANHs can be toxic, teratogenic, mutagenic, and/or carcinogenic.

Non-Chlorinated Phenols - Concentrations of phenols and cresols ranging from 25-152 µg/L have been measured in samples from Syncrude's settling pond. A number of simple alkylphenols were also identified in the pond samples. Samples from dyke drainage, groundwaters and surface waters contained <1 µg/L of the simple phenols analyzed and did not contain any of the simple alkylphenols identified in the MLSB samples. A sample of surface water that drained over exposed oil sands contained low concentrations of phenol (4 µg/L) but no detectable concentrations of cresols or simple alkylphenols. Low concentrations of simple phenols are of concern because of the potential for tainting fish flesh.

Volatile Organics - Low molecular weight, non-polar, volatile organic compounds represent another potential issue as they account for up to 20 % of the acute toxicity of Suncor's Pond 1A surface water. The exact compound(s) causing the toxicity have not been identified, however, naphtha, which is used as a dilutant in the bitumen froth treatment, is likely the source of these light-end hydrocarbons.

Oil and Grease/Total Extractable Hydrocarbons - TEH is a parameter that indicates of the quantity of hydrocarbons in a sample. Typically, the bulk of hydrocarbons in process-affected waters are in the C_{15} to C_{28} range, which is consistent with the presence of naphthenic acids. In addition, work on Suncor's constructed wetlands indicates that the GC chromatographs can serve as a useful marker to monitor oil sands wastewater and to assist in identifying the source of hydrocarbons in water. However, since (1) most of the TEH in process-affected waters and in natural waters exposed to bitumen is naphthenic acids and (2) naphthenic acids are being measured on all water samples collected from the site, it would be redundant to measure TEH in water samples. We are, therefore, proposing to measure oil and grease, gravimetrically, following silica gel clean-up. Silica gel removes polar compounds (such as naphthenic acids), thus, the residual represents the non-polar component of the hydrocarbons.

Cyanide and Phenolics - These groups of compounds are associated with oil sands water and are potentially toxic to aquatic life.

Organic Carbon and Particle Size - Organic carbon content and particle size of soils are key parameters to assist in understanding partitioning between water and sediments and are required for modelling contaminant-fate processes.

Nutrients - The nutrients nitrogen and phosphorus are essential elements for growth of plants in aquatic environments. However, high levels of these nutrients can lead to excessive plant growth in lakes and streams. In addition, ammonia-nitrogen is toxic to aquatic life at high concentrations.

Metals and Trace Elements - Metal concentrations in Suncor's process-affected waters are typically within the range observed in background groundwater and surface waters; the only notable exception appears to be arsenic. Arsenic is, however, toxic to aquatic life and wildlife and is classed as a human carcinogen. Lead has also been observed at relatively high concentrations in emergent insects from Suncor's constructed wetlands.

APPENDIX III

QUALITY ASSURANCE/QUALITY CONTROL PROGRAM (QAAP)

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ACKNOWLEDGMENTS

The Quality Assurance Project Plan (QAPP) was prepared by Dr. Judy Crane, EVS Consultants, whereas the Data Management section was prepared by Ms. Corinne Severn, EVS Consultants, and Mr. Michael Raine, Golder Associates. This document was peer-reviewed by Ms. Farida Bishay, EVS Consultants and Mr. Hal Hamilton, Golder. Word processing was provided by Ms. Vickie Duff, EVS Consultants and Carol Brittain, Golder Associates. Ms. Gail Binder, EVS Consultants assisted with report production.

1.0 INTRODUCTION

This combined Quality Assurance Project Plan (QAPP) and Data Management Guidelines (DMG) is designed to ensure data quality for the collection, analysis, and management of a range of environmental samples for the Steepbank Mine Environmental Impact Assessment (EIA). The discipline-specific issues, technical approach, and scope of work for each component of the EIA study are described in detail in Section 9.0.

The QAPP identifies quality assurance (QA) and quality control (QC) procedures that will be implemented to ensure that data are of sufficient quality to be used in support of the EIA. This QAPP has been prepared based on guidance given in "QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations: Chemical Evaluations" (U.S. EPA, 1995). Sections 2.0 - 9.0 of this document provide detail on the background and quality assurance requirements for the EIA studies. A glossary of terms used in the QAPP is given at the end of this document.

The Data Management Guidelines describe the division of data management tasks between the EIA team members, the data flow process, and the database structures to be used. These issues are described in detail in Section 10.0.

This document has been produced in a binder format so that, if changes or additions to procedures occur, only those pages containing new information will be distributed. All pages will be dated to ensure that the most current procedures are followed. This current QAPP-DMG supersedes the draft report dated April 7, 1995.

2.0 PROJECT DESCRIPTION

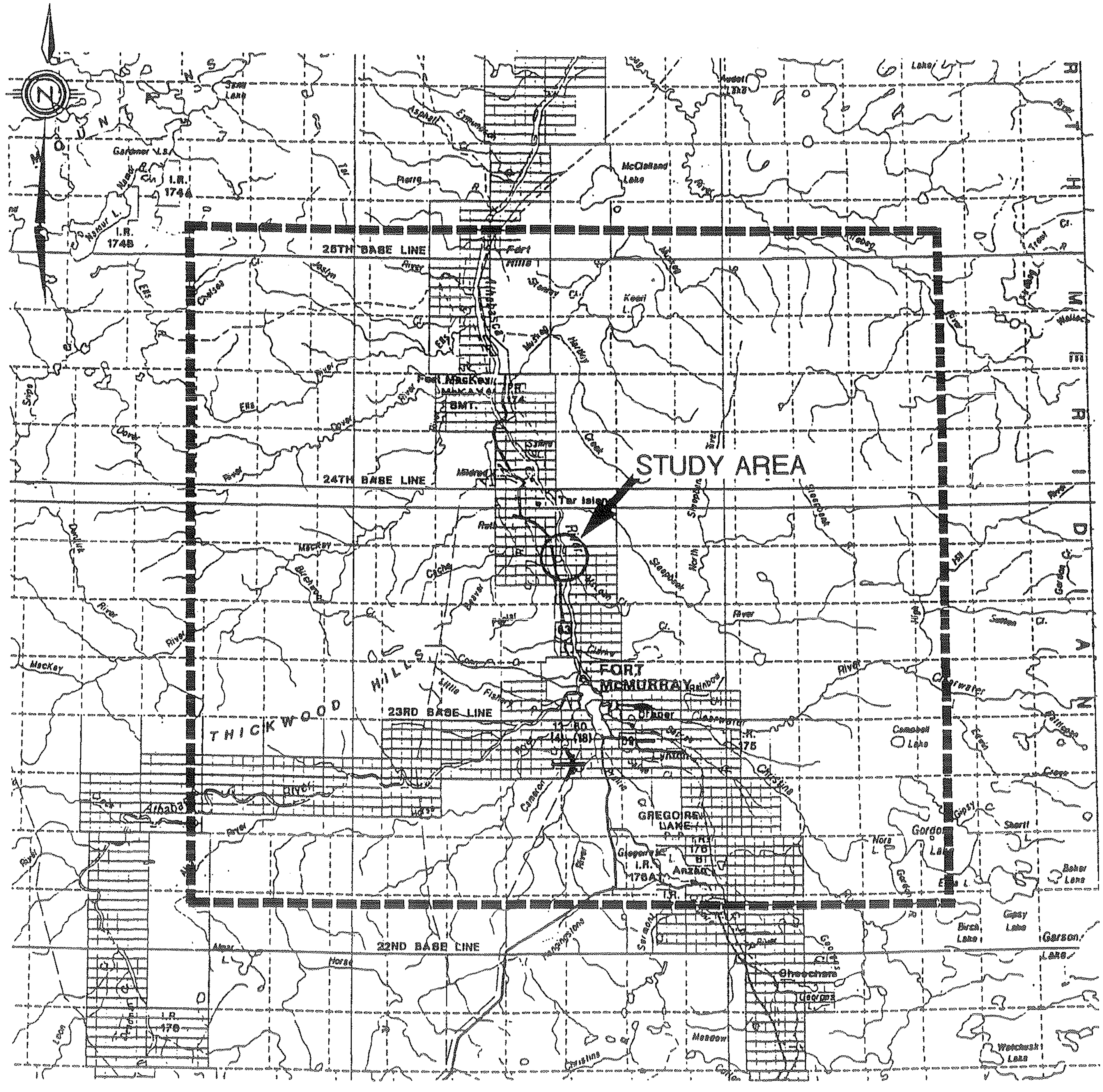
Suncor's proposed Steepbank Mine expansion to a new lease on the east side of the Athabasca River in northern Alberta (Figure 1) will require an EIA to be conducted before approval will be granted from regulatory agencies. As described in the "Suncor Steepbank Mine EIA Project" report (Golder 1995), the EIA study team will consider impacts associated with preparation and development of a new mine on Lease 97 and Lots 1 and 3 (Figure 2). The scope of the new mine investigation could expand to Leases 19 and 25 at a later date; therefore, Suncor wants to collect baseline data from these areas as well. Hydrotransport will be used to move the oil sands via pipeline to the existing extraction facility on Lease 86. A desanding plant may also be built on the new lease along with necessary service facilities for the truck and shovel mining operation. A bridge across the Athabasca River will have to be constructed early in the new mine development process and there will be modifications to both the Primary Extraction and Froth Treatment Plants. In addition to the new mine development, the EIA will have to assess potential impacts related to Reclamation of Leases 86 and 17. Of special concern here is the strategy for final handling of fine tails.

Data collection efforts will be made for the following EIA tasks:

- Aquatics (fisheries/benthos/water quality)
- Hydrology
- Hydrogeology
- Biophysical (terrestrial vegetation/soils)
- Wildlife
- Socio-Economics
- Historical Resources

A number of field surveys will be conducted through January 1996 in support of the aforementioned tasks. Some of the data obtained from the field surveys will be used to conduct a risk/performance assessment. Impact assessment and reporting tasks will be completed by March 1996, and the final EIA report will be completed by the end of June 1996. Additional detail on the environmental assessment framework adopted for this project is given in Golder (1995).

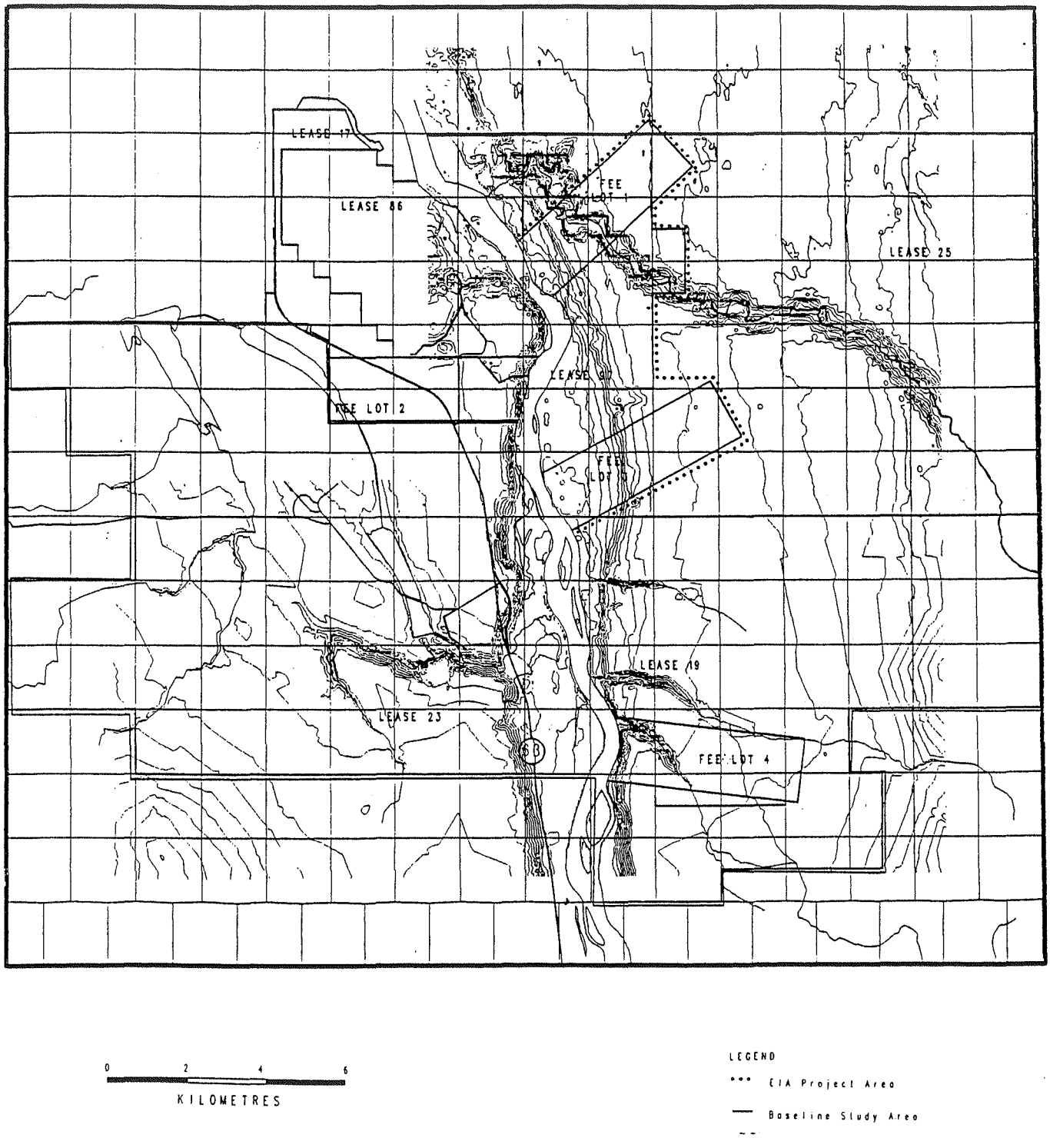
Figure 1 EIA Regional Study Area



NOTE

APPROXIMATE BOUNDARY OF REGIONAL STUDY AREA. THE SCENE CENTRE IS AT 56 55' LAT 111 27' LONG WITH AN AVERAGE RADIUS OF 60km TO THE SCENE BOUNDARY.

Figure 2 Preliminary Local Study Area



3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Project organization and individuals responsible for quality assurance and data management are shown in Figure 3. Responsibilities of these personnel, as well as for the quality assurance officers/principal contacts for contract laboratories are described in the following sections. Addresses and phone numbers of key team members are given in Appendix I.

3.1 Suncor Management

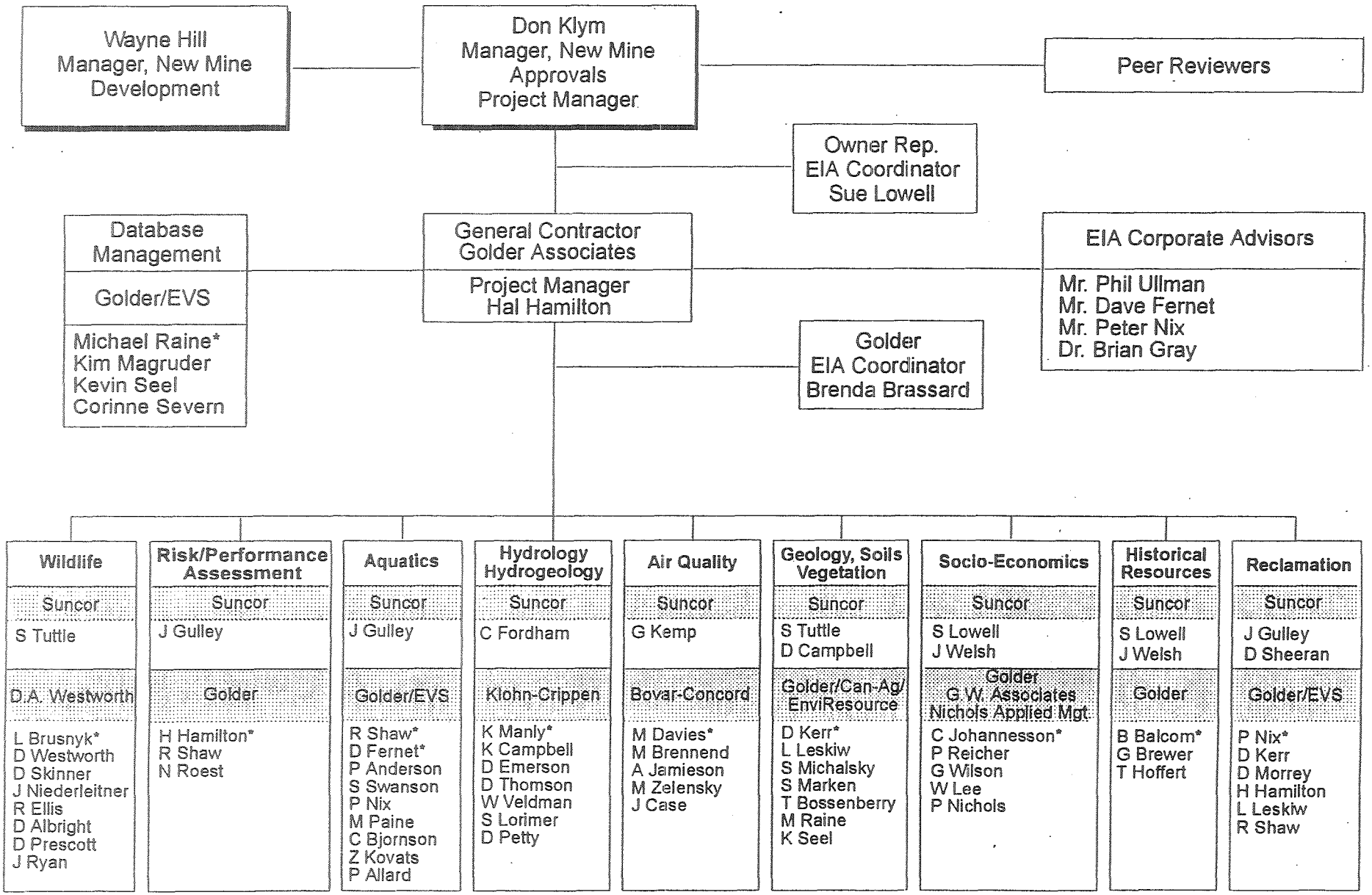
The technical staff at Suncor are responsible for providing the Golder Project Manager and team leaders with technical guidance and direction. The primary technical contacts at Suncor include:

- Don Klym: Suncor Project Manager and Manager of Regulatory Affairs
- Sue Lowell: Suncor EIA Coordinator; Socio-Economics; Historical Resources
- John Gulley: Aquatics; Land Reclamation; Risk/Performance Assessment
- Christopher Fordham: Hydrogeology
- Gordon Kemp: Air Monitoring
- Don Sheeran: Land Reclamation
- Stephen Tuttle: Land Reclamation; Wildlife; Biophysical
- D. Campbell: Biophysical
- Jerry Welsh: Socio-Economics; Historical Resources

3.2 Golder Project Manager

Mr. Hal Hamilton, of Golder Associates Ltd. of Calgary, is the senior project manager for the Steepbank Mine EIA study. Mr. Hamilton will work with Mr. Don Klym and Ms. Sue Lowell of Suncor to ensure the EIA strategy is clearly defined and the discipline task leaders remain focused on dealing with the pertinent issues related to the New Mine development and Lease 86 reclamation. He will be assisted by Ms. Brenda Brassard as the project coordinator. Ms. Brassard will ensure the task definition and cost control systems are implemented. She will also facilitate communication between the discipline groups and Suncor.

Figure 3 Project Team



3.3 Database Management Team

The Database Management Team, listed in Figure 3, will be responsible for developing the QA program and database structure. The individual responsibilities of each team member are listed in Table 1.

The QA Coordinator has designed activities to provide a formalized system for evaluating the technical adequacy of sample collection and laboratory analysis activities. These QA activities begin before samples are collected and continue after laboratory analyses are completed, requiring ongoing coordination and oversight. Data which has received a QA review will be entered into the appropriate database. Two separate databases have been developed to manage the chemical and aquatic organism enumeration results as well as the spatial data for the EIA. The flow of data among the EIA teams, laboratories, QA Coordinator, and the Data Management Team is given in Figure 4. Additional detail on the evaluation and management of data is provided in Sections 8.0 and 10.0, respectively.

3.4 Team Leaders

The EIA project team is divided into a number of speciality teams, each headed by a Team Leader (see Figure 3). The Team Leaders are responsible for the successful direction and completion of their studies. Each team will be responsible for producing a stand alone baseline studies report. Each team will then conduct and document their own impact analysis under the direction of the Project Manager. The Team Leaders will, along with Suncor, develop and discuss mitigation measures and potential monitoring strategies to evaluate the EIA conclusions. Golder management will integrate this analysis and documentation into the impact assessment section of the EIA document.

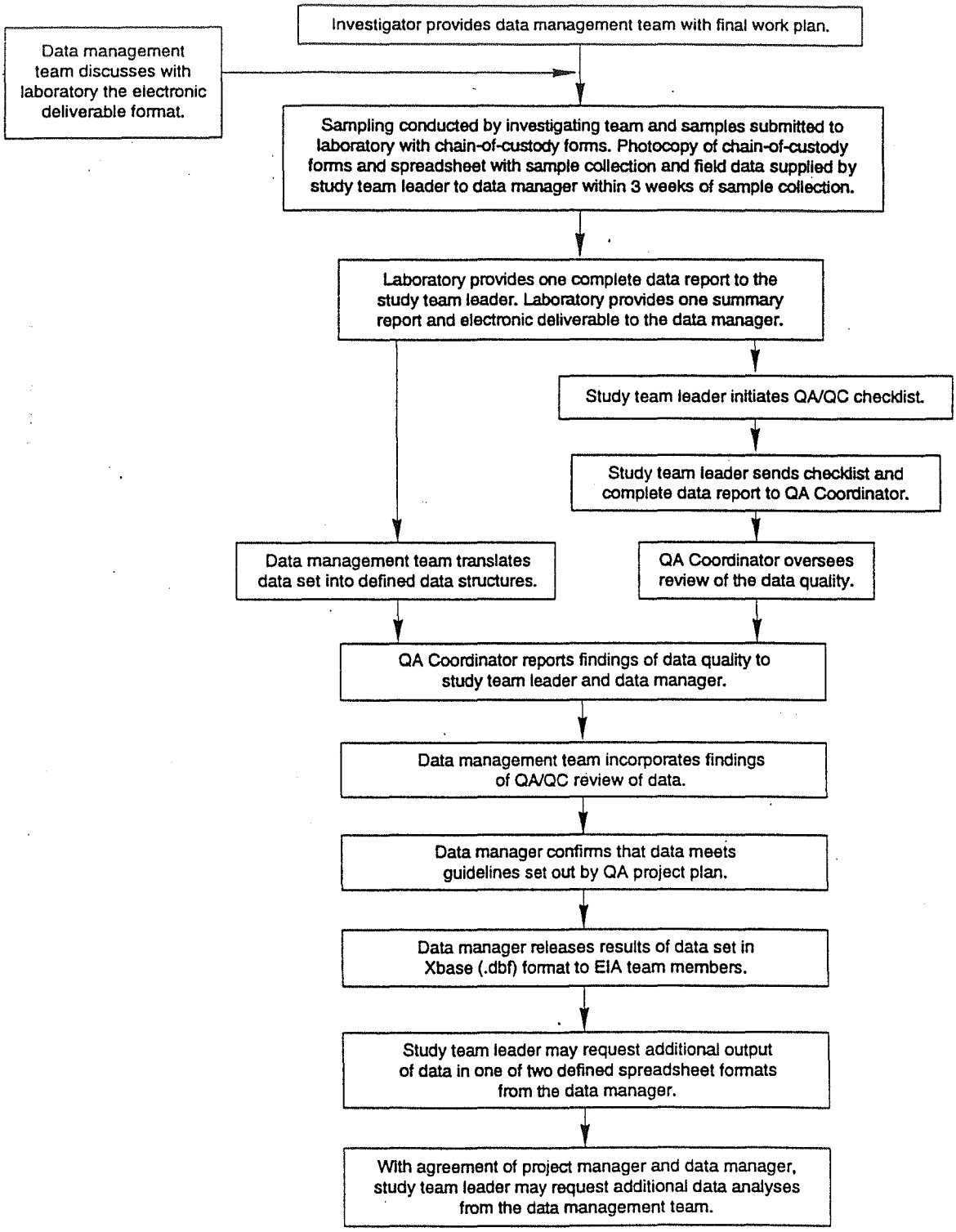
3.5 Contract Laboratories/Sub-Consultants

A number of samples will be sent to analytical/toxicological laboratories and to other sub-consultants for chemical, physical, and biological analyses. The Project Manager from each laboratory/sub-consultant is responsible for ensuring that all analyses performed meet the project data quality objectives specified in this QAPP (see Section 5.6).

Table 1 Project Responsibilities of Database Management Team

Personnel	Responsibilities
QA Coordinator Name: Kim Magruder EVS Consultants Telephone: (206) 217-9337	Provide technical quality assurance assistance; prepare and initially approve the Quality Assurance Project Plan (QAPP); review and direct the implementation of contractor quality assurance plans; ensure data quality objectives (DQOs) are met for all data collected; review 10% of all data from teams and analytical/toxicological laboratories; conduct a field audit of field studies; and notify Golder Project Manager and Team Leaders when problems occur.
Database Manager: Analytical Data and Aquatic Enumerations Name: Corinne Severn EVS Consultants Telephone: (206) 217-9337	Manage the data associated with analytical results and all associated sample collection information including: sample location, sample number, and the date of collection. These data include those related to tissue (fish and vegetation), water, sediment, and soil samples. Also responsible for compiling the results of benthic invertebrate, zooplankton, and phytoplankton enumerations.
Database Manager: Non-chemical Data Name: Michael Raine Golder Associates Telephone: (403) 299-4642	Manage non-chemical data that relate to the disciplines of vegetation, wildlife, soils and landforms, socio-economics, and archaeology and traditional land use, as well as hydrology and other physical measures.
Remote Sensing Specialist Name: Kevin Seel Golder Associates Telephone: (403) 299-5618	Responsible for handling remotely sensed spatial data within Golder's Geographical Information System (GIS) for the non-chemical database.

Figure 4 Data Flow Chart Between EIA Teams, Laboratories, QA Coordinator and Data Management Team



The QA/QC Manager (and/or principal contact) at each laboratory/sub-consultant are identified below:

Chemical Analyses: inorganic analyses and physical parameters

Christine O'Grady, primary contact
Sheldon Stewart, secondary contact
Nancy M. Maxwell, QA/QC Manager
Chemex Labs Alberta Inc.
2021 - 41 Avenue N.E.
Calgary, AB T2E 6P2

Phone: (403) 735-2201 (O'Grady)
(403) 735-2202 (Stewart)
(403) 735-2245 (Maxwell)
Fax: (403) 291-9466

Chemical Analyses: organic analyses, excluding naphthenic acids; MFO analyses

Simone Kanash, primary contact
Doug Johnson, secondary contact
Beth Weitzel, QA/QC Manager
Enviro-Test Laboratories
9936 - 67th Avenue
Edmonton, AB T6E 0P5

Phone: (403) 225-2803 ext. 237 (Kanash)
ext. 247 (Johnson)
ext. 257 (Weitzel)
Fax: (403) 437-2311

Chemical Analyses: soils

Jerry Raduy, primary contact
Keith LePla, secondary contact
Ansar Qureshi, QA/QC Manager
Norwest Labs
9938 - 67 Avenue
Edmonton, AB T6E 0P5

Phone: (403) 438-5522
Fax: (403) 434-8586

Chemical Analyses: QC samples

James Downie, QA/QC Manager
ASL Analytical Service Laboratories Ltd.
1988 Triumph Street
Vancouver, BC V5L 1K5

Phone: (604) 253-4188
Fax: (604) 253-6700

Chemical Analyses: naphthenic acids

Munir Jivraj
Syncrude Canada Ltd
Edmonton Research Center
9421 - 17th Avenue
Edmonton, AB T6N 1H4

Phone: (403) 970-6829 or 970-6888
Fax: (403) 970-6805

MicroTox® Testing

Munir Jivraj
Syncrude Canada Ltd
Edmonton Research Center
9421 - 17th Avenue
Edmonton, AB T6N 1H4

Phone: (403) 970-6829 or 970-6888
Fax: (403) 970-6805

Toxicity Testing (excluding MicroTox® testing)

Gordon Balch, QA/QC Manager
Hydroqual Laboratories Ltd.
#3, 6125 - 12th Street S.E.
Calgary, AB T2H 2K1

Phone: (403) 253-7121
Fax: (403) 252-9363

Biomarker Analyses: retinol in fish

Scott Brown
Freshwater Institute
501 Univeristy Crescent
Winnipeg, MB R3T 2N6

Phone: (204) 938-5009

Biomarker Analyses: sex steriods in fish

Tracy Marchant
University of Saskatchewan
Department of Biology
Veterniary Medicine
Saskatoon, SK S7N 0W0

Phone: (306) 966-4420

Benthic Analyses

Bob Wisseman, Senior Scientist
Aquatic Biology Associates
3490 NW Deer Run Road
Corvallis, OR 97330

Phone: (503) 752-1568
Fax: (503) 754-2460

The contract laboratories are expected to meet the following minimum terms in their negotiated contracts with Golder and any sub-consultants:

1. Statement of work including references to each analytical procedure
2. Per analysis price and total price of the analytical services provided (including any additional costs for electronic data files)
3. Specification of any electronic data files
4. Reporting requirements
5. Implementation of QA/QC procedures, including acceptance of the QAPP data quality requirements, performance evaluation testing requirements, and laboratory and data auditing rights by the QA Coordinator

6. Reference to documentation, chain-of-custody (COC), and sample logbook procedures
7. Turnaround time for deliverables

Changes in the QAPP procedures will not be permitted without written documentation of the reason and a detailed explanation of the intended change. All changes must be approved by the QA Coordinator prior to implementation.

4.0 TERMINOLOGY

Throughout this document, specific terminology will be used to designate whether certain actions must, should, may, can or might be done. These terms are defined as follows:

Must	is used to express an absolute, that is, to state that the test or procedure ought to be designed to satisfy the specified condition, unless the purpose of the test or procedure requires a different design; only used in connection with factors which directly relate to the acceptability of a test or procedure.
Should	is used to state that the specified condition or procedure is recommended and ought to be met if possible; although violation of one "should" is rarely serious, violation of several will render the results questionable.
May	is used to mean "is (are) allowed to".
Can	is used to mean "is (are) able to".
Might	is used to mean "could possibly" and is never a synonym for "may" or "can".

5.0 QUALITY ASSURANCE OBJECTIVES

This QAPP includes appropriate sampling and analysis procedures and outlines project-specific data quality objectives (DQOs) that should be achieved for field observations and measurements, physical analyses, laboratory chemical analyses, and biological tests. The DQOs should be adhered to for the duration of the project to guarantee acquisition of reliable data. Reliable data are also obtained by integrating quality control into all components of the EIA, including development of the study design, implementation of sample collection and analysis, and data evaluation. QC is the routine application of procedures for determining bias and precision. QC procedures include activities such as preparation of replicate samples, spiked samples, blanks; calibration and standardization; and sample custody and record keeping. Audits, reviews and compilation of complete and thorough documentation are QA activities used to verify compliance with predefined QC procedures. These QA activities provide a means for management to track project progress and milestones, performance of measurement systems, and data quality.

The overall quality assurance objectives for this project are to develop and implement procedures to ensure the collection of representative data of known, acceptable, and defensible quality. The data quality parameters used to assess the acceptability of the data are precision, accuracy, representativeness, comparability, and completeness.

5.1 Precision

Precision is the measure of the reproducibility among individual measurements of the same property, usually under similar conditions, such as replicate measurements of the same sample. Precision goals are definable for all parameters of this project (e.g., chemical, bioassay, and benthic analyses). Precision can be assessed by duplicate analyses which is expressed as a relative percent difference (RPD). When reference materials are not available or spiking the matrix is inappropriate, precision can be assessed by replicate analyses which is expressed as a percent relative standard deviation (%RSD). All precision measurements are impacted by the nearness of a value to the method detection limit where the percent

error measurements increase (expressed as either %RSD or RPD). The equations used to express precision are as follows:

$$RPD = \frac{|measured\ value - measured\ duplicate\ value|}{(measured\ value + duplicate\ value)/2} x\ 100$$

$$\%\ RSD = (SD\ /\ D_{ave})\ x\ 100$$

$$Where: SD = \sqrt{\left(\frac{\sum_{n=3} (D_n - D_{ave})^2}{(n-1)}\right)}$$

$$D = Sample\ value$$

$$D_{ave} = Average\ sample\ value$$

$$n = Number\ of\ samples$$

5.2 Accuracy

Accuracy is the closeness of a measured or computed value to its true value. Accuracy measurements apply to the chemical analysis portion of this project only. Accuracy measurements are not possible for toxicity testing or benthic sorting because true values do not exist. However, for toxicity testing, the use of negative and positive controls provides evidence for the calibration of the measurement system. For aquatic and terrestrial analyses, taxonomic identifications should be verified by an independent taxonomist. Accuracy may be expressed as the difference between two measured values (expressed as a percent difference), as a percentage of the true or reference value, or as a percent recovery in those

analyses where reference materials are not available and spiked samples are used. The equations used to express accuracy are as follows:

$$Percent\ difference = \frac{(measured\ value - true\ value)}{true\ value} x\,100$$

$$Percent\ recovery\,(true\ vs.\ measured) = \frac{measured\ value}{true\ value} x\,100$$

$$Percent\ recovery\,(spiked\ vs.\ unspiked) = \frac{(spiked\ sample\ result - unspiked\ sample\ result)}{amount\ of\ spike\ added} x\,100$$

5.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. For this program, the compounds selected for analysis have been identified as potential contaminants of concern in the study area. For biological collections/surveys, the species abundance results are a direct measure of the *in situ* biotic community (e.g., benthic invertebrates, wildlife). Other data collections (e.g., soil analyses) will be from representative areas. Careful stratification of the study areas and placement of sampling sites will ensure that representativeness is achieved.

5.4 Comparability

Comparability expresses the confidence with which one data set can be evaluated in relationship to another data set. For the study area, comparability of data is established through the use of: 1) program defined general methodology and reporting formats; 2) common traceable calibration and reference materials; and 3) participation in an interlaboratory comparison program (for chemical analyses only).

5.5 Completeness

Completeness is a measure of the proportion of data specified in the sampling plan which is determined to be valid. Completeness will be calculated as follows:

$$Completeness = \frac{number\ of\ valid\ measurements}{total\ number\ of\ data\ points\ planned} x100$$

The data quality objective for completeness for all components of this project is 95 percent. Data that have been qualified as estimates because the quality control criteria were not met will still be available for use.

5.6 EIA Data Quality Objectives

Tables 2 - 6 summarize the DQOs for each analysis type. Method detection limits were selected in consultation with the analytical laboratories contracted for this project. Limits for precision, accuracy, and completeness were selected by the QA Coordinator; this information was provided to the analytical laboratories for their feedback, prior to finalization of these tables. A list of target detection limits, obtained by Enviro-Test Laboratories, is given in Appendix II for the following chemicals: PAHs, target substituted PAHs, target PANH compounds, phenolic compounds, and volatile organic compounds.

Table 2 Summary of DQOs for Inorganic Chemicals and Physical Parameters Analyzed in Water Samples

WATER PARAMETER	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
Routine Water Analyses Package #3			500 mL			95%		
			250 mL			95%		
Calcium	mg/L	0.01	500 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Magnesium	mg/L	0.01	500 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Sodium	mg/L	0.01	500 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Potassium	mg/L	0.02	500 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Chloride	mg/L	0.5	500 mL	± 25%	± 25%		Colorimetry	1 (18th Ed., Method 407D)
Sulphate	mg/L	0.5	500 mL	± 25%	± 25%		Colorimetry	U.S. EPA 375.2
Total Alkalinity	mg/L	0.5	500 mL	± 25%	± 25%		Titration	1 (18th Ed., Method 403)
pH	unit	0.01	500 mL	± 10%	± 20%		Meter	1 (17th Ed., Method 4500-H+)
Carbonate	mg/L	0.5	NA	NA	NA		Calculated	1 (18th Ed., Method 403)
Bicarbonate	mg/L	0.5	NA	NA	NA		Calculated	1 (18th Ed., Method 403)
Total Hardness	mg/L	0.5	NA	NA	NA		Calculated	
Specific Conductance	µmhos/cm	0.1	500 mL	± 10%	± 20%		Meter	1 (18th Ed., Method 120.1)
Total Dissolved Solids (TDS)	mg/L	1	NA	NA	NA		Calculated	1 (18th Ed., Method 2540 D&E)
Aluminum	mg/L	0.01	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Barium	mg/L	0.01	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Beryllium	mg/L	0.001	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Boron	mg/L	0.01	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Cadmium	mg/L	0.003	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Chromium	mg/L	0.002	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Cobalt	mg/L	0.003	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Iron	mg/L	0.01	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Lead	mg/L	0.02	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7

Table 2 Continued...

WATER PARAMETER	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
Lithium	mg/L	0.001	250 mL	± 25%	± 25%	95%	ICP	EPA-600/4-79-020, Method 200.7
Manganese	mg/L	0.001	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Molybdenum	mg/L	0.001	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Nickel	mg/L	0.005	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Silver	mg/L	0.002	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Strontium	mg/L	0.002	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Titanium	mg/L	0.003	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Vanadium	mg/L	0.002	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Zinc	mg/L	0.001	250 mL	± 25%	± 25%		ICP	EPA-600/4-79-020, Method 200.7
Nitrate + Nitrite (dissolved)	mg/L	0.003	250 mL	± 25%	± 25%		Colorimetry	1 (17th Ed., Method 4500-N)
Hydride Metals Package #2	mg/L			± 25%	± 25%	95%		
Arsenic		0.0002	250 mL				AA	EPA-600/4-79-020, Method 206.5
Selenium		0.0002	250 mL				AA	EPA-600/4-79-020, Method 206.5
Mercury		0.00005	125 mL				CVAA	1 (16th Ed., Method 303F)
Antimony		0.0002	250 mL				AA	EPA-600/4-79-020, Method 206.5
Ammonia N	mg/L	0.01	250 mL	± 25%	± 25%	95%	Colorimetry	1 (17th Ed., Method 4500-NH_3D)
Total Cyanide	mg/L	0.001	250 mL	± 25%	± 25%	95%	Colorimetry	1 (17th Ed., Method 4500-CNE)
Total Phenolics	mg/L	0.001	125 mL	± 25%	± 25%	95%	Colorimetry	EPA-600/4-79-020, Method 420.2
Organic Carbon	mg/L	0.2	500 mL	± 20%	± 20%	95%	IR	1 (16th Ed., Method 505A)
Total Suspended Solids	mg/L	0.4	500 mL	± 10%	± 20%	95%	Gravimetric	1 (18th Ed., Method 2540 D&E)
Chlorophyll "a"	mg/L	0.001	1 L	± 25%	± 25%	95%	Colorimetry	1 (17th Ed., Method 10200 H)
BOD	mg/L	0.1	500 mL	± 25%	± 25%	95%	Winkler	1 (17th Ed., Method 5210B)
Total Phosphorus	mg/L	0.003	250 mL	± 25%	± 25%	95%	Colorimetry	EPA-600/4-79-020, Method 365.1

Table 3 Summary or DQOs for Inorganic Chemicals and Physical Parameters Analyzed in Soil Samples

SOIL PARAMETER	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
Texture (% sand, silt, clay)	%	0.1	1000 g	± 20%	NA	95%	Hydrometer	
Atterberg limits		-	500 g	± 20%	± 20%	95%	Plasticidy Index	
Available H_20				± 20%	± 20%	95%	Pressure Plate	
EXCAT6 Package			SP 500 g ER 100 g	± 20%	± 20%	95%	AA	
Cation Exchange Capacity	mg/kg	0.1	10 g					4 (Ch. 8, Part 2)
Exchangeable Cations	mg/kg	0.1	10 g					4 (Ch. 8, Part 2)
Exchangeable Sodium %	%	0.01	10 g					4 (Ch. 8, Part 2)
Total Exchangeable Cations	mg/kg	0.1	10 g					4 (Ch. 8, Part 2)
% Base Saturation		-	-					4 (No. 9, Part 2)
T.O.C. & Organic Matter	wt %	0.01	100 g	± 20%	± 20%	95%	Modified Meblus	4 (No. 9, Part 2)
Total Nitrogen	wt %	0.1	SP 500 g ER 100 g	± 20%	± 20%	95%	Combustion	
C:N Ratio		NA	NA	NA	NA	95%	Calculated	
NUTRS Package			SP 500 g ER 100 g	± 35%	± 35%	95%		
Nitrate N (soluble)	mg/L	0.05					Colorimetry	4 (No. 9, Part 2, Method 10-3.2)
Ammonia N (extractable)	mg/L	0.05					ICP	4 (No. 9, Part 2, Method 33-3.2)
Phosphorus		0.02					IC	3 (Section 4.4)
Sulphate (soluble)	mg/L	0.1					IC	4 (No. 9, Part 2, Method 10-3.2)
Avail. Calcium, Magnesium, Sodium	meq/100 g		SP 500 g	± 35%	± 35%	95%	ICP	Ca, Mg: 4 (No. 9, Part 2, Method 10-2.3.1)
by ammonium N acetate extract		0.1	ER 100 g					Na: 3 (Section 4.5)
pH in $CaCl_2$ 1:2 ratio	std. unit	0.01		± 10%	± 20%	95%	Meter	2
Salinity Package #3			SP 500 g ER 100 g			95%		
pH	std. unit	0.01		± 10%	± 20%		Meter	2 (Ch. 7)
Electrical Conductivity (EC)	µmhos/cm	0.1		± 10%	± 20%		Meter	2 (Method 8)

Table 3 Continued...

SOIL PARAMETER	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
% Saturation		-		± 10%	± 20%			4
Calcium	mg/kg	0.01		± 35%	± 35%		ICP	3
Magnesium	mg/kg	0.01		± 35%	± 35%		ICP	3
Sodium	mg/kg	0.02		± 35%	± 35%		ICP	3
SAR		-		NA	NA		Calculated	3
Theoretical Gypsum Requirement	tonnes/ac	0.7		NA	NA		Calculated	5
Total Petroleum Hydrocarbon		0.2	150 g	± 50%	± 50%	95%	IR	EPA 9071A and 3550A
Mercury	µg/kg	0.05	100 g	± 35%	± 35%	95%	CVAA	1 (18th Ed., Method 303F)
ICP - 14 Element Scan°	mg/kg		100 g	± 35%	± 35%	95%	ICP-MS	EPA 200.7
Arsenic		0.0002					ICP-MS	
Barium		0.01					ICP-MS	
Beryllium		0.001					ICP-MS	
Cadmium		0.003					ICP-MS	
Chromium		0.002					ICP-MS	
Cobalt		0.003					ICP-MS	
Copper		0.001					ICP-MS	
Lead		0.02					ICP-MS	
Molybdenum		0.003					ICP-MS	
Nickel		0.005					ICP-MS	
Selenium		0.0002					ICP-MS	
Thallium		0.001					AA	
Vanadium		0.002					ICP-MS	
Zinc		0.001					ICP-MS	

Table 4 Summary of DQOs for Inorganic Chemicals, Organic Carbon, and Chorophyll a Analyzed in Sediment/Tissue Samples

SEDIMENT, TISSUE PARAMETER	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
ICP - 26 Element Profile	mg/kg		500 g	± 35%	± 35%	95%	ICP-MS	EPA SW-846, Method 3050
Aluminum		0.01						
Barium		0.01						
Beryllium		0.001						
Boron		0.01						
Cadmium		0.003						
Calcium		0.01						
Chromium		0.002						
Cobalt		0.003						
Copper		0.001						
Iron		0.01						
Lead		0.02						
Lithium		0.001						
Magnesium		0.01						
Manganese		0.001						
Molybdenum		0.003						
Nickel		0.005						
Phosphorus		0.1						
Potassium		0.02						
Silicon		0.02						
Silver		0.002						
Sodium		0.01						
Strontium		0.002						
Titanium		0.003						
Vanadium		0.002						
Zinc		0.001						
Uranium		0.5						
Hydride Metals Package #2	mg/kg		100 g	± 35%	± 35%	95%		
Total Arsenic		0.002					AA	
Antimony		0.002					AA	
Selenium		0.002					AA	
Mercury		0.00005					CVAA	
Organic Carbon	wt %	0.01		± 20%	± 20%	95%	Modified Mebius	4 (No. 9, Part 2, Method 29-35.3)
Chlorophyll "a"	mg/kg	0.001		± 20%	± 20%	95%	Colorimetry	1 (17th Ed., Method 10200 H, 10300 A&C, 10400A)

References for Tables 2 - 4

Reference No.	Description
1	Standard Methods for the Examination of Water and Wastewater
2	Methods Manual for Forests and Plant Analysis
3	Soil Sampling and Methods of Analysis - McKeague
4	Methods of Soil Analysis Chemical and Microbiological Properties
5	Soil Science Principles and Practices

Table 5 Summary of DQOs for Organic Chemicals Analyzed in Benthic, Fish, Soil, and Water Samples

PARAMETER	MATRIX	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
PAHs[1]	WATER	µg/L	0.02 - 0.04	4 L	20	80	95%	GC/MS	EPA 3510/8270 modified
PAHs	SOIL	µg/g	0.01 - 0.02	100 g	20	80	95%	GC/MS	EPA 3540/8270 modified
PAHs	FISH	µg/g	0.02 - 0.04	100 g	20	90	95%	GC/MS	EPA 3540/3640/8270 modified
PAHs	BENTHIC	µg/g	0.02 - 0.04	500 g	20	80	95%	GC/MS	Polytron\EPA 8270 modified
Volatiles	WATER	µg/L	1 - 200	3 x 40 mL	20	85	95%	GC/MS	EPA 3810/8240 modified
Non-chlorinated Phenolics	WATER	µg/L	0.1 - 20	4 L	25	50	95%	GC/MS	EPA 3510/8270 modified
Total Recoverable Hydrocarbons	WATER	mg/L	1	1 L	20	80	95%	gravimetric/silica	APHA 5520B, F

[1] PAHs includes PAHs, PASHs, and Alkylated PANHs, PAHs, PASHs, and PANHs.

Table 6 Summary of DQOs for MicroTox® Bioassays and Naphthenate Analyses

PARAMETER	UNITS	METHOD DETECTION LIMIT	SAMPLE SIZE	PRECISION	ACCURACY	COMPLETENESS	METHOD	REFERENCE
Acute Toxicity by Microtox Bioassay	IC % Vol. (or Toxic Units*)	N/A (1)	5 g			95%	Bacterial Bioluminescent Assay	Microbics Inc.
Naphthenates	mg/L	1 mg/L**	25 - 75 g			95%	Solvent Extraction with FTIR Quantification	Syncrude

* If IC50 > 100% then not acutely toxic; Toxic Unit (TU) = 100/IC50

** Dependent on volume of extracted sample.

6.0 FIELD PROCEDURES

A number of field surveys, including collection of samples for chemical, physical and biological analyses, will be conducted to support the EIA. This section describes procedures and documentation to be provided for handling and shipment. Documentation will ensure that all sample handling requirements are carried out properly and in a legally defensible manner. Proper chain-of-custody procedures must be used to trace the possession and handling of samples from field collection through analysis to final disposal. Each team involved in field work must have documented procedures for insuring the safety of their workers. General safety procedures for field work are listed in Appendix III. The health and safety plan for the aquatic baseline study is given in Appendix IV.

6.1 Sample Collection

Generation of quality data begins with sample collection, and therefore the integrity of the sample collection process is of concern to the laboratory performing the analyses (either biological, chemical, or physical). Samples must be collected in appropriate clean containers in such a way that no foreign material is introduced into the sample and no material of interest is lost due to adsorption, chemical or biological degradation or volatilization. Methods of transportation and preservation (where applicable) must also be considered. Sample container labels must maintain their integrity even when wet. Because of the different interpretations of dates in the U.S. and Canada (i.e., "11/06/94" could be November 6 or June 11), always spell out the month (e.g., Nov. 6, 1994) when writing dates.

Sufficient volumes of sample must be collected to ensure that tests may be conducted properly, that required detection limits can be met for chemical analyses and that quality control samples can be analyzed. Always confirm in advance the required sample volumes and handling procedures with the laboratory that will be performing the analyses. Costs of collection and transport should be considered so that excessive volumes are not collected.

Sampling procedures for this investigation are to be described in detail in individual sampling plans developed by each team. Upon review of the draft workplan, each Team Leader will be assigned station identifiers for sample collection sites (see Section 10.0). The workplan will also identify the laboratory conducting analyses of the samples and specify the variables that will be measured. After finalizing the

workplan, the field study will commence upon approval of Golder and Suncor Project Managers as well as the QA Coordinator.

6.2 Sample Handling and Custody

Sample custody is a critical aspect of environmental investigations. Sample possession and proper handling of samples must be traceable from the time of sample collection, through laboratory and data analysis, to introduction as evidence. This section provides minimal program requirements for sample handling and chain of custody procedures.

6.2.1 Field Sampling Operations

6.2.1.1 Field Logbook

All pertinent information on field activities and sampling efforts must be recorded in an appropriate (i.e., waterproof) bound logbook. The field project coordinator is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible black ink (a pencil can be used in an emergency), with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by making a single-line cross-out of the error, entering the correct information, dating and initialling the change. Upon return to the laboratory, all field notes must be photocopied and placed in the appropriate project file.

Entries in the logbook must include:

- Purpose of proposed sampling effort
- Date and time of starting work
- Names of field supervisor and team members
- Description of each sampling site, including information on any photographs that may be taken
- Location of each sampling site (including applicable navigational coordinates)
- Details of sampling effort, particularly deviations from standard operating instructions

- Clear identification of site names and sample numbers
- Field observations
- Field measurements made (e.g., pH, temperature, flow, dissolved oxygen)
- Sample shipping information

6.2.1.2 Field Quality Control Criteria

Although validation guidelines have not been established for field QC samples, the results are useful in identifying possible problems as a result of sample collection and/or sample processing in the field. The field QC samples that will be collected during this investigation are discussed in this section.

Field Replicates

Field replicates provide information that is useful in assessing sample heterogeneity and variability of contaminant concentrations in the field. Field replicates are prepared by taking two co-located samples alongside the original sampling station (for a total of three samples from the same station). These samples are prepared separately in the field and submitted blind to the laboratory as separate samples. A minimum of one field replicate set will be collected per 20 stations sampled or per sampling event (any continuous sampling period not interrupted by more than two days), whichever is most frequent.

Certified Reference Materials

Analysis of reference materials and certified reference materials provides information on the accuracy of the laboratory performing the analysis. At least one reference material sample will be analyzed for each analyte group, contingent on availability and at the discretion of the QA Coordinator.

Field Blanks

Field blanks are useful in assessing whether or not the samples have been contaminated during sample collection. Field blanks that will be collected during this investigation are discussed in the following sections.

Bottle Blanks

To determine whether or not the sample bottles are introducing contamination to the samples, bottle blanks are submitted with the sediment and soil samples to the laboratory. One bottle blank will be submitted per 50 samples collected, per sampling event, or per bottle lot, whichever is most frequent.

6.2.2 Sample Preservation

Sample preservation requirements must be followed for each type of analyses. For example, sediment samples will be placed in coolers with a sufficient number of ice packs (or crushed ice) to keep them cold through the completion of that day's sampling, and through transport to the laboratories. Samples for other media will have different sample preservation procedures (Appendix V). Each team is responsible for insuring proper preservation techniques are used to preserve the integrity of the samples.

6.2.3 Sample Chain of Custody

Samples are considered to be in "custody" if they are: 1) in the custodian's possession or view; 2) retained in a secured place (under lock) with restricted access; or 3) placed in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). The principal documents used to identify samples and to document possession are chain-of-custody (COC) records and field notebooks. COC procedures will be used for all samples, no matter where in the analytical or transfer process. Figure 5 contains the COC form to be used for the Suncor EIA studies. Revisions to this form must be approved by the QA Coordinator before implementation.

When samples have been collected, they will be submitted with a COC form to the laboratory. Photocopies of the COC forms will be submitted to Brenda Brassard, Golder EIA Coordinator, for filing in the Golder project file.

6.3 Sample Shipping

Appropriate shipping procedures must be used to ensure that COC is maintained, sample containers are properly packaged to prevent damage, and that samples are received within the appropriate time frame so that holding times for analyses can be met.

The designated Field Coordinator for each study will be responsible for all sample tracking and COC procedures for samples in the field, as well as for final sample inventory. The field coordinator will maintain a copy of the sample custody documentation. At the end of each day, and prior to transfer, COC entries will be made for all samples. Finally, information on the labels will be checked against sample log entries and COC forms, and samples will be recounted. All samples will be accompanied by COC forms that will be signed at each point of transfer and will include sample numbers. All COC forms will be filled out in indelible, black ink.

Figure 5 Sample Chain of Custody Record

Field Sampler: (Signature) _____

Phone No._____

Shipment Date:_____

Carrier: _____

Weigh Bill No.: _____

Ship To:

Send Results To:

Project Name: _____ Project No. _____

P.O. No.: _____

Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

ANALYSIS REQUEST

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: _____

PLEASE RETURN WHITE COPY TO GOLDER ASSOCIATES LTD.

Prior to shipping, sample containers will be wrapped in bubble wrap, and securely packed inside the cooler with ice packs. The original signed COC forms will be placed into a zip-locked bag and taped to the outside lid of the cooler. Fiber tape will be wrapped completely around the cooler. On each side of the cooler a "This End Up" label will be attached, a "Fragile - Glass" label will be attached to the top of the cooler (if applicable), and the cooler will be sealed with custody seal tape. Samples will be transported from the sampling area to the designated laboratory by an authorized courier.

7.0 USE OF CONTRACT LABORATORIES/SUB-CONSULTANTS

7.1 Laboratory Documentation

7.1.1 Analytical Request Form

This form (Figure 6) is completed in duplicate for all samples which are being sent from the consultant to the contract laboratories for analysis. It identifies the client, project number, sample name(s), test(s) to be performed and who the results should go to. Send one copy with the sample(s) and submit the other copy to Brenda Brassard, Golder, for the Golder project file. This form is useful for following up on expected or overdue results. All chemical parameters must be cross referenced to the project parameter dictionary (Appendix VI) to ensure the codes are compatible for different parameters.

7.1.2 Laboratory Work Order Form

Upon arrival at the laboratory, a laboratory Work Order (WO) Form must be completed for each sample (or set of samples) that arrive from a client. Any paperwork accompanying the samples must be attached to the Laboratory Supervisor's copy of the WO Form (i.e., COC forms, client's purchase orders, etc.). When testing is complete, this information is transferred to the laboratory project file. If any work is to be done by other contract laboratories this must be recorded and a copy of any related documents attached to the WO form.

Each laboratory will be requested to use the same sample numbering system used to identify samples, based on station and sample identifiers (see Section 10.0), rather than assign a code name to the sample. If a laboratory insists upon assigning their own code names, a list of codes which correspond to the station and sample identifiers must be provided by the laboratory.

Figure 6 Analytical Request Form

Field Sampler: (Signature)

Phone No.

Shipment Date:
Carrier:
Weigh Bill No.:

Ship To:

Send Results To:

Project Name:

Project No.
P.O. No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested

Special Instructions/Comments:

Rush (surcharge):

Standard Turnaround Time:

7.1.3 Data Sheets and Notebooks

Data sheets and other information logs must be filled in completely and legibly. Most data sheets have spaces for information about sample and project identification at the top. It is important that this information is completed for all pages, not just the first one. All entries must be made in indelible black ball-point pen, and initialed by the person making the entry. Never use correction fluid (e.g., Liquid Paper®) or correction tape on data sheets. Make corrections by crossing out the entry with a single line, dating and initialing the new entry and providing a reason for the correction. Having this sort of permanent record of all entries is especially important if the data will be used in legal actions.

The information about a particular test must be complete enough so that testing activities can be reconstructed by someone unfamiliar with the test. Record all observations and any calculations made, particularly for preparing test concentrations. Record these in the notebooks and attach them to the data sheets. Initial and date all entries you make.

All original data sheets and supporting documentation must be filed in the project file at Golder after study completion. This includes tests which were terminated before completion for any reason (i.e., control failure, sample delivery problems). Copies of documentation must also be retained in the laboratory project file.

7.1.4 Laboratory Sample Logbook

All samples received at the laboratory must be logged into a sample logbook. This logbook acts as an additional check that samples have been received and provides information about the status of testing of samples. Samples not entered in this logbook are considered not to have been received.

7.1.5 Reagent Preparation Logs

Documentation of procedures used to prepare various reagents is important to maintain consistency and identify possible errors. Reagent preparation logs are used for recording preparation of synthetic dilution water, chemical samples, reference toxicant stock solutions and other reagents.

7.1.6 Instrument Calibration Logbooks

Instrument calibration is required to confirm that accurate measurements are being made during a test and that equipment is operating correctly. Each piece of equipment must have a logbook (identified by the consultant equipment number) for daily recording of calibration, maintenance, repairs and replacement. Entries must be made each day that an instrument is used; periods when the instrument is unavailable (e.g., for repairs) should be recorded so there are no information gaps. Equipment should be subject to regular inspection and preventive maintenance procedures to ensure proper working order. Calibration logbooks have to be kept on file for five years after the instrument is no longer in operation.

7.2 Sample Handling

7.2.1 Sample Receipt

The QA/QC Officer at each laboratory will ensure that COC forms are properly signed over upon receipt of the samples and note questions or observations concerning sample integrity on the COC forms. The laboratories will contact the QA Coordinator immediately if discrepancies between the COC forms and the sample shipment are discovered upon receipt. The Laboratory QA/QC Officer will specifically note any coolers that do not contain ice packs or are not sufficiently cold (e.g., $4\,^{\circ}C \pm 2\,^{\circ}C$) upon receipt. The laboratory will not dispose of the environmental samples for this project until notified by the QA Coordinator and client in writing.

7.2.2 Intra-Laboratory Sample Transfer

The Laboratory QA/QC Officer will ensure that a sample-tracking record is maintained and that it will follow each sample through all stages of laboratory processing. The sample-tracking record must contain at a minimum the name/initials of responsible individuals performing the analyses, date of sample extraction/preparation, and type of sample analysis.

7.2.3 Inter-Laboratory Sample Transfer

Any samples which are subcontracted out will follow the same COC and sample shipping requirements described in the above sections.

7.3 Sample Archival

All excess sample and extraction/digestion aliquots will be archived by the laboratories. The laboratories will maintain COC procedures and sample integrity for the entire time that the samples are in their possession. Each laboratory will store the archived samples and digestion/extraction aliquots for up to 6 months after the QA Coordinator has completed data validation. After the 6 months has passed, the samples will become the responsibility of Suncor.

7.4 Analytical Procedures

Prior to the analysis of the samples, the laboratory must demonstrate proficiency through the analysis of a blind certified reference material. The results of performance evaluation samples analyzed under the Canadian Association for Environmental Analytical Laboratories (CAEAL) may be used in lieu of the QA Coordinator submitting certified reference materials to the laboratory. The laboratory must also provide written protocols for the analytical methods to be used for sample analysis; calculate method detection limits for each analyte in each matrix of interest and establish an initial calibration curve for all analytes. The laboratory must demonstrate its continued proficiency by participation in interlaboratory comparison studies and repeated analysis of certified reference materials, calibration checks, laboratory reagent blanks, and spiked samples. The laboratory may be audited during the project in order to determine and document if the laboratory has the capability to analyze the samples and is performing in compliance with the QAPP.

7.4.1 Contaminants of Concern and Method Detection Limits

The contaminants of concern, methods of analyses, and their associated targeted detection limits are identified in Tables 2-6 in Section 5.6.

7.4.2 Determination of Method Detection Limits

The method detection limit (MDL) is defined as the lowest concentration of an analyte or compound that a method can detect in either a sample or a blank with 99% confidence. In summary, seven replicate samples are fortified at 1 to 5 times (but not to exceed 10 times) the level expected to be the method detection limit. The MDL is then determined by calculating the standard deviation of the replicates and multiplying by three. All analytical laboratories must supply MDLs for each type of analysis.

7.4.3 Methods of Analyses

All methods of analyses must comply with required methodologies and guidelines, where applicable. Analytical laboratories must have (or be in the process of developing) in-house standard operating procedures (SOPs) for each test used in this project. The specific methods of analyses used for the EIA study are given in Tables 2 - 6 in Section 5.6.

7.4.4 Laboratory Quality Control Criteria

ASL Analytical Services Laboratory will be used to analyze a portion of the quality control samples generated from this project. This will serve as a QC check of the other analytical labs. The percentage of QC samples to be analyzed by ASL will be determined by the project managers from Suncor and Golder in consultation with the QA Coordinator and Team Leaders.

The quality control samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The quality control sample results will then be evaluated to determine if control limits have been exceeded. If control limit exceedances have been identified in the sample group, the QA Coordinator will be contacted immediately and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

All primary chemical standards and standard solutions used in this project will be traceable to the National Research Council Canada; National Institute of Standards and Technology; or other documented, reliable, commercial sources. Standards should be validated to determine their accuracy by comparison with an independent standard. Any impurities found in the standard will be documented.

The following sections summarize the procedures that will be used to assess data quality throughout sample analysis (e.g., use and frequency of replicates, spikes, blanks, surrogate samples or reference materials, and calibration materials). A summary of the types of QC procedures to be performed by Syncrude for MicroTox® and naphthenic acid analyses are given in Table 7. The QC procedures for other types of analyses are discussed in the following sections.

Table 7 Summary of Quality Control Samples for MicroTox® and Napthenic Acid Analyses

ANALYSIS TYPE	INITIAL CALIB.	ONGOING CALIB.	STD REFERENCE	REPLICATE	MATRIX SPIKES	MATRIX DUPLICATES	METHOD BLANK	SURROGATE SPIKES
Microtox	each set	1 per 3 samples (a)	1 per 10 (phenol std)	1 per 10	N/A	N/A	N/A	N/A
Naphthenates	each batch (b)	1 per 5 samples (c)	1 per 5 (Kodak Naphthenates or Fatty Acids)	1 per 10 (d)	N/A	N/A	1 per 20 (e)	1 per 20

a. Instrument adjustment.

b. Standard Calibration Curve based on Kodak naphthenic acid in Methylene Chloride (0 - 1000 ppm)

c. Standard solutions of naphthenic acids run every 5 samples.

d. Random selections of samples.

e. Solvent and extraction system.

7.4.4.1 Initial Calibration

Multi-point initial calibration will be performed on each instrument at the start of the project, after each major interruption to the analytical instrument, and when any ongoing calibration does not meet control criteria. The number of points used in the initial calibration is defined in each analytical method. Ongoing calibration will be performed daily for organic analyses and for every sample batch for conventional parameters (when applicable) in order to track instrument performance.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately after every continuing calibration verification at a frequency of one continuing calibration blank for every ten samples analyzed at the instrument. If the ongoing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to within control specifications. All project samples analyzed while instrument calibration was out of control will be reanalyzed.

7.4.4.2 Standard Reference Materials

Analysis of reference materials and certified reference materials provides information on the accuracy of the laboratory performing the analysis. At least one reference material sample will be analyzed for conventional parameters per ten samples or per group of samples, whichever is most frequent. All certified reference material results must fall within the acceptance range values established for the reference material.

7.4.4.3 Matrix Replicates

Analytical replicates provide information on the precision of the analysis procedures and are useful in assessing potential sample heterogeneity and matrix effects. Analytical replicates are prepared by preparing a subsample and submitting it blind to the analyst to be extracted and analyzed as a separate sample. A minimum of 1 duplicate will be run per sample group or for every 20 samples, whichever is more frequent.

7.4.4.4 Matrix Spikes and Matrix Spike Duplicates

Analysis of matrix spike samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate matrix spike analyses, information on the precision of the

method is also provided for organic analyses. A minimum of 1 matrix spike will be analyzed for every sample group or for every 20 samples, whichever is more frequent. A standard reference material will be used when spiked samples are not appropriate, to assess method accuracy for specific parameters.

7.4.4.5 Surrogate Spikes

All project samples to be analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods. Recoveries determined using these surrogate compounds will be reported by the laboratories; however, no sample result will be corrected for recovery using these values.

7.4.4.6 Method Blanks

Method blanks are analyzed to assess possible laboratory contamination of samples associated with all stages of preparation and analysis of sample extracts. A minimum of one method blank will be analyzed for every extraction batch for every 10 samples for conventional parameters and at documented frequencies for other parameters.

7.4.5 Data Deliverables

Prior to issuing a final report to Golder Associates, each analytical laboratory must take steps to ensure the data are of acceptable quality. All laboratory personnel are responsible for reporting problems that may compromise the quality of the data to their laboratory manager who will report it to the designated contact from Golder Associates. The QA Coordinator must be informed of all corrective actions, by memorandum, within 5 days of the initial notification.

Each data file must be thoroughly reviewed internally by the analyst and Laboratory QA/QC Officer to ensure completeness of sample chain-of-custody documentation, verification of sample history information and analytical requirements, acceptability of QC data and validity of sample results. The Laboratory QA/QC Officer must certify each page of data with the date and their initials. The Laboratory Project Manager must concur with the data results and sign-off on the report to Golder.

Each analytical laboratory should have a turn-around-time of 2-3 weeks, depending on test type, from the date samples are received at the laboratory to the date the report is delivered to Golder Associates. The test report should describe the materials and methods used, as well as the test results. The report

should clearly state whether the conditions and procedures of the test rendered the results acceptable for use. The assignment of any codes used to qualify the data must be clearly stated. The report must include the following information:

Project Narrative

This summary, in the form of a cover letter, will briefly discuss the results. Any problems encountered during any aspect of analysis must be described. This should include, but not be limited to, quality control, sample shipment, sample storage, and analytical difficulties. Discussion of any problems encountered, actual or perceived, and corresponding resolutions made will be documented in as much detail as necessary.

Chain-of-Custody Records

Legible copies of the chain-of-custody forms will be provided as part of the data package. This documentation will include the time and condition of each sample received by the laboratory. Any additional tracking administered internally by the laboratory shall also be included.

Sample Results

The data package should summarize the results for each sample analyzed. This summary should follow Alberta Environmental Protection or Environment Canada protocols for data reporting, where applicable. The summary will include the following information:

- Field sample identification code and the corresponding laboratory identification code
- Sample matrix
- Date of sample extraction
- Date and time of analysis
- Weight and/or volume used for analysis
- Final dilution volumes or concentration factor for the sample
- Percent moisture in sediment samples
- Identification of the instrument used for analysis
- Method detection limits and instrument detection limits (IDLs)
- Analytical results reported to three significant figures with reporting units identified
- All data qualifiers assigned and their definitions

Quality Assurance/Quality Control Summaries

This section must contain the results of all QA/QC procedures. Each QA/QC procedure summary should include all the information as indicated in the data package section (see above) for each QA/QC sample. No recovery or blank corrections will be applied by the laboratory. Each analytical laboratory will be required to conduct a program of 20% quality control samples for every batch of samples. Quality control samples will include calibration and verification standards, standard reference materials, matrix spikes, duplicates, method and reagent blanks, transportation and storage blanks and glassware proofs. For spiked samples, list the name and concentration of all compounds added, percent recoveries, and range of recoveries.

Electronic Spreadsheet of Test Data

An electronic spreadsheet of the data, including QC data, must be supplied with the final report. The Data Manager will discuss the format of data transfer with each laboratory. A labeled, 3.5 inch diskette should be used, and a record of the data files (and any explanation needed) should be provided.

Original Data

Legible copies of the following original data, while not required to be reported, must be available to the QA Coordinator if an audit is conducted:

- Sample refrigerator temperature log
- Sample extraction, preparation, and cleanup logs
- Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
- Reconstructed ion chromatograms for all samples, standards, blanks, tunes, spikes, replicates and reference materials
- Enhanced spectra of detected compounds with associated best-match spectra for each sample
- Summary of calibration data including reporting the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. The response factor (RF), %RSD, percent difference (%D) and retention time for each analyte should be reported as appropriate
- Summary of internal standard areas to show whether they were stable
- Record of the relative retention time of each analyte detected in the samples for both primary and confirmation analyses

- Measurement printouts and quantitation reports for each instrument used including reports for all samples, standards, blanks, tunes, spikes, replicates and reference materials
- Original data quantification reports for each sample
- Original data for blanks and samples not reported

7.5 Biological/Toxicological Procedures

7.5.1 Quality Assurance

A number of biological and toxicological analyses will be performed to support the EIA. At the present time, not all types of analyses have been determined yet (e.g., types of toxicity tests). Each Team Leader must ensure that the sub-consultant they use have documented procedures for QA/QC.

The following sample analyses and quality control criteria will apply to the collection and enumeration of benthic samples:

- Sample Sorting and Sorting Efficiency
- Identification of Organisms
- Data Validation
  - Sample sorting quality control report
  - External taxonomic quality control report
  - Verification report from the outside experts on specimen voucher collection

Specific sample analyses and quality control criteria will need to be determined for the other biological procedures as well. Once all of the types of biological/toxicological studies have been determined, the QA Coordinator will work with the Team Leader and sub-consultant to develop acceptable sample analysis and quality control criteria. In most cases, these criteria will be based on published or documented procedures.

7.5.2 Data Deliverables

All sub-consultants for biological and toxicological work will be responsible for internal checks on data reporting and will correct errors identified during their quality assurance review. Each sub-consultant will be required to report results that are supported by the following:

- A cover letter discussing problems (if any) and procedures
- Summary report for any taxonomic work
- Original data sheets
- COC and transfer logs

In addition, other QA/QC data pertinent to the work must be included. For example, benthic results must include:

- Spreadsheet containing replicate abundance data
- QA results for 20% resorting
- Screening logs

The QA Coordinator will maintain close contact with the sub-consultants to resolve any quality control problems in a timely manner.

8.0 DATA EVALUATION

8.1 Data Review

Upon completion of the sample analyses, the laboratory will supply one complete data package to the study Team Leader (see Figure 4). The laboratory will also supply one summary data report and the electronic deliverable to the Data Manager. The study team leader will initiate the QA/QC checklist and send the complete data package to the QA Coordinator.

The QA Coordinator will review each laboratories' data to ensure the data comply with this QAPP (Figure 7). At least 10% of the sample data and 100% of the laboratory quality control samples will be validated. If transcription errors or other concerns (e.g., correct identification of chemicals in the samples) are found in the initial check on field samples, then data for an additional 10-20% of samples will be reviewed. If numerous errors are found, then the data package will be sent back to the analytical laboratory for corrections prior to completing the QA review.

8.2 Corrective Action Procedures

8.2.1 Corrective Action for Field Sampling

Each Field Coordinator will be responsible for correcting equipment malfunctions throughout the field sampling effort. The QA Coordinator will be responsible for resolving situations in the field that may result in nonconformance or noncompliance with the QAPP. All corrective measures taken will be documented in the field notebook immediately. A corrective actions checklist form (Figure 8) must also be filled out and sent to the QA Coordinator within five days of the action.

Figure 7 Guidance for Data Assessment and Screening for Data Quality

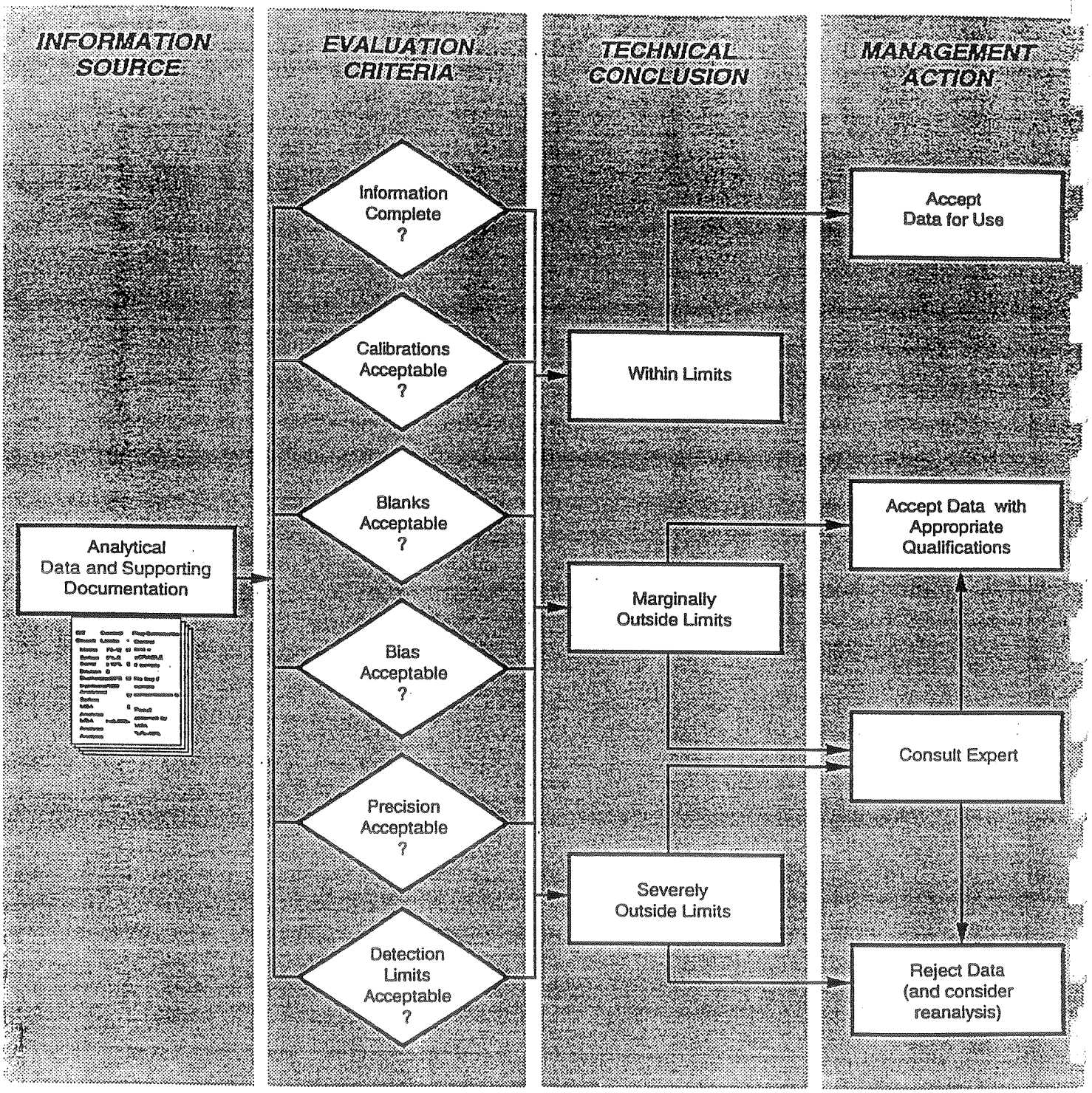


Table 8 *Corrective Actions Checklist*

SAMPLE PROGRAM IDENTIFICATION: _____

SAMPLING DATES: _____

MATERIAL TO BE SAMPLED: _____

MEASUREMENT PARAMETER: _____

ACCEPTABLE DATA RANGE: _____

_____

CORRECTIVE ACTIONS INITIATED BY: _____

TITLE: _____

DATE: _____

PROBLEM AREAS REQUIRING CORRECTIVE ACTION: _____

_____

_____

MEASURES TO CORRECT PROBLEMS: _____

_____

_____

MEANS OF DETECTING PROBLEMS (FIELD OBSERVATIONS, SYSTEMS AUDIT, ETC.):

_____

_____

_____

APPROVAL FOR CORRECTIVE ACTIONS: _____

TITLE: _____

SIGNATURE: _____

DATE: _____

8.2.2 Corrective Action for Laboratory Analysis

All laboratories are required to comply with the Standard Operating Procedures (SOPs) or other documented methodology given in Tables 2-6. The Laboratory Project Manager will be responsible for ensuring that the laboratory initiates the appropriate corrective actions required for conformance with the QAPP. All laboratory personnel are responsible for reporting problems that may compromise the quality of the data. The QA Coordinator will be notified immediately if any quality control sample exceeds the project specified control limits (Tables 2-6). The Laboratory Project Manager will document the corrective action by memorandum to the QA Coordinator within 5 days of the initial notification. The analyst will identify and correct the anomaly before continuing with the sample analysis. A narrative describing the anomaly noted, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, re-extraction) will be submitted with the data package in the form of a cover letter.

8.3 Laboratory and Field Performance Audits

Laboratory and field performance audits consist of onsite reviews of field and laboratory quality assurance systems and equipment for sampling, calibration, and measurement. All laboratories are required to have written procedures addressing internal QA/QC; these procedures have been submitted to the QA Coordinator and are acceptable. All personnel engaged in sampling and analysis tasks must have appropriate training. The contract laboratories will not be audited except for Syncrude's analytical laboratory for naphthenic acid analyses. The other analytical laboratories will not be audited for this project due to their recent accreditation by CAEAL which involves a thorough audit process.

A field audit will be conducted to review field operations including: SOPs or other documented field methodology, equipment maintenance and calibration records, chemical application and sampling techniques, and record keeping (e.g., chain-of-custody forms). The highest priority will be given to review field work which involves the collection of samples for chemical and physical analyses.

The results of the audit will be discussed with each field team and with Suncor, followed by a formal audit report. The audit report will list action items for correction and will provide a time-line for implementing corrections.

APPENDIX IV

GOLDER TECHNICAL PROTOCOLS

Fish Inventory and Fish Biomarker Method

1. PURPOSE

This technical procedure establishes the methodology to be used for the standard sampling of fish. Because of the nature of fisheries work, decisions regarding the type of sampling gear to use and the timing of sampling will depend upon conditions in the field. The following methods are covered in this technical procedure:

- General Fisheries Work
- Biomarkers
- Organochlorine Contaminants Sampling
- Mixed Function Oxidase Sampling
- Sex Steroid Sampling
- Biomarker Number
- Field Records and Logbook
- Chain-of-Custody Form

2. APPLICABILITY

This technical procedure is applicable to all personnel involved in fish surveys.

3. DEFINITIONS

3.1 Ageing Structures

Parts of the fish which are taken for ageing analyses. These structures contain bands (annuli) which delineate seasonal variation in growth which can be counted. Primary examples of these structures are scales, fin rays, otoliths, eleithra and opercula. The appropriate ageing structures to collect vary according to fish species and lifestage and include lethal and non-lethal sampling measures.

3.2 Tagging

3.2.1 Anchor (Floy) Tagging

A practical and inexpensive method of permanently marking individual fish. The tag, shaped like an inverted "T", is most commonly inserted in the epipleural bones of the dorsal spine. The posterior of the tag is usually brightly coloured and carries a numeric identification code. This method is prefered when seeking angler return data to aid in establishing fish movements.

3.2.2 Visual Implant (VI) Tagging

A "micro-tag" method suitable for use when a tagging method is required which has minimal effects on the swimming and feeding efficiency of the fish. Good for tagging smaller fish than is possible with the anchor

tag method, such as small fish species or juvenile fish. Each tag consists of a small metal strip with an individual alpha-numeric code which is inserted using an injector into a clear tissue somewhere on the fishes body (i.e. post-ocular tissue for salmonids).

3.2.3 Batch Marking

A marking method which does not distinguish between individual fish. Common methods are fin clipping or dye marking.

3.3 Archive Samples

Extra samples which are taken and kept in storage for possible later analysis.

3.4 Bile

An alkaline secretion of the vertebrate liver, which is temporarily stored in the gall bladder. It is composed of organic salts, excretion products and bile pigment. It is responsible primarily for emulsifying fats in the small intestine.

3.5 Biomarker

Biomarker refers to a chemical, physiological or pathological measurement of exposure or effect in an individual organism from the laboratory or the field. Examples include: contaminants in liver enzymes; bile; sex steroids.

3.6 Chain-of-Custody Forms

Standardized forms which are used as a means of keeping close track of samples which are taken from the field and transported to laboratories for analysis. Whenever the samples are transported from the field, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

3.7 Contaminants

A general term referring to any chemical compound added to a receiving environment in excess of natural concentrations. The term includes chemicals not generally regarded as "toxic", such as nutrients, colour and salts.

3.8 CPUE

Catch-Per-Unit-Effort. A measure which relates the catch of fish, with a particular type of gear, to the sampling effort expended; it is expressed as: number of fish captured/unit of effort. Results can be given for a particular species or the entire catch. CPUE is used to define species relative abundance and compare abundance between sites and/or seasons. Effort can be expressed a number of ways depending on

the sampling equipment. Some examples are time (sec/hr), area (m^3) and net length (m). If CPUE data is required, sampling effort must be recorded.

3.9 Effluent

A waste material discharged into the environment.

3.10 Effluent Plume

The portion of a water body exposed to discharge; the plume is delineated by tracking concentrations of compounds known to occur in the discharge. A plume ends when concentrations are equal to natural background levels or when they reach an arbitrary limit, for example 0.1%.

3.11 Electroshocking

The use of electricity to stun and capture fish. An electrical current is passed between electrodes placed in the water and attracts passing fish (galvanotaxis) toward the positive electrode (anode). Once fish pass close to the anode the current acts as a narcotic and stuns the fish (galvanonarcosis), allowing them to be easily netted. Once captured, the fish may be identified, weighed, measured, tagged and then returned to the water. Fish taken by electrofishing revive quickly when returned to the water. Effort is automatically recorded by the electrofishing unit as the number of seconds of active electrofishing (i.e. time current is applied to the water).

3.12 EROD

Ethoxyresorufin-O-deethylase. EROD is a laboratory technique that indirectly measures the presence of catalytic proteins that remove a CH_3CH_2-group from the substrate ethoxyresorufin. The substrate was chosen because of the fluorescent product formed is very easy to monitor in the laboratory. In the animal, various hydrophobic compounds can be transformed by this more polar products, which prepares them for eventual elimination from the body. Thus, this is a "detoxification" system that reduces the amounts of potentially harmful substances in the body. Cytochrome P4501A is the scientific designation of the dominant protein that carries out this catalytic function in fish and animals. EROD activity refers to the rate of deethylation and indirectly reflects the amount of protein present.

3.13 Fecundity

The most common measure of reproductive potential in fish. It is the total number of eggs in the ovary of a gravid female fish. Fecundity normally increases with the size of the female within a given species.

3.14 Forage Fish

A general term applied to smaller species of fish that "forage" on small invertebrate animals or plant materials.

3.15 Game Fish

Fish used by anglers for recreational fishing, e.g., northern pike, walleye.

3.16 Gillnetting

A method of capturing fish that involves the setting of nets of various mesh sizes (usually from about 2 to 10 cm) anchored in place in a river or lake. The nets function by catching on the gills of fish as they attempt to swim through. Effort should be recorded as the number of hours the net is set and expressed as either duration (hrs), panel-hours, or meter-hours, depending on the type and variety of nets set.

3.17 Gonads

Organs which are responsible for producing haploid reproductive cells in multicellular animals. In the male, these are the testes and in the female, the ovaries.

3.18 GSI

Gonad-Somatic Index. The proportion of reproductive tissue in the body of a fish. It is calculated by dividing the total weight of the gonad by the total body weight and multiplying the result by 100. It is used as an index of the proportion of growth allocated to reproductive tissues in relation to somatic growth.

3.19 LSI

Liver-Somatic Index. Ratio of liver versus total body weight. Expressed as a percentage of total body weight.

3.20 Lesions

Pathological change in body tissue.

3.21 m^3/s

Cubic metres per second. The standard measure of water flows in rivers, i.e., the volume of water in cubic metres that passes a given point in one second.

3.22 Necrosis

The death of a tissue due to injury or disease.

3.23 Reach

A reach is a relatively homogenous section of stream having repetitious sequence of assigned characteristics and habitat types. A reach is relatively uniform with respect to channel morphology, flow volume, gradient and habitat types and is separated from other reaches by changes in these characteristics.

Conventionally, reach numbers are assigned upstream ascending order starting from the mouth of the stream. Reach boundaries are identified using maps or air photos, then verified in the field.

3.24 Reference Site

A site used for comparison with a site exposed to the discharge being studied. Ideally, reference sites should be as similar as possible to the exposed site, but without the discharge.

3.25 Relative Abundance

The proportional representation of a species in a sample or a community.

3.26 Sampling Error

Sample inaccuracy caused by bias or imprecision in sampling; e.g., bias towards large fish because of the type of sampling gear. In statistics, sample error is expressed by the standard deviation, which expresses the variability of results around the mean.

3.27 Secondary Sex Characteristics

External physical characteristics displayed by fish, particularly during spawning season. Examples are tubercles on fins or body coloration.

3.28 Seine Netting

The use of a large, fine mesh net to catch fish from shallow (wadable) areas. The net is dragged along the bottom or through the water column to collect fish by straining them from the water. This technique is typically used to catch forage species, using fine mesh nets.

3.29 Set Lines

A series of leaders and baited hooks strung from one central line which is anchored to shore. Set lines are usually set out overnight to catch predatory fish..

3.30 Sex Determination (Lethal)

To determine the sex of a fish, an incision should be made on the ventral surface of the body from a point immediately anterior to the anus toward the head to a point immediately posterior to the pelvic fins exposing the gonads. If necessary, a second incision may be made on the left side of the fish from the initial point of the first incision toward the dorsal fin (USEPA, 1993). To observe the gonads, fold back the tissue. Ovaries appear whitish to greenish to orange and have a granular texture. Testes appear creamy white and have a smooth texture (Texas Water Commission, 1990).

3.31 Sex Determination (Non-Lethal)

For some species, sex may be determined from external secondary sexual characteristics, observable either during the spawning season (e.g. suckers - tubercles) or at any time of year (e.g. goldeye - anal fin morphology). For most fish species, sex can be determined during the spawning season by forcing extrusion of the sexual product (milt/roe)

3.32 Species Composition

A term that refers to the species found in the sampling area.

3.33 Species Distribution

Where the various species in an ecosystem are found at any given time. Species distribution varies with season and life history stage.

3.34 Standard Deviation

A measure of the variability or spread of the measurements about the mean. It is calculated as the positive square root of the variance.

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5. DISCUSSION

5.1 General Fisheries Survey

A combination of sampling techniques should be used according to river flow conditions lake morphometry, season, fish species and previous sampling success. These sampling techniques include: boat electroshocking, back-pack electroshocking, gillnetting, seine netting, set lines, minnow traps, fry traps, drift traps, underwater videos, counting fence and angling. However, only the sampling techniques

specified for in the project fish collection permit are allowed. If a change in sampling techniques is deemed necessary, the Project Manager should be informed before altering planned fishing methods. Therefore, all techniques that may be required, including those in contingency plans, must be included in the request for a collection permit. Note: for targeting a specific species, the sampling gear used can be selective to minimize variance in fish size, thus reducing sample size and processing requirements.

For seine netting, gill netting, back-pack electroshocking, set lines and angling, the sample site should be described fully and a sketch map of the location provided in the field book. Sufficient detail on the site must be known to enable accurate assignment of grid coordinates. It is preferable to note the location on a topographical map directly when in the field. Some studies may require that sites be located by a Geographic Positioning System. Specific Work Instructions will note this requirement. Assign a code number for each sample site according to the main sites in the study area. For example, if gill net set #2 is within site 2, then code number would be #GS2-2. This code is to marked on the topographical map. For boat electroshocking, the reach (start point to end point of boat run) should be recorded on the map. For all sampling types, the effort set should be recorded. That is, the start and end times, using a 24 hour clock, for each individual effort and the number of fish caught during that effort. In addition, time of active electrofishing for each run should be recorded from the counter on the electrofishing unit. Moreover, all seine netting effort should be recorded by pacing or measuring the distance seined and recording the haul type (upstream or downstream). The dimensions (length/panel, depth, mesh size(s)) of all seine nets and gill nets used should be recorded.

At each site, supporting receiving environment measurements are to be taken and recorded. These measurements include: water temperature, pH, dissolved oxygen, conductivity, secchi reading and current weather conditions (e.g., cloud cover, air temperature, approximate wind speed, precipitation, etc.).

All fish that are captured should be identified to species, assigned a fish number, weighed (g), measured for length (mm), determined for life history stage (fry, juvenile, adult), sex (refer to Section 3.27) and sexual maturity (if possible), noted for abnormal external pathology (e.g., fin erosion, ulcers, skeletal anomalies, neoplasms) and aging structures taken. Ageing materials to be collected for each fish species are specified in MacKay et al. 1990. For field collections, refer to Table 2 for recommended ageing structures. Non-target species or specimens of target species that do not meet size requirements should be tagged if necessary (refer to Specific Work Instructions) and returned to the water. If required, tag fish with either Floy Tags, Visual Implant Tags or Dye Marks depending on age and size of fish. Fish should be identified to species by experienced crew members. Taxonomic keys appropriate for the sampling waters, should be reviewed. Any fish that cannot be identified in the field should be sacrificed and preserved in 10% neutral buffered formalin with the appropriate label showing date and location of capture. Collected fish should be marked on the data sheets as unidentified and collected and following identification, the data sheets should be updated. For fish selected for biomarker processing, record time (24-hour clock) of capture. Large fish that are moribund or dead should be fully processed for biological data (sex maturity, internal pathology).

Standard abbreviation of fish species names is based on the following rules (MacKay et al. 1990):

a) use a four letter base abbreviation
b) for a one word name - use the first four letters
e.g., GOLD for goldeye

c) two word names - use the first letter in each word plus the next consonant in each word
e.g., ARGR for Arctic grayling,
LKWH for lake whitefish, and,
WHSC for white sucker

d) three word names - use the first letter in the first two words and the first letter and next consonant in the last word
e.g., NRDC for northern redbelly dace

5.1.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.1.2 Electrofishing Safety

All crew leaders must be thoroughly familiar with electrofishing safety standards. All crew leaders must ensure that each crew member is instructed in safety requirements and complies with safety measures. Please refer to the Golder Safety Manual and Electrofishing Manual by the United States Department of the Interior, Fish and Wildlife Service, section on Electrical Safety and Electrofishing.

5.2 Fish Biomarkers Collection

Note: The full biomarker procedure may not be required for a particular project. Refer to the Specific Work Instructions for your project.

Preparation

1. All new personnel must read the protocol, have it demonstrated and then practice the procedures on at least 2 practice fish.

2. All dissecting instruments and aluminum foil (assuming no metal analysis samples to be taken) should be cleaned in a acetone wash followed by a hexane wash. Dirt and tissues should be removed from the instruments with organic-free water before the acetone/hexane wash. All dissecting equipment is to be wrapped in the washed foil.

3. Battery operated balances are to be checked daily. Level balance at work area and check calibration using standard weights. A vial, weigh paper; anything that has been weighed on a calibrated lab balance may be used. Shield from wind if necessary.

4. All biomarker data are to be recorded in waterproof field notebooks, Biomarker forms (Exhibit A), Internal and External Examination forms (Exhibit B and C).

5. All dissecting equipment, sample containers, sample wrapping and wash equipment must be shipped and stored in clean waterproof containers with leak-proof lids.

6. All solvents and preservatives required for field work must be packaged and labelled according to WHMIS and TDG regulations.

Sampling

1. Put on a clean pair of non-chlorinated, non-powdered latex examination gloves.

2. Select fish from holding facility. Only live fish are to be sampled. Excessive handling of fish and stress is to be avoided. *Any fish that has been held after capture for more than an hour must be rejected*, refer to time of capture. If necessary, fish can be marked with temporary tags for identification at time of capture. Ensure that the skin on the specimen has not been lacerated during sampling. If there has been laceration and loss of fluids, reject the specimen.

3. Assign a biomarker number to fish based on instructions in 5.7.

4. Take blood from fish via the caudal artery using a 10 cc syringe and an 18-21 gauge needle. Label and store blood on wet ice (4°). Within 24 hours, blood tubes are to be centrifuged for at least 10 minutes. Decant the resulting separated serum using a micro-pipette and placed in a 3-5 ml cryovial. Preserve samples on dry ice until shipment to a laboratory.

5. Sacrifice the fish with a blow to the head. Note sacrifice time (24 hour clock) on log sheet.

6. Weigh and measure the fish (to nearest gram and mm) and record results. Use fork length measurement except for species with no anal fin indentation which should be measured for total length.

7. Rinse the fish in ambient water to remove any foreign material from the external surface.

8. Place the fish on a piece of acetone/hexane washed foil on a clean cutting board.

9. Make an full incision just below the area between the left pectoral fin and midline. Carefully remove liver and gall bladder. Clamp bile duct with a hemostat. Separate gall bladder from liver. Weigh liver to nearest 0.1 gr., note colour and firmness and record. If analysing for Mixed Function Oxidase (MFO), quickly place liver on a small rectangle of washed foil, wrap, place label between folds of foil (no contact with liver) and freeze immediately in liquid nitrogen. If mincing of liver is required by Specific Work Instructions, rinse the liver first in 0.15 M KCl, mince, wrap in washed foil and then freeze in liquid nitrogen (Hodson et al., 1991). **MFO analysis requires approximately 1.00 g liver, MFO samples must be taken within 2 - 5 minutes of sacrifice of fish. Samples not meeting this requirement must be rejected.** For species with diffuse livers (e.g., longnose sucker), quickly sample a representative portion of the liver from several locations along the intestine.. If analysing for organic contaminants (i.e., non-metal), quickly place liver on a small rectangle of washed foil, wrap, place label between folds of foil (no contact with liver), wrap with medical tape and label externally. Place sample in cooler of dry ice. NOTE: ANY PORTIONS OF LIVER FOR CONTAMINANTS ANALYSIS WHICH COME IN CONTACT WITH BILE FROM A RUPTURED GALL BLADDER SHOULD BE RINSED WITH 0.15 KCl. Remove bile from gall bladder with a 5 ml syringe and a 27-28 gauge

needle. Note and record bile volume and colour on biomarker form. Place bile sample in a labelled 5 ml cryovial and store on dry ice.

10. Complete external examination and record on external examination form.

11. **REFER TO SPECIFIC WORK INSTRUCTIONS FOR PROJECT APPLICABLE PROCEDURES.**

For individual fillet contaminant samples: remove approximately two 100 g fillets with a filleting knife that has been washed in acetone/hexane. Remove skin from fillets and ensure that no part of the fillet touches a surface that has not been washed in acetone/hexane. Place each fillet on a piece of washed foil and record weight. Wrap each fillet in the washed foil, insert label between folds of foil taking care not to touch the fillet. Securely tape a label onto the foil, make sure that one fillet per fish is labeled as an archive sample for possible later analysis. Place one fillet sample from each fish in a cooler with dry ice and store there until shipment to a lab. Place the archive fillet sample per fish in a cooler with dry ice clearly marked "archive samples or QC samples". Note: an alternative packaging for contaminant samples is organic-free plastic bags.

For samples taken for metals analysis: take care that the tissues designated as metal samples are dissected on a glass (preferably) or washable plastic surface, rather than on the foil. Dissecting instruments and knives used to take samples for metals analysis should be made of quartz, PTFE, ceramic, polypropylene or polyethylene. Stainless steel dissecting instruments are made predominantly of chromium and nickel. If these metals are not of concern, the use of high-quality, corrosion-resistant stainless steel sample processing is acceptable (USEPA 1993). Knives with titanium blades and PTFE handles are recommended for performing tissue resections (Lowenstien and Young 1986, USEPA 1993). For fillets, it is recommended that the fillet destined for organics analysis be taken first on the washed foil. Then the fish should be transferred to a plastic dissection surface and the fillet for metals taken. The fillet for metals must be placed in a plastic bag. If other organs are also being taken for contaminants analysis (e.g. liver, kidney) special care will have to be taken to isolate the section of the organ to be used for organics and take it while still on foil and then carefully remove the other section of the organ without contacting foil. ALL SAMPLES TO BE ANALYSED FOR METALS MUST BE PLACED IN PLASTIC BAGS, NOT FOIL. Utensils and containers should be cleaned thoroughly with a detergent solution, rinsed with tap water, soaked in acid, and then rinsed with metal-free water. Quartz, PTFE, glass, or plastic containers should be soaked in 50% HNO_3 for 12 to 24 hours at room temperature (USEPA 1993). **Chromic acid should not be used for cleaning any materials.** A minimum of regeant grade acids should be used. Stainless steel parts may be cleaned as stated for glass or plastic, omitting the acid soaking step (Stober 1991, USEPA 1993).

NOTE: THE SAMPLE MUST NOT THAW ONCE FROZEN. ONCE FROZEN, PROTECT SAMPLE INTEGRITY BY ENSURING ADEQUATE ICE LEVELS IN COOLER AND THEN TAKE MEASURES TO EXPEDITE SHIPPING TO THE ANALYTICAL LABORATORY.

For composite fillet contaminant samples: remove approximately two 100 g fillets with a filleting knife that has been washed in acetone/hexane. Remove skin from fillets and ensure that no part of the fillet touches a surface that has not been washed in acetone/hexane. Place each fillet on a piece of

washed foil and record weight. Wrap each fillet in the washed foil, insert label between folds of foil taking care not to touch the fillet). Place one wrapped fillet per fish into a plastic "zip-loc" bag and then place the Zip-loc bag into a large plastic bag that will hold all the specimens to be made into the composite. Put a "composite identification label" on the large plastic bag with tape or string. Place the other wrapped fillet per fish into a zip-loc bag and place into another large plastic bag that will hold all of the specimens to be archived for possible individual identification or QC analysis. Place an "archive sample label" on the large plastic bag with tape or string and store on dry ice until shipment. Note: only fillets from same species may make up a composite sample.

NOTE: IF SAMPLES ARE FOR ANALYSIS OF METALS, THEY MUST BE PLACED IN PLASTIC BAGS, NEVER WRAP METALS SAMPLES IN FOIL

NOTE: THE SAMPLE MUST NOT THAW ONCE FROZEN. ONCE FROZEN, PROTECT SAMPLE INTEGRITY BY ENSURING ADEQUATE ICE LEVELS IN COOLER AND THEN TAKE MEASURES TO EXPEDITE SHIPPING TO THE ANALYTICAL LABORATORY.

For composite internal organ contaminant samples: composite homogenates should be prepared from equal weights of individual homogenates (internal organ). The same type of homogenate should always be used in a given composite sample (USEPA 1993). Remove homogenate sample and any associated liquid using a washed scalpel or dissecting scissors. Divide into two 100 g samples (if sample is large enough). Ensure that no part of the sample touches a surface that has not been washed in acetone/hexane. Place each sample on a piece of washed foil and record weight. Wrap each sample in the washed foil, insert label between folds of foil taking care not to touch the fillet). Place one wrapped sample per fish into a plastic "zip-loc" bag and then place the Zip-loc bag into a large plastic bag that will hold all the specimens to be made into the composite. Put a "composite identification label" on the large plastic bag with tape or string. Place the other wrapped fillet per fish into a zip-loc bag and place into another large plastic bag that will hold all of the specimens to be archived for possible individual identification or QC analysis. Place an "archive sample label" on the large plastic bag with tape or string and store on dry ice until shipment.

NOTE: SAMPLES TO BE ANALYSED FOR METALS MUST BE PLACED IN PLASTIC BAGS; NEVER WRAP METALS SAMPLES IN FOIL.

NOTE: THE SAMPLE MUST NOT THAW ONCE FROZEN. ONCE FROZEN, PROTECT SAMPLE INTEGRITY BY ENSURING ADEQUATE ICE LEVELS IN COOLER AND THEN TAKE MEASURES TO EXPEDITE SHIPPING TO THE ANALYTICAL LABORATORY.

For whole fish contaminant samples to be later resected in the laboratory: each fish should be individually wrapped in extra heavy duty wash aluminum foil. Spines on fish should be sheared to minimize punctures in the aluminum foil packaging (Stober, 1991). The sample identification label should be taped to the outside of the package, each individual fish should be placed into a waterproof plastic bag and sealed. The Chain-of-Custody form should be attached to the outside of the plastic bag with string or tape. Note: for specimens making up a composite sample, keep all composite sample specimens together (if possible) in the same shipping container for transport. Once packaged, samples should be cooled on wet ice or blue ice immediately. Samples are to be shipped to the processing

laboratory within 24 hours (Smith 1985; USEPA, 1990d). If the shipping time to the laboratory is to exceed 24 hours, dry ice should be used. Note: if analyses will include edible tissue, freezing may cause internal organs to rupture and contaminate fillets or other edible tissues (Stober, 1991, USEPA 1986b).

12. Examine and record the internal condition of the fish on the Internal Examination Form. Preserve any abnormal tissues in 10% neutral, buffered formalin for later histopath analysis. Ensure that histopath samples contain both internal labels (waterproof paper and pencil) and external labels. Record tissues taken on the internal examination sheet as well as in field notebook.

13. Examine gonad, remove and weigh to nearest 0.1 g. Note sex (refer to Section 3.27) and assign maturity rating (refer to Table 1 for maturity codes). If there is uncertainty regarding the maturity code to assign, take a section of the gonad (mid-section) and preserve it in 10% buffered formalin for later examination in the laboratory. If collecting for fecundity and egg diameters, then remove 1 gram of eggs from the midregion of the ovary and place them in round histology cassettes that are lined with foil. Tare the balance to the weight of any empty cassette and then weigh the samples. Label the cassette. A minimum of 50% of the total sample size per species per site must have fresh measurements of egg diameter. Measure 30 individual fresh eggs/female using a micrometer for egg diameter. Record, label and store each egg individually in a histology cassette with 10% neutral, buffered formalin. After the minimum sample size for fresh measruements has been reached, store 30 eggs/female together in a histology cassette with 10% neutral, buffered formalin for analysis at the lab. At the lab, the individual eggs measured fresh in the field will be remeasured and calculated for % shrinkage. The % shrinkage will be used to correct measurement of the samples that were not measured fresh in the field. Volumetric determinations of egg size are made by counting 100 eggs and placing in a graduated cylinder with a pre-measured volume of water. Measure the new volume after the eggs have been added and record. Eg. Pre-volume = 5 ml. Volume with eggs = 5.5 ml. Volume of eggs = 0.5 ml. Precision of volumetric measurements will be dependent upon the graduated cylinder used. NOTE: The precision required for volumetric measurements of egg size in Environmental Effects Monitoring studies is $\pm$ 1%. (E.g. if a 10-ml cylinder is used, measurements are expected to be precise to 0.1 ml. This may not be achievable with 100 very small eggs. If not achievable, make note in the field notes and record the actual precision - e.g. 0.5 ml).

14. Observe and record qualitative stomach contents on internal examination form. Qualitative measurement of stomach contents is to be done by estimating the % of total volume of contents taken up by each food item. Be as specific as possible. For example, mayflies, stoneflies, caddisflies, water boatmen, water striders, beetles, not just "insects". Include % sediment or detritus and % plant material. Identify fish to species if possible, e.g., longnose sucker. Identify amphibian, bird or mammal prey as accurately as possible.

15. Collect two different ageing structure materials (i.e., scales, pectoral fin ray, otoliths) as per species requirements in Table 2, unless otherwise specified in the Specific Work Instructions. Place ageing materials in an "ageing materials" envelope and label.

16. Discard the remains of the specimen into a sealed bag for later disposal at a landfill. Discard latex gloves.

17. Rinse off cutting board with ambient water. Put on a clean pair of latex gloves and place a fresh piece of washed foil on the board. Proceed to the next fish.

    NOTE: IF YOU ARE COLLECTING CONTAMINANT SAMPLES, USE A FRESH FILLETING KNIFE AND DISSECTING EQUIPMENT FOR EACH FISH. FRESH SYRINGES MUST ALSO BE USED FOR EACH BILE AND BLOOD SAMPLE.

18. Once all samples have been taken from one site, ensure adequate ice levels in the cooler, attach a Chain-of-Custody (Exhibit D) to the inside lid of the cooler and then seal the cooler using duct tape. Do not mix samples from different sites in one cooler.

19. All used "sharp" dissecting/sampling equipment (needles, scalpel blades, etc.) must be placed in a designated "sharps" disposal container.

5.3 Field Recordkeeping

For proper interpretation of field survey results, thorough documentation of all field sample collection and processing activities is required. All logbooks should be perfect-bound and waterproof, forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

To document field activities, sample identification labels, Chain-of-Custody forms, field logbooks, biomarker form, internal/external examination forms, catch records (Exhibit E) and fish sample records (Exhibit F) should be used. This will serve as an overall "Chain-of-Custody" documenting all field samples and field events beginning with sample collection through biomarker processing and preservation and shipment to the laboratory.

5.3.1 Sample Identification Label

<u>Individual Contaminant Samples</u>

All individual samples must be labelled. Each label must be completed in indelible ink for each sample. For contaminant samples, the following information must be included on the label:

Project number
Collecting Agency or Firm-Golder
Sampler (name)
Biomarker number
Length/weight of specimen
Sampling date/time (24 hour clock)
Sample type: F = fillet, W = whole, ungutted, L = liver, B = bile, G = gonad, S = stomach, K = kidney.
Time-frame for analysis - immediate or archive

A completed sample identification label must be taped securely onto each foil-wrapped or bagged sample.

Composite Contaminant Samples

All composite samples must be labelled. Each label must be completed in indelible ink for each sample. For contaminant samples, the following information must be included on the label:

Project number
Collecting agency or firm
Sampling date/time (24 hour clock)
Sample Site
Sampler (name and signature)
Composite number
Species abbreviation
Sample type: F = fillet, W = whole, ungutted, L = liver, B = bile, G = gonad, S = stomach, K = kidney.
Chemical analysis requested - or refer to an accompanying Chain-of-Custody Form or Analysis Request Form
Time-frame for analysis - immediate or archive

A completed sample identification label must be taped securely onto each foil-wrapped or bagged sample. An additional label identifying the composite sample must be placed on each plastic bag containing the foil-wrapped or bagged samples. The same type of label may also be used for archive samples; simply indicate on the label that the samples are to be archived.

MFO's, Blood and Bile Samples

All MFO, blood and bile samples must be labelled. Each label must be completed in indelible ink for each sample. For MFO, blood and bile samples, the following information must be included on the label:

Biomarker number
Sampling date/time (24 hour clock)

Then place a label on outside of the dewar, bag or cooler containing several bile, blood or MFO samples and including the following information on the label:

Project number
Collecting agency or firm
Sampler (name)
Time frame for analysis - immediate or archive
General sample type (eg., bile, liver, etc.)

Histopathology and Egg Samples

All histopathology and egg samples must be labelled. Each label must be completed in indelible ink for each sample. For histopathological and egg samples, the following information must be included on the label:

Project number
Sampling date/time (24 hour clock)
Biomarker number
Tissue type:

O = ovary	T = testes
L = liver	S = spleen
H = heart	K = kidney
G = gill	I = intestine
ST = stomach	SK = skin
F = fin	AB = air bladder

An additional label must be placed on the jar or plastic bag identifying the several cassettes or jars of preserved specimens contained within. The label must include the following:

Project number
Collecting agency or firm
Sampler (name)
Time frame for analysis - immediate or archive
General sample type (eg., eggs for fecundity, histopathology samples)

NOTE: THE USE OF PRE-PRINTED LABELS IS STRONGLY ENCOURAGED.

5.4 Chain-of-Custody Form

Sample possession and proper handling of samples must be traceable from the time of sample collection, through laboratory and data analysis. A Golder Chain-of-Custody form must be completed and signed in indelible ink for each shipping container (e.g. ice cooler) used. Prior to sealing the cooler, two copies of the Chain-of-Custody form must be sealed in a plastic bag and taped to the inside cover of the cooler. Ensure that the carrier responsible for delivering the samples also signs and dates all Chain-of-Custody forms.

5.5 Field Records and Logbook

All pertinent information on field activities and sampling efforts must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort.
- Date and time (24 hour clock) of sampling.

- Names of field crew leader and team members.
- Description of each sampling site, including information on any photographs that may be taken.
- Location of each sampling site, name and number, applicable navigational coordinates, waterbody name/segment number.
- Details of sampling method and effort, particularly deviations from Specific Work Instructions.
- Clear identification of site names and sample numbers.
- Field observations.
- Field measurements taken (e.g., pH, temperature, flow, dissolved oxygen, secchi, weather conditions).
- Sample shipping information.

The field logbook should also be used to document any additional information on sample collection activities, hydrologic conditions, boat or equipment operations, or any unusual activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the monitoring data.

A biomarker logbook should also be kept. All pertinent information on fish biomarkers must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct fish biomarker field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field logbooks and notes must be photocopied and placed in the appropriate project files.

Entries in the fish biomarker field logbook must include:

- Date and time (24 hour clock) of sampling.
- Names of field crew leader and team members.
- Site name and number.
- Secchi, water temperature, conductivity,
- Fish number and Biomarker number.
- Capture time/sacrifice time (24 hour clock)
- Length/ Total Weight.
- Sex and stage
- Liver: total weight, sample weights, sample time (24 hour clock), canister storage number, colour
- Fillet: sample weights
- Bile: color, volume, canister storage number
- Gonads: total weight (testes or ovaries), egg weights, total fecundity count
- Abnormal tissues collected and preserved

- Ageing structures collected

Biomarker Forms, Catch Records, Fish Sample Records, External/Internal Examination Forms and Photo-Log Sheets are to be filled out, dated and signed. All forms should be cross-referenced to the appropriate field record via the fish number and/or composite number.

5.6 Fish Biomarker Number

All fish that are selected for biomarker analysis are to be given an individual biomarker number. This number is to be recorded on all individual sample labels. The biomarker number is an unique number which identifies the fish by project, species type, site, season and year.

The following format is to be used for biomarker numbering:

e.g.,

WLD	95	P	2A	LNSC	013
Project	Year	Season	Site	Species	Fish No.

Project - a unique 3 character code relating to the project.
Year - use the last two numbers of the year e.g., 1986 = 86.
Season - a one character code relating to season.

P - Spring
U - Summer
F - Fall
W - Winter

Site - a one or two alphanumeric code relating to the site the sample was caught.
Species - a four character abbreviation for species, see Section 5.1.
Fish No. - a three digit consecutive number. Individual numbering scheme for each species are to be used.

NOTE: THIS LABELLING SCHEME MAY BE SUPERCEDED BY LABELLING REQUIREMENTS SPECIFIC TO A PROJECT. HOWEVER, A SPECIAL LABELLING SCHEME MAY ONLY BE USED AT THE AUTHORIZATION OF THE PROJECT MANAGER AND QA OFFICER.

5.7 Shipping of Samples

Samples are to be shipped by the fastest possible means to the analytical laboratory. The primary QA consideration in shipping samples is protecting sample integrity. Preserve sample integrity by ensuring adequate ice levels in coolers before shipment to laboratory. Coolers are to remain sealed throughout shipment. Weigh-bill numbers are to be noted on the copies of the Chain-of-Custody form retained after sealing the coolers. Each transfer of custody is to be noted and signed for. The coolers should be labeled as Perishable/Keep Cold/Time-Sensitive. Clearly indicate the analytical laboratory address as well as a Golder contact person and phone number. The crew leader is to telephone the processing laboratory and

inform them of the upcoming delivery. The crew leader is also required to phone the processing laboratory to confirm arrival of the shipment and that analysis instructions are clear.

5.8 Procedure Alteration Checklist

Variations from the established procedure requirements may be necessary due to unique circumstances in the field. All variations from established procedures shall be documented on Procedure Alteration Checklists (Exhibit G) and reviewed by the Project Manager and the QA Manager.

The Project Manager may authorize the individual Field Crew Members to initiate variations as necessary. If practical, the request for variations shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented at the direction of the Field Biologist, provided that the Project Manager is notified of the variation within 24 hours of implementation and the Procedure Alteration Checklist is forwarded to the Project Manager and the QA Manager for review within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be repeated or action shall be taken as indicated in the Comments section of the checklist.

All completed Procedure Alterations Checklists shall be maintained in project records.

6. RESPONSIBILITY

All aquatic field crew members engaged in conducting fish inventories or fish biomarking studies are responsible for compliance with this procedure.

7. EQUIPMENT AND MATERIALS

Boat supplies
Fuel supply (primary and auxiliary supply)
Spare parts repair kit
Life preservers
First aid kit (including emergency phone numbers of local hospitals, family contacts for each crew member)
Spare paddles
Spare key
Floater Coats
Topographical maps of sampling sites
Flagging material
Tool box
Electrical tape
Water pump

Collection Equipment
Seine nets
Electroshocking device (boat and/or backpack unit)
Gill nets (if required)
Rubber gloves
Dip nets
Fish tubs (if required)

Recordkeeping
Field logbook (perfect-bound, waterproof)
Labels
Chain-of-Custody forms
Fish Sample Records
Unique Catch Records (boat, backpack, gillnet, seine net, etc.)
Indelible pens
Pencils
Applicable MSDS sheets and TGD placards

Biomarking Equipment (to be stored in waterproof, sealable equipment containers)
Specific Work Instructions
20 Litre pails for transfer and holding of fish
Fish measuring board (metric)
Balance (metric), calibration weights, balance levels and 9 volt batteries
Stainless steel forceps
Stainless steel filleting knives
Stainless steel dissecting scissors
Stainless steel scalpels
Stainless steel scalpel blades
Centrifuge (if taking blood samples)

Small whirlpacks
Nalgene bottles or small jars for pathology samples
Histology cassettes
Hemostats for clamping off gall bladder
5 ml Cryovials
Blood tubes
Tube rack
Paper towels
0.15 M KCl
Non-chlorinated, non-powdered latex surgical gloves
Aluminum foil (extra heavy duty)
10 ml syringe
18 g needle
5 ml syringe
27 g needle
Pipettes (if taking blood smears or serum samples)
Pipette Bulbs
Goggles for Liquid Nitrogen handling
Gloves for handling dewar racks (to prevent burns from Liquid Nitrogen)
"Sharps" disposal containers
Wash-tubs for field-washing of dissecting equipment in acetone/hexane
Used acetone/hexane containers
Cutting boards (washable)
Fish bonker
Folding tables (for biomarking stations)
Biomarker tent
Teflon wash bottle with distilled water
Medical tape
String
Several sizes of plastic bags including garbage bags
Cage material for holding fish in situ, if live-wells or fish tubs not available or too small

Sample preservation and shipping supplies
Ice (wet ice and/or dry ice)
Dewar (charged with liquid nitrogen if taking MFO samples)
Dry shipper (if taking MFO samples)
10% neutral buffered formalin
0.15% KCl
Scale envelopes
Ice chests
Duct tape
Clear shipping tape for Chain-of-Custody forms
Pesticide grade Hexane
Acetone
Pre-printed labels

Addendum to Golder Technical Protocol TP8-1

Instructions for making a composite fish fillet sample

1) All fish fillet samples for each composite will be placed in a labelled bag. The bag containing the samples to be composited will be labelled in indelible ink with the following information:

- name of the composite
- type of sample (i.e. bile, fillet etc.)
- project number
- name of the collecting company (i.e. Golder)
- analysis requested

2) Upon arrival at the laboratory all samples should be kept in the labelled bag and returned to it upon completion of preparation of the composite

For fish fillets the following procedure should be used to prepare the composite:

- unwrap the individual samples that are to form one composite
- take a portion of fillet from each individual sample to use in the composite
- make sure to retain a portion of each individual sample and rewrap it
- the remaining portion of each individual sample should be returned to the labelled composite bag and archived (frozen to -25° C)

For bile samples the following procedure should be used to prepare the composite:

- take a small amount of bile from each cryovial that is to form part of the composite
- if possible, leave some of the bile in each cryovial to be archived for future analysis. In some circumstances when the volume of bile is small (< 0.1 ml), the whole sample may have to be used
- the remaining portion of each individual sample should be returned to the labelled composite bag and archived (frozen to -25° C)

For serum samples the following procedure should be used to prepare the composite:

- take a small amount of serum from each cryovial that is to form part of the composite
- leave some of the serum in each cryovial to be archived for future analysis
- each remaining portion of the individual samples should be returned to the labelled composite bag and archived (frozen to -25° C)

SPECIAL INSTRUCTION TO ETL FOR COMPOSITES OF LIVERS

For liver samples from Golder project 952-2308 (Syncrude/Aquatic Baseline/Ft. McMurray) presently archived by Environ-test in liquid nitrogen:

- remove individual samples that are to form part of the composite sample from liquid nitrogen
- unwrap individual samples that are specified on the Analytical Request forms to be used in the composites
- cut the individual livers in half and retain half of the liver for the required analysis
- re-wrap each individual sample and place in liquid nitrogen
- further instructions will be sent to you shortly regarding shipment of these archived samples to another laboratory

Surface Water Substrates (Sediment) Sampling

1. PURPOSE

This technical procedure describes the methods to be used for the manual sampling of surface water substrates, commonly referred to as sediments.

2. APPLICABILITY

This technical procedure is applicable to any persons involved in the manual collection of surface water substrates.

3. DEFINITIONS

3.1 Chain-of-Custody Forms

Standardized forms which are used as a means of keeping close track of samples that are taken from the field and transported to laboratories for analysis. Whenever the samples are transported from the field, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

3.2 Surface water

Refers to any water either flowing or still that exists above ground level.

3.3 Substrate or sediment

Material at bottom of surface water, includes organic material (detritus), silt, sand, gravel, cobble and bedrock.

4. REFERENCES AND SUGGESTED READING

Environment Canada. 1993. Quality Assurance in Water Quality Monitoring. Ecosystem Sciences and Evaluation Directorate Conservation and Protection. Ottawa, Ontario.

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Methods

Sampling Site Selection and Identification

When selecting sampling locations one must select actual field sampling sites based on program design, access and logistical considerations. Once the sampling location has been determined it must be accurately located relative to permanent landmarks such as groundwater wells, outfalls or distinctive landscape features. Actual measurements with long tape measures or electronic distance measuring devices and compass headings are recommended as a minimum to accurately determine position. Locations can be easily recorded as the perpendicular distance from the shoreline and the distance upstream or downstream of a permanent landmark. If the project requires greater precision in site identification, global positioning system (GPS) should be used.

Sampling Methods

To ensure the contaminant-free collection of representative sediment samples, consider the following points:

- collect as representative a sample as possible based on the local substrate conditions and safety of access;
- avoid obvious sources of contamination when collecting samples;
- use an appropriate sampling device, cleaned consistently with the specific requirements of the sampling program.

Sample containers (usually provided precleaned by the analytical laboratory) should be rinsed a minimum of two times with ambient water. Rinse jars by partially filling, put the cap on loosely and shake. Drain water and rinse again. Polyethylene bags should also be rinsed.

Sample Handling

Sediment samples should be treated in a manner specific to the parameters that are to be analysed for. Each sampling container should be permanently and uniquely marked to avoid confusion. The samples should be submitted to the laboratory with the appropriate documentation, i.e. Chain-of-Custody forms and Analytical Request forms.. The bottles are to be permanently labelled at the time of sampling with pre-printed, waterproof labels containing the following information:

- Sampling date
- Sampling time (using a 24 hour clock)
- Sample location or site
- Sample number
- Sampler identification
- Chemical analysis requested - or refer to an accompanying Chain-of-Custody or Analytical Request form

In some cases, bottles are identified by code numbers which are referenced on the sample submission sheets (refer to Specific Work Instructions (SWIs) for specific project requirements). Once labelled, samples should be stored in a cooler which was cleaned according to the specific requirements of the study, on wet or dry ice (see below). Analytical request forms for all of this information are provided with the empty sample containers. A Chain-of-Custody form is be completed and attached to the outside of the cooler with string or adhesive tape.

Storage and shipping times are very important and must be considered, as many analytical parameters require that the sample needs to be in the laboratory for analysis within a specific time frame to ensure sample integrity. As an example, BOD samples must be to the analytical laboratory within 24 hours of sampling. Refer to SWIs for specific project requirements. Toxicity samples are to be shipped to the laboratory so that they arrive within 2 days of being sampled. Contact the associated laboratory in advance to secure recommended sample storage and transportation times specific to the analytical parameters. Crew leader is to confirm shipment arrival at the laboratory and to explain analysis requests if needed.

Samples for analysis need to be treated or preserved according to their specific handling protocols as prescribed by the laboratory. As a general rule, all samples should be kept at 4°C, on wet ice or in a refrigerator.

Cleaning Sampling Equipment

In some cases (refer to Specific Work Instructions for the project requirements) it may be necessary to clean sampling equipment between sampling locations. In these cases, equipment should be cleaned using cleaning agents such as distilled water or solvents as per Specific Work Instructions. At a minimum and before sampling, rinse the sampling equipment thoroughly with ambient water. In general, sample in an upstream direction and start at the uncontaminated (i.e. reference or control) sites first.

5.3 Field Records and Logbook

For proper interpretation of field survey results, thorough documentation of all field sample collection and processing activities is required. All logbooks should be perfect-bound and waterproof, forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

All pertinent information on field activities and sampling efforts must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort.
- Date and time (24 hour clock) of sampling.
- Names of field crew leader and team members.
- Description of each sampling site, including information on any photographs that may be taken.
- Location of each sampling site, name and number, applicable navigational coordinates, waterbody name/segment number.
- Details of sampling method and effort, particularly deviations from Specific Work Instructions.
- Clear identification of site names and sample numbers.
- Field observations.
- Field measurements taken (e.g., pH, temperature, flow, dissolved oxygen, secchi, weather conditions).
- Sample shipping information.

The field logbook should also be used to document any additional information on sample collection activities, hydrologic conditions, boat or equipment operations, or any unusual activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the monitoring data.

To document field activities, sample identification labels, Chain-of-Custody forms, field logbooks, field record sheets should be used. This will serve as an overall "Chain-of-Custody" documenting all field samples and field events beginning with sample collection through processing and preservation and shipment to the laboratory.

6. EQUIPMENT

6.1 Sampling Equipment

The following is a list of the equipment recommended for surface water sediment sampling:

- precleaned sample containers from analytical laboratory
- sampling protocol specific sampling equipment
- coolers and ice

6.2 Field Location Equipment and Logs

The following is recommended for the complete documentation of surface water substrate samples:

- field record sheets
- maps of area for site locations
- indelible ink pens and felt tip markers and pencils
- 50 metre long tape measure
- survey flagging tape
- survey lathe
- Analytical Request forms
- Chain-of-Custody forms

6.4 Health and Safety Equipment

- waders and water proof gloves
- suitable clothing for prolonged water work: heavy socks, warm pants, rain gear, etc.
- approved personal floatation device for deep water or boat work

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SEDIMENT SAMPLE COLLECTION
FIELD DATA SHEET

PROJECT: SITE:

RIVER/LAKE: DATE/TIME:

PERSONNEL: SIGNATURE OF FIELD LEADER:

FIELD NOTES BY:

WEATHER WIND: AIR TEMP.: PRECIPITATION: CLOUD COVER:

SITE DESCRIPTION (MAP):

WATER QUALITY MEASUREMENTS / OBSERVATIONS

Diss. Oxygen (mg/L):	Conductivity (µS/cm):	Current Vel. (m/s):	Other:
pH:	Water Temp. (°C):	Secchi Depth (m):	
Macrophytes (species, %cover):			

SEDIMENT SAMPLES

Sample Label	Depth (m)	Method	Fullness	Person	Notes (texture, colour, organic content, etc.)

SHIPPING INFORMATION

ADDITIONAL NOTES

Surface Water Sampling

1. PURPOSE

This technical procedure describes the methodology to be used for the manual sampling of surface water. Contained within are detailed sampling instructions.

2. APPLICABILITY

This technical procedure is applicable to any persons involved in the manual collection of surface water.

3. DEFINITIONS

3.1 Chain-of-Custody Forms

Standardized forms which are used as a means of keeping close track of samples which are taken from their field and transported to laboratories for analysis. Whenever the samples are transported from the field, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

3.2 Surface water

Refers to any water either flowing or still that exists above ground level..

4. REFERENCES AND SUGGESTED READING

Environment Canada. 1993. Quality Assurance in Water Quality Monitoring. Ecosystem Sciences and Evaluation Directorate Conservation and Protection. Ottawa, Ontario.

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Methods

To ensure the contaminant free collection of surface water quality samples, the following points in the selection of a sampling location must be observed:

- select actual field sampling site based on program design and access logistics.

Once the general location has been determined, the specific sampling site needs to be located. When locating the specific site the following is to be considered:

- for lotic systems, collect water samples using appropriate sampling device cleaned consistently with the specific requirements of the sampling program (refer to Specific Work Instructions for specific project requirements). Sample collection should be carried out before any disruptions of the water column;
- sample containers (usually provided precleaned by the analytical laboratory) should be rinsed a minimum of two times with ambient water. Rinse the bottles by partially filling, loosely attaching the cap and the shaking the bottles. Drain water and rinse again;
- in flowing water collect as representative a sample as possible based on the local flow conditions and safety of access
- avoid obvious sources of contamination when collecting samples, keep hands and fingers downstream of bottle opening, sample upstream of bridges, boats and yourself.

5.3 Site Location

Once the sampling location has been determined it must be accurately located relative to permanent landmarks such as groundwater wells, outfalls or distinctive landscape features. Actual measurements with long tape measures or electronic distance measuring devices and compass headings are recommended as a minimum to accurately determine position. Locations can be easily recorded as the perpendicular distance from the shoreline and the distance upstream or downstream of a permanent landmark or by global positioning system.

5.4 Sample Handling

The surface water samples should be treated in a manner specific to the parameters that are to be analysed for. In the case of toxicity samples, the vials should be kept cool, either on ice or in a refrigerator. They should be kept from freezing. Each sampling container should be permanently and uniquely marked to avoid confusion. The sample bottles should be submitted to the laboratory with the appropriate documentation (Chain-of-Custody form and Analytical Request Form). Included in the documentation should be the date, time, location, sample number, sampler identification and analytical request. Bottles are to be permanently labelled at the time of sampling with pre-printed, waterproof labels containing all of the pertinent sampling information. In some cases, bottles are to be identified by code numbers which are referenced on the sample submission sheets (check Specific Work Instructions). Analytical request forms for all of this information are provided with the empty sample bottles.

Storage and shipping times must comply with the specific laboratory time frame for analysis to ensure sample integrity. As an example, BOD samples must be to the analytical laboratory within 24 hours of sampling. Toxicity samples should be sent to the laboratory within 2 days of being sampled. Contact the associated laboratory in advance to secure recommended sample storage and transportation times specific to the analytical parameters. The crew leader to is confirm shipment arrival at the laboratory and to explain analysis requests if needed

Samples for water quality analysis need to be treated or preserved according to their specific handling protocols as prescribed by the laboratory. All samples should be kept at 4°C, where this is not possible then maintain unpreserved samples at 4°C.

5.5 Cleaning Sampling Equipment

In some cases, refer to Specific Work Instructions for project requirements, it may be necessary to clean sampling equipment between sampling locations. If this is the case, equipment should be cleaned using cleaning agents such as distilled water or solvents depending on the specific project and parameter requirements. At a minimum, before sampling rinse the sampling equipment thoroughly with ambient water. In general, sample in an upstream direction and start at the clean sites first (i.e.: background).

5.6 Field Records and Logbook

For proper interpretation of field survey results, thorough documentation of all field sample collection and processing activities is required. All logbooks should be perfect-bound and waterproof, forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

All pertinent information on field activities and sampling efforts must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort.
- Date and time (24 hour clock) of sampling.
- Names of field crew leader and team members.
- Description of each sampling site, including information on any photographs that may be taken.
- Location of each sampling site, name and number, applicable navigational coordinates, waterbody name/segment number.
- Details of sampling method and effort, particularly deviations from Specific Work Instructions.
- Clear identification of site names and sample numbers.
- Field observations.
- Field measurements taken (e.g., pH, temperature, flow, dissolved oxygen, secchi, weather conditions).
- Sample shipping information.

The field logbook should also be used to document any additional information on sample collection activities, hydrologic conditions, boat or equipment operations, or any unusual activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the monitoring data.

To document field activities, sample identification labels, Chain-of-Custody forms, field logbooks, field record sheets should be used. This will serve as an overall "Chain-of-Custody" documenting all field samples and field events beginning with sample collection through, preservation and shipment to the laboratory.

6. EQUIPMENT

6.1 Sampling Equipment

The following is a list of the equipment recommended for surface water sampling:

- precleaned sample bottles from analytical laboratory with necessary preservatives,
- sampling protocol specific sampling equipment,
- coolers and ice,

6.2 Field Location Equipment and Logs

The following is required for the complete documentation of surface water samples:

- perfect bound, water-proof field logbook
- field record sheets (sample included in this section)
- maps of area for site locations
- indelible ink pens and felt tip markers and pencils
- 50 metre long tape measure
- survey flagging tape
- survey lathe
- Analytical Request forms
- Chain-of-Custody forms

6.4 Health and Safety Equipment

- waders and water proof gloves,
- suitable clothing for prolonged water work: heavy socks, warm pants, rain gear, etc.,
- approved personal floatation device for deep water or boat work.

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SURFACE WATER SAMPLE COLLECTION
FIELD DATA SHEET

PROJECT: SITE:

RIVER/LAKE: DATE/TIME:

PERSONNEL: SIGNATURE OF FIELD LEADER:

FIELD NOTES BY:

WEATHER WIND: AIR TEMP.: PRECIPITATION: CLOUD COVER:

SITE DESCRIPTION (MAP):

MEASUREMENTS / OBSERVATIONS

Diss. Oxygen (mg/L):	Conductivity (µS/cm):	Current Vel. (m/s):	Other:
pH:	Water Temp. (°C):	Secchi Depth (m):	
Macrophytes (species, %cover):			

WATER QUALITY SAMPLES

Sample Label	Depth (m)	Method	Preserved?	Person	Notes

SHIPPING INFORMATION

ADDITIONAL NOTES

Porewater Sampling

1. PURPOSE

This protocol establishes the technical procedure to be used for the sampling of porewater by mini-piezometer. Contained within are detailed sampling instructions and an equipment list.

The intent of porewater sampling with mini-piezometers is to monitor groundwater inflow quality at the groundwater-surface water interface. The mini-piezometers are designed to allow for easy installation to this active interface. The perforated well point allows "porewater", the water contained in the spaces between the sands, gravels and cobbles in the river bottom, to enter the piezometer pipe. The infiltrating water is then sampled and can be tested in any number of ways.

2. APPLICABILITY

This technical procedure is applicable to any persons involved in the collection of porewater using mini-piezometers.

3. DEFINITIONS

3.1 Chain-of-Custody Forms

Standardized forms which are used as a means of keeping close track of samples which are taken from their field and transported to laboratories for analysis. Whenever the samples are transported from the field, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

3.2 Porewater

This is the water that is contained within the spaces between the substrate particles in the bottom of a river.

3.3 Mini-piezometer pipe

The hollow stainless steel pipe that is threaded at one end to join to the well point.

3.4 Mini-piezometer well point

The hollow stainless steel, perforated fitting that is installed between the pipe and the solid tip on a mini-piezometer.

3.5 Mini-piezometer tip

The stainless steel, solid tip that joins to the well point.

3.6 Mini-piezometer

A metal pipe that has a removable tip assembly. Used in the sampling of the porewater in a river bed.

4. REFERENCES AND SUGGESTED READING

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Site Selection

There are several criteria upon which to base the selection of a porewater sampling site. The gross position of the site is determined by:

- any specifications that may have been received;
- relevant landmarks (i.e. ground water wells or outfalls); and,
- previous porewater sampling sites.

Once the general location has been arrived at, then the specific sampling site needs to be located. When locating the specific site consider the following:

- water depth, generally limited to less than the height of one's waders;

- substrate type, avoid obvious depositional zones;
- current velocity, moderate to fast following water is usually the most productive as these areas generally have less fine sediment and greater porewater inflow rates;
- proximity to other mini-piezometers, if doing an array of mini-piezometers then the distance between the other piezometers needs to be considered.

5.3 Methods

Once the sampling location has been determined, it must be accurately located relative to permanent landmarks such as groundwater wells, outfalls or distinctive landscape features. Actual measurements with long tape measures or electronic distance measuring devices and compass headings are recommended as a minimum to accurately determine position. Locations can be easily recorded as the perpendicular distance from the shoreline and the distance upstream or downstream of a permanent landmark.

At the site, select a clean piezometer and ensure that the threaded connections are tight. Place the piezometer tip on the river substrate and hold the pipe vertical. Measure the depth of the water and the distance from the water surface to the top of the piezometer pipe. Record these two numbers in the field logbook and if applicable, field record sheet. Hammer the piezometer 50 centimetres into the substrate, checking the distance from the water surface to the top of the pipe regularly. When the piezometer has been hammered to the correct depth, the sampling procedure can begin.

The first step, once the piezometer is installed, is to purge the pipe and well point. Wash the vacuum hose and flask with river water before the purge. Purge by sliding the vacuum hose down the open top end of the piezometer pipe. When the hose hits the bottom of the pipe connect the outside end of the hose to the vacuum flask and begin pumping. Extract purge water until either the well goes dry or a 500 ml volume of purge water has been extracted.

The purge water should be completely described by measuring its conductivity, temperature, colour, volume, sediment load, time and location. After the purge, allow the well a period of time to recover. The length of the rest period is largely dependent on the rate of porewater infiltration to the piezometer. This is indicated by the amount of water attained during the purge. If 500 ml of purge water were extracted then the sampling can commence after 5 minutes. If only 100 ml of purge water were obtained then wait 15 minutes. Less than 100 ml of purge water usually suggests a plugged well point. While the well is resting install another well or complete field notes.

Once the piezometer has been purged and has had a period to recover, it is time to sample. Before sampling, wash the vacuum hose and flask well with river water. Insert the hose back down the pipe and pump until 500 ml has been sampled or the well goes dry, whichever is less sample volume. If the required sample volume exceeds that of the vacuum flask then several samples should be collected and composited in an appropriate container. Fill pre-labelled, river water rinsed sample vials or bottles with sample water. Describe remaining sample water by measuring conductivity and temperature and noting the sample colour, volume and sediment load. Also record the time and sample bottle number for each sample. Mark the site using lathe and or survey flagging tape if necessary. Remove the mini-piezometer and clean the equipment.

5.4 Sample Handling

The porewater samples should be treated in a manner specific to the parameters that are to be analysed for (refer to Specific Work Instructions for project requirements). In all cases, whether preserved or unpreserved, the samples should be kept cool, either on ice or in a refrigerator. Protect from freezing. Each bottle must be permanently and uniquely marked. It is recommended that preprinted, waterproof labels be used for this. The sample bottles must be submitted to the laboratory with the appropriate documentation consisting of Chain-of-Custody forms and Analytical Request Forms. Included in the documentation should be the date, time, location, project number, sample number, sampler identification and analytical request. Analytical request forms for all of this information should be provided with the empty sample bottles.

Storage and shipping times must be considered as many water quality parameters must be in the laboratory for analysis within specific time frames to ensure sample integrity. As an example, BOD samples must be to the analytical laboratory within 24 hours of sampling. Toxicity samples should be sent to the laboratory so that they arrive within 2 days of being sampled. Contact the associated laboratory in advance to secure recommended sample storage and transportation times specific to the analytical parameters. The crew leader to is confirm shipment arrival at the laboratory and to explain analysis requests if needed

Samples for water quality analysis need to be treated or preserved according to their specific handling protocols as prescribed by the laboratory. All samples should be kept at 4°C, where this is not possible then maintain unpreserved samples at 4°C.

5.5 Cleaning Equipment

Remove the well point and tip from the piezometer pipe. Clean all three pieces in river water. The well point may require cleaning with the bottle washing brush to remove clay from the perforations. Sometimes it is necessary to use something sharp, like a knife, to effectively clean stubborn clay from the well point slots. Wash the vacuum hose and flask by drawing river water up through the hose into the flask. In some cases, depending on specific sampling protocols, it may be necessary to use other cleaning agents such as distilled water or solvents to clean all equipment.

5.6 Trouble-Shooting

1. The well purges dry after less than 100 ml are pumped up:

    - this is generally a strong indication that the well point is blocked, the easiest solution is to remove the piezometer, clean and reinstall.

2. The piezometer is not going down when it is hit by the hammer:

    - the tip is likely up against a large stone, remove the piezometer, clean and reinstall.

3. Bent piezometer pipe:

    - straighten on a hard, flat surface by rolling and striking the high points with a sledge hammer;
    - make sure the well point and tip are screwed on for this procedure.

4. Piezometer stuck in substrate:

    - use clamped on visegrips to turn the piezometer in a clockwise direction while pulling up.

5. No water coming up when vacuuming:

- either the well is dry, in which case it should be abandoned, or the vacuum hose is plugged, usually at the bottom end of the pipe;
- raise the vacuum hose up and down in the piezometer, the water flow usually starts when the end of the hose is lifted out of the sediments that accumulate in the well point during installation.

6. Piezometer not going into the substrate vertically:

- let it follow its own course, if the angle from vertical exceeds 30 degrees then remove the piezometer.

5.7 Field Records and Logbook

For proper interpretation of field survey results, thorough documentation of all field sample collection and processing activities is required. All logbooks should be perfect-bound and waterproof, forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

All pertinent information on field activities and sampling efforts must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort.
- Date and time (24 hour clock) of sampling.
- Names of field crew leader and team members.
- Description of each sampling site, including information on any photographs that may be taken.
- Location of each sampling site, name and number, applicable navigational coordinates, waterbody name/segment number.
- Details of sampling method and effort, particularly deviations from Specific Work Instructions.
- Clear identification of site names and sample numbers.
- Field observations.

- Field measurements taken (e.g., pH, temperature, flow, dissolved oxygen, secchi, weather conditions).
- Sample shipping information.

The field logbook should also be used to document any additional information on sample collection activities, hydrologic conditions, boat or equipment operations, or any unusual activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the monitoring data.

To document field activities, sample identification labels, Chain-of-Custody forms, field logbooks, field record sheets should be used. This will serve as an overall "Chain-of-Custody" documenting all field samples and field events beginning with sample collection through, preservation and shipment to the laboratory.

6. EQUIPMENT

6.1 Installation Equipment

The following is a list of the equipment recommended for mini-piezometer installation:

- mini-piezometers, straight and clean;
- extra well points and tips;
- slide hammers;
- tools (pipewrenchs, visegrips, sledge hammer);
- meter stick or tape measure.

6.2 Sampling Equipment

The following is a listing of the recommended equipment for collecting samples from mini-piezometers:

- vacuum flasks (minimum 2);
- vacuum sampling hose (5 x 3-4 metre sections);
- handheld, electrical or gas powered vacuum pumps (depending upon availability);
- battery for electric vacuum pump (only if electric pump used);
- gas and oil for gas power vacuum pump (only if gas powered vacuum pump used);
- sample bottles for toxicity or regular water quality sampling;
- bottle washing brush for well point;
- pocket knife for cleaning clay from well point perforations;

- marking pen and scribe (to etch plastic lids on glass or plastic bottles).

6.3 Field Location Equipment and Logs

The following is recommended for the complete documentation of mini-piezometer sampling:

- field record sheets (sample included in this section);
- maps of area for site locations;
- indelible ink pens and felt tip markers and pencils
- Chain-of-Custody Forms
- Analytical Request Forms
- perfect bound, water-proof logbooks
- 50 metre long tape measure
- survey flagging tape
- survey lathe

6.4 Health and Safety Equipment

- waders and gloves
- protective eyewear
- hearing protection
- suitable clothing for prolonged water work: heavy socks, warm pants, rain gear, etc.
- first aid kit

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POREWATER SAMPLING
FIELD RECORD SHEET

GENERAL INFORMATION

PROJECT: GENERAL LOCATION: PERSONNEL:

RIVER: DATE: FIELD NOTES TAKEN BY:

SPECIFIC INFORMATION

SITE DESCRIPTION	BANK (L/R) looking d/s	DISTANCE FROM BANK (m)	WATER DEPTH (cm)	SUBSTRATE (SI/SA/ G/C/B)	RELATIVE WATER VELOCITY (N/L/M/H)	SAMPLE	TIME (24 h)	SAMPLE DEPTH (cm)	TEMP. (oC)	COND. (uS/cm)	VOLUME (mL)	COLOUR	ODOUR	SEDIMENT LOAD (L/M/H)	BOTTLE NUMBER
						PURGE									
						SAMPLE									
						PURGE									
						SAMPLE									
						PURGE									
						SAMPLE									
						PURGE									
						SAMPLE									
						PURGE									
						SAMPLE									
						PURGE									
						SAMPLE									

NOTES

LEGEND: L=left or low ; R=right; d/s=downstream; SI=silt; SA=sand; G=gravel; C=cobble; B=boulder; N=none; M=moderate; H=high; TEMP.=temperature; COND.=conductivity

Habitat Mapping and Classification System

1. PURPOSE

This technical procedure details the classification system and map coding system to be used for habitat mapping a watercourse. The habitat mapping system consists of two components; a general system for mapping large mainstem rivers and a more detailed system for mapping discrete channels units which is primarily used for smaller streams.

2. APPLICABILITY

This technical procedure is applicable to all personnel involved in habitat mapping of all sizes of watercourses in Alberta. The technique was developed primarily in Alberta in consultation with Alberta Fish and Wildlife. With respect to describing aquatic habitats it is applicable outside of Alberta but may be superseded by local criteria (eg. B.C. MOE guidelines).

3. DEFINITIONS

The habitat mapping system is divided into a set of habitat types or categories, the definitions of which are included in the classification system. Some more general definitions are presented here.

3.1 Channel

A natural or artificial waterway which periodically or continuously contains moving water. It has a definite bed and banks which normally confine the water, and which display evidence of fluvial processes.

3.2 Channel Form

The shape of river confinement.

3.3 Channel Unit

Hydraulic and morphological features of a stream channel. A channel unit is a section of channel which exhibits homogeneity with respect to water depth and velocity and is separated from other channel units by gradients in these parameters. The most common channel units are pool, riffle and run.

3.4 Channel Width

The horizontal distance along a transect line from stream bank to stream bank (rooted vegetation to rooted vegetation) at the normal high water marks measured at right angles to the direction of flow.

3.5 Cover

Aspects of the physical environment which provide cover for fish. Cover consists of two categories: 1) instream cover - any feature which provides a velocity shelter (eg. large substrate particles, submerged

debris, etc.); 2) overhead cover - any feature which provides visual isolation for the fish (eg. overhanging vegetation, undercut bank, turbulence, etc).

3.6 Discharge

A measurement of the volume of water flowing in the stream channel, measured as the volume flowing past a specific point over a given time (i.e. m^3/s).

3.7 Stream Habitat

The physical stream environment which provides a place for aquatic biota (fish, invertebrates, plants, etc.) to live, grow and reproduce. Several types of fish habitat should be considered when habitat mapping and include spawning habitat, nursery/rearing habitat, feeding habitat and overwintering habitat.

3.8 Stream Gradient

The slope of the streambed over which the stream runs. Velocity of the water flow is directly related to the gradient; i.e. the steeper the gradient, the greater the velocity of the stream or channel unit.

3.9 Wetted Width

The width of the water surface measured at right angles to the direction of flow. Multiple channel widths are summed to obtain total wetted width.

4. REFERENCES AND SUGGESTED READING

Hawkins C.P., J.L. Kershner, P.A. Bison, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman, and M.K. Young. 1993. A hierarchial approach to classifying stream habitat features. Fisheries 18(6):3-12.

R.L.& L Environmental Services Ltd. 1986. Fisheries resources upstream of the Oldman Dam: Prepared for Alberta Environment Planning Division, Edmonton. 131 pp. + App.

Northern River Basins Study. 1994. A general fish and riverine habitat inventory; Athabasca River, October 1993. Prepared by R.L.& L. Environmental Services Ltd. for the NRBS, Edmonton. Northern River Basins Study Project Report No. 40. 129 pp. + App.

5. DISCUSSION

The habitat mapping and classification system is used to provide an ecologically relevant inventory of stream habitats within a designated study area. The mapping procedure is meant to describe the habitats available within the stream and to detail the location and extent of each habitat type/class. The habitat classification system is intended to be ecologically meaningful with respect to describing and cataloguing

physical habitats in relation to the requirements of fish species and their various life stages (spawning, incubation, nursery, rearing, summer feeding, holding, overwintering, migration); and also to a lesser extent the relationship between physical habitat and benthic invertebrate productivity, at least with respect to fish food production. Researchers have determined that fish distinguish between the habitat types and sub-classes of habitat types that have been used to map streams and it is intended that this classification system provide an ecological association of habitat characteristics and fish use/abundance.
Streams are habitat mapped to provide an inventory of the available habitats and to show the locations of critical habitats, that is habitats that are of importance to a fish population such as migration routes, spawning habitat, rearing habitat etc. Habitat maps are used in several applications. A habitat map can be used to show the habitat types present at a specific site that may be impacted by a proposed point disturbance such as a pipeline crossing or bridge construction. A habitat map of a length of stream can be used to evaluate optional locations for such a disturbance to minimize the impacts to the fisheries resource. Habitat maps may be used to document changes to a stream environment over time, such as impacts from a disturbance or improvements due to habitat rehabilitation or improvement programs. Habitat maps can provide an inventory of habitat types present downstream of a discharge/effluent which has a continual impact on those habitats. A primary use of the habitat mapping procedure is to provide an inventory of the habitats present in a stream that is subject to a proposed impact in order to ensure compliance with the Federal Regulations stating that "No Net Loss" of productive fish habitat is to occur as a result of a proposed disturbance or alteration of the stream.

The habitat mapping and classification system is composed of two components. The first is a general system called the "Large River Habitat Classification System" which is used to map large mainstem rivers such as the Peace or Athabasca rivers where habitat heterogeneity is less than for smaller streams, and use of a more detailed system may not be appropriate or required by the project. The second component is a the more detailed "Stream Habitat Classification and Rating System", which itself consists of more than one component depending on the level of detailed required by the project.

The habitat map is produced by delineating on a base map the location and extent of each of the habitat features. The features to be included, the definitions of these features, and the abbreviations (map symbols) used to label each feature on the habitat map are detailed in Tables 1 and 2. Also to be recorded during the habitat mapping process is the location of the stream or section of stream being mapped, the project number, the date and, if possible, the discharge at the time of mapping.

Whether the large river classification system (Table 1) is used or the stream classification and rating system (Table 2) is used will depend on the size of the watercourse and the level of mapping detail required to meet the objectives of the project. For medium to large sized watercourses it may be possible to apply both systems to the same mapping program.

In addition to the two habitat classification systems, additional detail can be recorded on the habitat maps which describe, in qualitative terms, the general substrate conditions. Typically, this process would be applied during use of the stream habitat classification and rating system to describe the substrate conditions for specific areas, such as potential spawning habitats, or to describe the substrate type within each individual channel unit. Substrate composition is presented as the percent occurrence (visual estimation) of each substrate size category. Substrate particle sizes are presented on Table 3.

5.1 Large River Habitat Classification System

This is a general system based on gross morphology, surficial and hydraulic characteristics and consists of two primary components. These are: 1) "major habitat type", which defines the type of channel present, and; 2) "bank habitat type", which details the structure of the bank and near shore habitats. Also included on the map are "special habitat features" which are significant to fish distribution/use in these large rivers. Table 1 presents the details of the large river habitat classification system.

5.2 Stream Habitat Classification and Rating System

This is a detailed mapping system based on individual channel units, which are sections of stream of homogenous character with respect to depth, velocity and cover. The extent of each habitat unit is delineated on the map, as is the class rating for each unit (where appropriate). Some of the channel units also have modifiers (types) which should also be recorded. Table 2 presents the details of the stream habitat classification and rating system.

TABLE 1:

LARGE RIVER HABITAT CLASSIFICATION SYSTEM

(From R.L.&L. 1992 - General Habitat Inventory for the NRBS)

MAJOR HABITAT TYPES

Type	Abbreviation	Description
Unobstructed channel	U	single main channel, no permanent islands, side bars occasionally present, limited development of exposed mid-channel bars at low flow
Singular island	S	two channels around single, permanent island, side and mid-channel bars often present at low flow
Multiple island	M	more than two channels and permanent islands, generally extensive side and mid-channel bars at low flow

SPECIAL HABITAT FEATURES

Tributary confluences	TC	confluence area of tributary entering mainstem
[sub-classified according	TC1	intermittent flow, ephemeral stream
to tributary flow and	TC2	flowing, width <5m
wetted width at mouth at	TC3	flowing, width 5-15m
the time of the survey]	TC4	flowing, width 16-30m
	TC5	flowing, width 31-60m
	TC6	flowing, width >60m
Shoal	SH	shallow (<1m deep), submerged areas in mid-channel or associated with depositional areas around islands/side bars
	SHC	submerged area of coarse substrates
	SHF	submerged area of fine substrates
Backwater	BW	discrete, localized area exhibiting reverse flow direction and, generally, lower velocity than main current; substrate similar to adjacent channel with more fines
Rapid	RA	area with turbulent flow, broken surface (standing waves, chutes etc.), high velocity (>1 m/s), armoured substrate (large boulder/bedrock) with low fines
Snye	SN	discrete section of non-flowing water connected to a flowing channel only at its downstream end, generally formed in a side channel or behind a peninsula (bar)
Slough	SL	non-flowing water body isolated from flowing waters except during flood events; oxbows
Log jam	LJ	accumulation of woody debris; generally located on island tips, heads of sidechannels, stream meanders; provide excellent instream cover

BANK HABITAT TYPES

Armoured/Stable	A1	largely stable and at repose; cobble/s.boulder/gravel predominant; uniform shoreline configuration; bank velocities low-moderate; instream/overhead cover limited to substrate and turbidity
	A2	cobble/s.-l.boulder predominant; irregular shoreline due to cob/boulder outcrops producing BW habitats; bank velocity low (BW)-mod; instream/overhead cover from depth, substrate and turbidity
	A3	similar to A2 with more l.boulder/bedrock; very irregular shoreline; bank velocities mod-high with low velocity BW/eddy pools providing instream cover; overhead cover from depth/turbidity
	A4	rip-rap substrates consisting of angular boulder sized fill; often associated with high velocity areas; shoreline usually regular; instream cover from substrate; overhead cover from depth/turbulence
Canyon	C1	banks formed by valley walls; l.cobble/boulder bedrock; stable at bank-water interface; typically deep/high velocity water offshore; abundant velocity cover from substrate/bank irregularities
	C2	steep, stable bedrock banks; regular shoreline; mod-deep/mod-fast water offshore; occasional velocity cover from bedrock fractures
	C3	banks formed by valley walls, primarily fines with some gravel/cobble at base; moderately eroded at bank-water interface; mod-high velocities; no instream cover
Depositional	D1	low relief, gently sloping bank; shallow/slow offshore; primarily fines; instream cover absent or consisting of shallow depressions or embedded cobble/boulder; generally associated with bars
	D2	similar to D1 with gravel/cobble substrate; some areas of higher velocities producing riffles; instream/overhead cover provided by substrate/turbulence; often associated with bars/shoals
	D3	similar to D2 with coarser substrates (cobble/boulder); boulders often imbedded; mod-high velocities offshore; instream cover abundant from substrate; overhead cover from turbulence
Erosional	E1	high, steep eroded banks with terraced profile; unstable; fines; mod-high offshore velocity; deep immediately offshore; instream/overhead cover from submerged bank materials/vegetation/depth
	E2	similar to E1 without the large amount of instream vegetative debris; offshore depths shallower
	E3	high, steep eroding banks; loose till deposits (gravel/cobble/sand); mod-high velocities and depths; instream cover limited to substrate roughness; overhead cover provided by turbidity
	E4	steep, eroding/slumping highwall bank; primarily fines; mod-high depths/velocities; instream cover limited to occasional BW formed by bank irregularities; overhead cover from depth/turbidity
	E5	low, steep banks, often terraced; fines; low velocity; shallow-moderate; no instream cover; overhead cover from turbidity
	E6	low slumping/eroding bank; substrate either cobble/gravel or silt with cobble/gravel patches; moderate depths; mod-high velocities; instream cover from abundant debris/boulder; overhead cover from depth/turbidity/overhanging vegetation

TABLE 2:

STREAM HABITAT CLASSIFICATION AND RATING SYSTEM

(Adapted from R.L.&L. 1992 - General Habitat Inventory for the NRBS)

Channel Unit	Type	Class	Symbol	Description
Falls			FA	highest water velocity; involves water falling over a vertical drop; impassable to fish
Cascade			CA	extremely high gradient and velocity; extremely turbulent with entire water surface broken; may have short vertical sections, but overall is passable to fish; armoured substrate; may be assoc. with chute (RA/CH)
Chute			CH	area of channel constriction, usually due to bedrock intrusions; associated with channel deepening and increased velocity
Rapids			RA	extremely high velocity; deeper than riffle; substrate extremely coarse (l.cobble/boulder); instream cover in pocket eddies and associated with substrate
Riffle			RF	high velocity/gradient relative to run habitat; surface broken; relatively shallow; coarse substrate; limited instream or overhead cover
Run				moderate to high velocity; surface largely unbroken; deeper than RF; substrate size dependent on hydraulics
	Depth/Velocity Type			run habitat is differentiated into 4 types; deep/slow, deep/fast, shallow/slow, shallow/fast
		Class 1	R1	highest quality/deepest run habitat; generally deep/slow type; coarse substrate; high instream cover from substrate/depth
		Class 2	R2	moderate quality/depth; high instream cover except at low flow; generally deep/fast or moderately deep/slow type
		Class 3	R3	lowest quality/depth; generally shallow/slow or shallow/fast type; low instream cover in all but high flows
Flat			FL	area characterized by low velocity and near-laminar flow; differentiated from pool habitat by high channel uniformity; more depositional than RU3 habitat
Pool				discrete portion of channel featuring increased depth and reduced velocity relative to riffle/run habitats; formed by channel scour
		Class 1	P1	highest quality pool habitat based on size and depth; high instream cover due to instream features and depth; suitable holding water for adults and for overwintering
		Class 2	P2	moderate quality; shallower than P1 with high instream cover except during low flow conditions
		Class 3	P3	low quality pool habitat; shallow and/or small; low instream cover at all but high flow events
	Pool Type			several types of pool are specified, depending on the hydraulic factors which formed them, they include; eddy, trench, lateral, mid-channel, plunge and convergence
Impoundment		Class 1-3	IP (1-3)	includes pools which are formed behind dams; tend to accumulate sediment/organic debris more than scour pools; may have cover associated with damming structure; identify as Class 1, 2 or 3 as for scour pools
	Dam Type			four types of impoundments have been identified based on dam type; debris, beaver, landslide and abandoned channel
Backwater			BW	discrete, localized area of variable size exhibiting reverse flow direction; generally produced by bank irregularities; velocities variable but generally lower than main flow; substrate similar to adjacent channel with higher percentage of fines
Snye			SN	discrete section of non-flowing water connected to a flowing channel only at its downstream end; generally formed in a side-channel or behind a peninsula
Boulder Garden			BG	significant occurrence of large boulders providing significant instream cover; always in association with an overall channel unit such as a riffle (RF/BG) or run (eg. R1/BG)

ADDITIONAL HABITAT MAPPING SYMBOLS

Feature Symbol	Description	
Ledge plunge pool habitat	LE	area of bedrock intrusion into the channel; often associated with chute or
Overhead Cover	OC	area of extensive or high quality overhead cover
Instream Cover	IC	area of high quality instream cover (velocity shelter) for all life stages
Undercut Bank	UB	area of extensive/high quality undercut bank providing overhead cover
Unstable Bank habitat or producing	US	area of unstable bank with potential to collapse instream, affecting instream sedimentation
Overhanging Veg. stream shading	OV	area of high quality overhanging vegetation providing overhead cover and
Inundated Veg. terrestrial	IV	area of inundated vegetation; either submergent macrophytes or flooded
Debris Pile passage	DP	debris pile which influences instream habitat; include effect on cover and fish
Root Wad	RW	fallen terrestrial vegetation large enough to provide cover for fish
Log JamLJ	instream log pile; include effect on cover and fish passage	
Beaver Dam	BD	include effect on fish passage
Stream Blockage	XX	include effect on fish passage

TABLE 3: SUBSTRATE CRITERIA

SUBSTRATE DEFINITIONS, CODES AND SIZE-RANGE CATEGORIES

CLASS NAME	SIZE RANGE	
	MM	INCHES
Clay/Silt	<0.06	<0.0024
Sand	0.06-2.0	0.0024-0.08
Small Gravel	2-8	0.08-0.3
Medium Gravel	8-32	0.3-1.3
Large Gravel	32-64	1.3-2.5
Small Cobble	64-128	2.5-5
Large Cobble	128-256	5-10
Small Boulder	256-762	10-30
Large Boulder	>762	>30
Bedrock	-	-

Benthic Invertebrate Sampling

1. PURPOSE

This technical procedure describes the methods to be used for sampling benthic invertebrates for community structure analysis. Contained within are detailed sampling instructions for the use of the Neill cylinder and the Ekman and Ponar grabs.

2. APPLICABILITY

This technical procedure is applicable to any persons involved in the collection of benthic invertebrates from streams, rivers and lakes for community structure analysis. It was developed based on recommendations of Alberta Environmental Protection (1990), Environment Canada (1993) and the U.S. Environmental Protection Agency (Klemm et al. 1990).

3. DEFINITIONS

Benthic Invertebrates (benthic macroinvertebrates, benthos, zoobenthos)

Animals inhabiting the bottoms of waterbodies, such as insects, crustaceans, worms, and mollusks. Benthic invertebrates may live on the surface of the substratum, between particles, or burrowed into the substratum to various depths.

Chain-of-Custody Forms

Standardized forms used as a means of keeping close track of samples which are taken in the field and transported to laboratories for analysis. Whenever the samples are transported from the one location to the next, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

Stream Habitat

The physical stream environment which provides a place for aquatic biota to live, grow and reproduce. Invertebrate habitat may be characterized as run, riffle, backwater, pool, erosional and depositional.

Substratum

Material at bottom of waterbodies, includes organic detritus, clay, silt, sand, gravel, cobble and bedrock.

4. REFERENCES AND SUGGESTED READING

Alberta Environment. 1990. Selected methods for the monitoring of benthic invertebrates in Alberta rivers. Environmental Quality Monitoring Branch, Environmental Assessment Division, Edmonton, AB. 41 pp.

Environment Canada. 1993. Guidelines for monitoring benthos in freshwater environments. Prepared by EVS Consultants for Environment Canada, North Vancouver, BC. 81 pp.

Klemm, D.J., P.A. Lewis, F. Fulk and J.M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. Environmental Monitoring Systems Laboratory, Cincinnati, U.S. Environmental Protection Agency, EPA/600/4-90/030, 256 p.

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Site Selection

Approximate site locations should be identified prior to the field survey. Exact sampling sites should be selected in the field to ensure that sites within a habitat type (e.g. erosional or depositional) are as similar in terms of physical characteristics (especially current velocity, depth and substratum composition) as possible.

Sampling sites must be accurately located relative to permanent landmarks, such as man-made structures or distinctive landscape features. If possible, actual measurements with long tape measure, electronic distance measuring devices or Global Positioning System (GPS) should be used to identify site locations. Whatever system is used for this purpose, detailed notes regarding site locations should be made in the field logbook or on the field data sheets.

5.3 Sampling Methods

5.3.1 Neill Cylinder Sampling (streams or rivers with moderate to fast currents and hard bottoms)

The following steps will be used to collect samples using this device:

1. Select sampling site (Section 5.2). The area to be sampled should be undisturbed, at most 60 cm deep, in run or riffle habitat with moderate to high current velocity and gravel/cobble substratum.

2. Label sample bottle and attach it to the sampler net. (Shoulder-length gloves should be worn following this step to protect hands.)

3. Starting at the downstream limit of the sampling site, drive the bottom of the cylinder into the substratum and hold it there for the duration of sampling, with the sample net and attached bottle pointing downstream. Ensure that the seal at the bottom of the cylinder is adequate to prevent animals from escaping during sampling. Water should be flowing through the cylinder, entering through the circular hole at the front and exiting through the sampling net.

4. Reach into the cylinder and agitate the substratum manually to dislodge invertebrates, which will be transported into the downstream net. Gently rub the surfaces of all large rocks within the water enclosed by the cylinder and remove them until only smaller-sized particles (gravel/sand/silt) are left inside the cylinder. Using a small shovel or a heavy-duty garden trowel, stir up the bottom to a 5-10 cm depth. This entire step should take approximately 1 minute.

5. Allow suspended material to be transported into the net or to settle for 10-20 seconds. Lift the cylinder with the net pointing down and dip it into the water a few times to transport all invertebrates clinging to the inside of the sampling net into the sample bottle.

6. Place the sampler on the ground and fold the net over the mouth of the sample bottle. Pour out as much of the water as possible. When done, spray a small amount of water on the folded-over net to move clinging organisms back into the bottle.

7. Remove the bottle and add preservative. The 1 L sample bottle should be at most 1/3 full prior to adding preservative, consisting of sand, gravel, plant material, algae and invertebrates. Add 95% ethanol to obtain approximately 79-80% dilution or buffered formalin to obtain approximately 5% dilution. If there is a large amount of organic material in the sample, add more preservative. Cap bottle, gently agitate it to distribute preservative evenly, double-check label and place in container for transport.

8. Rinse the cylinder and net in river water thoroughly to remove any clinging invertebrates and plant material.

Additional replicate samples should be collected using the same methods, from an undisturbed area upstream from the location of the previous replicate sample.

5.3.2 Ekman or Ponar Grab Sampling (standing water or slow streams and rivers with soft bottoms)

The following steps will be used to collect samples using these devices:

1. Select sampling site (Section 5.2). The area to be sampled should be undisturbed, with slow moving or standing water and soft (sand/silt/clay) or organic substratum.

2. Label sample bottle. (Work gloves should be worn from this step to protect hands.)

3. Open grab and set triggering mechanism.

4. Slowly lower sampler to the bottom until it stops, at the approximate rate of 0.5 m/s. Allowing the sampler to free-fall will generate a shock wave which invertebrates can sense and mobile animals will evacuate the area quickly. In addition the Ponar grab is susceptible to closing before it reaches the bottom if lowered too quickly.

5. Send the messenger down (Ekman), or press button on top of pole (pole-mounted Ekman), or give the rope one quick, but gentle pull (Ponar) to close jaws. Pull sampler to the surface. As it comes out of the water check to see if the jaws were completely closed. If plant material or rocks caught in the jaws prevented complete closing, discard sample. Otherwise, continue with the next step.

6. Slowly pour water out of the sampler by tilting it and set it down into a metal or plastic tray. Open jaws and lift sampler to remove the enclosed sediment. Examine the sample. If the sampler was >60% full, with an undisturbed top layer, retain it for analysis; otherwise discard it and repeat procedure.

7. Use a spoon to scoop sample into a sieve or sieve bucket of appropriate mesh size (to be determined prior to field sampling). Lower the sieve into the water or pour water into it from the top to wash out silt and clay. If there is a large amount of material, it may be necessary to sieve small fractions at a time. Adding a drop of dish-washing detergent and mixing may help if surface tension is preventing draining of the sieve. If this step proves to be very time-consuming or impractical, it may be skipped, but the amount of preservative and the number of sample jars may have to be increased to accommodate the larger sample amount.

8. Spoon the sample into the sample jar and preserve. The 1 L sample bottle should be at most half full. Add 95% ethanol to fill the jar, or buffered formalin to obtain approximately 5-10% dilution. It may be necessary to use more than one jar per sample; if this is the case label jars as "1 of 2", " 2 of 2" etc. If there is a large amount of organic material in the sample, adjust the amount of preservative. Cap bottle, gently agitate it to distribute preservative evenly, double-check label and place in container for transport.

9. Rinse the sampler and tray in ambient water thoroughly to remove any sediment or clinging invertebrates.

Additional replicate samples (if required) should be collected using the same methods, from an undisturbed area.

5.4 Field Measurements

Benthic invertebrate samples should be accompanied by appropriate physical measurements and field observations to allow detailed data analysis. At minimum, habitat type, current velocity, substratum composition, sample depth and the presence and amount of algae and plant material should be recorded at each site. However, if time and equipment are available, it is preferable to record the following information:

- Habitat type (run/riffle/etc.) characteristic of the site;
- Current velocity and depth at each replicate sample location;
- Sampler fullness (if grab sampler used);
- Substratum composition in the general area of the site as percent cover by each major particle size;
- Relative amount of benthic algae on the substratum;
- Type and percent cover of aquatic macrophytes at the site;
- General water quality measurements: conductivity, pH, dissolved oxygen, water temperature;
- Any pertinent observations, such as the presence of visible pollution, disturbance by animals or humans, weather conditions, etc;
- Photograph of the sampling site.

5.5 Sample Handling

Chain-of-Custody forms should be used to track samples. Sample labels should include the project number, sampling date, site location or site code, replicate number (separated by a hyphen from the site code) and jar number (if applicable). Preserved benthic invertebrate samples do not require special handling and holding time is indefinite at room temperature. However, it should be noted that if ethanol is used as the preservative and there is a large amount of organic material in the samples, the preservative should be replaced within one day of sampling to prevent sample degradation.

5.6 Field Records and Logbook

For proper interpretation of field survey results, thorough documentation of all field sample collection and processing activities is required. All logbooks should be waterproof, field data forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

All pertinent information on field activities and sampling efforts must be recorded in the logbook. The field crew leader is responsible for ensuring that sufficient detail is provided. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections should be made by a single-line cross-out of the error, entering the correct information,

dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort;
- Date and time (24 hour clock) of sampling and related activities (travel, set-up, equipment calibration, etc.);
- Names of field crew leader and team members;
- Details of sampling method and effort;
- Equipment calibration;
- Location and description of each sampling site, including information on any photographs that may be taken;
- Field observations;
- Sample shipping information;
- Any additional information on sample collection activities;
- Hydrologic conditions
- Boat or equipment operation
- Any unusual activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the data.

If some of the above information is recorded on the field data sheets it need not be repeated in the field logbook. Specific information pertaining to each sample should be recorded on the field data sheets (one per site). An example field data sheet is provided in Exhibit "A" of this technical procedure.

6. EQUIPMENT

The following is a list of the equipment recommended for benthic invertebrate sampling. It should only be used as a guideline, since the specifics of a study should dictate exact equipment requirements.

Sampling

- Container for sample jars (plastic tub or cooler)
- Extra sampler net (Neill cylinder)
- Fine mesh net piece (for pouring water out of sample jar)
- Garden trowel or small shovel (for Neill cylinder)
- Indelible ink felt tip markers
- Metal or plastic tray
- Preservative
- Rope for grab samplers
- Sample containers (1-L plastic jars recommended)
- Sample jar labels (or waterproof tape)
- Sampling device (Neill cylinder, Ponar grab, Ekman grab)

- Scoops or spoons
- Sieve or sieve bucket of appropriate mesh size

Record-keeping and Site Locating/Marking

- Camera and film
- Chain-of-Custody forms
- Field data sheets on water-proof paper and clipboard
- Indelible ink pens and pencils
- Long tape measure, electronic distance measuring device, GPS unit
- Maps of area for site locations
- Survey flagging tape
- Water-proof field logbook

Physical Measurements

- Calibration solutions and buffers
- Conductivity meter
- Current velocity meter and wading rod
- Dissolved oxygen meter
- pH meter
- Winkler kit (dissolved oxygen calibration)

Health and Safety Equipment

- Approved personal floatation device for working in deep, fast water
- First aid kit

Personal Gear and Miscellaneous Equipment

- Appropriate clothing (plus one extra set)
- Drinking water
- Knife
- Rain gear
- Sun protection
- Waders (chest or hip)
- Waterproof gloves (shoulder length for Neill cylinder)
- Work gloves

Boat and Associated Equipment (if required)

- Air pump (if inflatable boat used)
- Approved personal floatation devices
- Anchor
- Fire extinguisher
- Floater coats
- Fuel
- Paddles
- Rope
- Spare keys
- Spare parts
- Tool box
- Two-stroke oil
- Water pump

EXHIBIT "A"

FIELD DATA SHEET FOR

BENTHIC INVERTEBRATE SAMPLING

GOLDER ASSOCIATES LTD.
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BENTHIC INVERTEBRATE SAMPLE COLLECTION FIELD DATA SHEET

PROJECT: SITE:

RIVER/LAKE: DATE:

PERSONNEL: TIME:

FIELD NOTES BY:

WEATHER WIND: AIR TEMP.: PRECIPITATION: CLOUD COVER:

SITE DESCRIPTION (MAP):

MEASUREMENTS / OBSERVATIONS		
Diss. Oxygen (mg/L):	Conductivity (µS/cm):	Benthic Algae (N/L/M/H):
pH:	Water temp. (°C):	Macrophytes (species, % cover):
HABITAT DESCRIPTION:		

SUBSTRATUM (%)	
Sand/Silt/Clay (<2 mm)	
Fine gravel (2-16 mm)	
Coarse gravel (16-64 mm)	
Small Cobble (64-128 mm)	
Large Cobble (128-256 mm)	
Boulder (>256 mm)	
COMMENTS:	

BENTHIC SAMPLES SAMPLING DEVICE: PERSON SAMPLING:

MESH SIZE: PRESERVATIVE:

SAMPLE LABEL	DISTANCE FROM BANK (m)	DEPTH (m)	CURRENT VELOCITY (m/s)	SAMPLER FULLNESS (%)	NUMBER OF JARS	NOTES

OTHER SAMPLES / MEASUREMENTS / OBSERVATIONS

NOTES: N = none; L = low; M = moderate; H = high

Epilithic Chlorophyll *a* Sampling

6. EQUIPMENT

6.1 Sampling Equipment

The following is a list of the recommended equipment:

- 4 cm^2 template
- tray for rocks
- waterproof pen
- $MgCO_3$ saturated solution or powdered $MgCO_3$
- 45 mm diameter GF/C filters (Whatman #1)
- cooler
- scalpel and extra blades
- pre-printed labels of waterproof label tape
- aluminum foil squares (10 x 10 cm)
- dry ice or ice
- plastic (Ziploc®) bags

6.2 Field Location Equipment and Logs

The following is recommended for the complete documentation of sampling location:

- field record sheets
- maps of area for site locations
- indelible ink pens and felt tip markers and pencils
- 50 metre long tape measure
- survey flagging tape
- survey lathe

6.4 Health and Safety Equipment

- waders and water proof gloves
- suitable clothing for prolonged water work: heavy socks, warm pants, rain gear, etc.
- approved personal floatation device for deep water or boat work

5.4 Sampling Methods

Wade along an imaginary transect extending out from shore, when past the low water line begin sampling. Randomly select five rocks from the substrate while moving out along the transect. Take two steps between rock selections. The rocks should be large enough to allow for the positioning of the sample quadrat on their surface. Orient each rock on the tray in the position that it was found in the substrate. During sampling and processing keep the algae out of direct sun.

Position the 2 X 2 cm quadrat on the upper surface of a rock in an area that is representative of the algal growth on the upper surface of the rock. Using the scalpel or a knife completely remove all of the attached algae within the quadrat. Place collected algae onto a wetted GF/C filter paper on a square piece of aluminum foil. Remove any stones or large invertebrates from the sample. Thoroughly cover the sample with $MgCO_3$; this buffers the sample neutralising any acids that may be present. Also, all sampling equipment and samples should be kept away from acids.

Repeat the template procedure for the other rocks in the group, put the algal scrapes on the same filter and cover with $MgCO_3$ each time. Where the layer of algae is extremely thick, reduce the number of rock scrapes taken for any one sample. As a guideline, a one cubic centimetre sample volume is ideal. Wrap the filter in the aluminum foil and label. The samples should be frozen immediately. This prevents any degradation of the chlorophyll *a*.

Each sample should be permanently and uniquely marked. The samples must be submitted to the laboratory with the appropriate documentation. Included in the documentation should be the date, time, location, sample number, sampler identification, the type of sample (epilithic algae), the area sampled in square centimetres and requested analysis (chlorophyll *a*). Ideally waterproof labels containing all of the pertinent sampling information are pre-printed. Analytical request forms for all of this information are provided with the empty sample bottles.

5.5 Cleaning Sampling Equipment

Equipment should be cleaned before sampling by rinsing the sampling equipment thoroughly with ambient water.

4. REFERENCES AND SUGGESTED READING

Environment Canada. 1993. Quality Assurance in Water Quality Monitoring. Ecosystem Sciences and Evaluation Directorate Conservation and Protection. Ottawa, Ontario.

Standard Methods for the Examination of Water and Wastewater. 1985. American Public Health Association, American Water Works Association and Water Pollution Control Federation. Sixteenth Edition.

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Methods

To ensure the collection of representative samples the following points in the selection of a sampling location must be observed:

- select actual field sampling site based on program design and access logistics;
- in streams and rivers select a site that is representative of the reach being tested and consider the local flow conditions and safety of access.

5.3 Site Location

Once the sampling location has been determined it must be accurately located relative to permanent landmarks such as groundwater wells, outfalls or distinctive landscape features. Actual measurements with long tape measures or electronic distance measuring devices and compass headings are recommended as a minimum to accurately determine position. Locations can be easily recorded as the perpendicular distance from the shoreline and the distance upstream or downstream of a permanent landmark or by global positioning system (GPS).

1. PURPOSE

This section describes the template method as used for the sampling of epilithic algae for chlorophyll *a* analysis. Contained within are detailed sampling instructions.

2. APPLICABILITY

This technical procedure is applicable to any persons involved in the collection of epilithic algae for chlorophyll *a* analysis.

3. DEFINITIONS

3.1 Surface water

Refers to any water either flowing or still that exists above ground level.

3.2 Epilithic

Refers to material attached to rock substrates in the bottom of surface water bodies.

3.3 Substrate

Material at bottom of surface water, includes organic detritus, silt, sand, gravel, cobble and bedrock.

3.4 Chlorophyll *a*

Plant and algal organic molecule which converts sunlight to energy used for fixing carbon for plant production. Used as a measure of the primary productivity.

3.5 Magnesium Carbonate ($MgCO_3$)

Used as a preservative in the sampling and analysis of algae. Buffers the sample so acids do not degrade chlorophyll *a*.

Phyto- and Zooplankton Sampling

1. PURPOSE

This section describes the method used for the sampling of zoo- and phytoplankton by plankton net for qualitative and quantitative analysis. Contained within are detailed sampling instructions.

2. APPLICABILITY

This technical procedure is applicable to any persons involved in the collection of zoo- and phytoplankton for qualitative and quantitative analysis.

3. DEFINITIONS

3.1 Surface water

Refers to any water either flowing or still that exists above ground level.

3.2 Zooplankton

Refers to microscopic animals living suspended in the water column.

3.3 Phytoplankton

Single celled plants living suspended in the water column.

3.4 Chlorophyll *a*

Plant and algae organic molecule responsible for conversion of sunlight to energy used for fixing carbon for plant production. Used as a measure of the primary productivity.

3.5 Magnesium Carbonate ($MgCO_3$)

Used as a preservative in the sampling and analysis of algae. Buffers the sample so acids do not degrade chlorophyll *a*.

3.6 Plankton Net

Conical net constructed of material with known opening size for pulling through water column and filtering plankton out of the water column.

3.6 Sampling Bucket

Rigid cylindrical filter at end of plankton net for final concentration of sample prior to filling of sample container.

4. REFERENCES AND SUGGESTED READING

Environment Canada. 1993. Quality Assurance in Water Quality Monitoring. Ecosystem Sciences and Evaluation Directorate Conservation and Protection. Ottawa, Ontario.

Standard Methods for the Examination of Water and Wastewater. 1985. American Public Health Association, American Water Works Association and Water Pollution Control Federation. Sixteenth Edition.

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Methods

To ensure the contaminant free collection of surface water quality samples the following points in the selection of a sampling location must be observed:

- select actual field sampling site based on program design and access logistics.

Once the general location has been arrived at then the specific sampling site needs to be located. When locating the specific site consider the following:

- select a site that is representative of the reach or the waterbody being tested;
- in flowing water consider the local flow conditions and safety of access.

5.3 Site Location

Once the sampling location has been determined it must be accurately located relative to permanent landmarks such as groundwater wells, outfalls or distinctive landscape features. Actual measurements with long tape measures or electronic distance measuring devices and compass headings are recommended as a minimum to accurately determine position. Locations can be easily recorded as the perpendicular distance from the shoreline and the distance upstream or downstream of a permanent landmark or by global positioning system (GPS).

5.4 Sampling Methods

Once the sampling location has been established the actual sampling can proceed. Clean plankton net with ambient water to remove any material adhering to the net, rinse the plankton bucket thoroughly. Attach sampling bucket to the end of the plankton net. In lake situations the recommended technique for qualitative assessments is vertical tows from the substrate to the surface. These are best accomplished while anchored to reduce the amount of drift while sampling. Lower the net to the bottom and tow hand over hand to the surface at an optimal rate of 0.5 metres per second.

In shallow bodies of water where complete mixing is expected hauls can be carried out as either oblique or horizontal. The net may be cast and drawn back through the water at the same speed of 0.5 metres per second. Care must be taken to avoid having the net drag along the bottom. Ideally the net is cast to a distance that allows for the net to sink almost to the substrate before the retrieval angle is steep enough to begin lifting the sampler towards the surface, this while a tow rate of 0.5 metres per second is observed.

In cases where the distance over which the sampler is being towed is small or the plankton densities are low , several distinct have may have to be made to collect a sample. Between individual hauls, the contents of the net and plankton bucket must be discharged to the sample container by washing any material adhering to the inside of the net to the plankton bucket. The sample bucket is then poured into the sample bottle.

When the entire sample has been collected the required preservative must be added. For phytoplankton use Lugol's solution for phytoplankton and 5% formalin for zooplankton. Prepare Lugol's solution by dissolving 20 grams of potassium iodide and 10 grams of iodine crystals in 200 millilitres of distilled water and 20 millilitres of glacial acetic

acid. Use enough Lugol's to stain the sample to a tea colour. For formalin preservation of zooplankton use 40 millilitres of buffer formalin per one litre of sample. For preserved samples use either polyethylene or glass sample bottles and ensure the sample container is full. For sample documentation record the location, date, time, sampler identification, type of sample, sampling method and total length of hauls. Provide this information on waterproof labels fixed to the sample containers as well as on any supporting paperwork.

Phytoplankton samples for biomass estimates are collected in the same manner as standards water quality parameters (refer to TP-8.3, Surface Water Sampling). In general the sample is collected into a water sample bottle as provided by the analytical laboratory. The sample is preserved by adding $MgCO_3$ supplied by the analytical laboratory. The sample should be collected in the same manner as the other water quality parameters. The method used is dependent upon the details of the project specific workplan, consult with project manager for this information. Provide the correct sample documentation and keep the samples cool and dark.

5.5 Cleaning Sampling Equipment

Equipment should be cleaned before sampling by rinsing the sampling equipment thoroughly with ambient water.

6. EQUIPMENT

6.1 Sampling Equipment

The following is a list of the recommended equipment:

- plankton net with bucket and graduated line
- sample bottles
- waterproof pen
- $MgCO^3$ saturated solution or powdered $MgCO^3$
- wash bottle
- cooler and ice
- preservative
- pre-printed labels or waterproof label tape

6.2 Field Location Equipment and Logs

The following is recommended for the complete documentation of sampling location:

- field record sheets
- maps of area for site locations
- indelible ink pens and felt tip markers and pencils

6.4 Health and Safety Equipment

- waders and water proof gloves
- suitable clothing for prolonged water work: heavy socks, warm pants, rain gear, etc.
- approved personal floatation device for deep water or boat work

APPENDIX V

DETAILED DESCRIPTION OF ALL LABORATORY ANALYSES

Methods Used by HydroQual to Determine Plasma Protein, Lactate and Glucose Levels

Protien, lactate and glucose levels were measured in the plasma. All results were expressed in mass units per 100 mL volume (blood or plasma). The analyses were done in 16 x 100 mm glass tubes which were read directly in a Milton Roy Spectronic Model 21 spectrophotometer. Ten to twenty per cent of the samples tested were duplicated and a blank and standard were analyzed for every 10 to 15 samples. The reagents and standards were freshly prepared on the day required. All attempts were made to complete the analyses on the day of sample collection. The whole blood and plasma were then frozen (-20°C) and archived.

Total plasma protein was measured with the dye, brilliant blue G on an aliquot diluted 100 times with deionized water (Coomassie blue; Sigma Diagnostic Procedure No. 610). The reagent was added to 10 μL of the diluted plasma and the absorbence was read at 595 nm (10μL of sample plus 2.5 mL or reagent). The protein standard was prepared fresh on the day of analysis and discarded after use (Sigma Catalogue No. 610-30).

Total lactate was determined on 10 μL of plasma with a quantitative, enzymatic assay (Sigma Diagnostic Procedure No. 735). Lactic acid was converted by lactic oxidase to pyruvate and hydrogen peroxide. The hydrogen peroxide catalyzed the oxidative condensation of chromogen precursors to produce a coloured dye with an absorbence maximum at 540 nm. The lactate reagent was added to 10 μL of plasma (2.5 mL of reagent diluted 2.5 x with deionized water). The reaction was allowed to proceed for one hour at room temperature. The absorbence was then measured at 540 nm and lactate levels calculated from a standard curve for lactate (Sigma Catalogue No. 735-11).

Plasma glucose levels were also determined enzymatically with the Trinder reagent (Sigma Diagnostic Procedure No. 315). Glucose was oxidized to gluconic acid and hydrogen peroxide by glucose oxidase. The hydrogen peroxide formed reacts in the presence of peroxidase with 4-aminoantipyrine and p-hydroxybenzene sulfonate to form quinoneimine dye with an absorbence maximum at 505 m. The reagent (2.5 mL) was added to 10 μL of plasma, the tubes were incubated at ambient temperature for one hour and the absorbence read at 505 nm. Glucose levels were obtained from a glucose standard curve prepared the same way (Sigma Catalogue No. 16-300).

Soil Parameters

Texture Class

The mineral part of the soil is separated into different size fractions of sand, silt and clay. The proportions of these fractions are determined by the sedimentation principle based on Stoke's law, which relates the radius of the particles to the velocity of sedimentation. A hydrometer is used to measure the density of a soil suspension at defined periods of time related to the settling time of particles of known size. The initial reading indicates the time at which all sands have settled, the second reading is that at which only clay remains in suspension. The soil textural class is determined by the % sand and % clay on the soil textural triangle.

Reference: Methods Manual for Forest Soil and Plant Analysis, Forestry Canada Northwest Region
Northern Forestry Centre, Edmonton, Alberta, 1991, pages 42 to 44, 52.

Atterberg Limits

The lower plastic limit of a soil is the moisture content at which a soil will just begin to crumble when rolled into a thread approximately 3.2 mm in diameter. A sample of soil is mixed with water and rolled into a thread of uniform diameter throughout its length. The amount of water required to acheive acceptable consistency according to the method is determined and expressed as a plasticity index.

Reference: Reference: Soil Sampling and Methods of Analysis, Canadian Society of Soil Science; Carter, Martin R., 1993, Section 49.3.

Cation Exchange Capacity

The exchange complex of a soil sample is first saturated with an index cation, ammonium acetate or sodium acetate, then washed free of any excess index cation with several washes of ethanol. The amount of index cation adsorbed by the soil is then displaced in a rinsing method with sodium chloride or ammonium acetate allowing the index cation to be released into the filtrate. The filtrate is then analyzed for NH_3 by means of the Berthelot Reaction on an autoanalyzer with alkaline phenol, EDTA and NaOCl or for Na using the method described in Inorganic Methodology Summaries.

Reference: Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed.,J.A McKeague, Ed., 1978, Section 3.3.

Total Organic Carbon / Organic Matter

Modified Mebus Method, Potassium Dichromate Oxidation
A soil sample is refluxed with potassium dichromate and sulphuric acid, the excess dichromate is titrated with ferrous ammonium sulphate. The amount of oxidized organic matter is proportional to the potassium dichromate used in the oxidation process, which in turn is proportional to the total organic carbon.

Detection Limit 0.01 Wt.%

Reference: Methods Manual for Forest Soil and Plant Analysis, Forestry Canada Northwest Region, Northern Forestry Centre, Edmonton, Alberta, 1991, Y.P. Kalra and D.G. Maynard, pages 27-30.

Methods of Soil Analysis Chemical and Microbiological Properties, No. 9, Part 2, 2nd ed., American Society of Agronomy, Inc., Madison, Wisconsin, 1982, Method 29-3.5.3.

Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed. McKeague, Ed., 1978, Section 4.22.

Total Nitrogen ,Total Carbon and Total Sulphur

A preweighed sample undergoes a complete and instantaneous oxidation by flash combustion which converts all organic and inorganic substances into combustion products. The resulting combustion gases pass through a reduction furnace and are swept into the chromatographic column by the carrier gas helium. The gases are separated in the column and detected by the thermal conductivity detector (TCD) which gives and output signal proportional to the concentration of the individual components of the mixture. From these numbers the C:N:S ratio can be determined.
Subcontracted to Birtley Coal.

Reference: Nitrogen Analyzer 1500 Instruction Manual, Section 1.3, October 1986.

Available Nitrogen
Available Phosphorous

A dried and ground soil sample is extracted in an ammonium fluoride extracting solution, filtered and the extract is measured for nitrogen by means of the Berthelot Reaction on an autoanalyzer with alkaline phenol, EDTA, and NaOCl. For phosphorous the extract is run through an automated ascorbic acid reduction and measured spectrophotometrically on the LACHAT.

Reference:
Standards Soil Manual, Produced Water Manual, Chemex Labs Alberta Inc., April 1986, Prepared by
Barb Morey, pages 20-22.

Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2nd ed., J.A.
McKeague, 1978, section 4.44 (modified).

Available Potassium

A dried and ground soil sample is extracted in an ammonium acetate extracting solution, filtered and the extract is aspirated and atomized by an air jet as it passes into a controlled air-propane flame. The amount of light energy emitted by the potassium in the extract upon returning to the ground state is directly proportional to its concentration.

Reference: Recommended Methods of Soil Analysis for Canadian Prairie Agricultural Soils, Prepared By Alberta Agriculture. Method #7, page 25. January 1988.

Available Sulphur

A preweighed dried and ground soil sample is extracted with calcium chloride for 30 minutes, filtered and the extract is run by inductively coupled plasma (ICP) in the water lab.

Reference: Recommended Methods of Soil Analysis for Canadian Prairie Agricultural Soils, Prepared By Alberta Agriculture. Method #9, page 28. January 1988.

Methods of Soil Analysis Chemical and Microbiological Properties, NO. 9, Part 2, 2nd ed., American Society Of Agronomy, Inc., Madison, Wisconsin, 1982, Section 28-5.

pH in $CaCl_2$ 1:2 ratio

Approximately 30g of air dried soil is weighed into a beaker and 60 mLs of 0.01M CaCl2 is added. The pH is determined after 12 hours.

Reference: Soil Sampling and Methods of Analysis, Canadian Society of Soil Science; Carter, Martin R., 1993, Section 16.3.

pH
The pH is measured potentiometrically on a saturated paste or on a specified ratio of water to soil.

Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed. McKeague, Ed., 1978, Section 4.

Electrical Conductivity
The electrical conductance is measured in umhos/cm on a saturated paste or on a specified ratio of water to soil.

Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed.,J.A McKeague, Ed., 1978, Section 4.

Saturated Paste
Deionized water is added to a preweighed sample of soil or sediment until saturation is reached and mixed thoroughly. The paste is left overnight and the criteria for saturation is rechecked after 24hrs. The paste is allowed the stand an additional 4 hrs if greater than 10% more water needs to be added to bring it back to saturation criteria.

Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed.,J.A McKeague, Ed., 1978, Section 4.

Sodium Adsorption Ratio
A soluble extract is made from a dried and ground soil sample and soluble Na, Ca, and Mg cations are run. From these values the SAR is calculated and the potential sodicity of a soil is determined.

Reference: Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed.,J.A McKeague, Ed., 1978, Section 3.26.

Gypsum Requirement
Dried and ground soil samples are leached with an excess of neutral, 1N ammonium acetate then filtered. The extract is analyzed for extractable Na, K, Ca, and Mg using methods in the Inorganic Methodology Summaries. From these values an exchangeable sodium percentage (ESP) is calculated. If the ESP is greater than 10% then a further calculation for gypsum requirement is required. If the ESP is less than 10% then there is no qypsum requirement.

Reference: Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 ed.,J.A McKeague, Ed., 1978, Section 3.25.

Total Petroleum Hydrocarbons

Total Petroleum Hydrocarbons are extracted from the soil samples using an ultrasonic extractor and Freon and from water using Freon and a separatory funnel. The sample is then shaken with silica gel which binds the polar molecules leaving the non-polar molecules in solution. The Freon is then analyzed with an infrared finish. (FTIR)

Water

Average Percent Recovery - 96.7 at 77.0 mg/L

Standard Deviation - 3.67 at 77.0 mg/L

Soil

Average Percent Recovery - 99.5 at 1700 ug/g

Standard Deviation -

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 503B.

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 418.1.

Mercury (Soil) NAQUADAT 80401

Soil samples are digested with strong acid mixture and oxidant ($KMnO_4$) at a moderate temperature to yield Hg^{2+} ions. These samples are then reduced with $SnCl_2/NH_2OH$ solution to determine total mercury which is measured spectrophotometrically at 253.7 nm and compared to identically prepared standards.

Detection Limit: 20 µg/Kg (0.02 µg/g)

Average Percent Recovery: 104.9 at 0.16 ug/g

Standard Deviation: 14.7 at 0.16 ug/g

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 303 F.

Drying and Grinding

All soil samples are dried in an 80°F oven for 24 hrs, ground, and passed through a 2mm sieve to achieve a homogeneous sample. For certain analysis the dried samples are ring ground to a fine powder to greatly increase the working surface area.

Reference: Manual on Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, 2 .McKeague, Ed., 1978.

Nitric Acid Digestion

A dried and ground soil sample or wet fish tissue sample is extracted with concentrated nitric acid, heated to 95°C and refluxed without boiling to reduce the volume to 2 mls. This is repeated again with another aliquot of concentrated nitric acid. The sample is then subjected to an hydrogen peroxide reaction until sample appearance remains unchanged. After bulking the sample up with deionized water, it is heated again on low temperature for 30 minutes. The sample solution is bulked to a volume dependent on initial weight of sample used and filtered through a Whatman No. 41 filter paper to remove particulates in the digestate. The filtrate is analyzed for metals on the ICP.

Samples high in hydrocarbons are extracted with concentrated nitric acid, heated to 95°C and refluxed without boiling, allowed to go to dryness and then ashed. De-ionized water is added and the sample heated on low temperature for 30 minutes. The sample solution is bulked up to volume and filtered through a Whatman No. 41 filter paper to remove particulants in the digestate. The filtrate is analyzed for metals by ICP.

Reference: Test Methods for Evaluating Solid Wastes, U.S. Environmental Protection Agency, SW-846, Method 3050.

Soil
ICP

		Detection Limit µg/g	Leachate mg/L
Aluminum	NAQUADAT 13311	1.0	0.01
Barium	NAQUADAT 56311	1	0.01
Beryllium	NAQUADAT 04330	0.1	0.001
Boron	NAQUADAT 05449	1.0	0.01
Cadmium	NAQUADAT 48311	0.3	0.003
Chromium	NAQUADAT 24311	0.2	0.002
Cobalt	NAQUADAT 27311	0.3	0.003
Copper	NAQUADAT 29311	0.1	0.001
Iron	NAQUADAT 26311	1	0.01
Lead	NAQUADAT 82311	2	0.02
Manganese	NAQUADAT 25311	0.1	0.001
Molybdenum	NAQUADAT 42311	0.3	0.003
Nickel	NAQUADAT 28311	0.5	0.005
Silver	NAQUADAT 47449	0.2	0.002
Strontium	NAQUADAT 38311	0.2	0.002
Vanadium	NAQUADAT 23311	0.2	0.002
Zinc	NAQUADAT 30311	0.1	0.001
Calcium	NAQUADAT 20311	1	0.01
Magnesium	NAQUADAT 12311	1	0.01
Sodium	NAQUADAT 11311	1	0.01
Potassium	NAQUADAT 19111	1	0.01
Silicon	NAQUADAT 14449	2	0.02
Lithium	NAQUADAT 03311	0.1	0.001
Uranium		50.0	0.5
Phosphorous	NAQUADAT 15447	10	0.1
Titanium	NAQUADAT 22009	0.3	0.003
Sulphur		20.0	0.2
Arsenic		20	0.2
Selenium		4	0.04

Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. The basis of the method is the measurement of atomic emission by an optical spectroscopic technique. Characteristic atomic-line emission spectra are produced by a radio frequency inductively coupled plasma (ICP). The spectra are dispersed by a grating spectrometer and the intensities of the lines are monitored by photomultiplier tubes. The photocurrents from the photomultiplier tubes are processed and controlled by a computer system. A background correction technique is required to compensate for variable background contribution to the determination of trace elements.

	Average % Recovery	Standard Deviation
Cadmium	102.0	3.81 mg/L
Chromium	100.3	5.18 mg/L
Manganese	100.2	7.02 mg/L
Nickle	102.6	6.91 mg/L
Lead	100.6	9.14 mg/L
Vanadium	101.3	3.11 mg/L
Boron	97.5	4.23 mg/L

Further precision and accuracy data available on request.
Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 200.7.

Water Parameters
ICP

	Detection Limit (mg/L)	
Aluminum	0.01	NAQUADAT 13109L
Arsenic	0.2	
Barium	0.01	NAQUADAT 56101L
Beryllium	0.001	NAQUADAT 04102L
Boron	0.01	NAQUADAT 05107L
Cadmium	0.003	NAQUADAT 48102L
Chromium	0.002	NAQUADAT 24052L
Cobalt	0.003	NAQUADAT 27102L
Copper	0.001	NAQUADAT 29105L
Iron	0.01	NAQUADAT 26104L
Lead	0.02	NAQUADAT 82103L
Manganese	0.001	NAQUADAT 25104L
Molybdenum	0.003	NAQUADAT 42102L
Nickel	0.005	NAQUADAT 28102L
Selenium	0.04	
Silver	0.002	NAQUADAT 47102L
Strontium	0.002	NAQUADAT 38101L
Vanadium	0.002	NAQUADAT 23102L
Zinc	0.001	NAQUADAT 30105L
Calcium	0.01	NAQUADAT 20311L
Magnesium	0.01	NAQUADAT 12311L
Sodium	0.01	NAQUADAT 11311L
Potassium	0.02	NAQUADAT 19111L
Silicon	0.02	NAQUADAT 14449L
Lithium	0.001	NAQUADAT 03101L
Uranium	0.5	
Phosphorous	0.1	NAQUADAT ICPPHO
Titanium	0.003	NAQUADAT 22009L
Sulphur	0.2	NAQUADAT ICPSUL

Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. The basis of the method is the measurement of atomic emission by an optical spectroscopic technique. Characteristic atomic-line emission spectra are produced by a radio frequency inductively coupled plasma (ICP). The spectra are dispersed by a grating spectrometer and the intensities of the lines are monitored by photomultiplier tubes. The photocurrents from the photomultiplier tubes are processed and controlled by a computer system. A background correction technique is required to compensate for variable background contribution to the determination of trace elements.

	Average % Recovery	Standard Deviation
Cadmium	102.0	3.81 mg/L
Chromium	100.3	5.18 mg/L
Manganese	100.2	7.02 mg/L
Nickle	102.6	6.91 mg/L
Lead	100.6	9.14 mg/L
Vanadium	101.3	3.11 mg/L
Boron	97.5	4.23 mg/L

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 200.7.

Chloride - (Autoanalyzer/ I.C.) NAQUADAT 17206L

In an automated system thiocyanate ions (SCN) are liberated from mercuric thiocyanate through sequestration of mercury by chloride ion to form un-ionized mercuric chloride. In the presence of ferric ion, the liberated SCN forms highly colored ferric thiocyanate in concentration proportional to the original chloride concentration.

Waters analysis by Technicon
Soils analysis by Ion Chromatography
Detection Limit 0.5 mg/L
Average Percent Recovery: 100.3 at 36 mg/L
Standard Deviation: 2.95 mg/L at 36 mg/L

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 407 D.

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 235.2.

Sulfate- (Autoanalyzer/I.C)) NAQUADAT 16306L

Sulfate ion is reacted with barium chloride and methythymol blue at pH 2.3 - 3.0. The pH is then raised to 12.5 - 13.0, where excess barium reacts with methythymol blue to produce a blue-colored chelate. The mount of gray, uncomplexed methythymol blue indicates the concentration of Sulfate ion. Absorbances of excess methythymol blue is measured at 460 nm.

Waters analysis by Technicon
Soils analysis by Ion Chromatography
Detection Limit 0.5 mg/L
Average Percent Recovery: 99.5 at 42 mg/L
Standard Deviation: 2.04 mg/L at 42 mg/L

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 375.2.

Alkalinity:	Detection Limit	
Total Alkalinity	0.5 mg/L	NAQUADAT 10111L
Bicarbonate	0.5 mg/L	NAQUADAT 06201L
Carbonate	0.5 mg/L	NAQUADAT 06301L
Phenolphthalein	0.1 mg/L	NAQUADAT 10151L
Hydroxide	0.5 mg/L	NAQUADAT 08501L

The phenolphthalein alkalinity and the total alkalinity are determined by potentiometric titration of an unfiltered sample aliquot with a standard solution of strong acid to pH 8.3 and 4.5, respectively, using an automated titration system and pH meter. The carbonate, bicarbonate, and hydroxide are calculations made from the total alkalinity and the phenolphthalein alkalinity.

Total Alkalinity:
Standard Deviation: 1.60 mg/L at 270 mg/L

Bicarbonate:
Standard Deviation: 1.80 mg/L at 330 mg/L

Reference: Standard Methods for Examination of Water and Wastewater, 18th ed., American Public Health Association, Washington, DC, 1985, Method 2320B.

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 310.1.

pH NAQUADAT 10301L

A glass electrode in combination with a reference electrode, generally a saturated calomel electrode, is used for pH measurement. The glass electrode has a membrane, which forms a partition between the liquid sample and an internal solution of constant pH. The potential developed by the glass electrode with reference to the saturated calomel electrode is measured by an electrometer.

Detection Limit 0.01 units
Standard Deviation: 0.02 pH units at an average pH of 7.20

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 4500-H.

Total Hardness NAQUADAT 10602
Hardness is calculated from results of separate determinations of calcium and magnesium.

Reference: Standard Methods for Examination of Water and Wastewater, 18th ed., American Public Health Association, Washington, DC, 1992, Method 2340B.

Specific Conductance NAQUADAT 02041L
The standard unit of electrical resistance is the ohm. The standard unit for conductance is its inverse, the siemens or the mho. Specific conductivity is defined as the conductance of a conductor 1 cm long and 1 cm^2 in cross-sectional area, and is numerically identical to conductivity in umhos/cm.

Detection Limit 0.02 umhos/Cm
Standard Deviation: 4.22 umhos/Cm at a average conductance of 3600 umhos/Cm

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 403.

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 310.1.

Total Dissolved Solids (NAQUADAT 00201L)
Total Dissolved residue (solids) is the amount of dissolved solids in water and is the residue that remains in the filtrate after evaporation and drying at 180°C. TDS can be determined gravimetrically or by calculation using the sum of the major ions.

Detection Limit: 1.0 mg/L
Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 209B.

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 160.1.

Nitrate-Nitrite as Nitrogen) (NAQUADAT 07110L)

A sample aliquot is mixed with a disodium EDTA and passed through a column of Cd filings. A sulphanilamide solution, then a N-1-naphthylethylenediamine dihydrochloride solution are added to the sample to form an azo dye. The dye intensity is measured spectrophotometrically at 550 nm and compared with those of standard nitrate-nitrite standards.

Detection Limit: 0.003 mg/L
Average Percent Recovery: 99.5
Standard Deviation: 0.004 at 0.074 mg/L

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 353.2.

Atomic Absorption: Hydride Metals

Arsenic (NAQUADAT 33005L)
Selenium (NAQUADAT 34005)
Antimony (NAQUADAT 51003)

Samples are manually digested with sulfuric and nitric acids. Then, in an automated system, inorganic arsenic selenium, and antimony are reduced to their respective hydrides. These gaseous hydrides are passed to a tube furnace mounted in the light path of an atomic absorption spectrophotometer.

	Detection limits (mg/L)	Ave. % Recovery	Standard Deviation
Arsenic	0.0002	102.0	NA
Selenium	0.0002	97.4	NA
Antimony	0.0002	99.0	NA

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 303E.

Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 206.5.

Mercury (Water) - (Cold Vapor)

A sample aliquot is mixed with KMnO4 and concentrated H_2SO_4, then digested at 90-110°C. This solution is then mixed with hydroxylamine hydrochloride and NaCl, then SnCl and $K_2S_2O_8$. The mixture is sparged with air and the liquid removed by a gas separator. The air flow, containing Hg vapor, is then passed through an absorption cell. Absorbance is measured spectrophotometrically at 253.7 nm and compared to identically prepared standard mercury solutions.

Detection Limit: 0.05 µg/L
Average Percent Recovery: 101.5
Standard Deviation: 0.06 µg/L

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 245.2

Standard Methods for the Examination of Water and Wastewater, 16 th ed., American Public Health Association, Washington, D.C.,. 1985, Method 303F.

Ammonia as Nitrogen (NAQUADAT 07555L)

Ammonia is measured by means of the Berthelot Reaction on an autoanalyzer with alkaline phenol, EDTA and NaOCl and compared to identically prepared standards.
Detection Limit: 0.01 mg/L
Average Percent Recovery:
Standard Deviation:
Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 417C

Total Cyanide

The cyanide, as hydrocyanic acid (HCN), is released from cyanide complexes by means of a closed reflux-distillation apparatus and absorbed in a flask containing sodium hydroxide and magnesium chloride solution. The extract is then put through an automated system where it is acidified, distilled and buffered then reacted with chloramine-T and a pyridine-barbituric acid reagent. The color is measured spectrophotometrically at 580 nm and compared to KCN standard solutions.
Detection Limit: 0.001 mg/L (Water), 0.1 ug/g (Soil)

Average Percent Recovery: 103%
Standard Deviation: 6.9%

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 335.2.

Standard Methods for Examination of Water and Wastewater, 17th ed., American Public Health Association, Washington, DC, 1989, Method 4500-CN E.

Phenol (NAQUADAT 06537L)

A small aliquot is mixed with H_3PO_4 and steam distilled in an automated system. The distillate is reacted with 4-aminoantipyrine in the presence of an alkaline ferricyanide buffer. The resulting color is measured spectrophotometrically at 505 nm and compared to identically treated phenol standards.

For soil samples, a known weight (4 grams) is extracted into a solution of 40 mls of 0.15 M sodium hydroxide. The sample is shaken for 10 minutes on a shaker and centrifuged for 5 minutes at 2000 rpm. The liquid portion is then acidified with 50% H_2SO_4 to a pH of <4. If the liquid portion of the extract is colored or turbid, a further dilution must be done to minimize interference.
Detection Limit: 0.001 mg/L (water), 0.01 ug/g (soils)
Average Percent Recovery: 98.9%
Standard Deviation: 6.1% at 0.05mg/L

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 420.2.

Total Organic Carbon/Dissolved Organic Carbon (NAQUADAT 06005L / 06104L)

This method determines the quantity of all carbon atoms covalently bonded in organic molecules. For TOC, an aliquot of sample is taken from a shaken sample. For DOC (dissolved), an aliquot is decanted from an unshaken sample. Filter papers cannot be used to filter an DOC sample because they contain acetate which will contaminate the sample. In an automated system, the sample is acidified to convert inorganic carbon to CO_2 which is stripped from solution. The remaining liquid phase is passed through a UV coil to oxidize organic carbon compounds. The resulting CO_2 is measured by an IR analyzer and compared with standard organic carbon solutions.

Detection Limit: 0.2 mg/L
Average Percent Recovery: 104.7
Standard Deviation: 0.71 at 20 mg/L

Reference: Standard Methods for Examination of Water and Wastewater, 16th ed., American Public Health Association, Washington, DC, 1985, Method 505A.
Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 415.1.

Non-filterable Residue (TSS)

NAQUADAT 10401L
NAQUADAT 10501L (Fixed)
NAQUADAT 10511L (Volatile)

Non-filterable residue is the suspended material in water and is the residue retained by a glass fiber filter and dried to a constant weight at 105°C.
Fixed non-filterable residue is the amount of non-filterable residue left after ignition at 550°C for 30 minutes in a furnace. (NAQUADAT 10501L)
Volatile non-filterable residue is the amount of non-filterable residue that is lost during ignition at 550°C for 30 minutes in a furnace. (NAQUADAT 10511L)

Detection Limit: 0.4 mg/L

Reference:Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 160.2

Standard Methods for Examination of Water and Wastewater, 17th ed., American Public Health Association, Washington, DC, 1989, Method 2540 D&E.

Chlorophyll A

Chlorophyll in fresh water is concentrated by filtration of the water onto a glass fibre filter. The chlorophyll pigments are extracted from the glass fibre filter using aqueous acetone and a vortex to mechanically break down the cells. The optical density (absorbance) of the extracts are determined with a spectrophotometer.

Detection Limit 0.001 mg/L

Reference: Standard Methods for the Examination of Water and Waste Water, 17th edition, American Public Health Association, Washington, D.C., 1989, Method 10200 H.

Biochemical Oxygen Demand (NAQUADAT 08202L)
A sample of water is incubated for 5 days at 20 +/- 2°C under laboratory conditions. The reduction in dissolved oxygen over the incubation period provides a measure of the BOD.
Detection Limit - 0.1 mg/L

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), Method 405.1.

Standard Methods for Examination of Water and Wastewater, 17th ed., American Public Health Association, Washington, DC, 1989, Method 5210 B.

Total Phosphate as P (NAQUADAT 15406L) (dissolved NAQUADAT 15423L)
Potassium persulfate and sulfuric acid solutions are added to sample aliquots, which are then autoclaved 30 minutes at 15 psi. In a automated system these sample aliquots are then mixed with an ammonium molybdate-ascorbic acid-potassium antimonyl tartrate colour reagent. The resuling colour is measured spectrophotometrically at 660 nm and compared with those of identically prepared standard PO4-3 ion solutions.

Detection Limit - 0.003 mg/L PO_4 as P.
Average Percent Recovery: 103.6% at 0.39 mg/L
Standard Deviation: 4.93% at 0.39 mg/L

Reference: Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EMSL, Cincinnati, OH 45268, March, 1979 (EPA-600/4-79-020), 365.1

General Operating Instruction Manual Technicon Auto Analyzer, Manual NO. 2, Technicon Instruments Corporation, Chauncey, New York, 1966.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Semi-Volatile Organic Priority Pollutants in Water

The analysis is carried out in accordance with U.S. EPA Method 625 (EPA 1984 - 40 CFR, Part 136 49:209) and 3510/8270 (Publ. #SW-846 3rd Ed., Washington, DC 20460). The procedure involves extraction with methylene chloride followed by analysis by capillary column gas chromatography with mass spectrometric detection.

Mineral Oil & Grease In Water

The analysis involves extraction of the sample with the requested 80% Hexane/ 20% MTBE followed by a silica gel cleanup. This cleanup procedure removes a portion of the heterocyclic hydrocarbons and other non-polar compounds. The resulting extract is evaporated to dryness and the residue weighed to determine gravimetric oil and grease.

End of Report

FR . . VAN DER KRAAK
UNIV. OF GUELPH

Protocol for Steroid Hormone RIA

General:

1. RIA BUFFER = "Phosgel"
   5.75 g Na_2HPO_4
   1.28 g $NaH_2PO_4 \cdot H_2O$
   1 g gelatin
   0.1 g Thimersol
   800 ml distilled H_2O

   Heat at 45-50°C for about 15 min to dissolve the gelatin
   Adjust to 1 litre with distilled H_2O
   pH should be 7.6 adjust if required
   Store at 4°C for up to 1 week

2. Charcoal Solution
   0.5 g activated Charcoal
   0.05 g Dextran T-70 Pharmacia
   100 ml Phosgel

   Store at 4°C for 2-3 days.

3. Scintillation Cocktail
   2 litres toluene
   1 litre Triton X-100
   12 g PPO = 2,5-Diphenyloxazole
   0.6 g POPOP = 1,4-Bis(2-5-Phenyloxazolyl))Benzene

   This must be stored in a "dark" well-sealed bottle. Toluene is highly flammable and must be handled and stored in a fume hood.

4. Steroid Stock Solutions:
   For 17β-estradiol, testosterone and 17α20βP prepare stock solutions at 1000 ng/ml in Absolute Ethanol.

   Note: These must be stored in a glass container which is tightly sealed so as to prevent evaporation of the ethanol.

   Store at -20°C for up to 1 year.

5. ^3H-labelled Steroids
   2,4,6,7-^3H-estradiol
   1,2,6,7-^3H-testosterone
   17αhydroxy 1,2,6,7-^3H Progesterone

   Specific activity of these steroids should be approximately 100 Ci/mmol.
   Store at -20°C.

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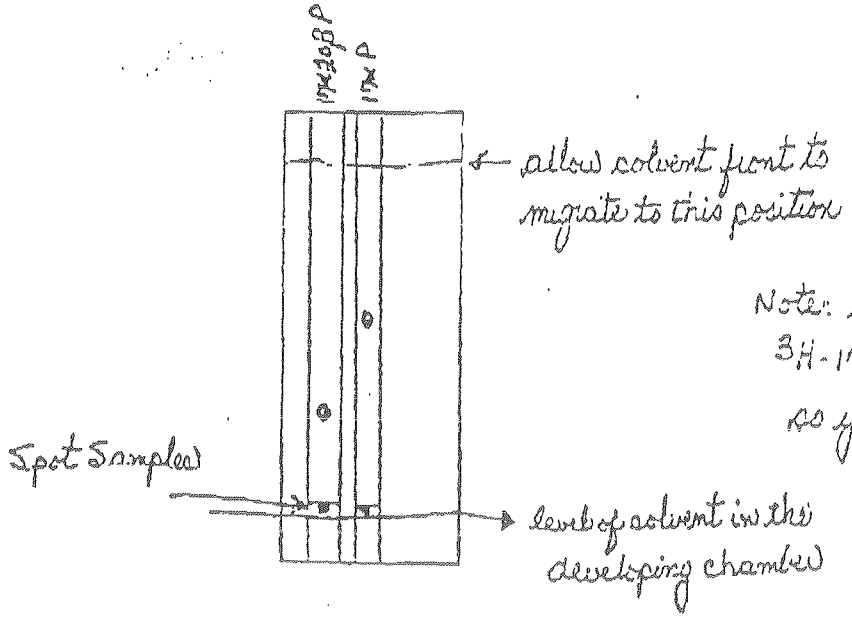
^{3}H-labelled 17α20βP is not available commercially. It must be prepared in your lab from ^{3}H-17αhydroxy progesterone (Reference Scott, Sheldrick and Flint, Gen. Comp. Endocrinol. 46, 444-451; Van Der Kraak et al., Gen. Comp. Endocrinol., 55, 36-45).

1. Place 40 µl of ^{3}H-17αhydroxy Progesterone in a 16x125 mm Glass tube.
2. Dry under a stream of Nitrogen.
3. Add 500 µl of 0.05 M Tris Buffer pH 7.6.
4. Add 40 µl of 3α20β-hydroxysteroid dehydrogenase (Sigma Cat # H 7252 containing ~19.2 units/ml.
5. Add 500 µl of 0.05 M Tris containing 2 mM NADH.
6. Incubate for 2 hr at 18-22°C.
7. Add 3 ml of ether, Vortex for about 1 min.
8. Allow phases to separate and transfer upper (organic) phase to a glass vial.
9. Repeat steps 7 and 8 and combine with organic phase from step 8.
10. Evaporate the ether.
11. Add 100 µl of ethanol to tubes containing the dried ether extract.
12. Apply ethanol in a single spot on a sheet of Whatman LK5DF Thin layer chrometogram*. This should be applied in a single lane. You must only apply about 15-20 µl at one time, dry, then repeat.
13. Repeat steps 11 and 12 two times.
14. Run chromatograph using 50 ml dicloromethane: 20 ml ether until the solvent front is 2-4 cm from the top of the gel. Allow to dry in a fumehood (20 min).
15. Divide the plate into 1 cm fractions and carefully scrape the sections of gel into individual 16x125 mm glass tubes.
16. Add 500 µl of distilled H_2O and then add 5 ml of ether Vortex 1 min, allow phases to separate and transfer organic layer to glass vials.
17. Remove a small aliquot for counting.
18. Once the fractions containing ^{3}H-17α20βP are identified Repeat extractions with ether to maximize the yield.
19. Dry ether fractions and redissolve ^{3}H-17α20βP in Absolute ethanol. Store at 4°C.



Note: in separate lanes apply ^{3}H-17αP & ^{3}H 17α20βP so you can show that the reaction worked

* We can provide you with these plates).

P.03
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Plasma or Serum

Preparation of Samples for RIA

1. Add 500 µl-1000 µl of sample to 16x125 mm glass tube.
2. Add 5 volumes of ether.
3. Vortex for 30 seconds.
4. Allow phases to separate.

Either

5a. Freeze tubes in a dry ice/ethanol or acetone bath.
6a. Decant upper organic layer to glass scintillation vials.

or

5b. Carefully remove upper (organic) layer to a glass scintillation vial.
6b. Repeat steps 2-4 and 5b.

Then

7. Evaporate ether.
8. Add 1.0 ml of Phosgel.

You must establish the efficiency of steroid extraction to ensure that recovery of steroid is high.

For at least one experiment add known amounts of ^{3}H-steroid to tubes before extraction. Extract with ether and measure the amount of ^{3}H steroid present in the extract. Recovery should be greater than 90%.

RIA Protocol

Use 12x75 mm Glass tubes used for the GtH RIA.

Format General

1. 200 µl Standard or Sample
2. 200 µl of ^{3}H-steroid
3. 200 µl of diluted antisera
4. Incubate
5. Cool tubes on ice for 15 min
6. Add 200 µl Charcoal Solution
7. Vortex and let sit 10 min
8. Centrifuge in RIA Centrifuge
9. Carefully decant the supernatant to scintillation vials.
10. Add Scintillation fluid and count.

Detailed Format

1. Standards are prepared by adding 0.1 ml of stock solution to 24.9 ml of Phosgel:

   This equals the highest standard: 800 pg per 200 µl
   Then do a series of 1/2 dilutions preparing standards of 400, 200, 100, 50, 25, 12.5, 6.25, 3.125 and 1.56 pg per 200 µl of Phosgel.
   Standarads should be prepared in Triplicate.

2. ^{3}H-steroid should be diluted to contain 5000 cpm per 200 µl

3. Antisera should be diluted so as to bind 35-45% of added ^{3}H-steroid in the absence of competitor.

For anti 17β Estradiol serum (Yaron) use at 1:80000

For anti-testosterone : YOU WILL HAVE TO DETERMINE THE TITRE DEPENDING ON YOUR SOURCE OF ANTIBODY.

For 17α20βP (Scott) use at 1:15,000

4. Incubate at room temperature (20°C) for 12-24 hr. If you cannot maintain the temperature below 20°C incubate at 4°C for 24 hr.

5. The tubes must be cold 0-4°C before the addition of charcoal. Place racks with the RIA in ice/water bath.

6. The charcoal solution should be cooled (as in 5) and then placed on a magnetic stirrer. The charcoal must be stirred when being added, or charcoal will settle to the bottom of the beaker. Cut the end of the pipet tip so the charcoal does not block the tip.

7. After addition of charcoal to the last tube, vortex the samples and begin a ten minute incubation. During this period, place tubes in the centrifuge so that it can be turned on 10 min after the addition of charcoal to the last tube.

   You must <u>not</u> add charcoal to more tubes than can be held in the centrifuge at one time. If you have more samples than can be centrifuged in one run, include a second standard curve with those samples.

8. Centrifuge for 15 min at the same setting used for the GtH RIA. Centrifuge must be at 4°C.

Note: The timing of 6, 7, and 8 is critical. Once you commence the addition of charcoal you cannot stop. Additionally you must add charcoal to all tubes quickly so that the time interval between the first and last tubes is minimized.

9. Carefully pour off the supernatant fluid into counting vials. Care must be taken to avoid shaking of the tubes and disturbing the charcoal pellet.

P.05

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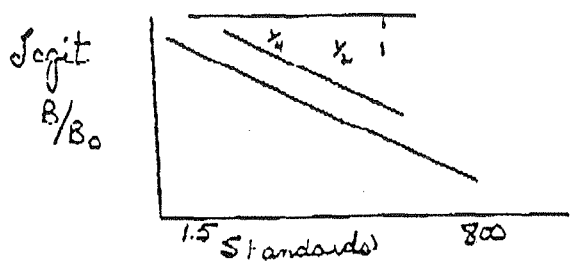
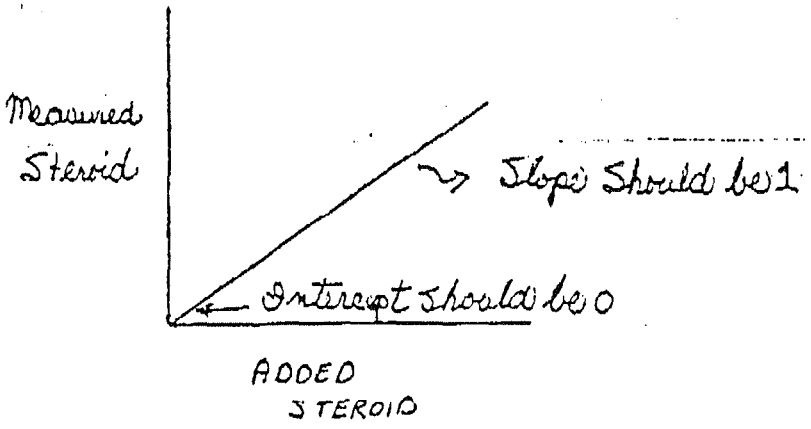
10. Add 5 ml of scintillation fluid and shake well. Count for 3-5 min per sample. Because exposure of the scintillation fluid to light will result in flourescence of the dyes, it is necessary to leave the vials for 1-2 hr prior to counting.

Validation of Steroid RIAs

1. Parallelism: Test serial dilutions of extracted plasma in each of the RIA to ensure that the resultant displacement curves are parallel with the standards.



2. Recovery of Added Hormone: Spike samples with known amounts of unlabelled steroid and measure RIA. The amounts of steorid added must be equal to the amounts of measured steroid.



UNIVERSITY OF SASKATCHEWAN

WESTERN COLLEGE OF
VETERINARY MEDICINE
DEPARTMENT OF VETERINARY PATHOLOGY

SASKATOON, CANADA
S7N 0W0
(306) 966-7280

RECEIVED
SEP 10 1991

September 9, 1991

Dear Beak Associates,

Please find enclosed operating procedures and an equipment list used in the determination of both Hematology and Chemistry test values on fish blood.

On a cautionary note, please be advised that wbc differentials were performed largely without reference, relying on the experience of Ms. Joan Bernstein for cellular identification.

If more information or further detail is required, please do not hesitate to phone me at 966-7401 during business hours.

Sincerely,

Kim Lewis

Kim Lewis, R.T.
Hematology, WCVM

September 9, 1991

Laboratory Equipment List Used in Fish Blood Testing

Department of Clinical Pathology, WCVM

Chemistry Analysis

Dacos Discrete Analyzer with Continuous Optical Scanning — Coulter Electroni

Hematology Analysis

Coulter Hemoglobinometer	Hemoglobin determination
Coulter Dual Diluter III	Dilution for rbc count
Coulter Counter Model FN	Counting rbc's
IEC/MB Micro Hematocrit Centrifuge	Determination of PCV's
Ames Hema Tek Slide Stainer	Staining of peripheral blood smears
Hand-Held Refractometer	Plasma protein determinations

FISH CBC PROCEDURE

1) Make slides (just in case).

2) Manual PCV
   - interface of sealant and rbc's on bottom of black line
   - slide clear plastic carrier to where the plasma meniscus intersects the diagonal black line
   - move red line to plasma/rbc interface and read PCV

3) Manual WBC
   - use 2 tubes per dilution
     - 1st tube: 0.1 ml in 0.9 ml Na++ and Herrick's stain
     - 2nd tube: 0.1 ml of 1st dilution in 1.9 ml Na++ and Herrick's stain

     (therefore final dilution is 1:200)

     - let sit 10 minutes
     - flood both sides of hemocytometer
     - let sit for 10 min

   - Look for darkly staining, round cells
     - count both sides of hemocytometer
     - count all 9 squares. Average count.

Calculation: $WBC = \frac{(Count + 10\%) \times 200}{1000}$

4) Manual Hgb
   - see attached method

5) RBC on Coulter FN
   - Run 4c normal on human setting
   - Run fish with attenuation at .354
   - aperature at 128.

a) Run background with isoton only on human setting
   - rinse cup out x 5 before doing background

b) Put lever on dilutor to wbc
   - hold sample to pipette tip and press to draw up sample
   - press bar again to dispense sample into acuvette.

c) Put lever on dilutor to rbc
   - your wbc dilution is now your sample
   - repeat procedure as in b)

d) Count the RBC diltion x 2 and record on steno book which is on top of the Coulter FN
   - correct for coincidence from chart

ATLANTIC VETERINARY COLLEGE
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PRINCE EDWARD ISLAND C1A 4P3
DIAGNOSTIC SERVICES
(902) 566-0863 (LABORATORIES)
(902) 566-0864 (POST MORTEM)
FAX# (902) 566 0958

DETERMINATION OF FISH HEMOGLOBIN

Required:

1. Reagent - Lyse II
2. Instrument - Coulter Hemoglobinometer (position: 1/501)
3. Reference Solution - Hemoterge
4. Controls - 4C Plus (L,H,N)

Procedure:

I Calibration of Hemoglobinometer to do Fish Hgb.

1. 20 ul. of 4C plus Normal Control in 10 ml. of Lyse II.
2. Adjust Hemoglobinometer to mean value ± 0.2 g/dL. Use semi-automated value and range. Repeat with H/L controls and insure that values fall within assigned expected ranges.

II To Run Fish/Avian Hgb

1. 20 ul. of blood in 10 ml. of Lyse II.
2. Incubate suspension for 10'(37°C) to insure complete Lysing.*
3. Spin down (3000 rpm) to remove cellular debris.
4. Read supernatant(clear) on Hgbometer.
5. Convert g/dL x 10 to g/L.

* This may not be necessary
* Reference - Dennis Olesson)

D W Olesson

DACOS® *Analyzer*

plus LYTES Option

PN 6602743

An automated analyzer, intended for the quantitative analysis of sodium and potassium.

FOR IN VITRO DIAGNOSTIC USE

Read the complete manual
before attempting to operate
the instrument.

There is no drug-plastic interaction of clinical significance under recommended conditions of use.

HAZARDS AND/OR OPERATIONAL PRECAUTIONS AND LIMITATIONS

Footnotes identified as WARNINGS, CAUTIONS, and IMPORTANTS alert the operator as follows:

WARNING: May cause injury.
CAUTION: May cause damage to the instrument.
IMPORTANT: May cause misleading results.

PN 4235544 (September 1985)

2.4 ELECTRODE SYSTEM

Sodium and Potassium det'n.

The measurement of the two electrolytes, sodium and potassium, is done by ion-selective electrodes (ISEs) in the plus LYTES. A general description of the ISE principles is given below; however, see the References for additional reading material on ion-selective electrodes.

The ISE performs an electrochemical measurement. The response of the electrode is logarithmic and proportional only over a limited range of both the concentration of the ion to be measured as well as any competing ions. The measurement is of an electrical potential developed at the electrode, this potential is related to the ion activity which is proportional to the concentration.

An ion-selective electrode as well as a reference electrode are needed for this type of measurement. The sodium electrode is a glass membrane type encasing a reference solution of sodium ions and chloride ions, and a silver/silver chloride (Ag/AgCl) reference element. It is specifically formulated for high selectivity for sodium ions. A potential is developed and measured at the inner surface of the ISE when a sample or standard comes in contact with its outer membrane surface. This potential is compared to that of the reference electrode. The reference electrode consists of a Ag/AgCl reference element encased in a reference solution containing chloride ions. The potassium electrode system is similar except that valinomycin, an antibiotic, is used for the membrane. Valinomycin is able to replace the hydration shell of a potassium cation thereby making the ISE highly selective for potassium.

This measurement can be expressed for ideal situations in which insignificant or no amount of competing ions occur in the solution, by the Nernst equation below:

$$E = E_o + 2.303 \left(\frac{RT}{ZF} \right) \log A$$

Where:

E = the potential developed in millivolts (mV)

E_o = the constant potential

RT/ZF = the "slope". R = the gas constant; T = absolute temperature; Z = ion charge, with sign (valence); and F = Faraday's constant

A = ion activity (concentration x activity coefficient).

Since patient samples do not present ideal conditions, but vary greatly in ionic strength, a comparative method of measurement is used. This includes the measurement of two standards containing known amounts of the selected ion as well as the sample. A two-point calibration is performed using the two standards. The slope of the calibration curve is substituted in the Nernst equation. For a comparative measurement the equation becomes:

$$E_x - E_s = S_x \log \left(\frac{A_x}{A_s} \right)$$

Where:

E_x = the potential developed by the ISE for the sample

E_s = the potential developed by the ISE for the standard

S_x = slope, with sign

A_x = ion concentration in the sample

A_s = ion concentration in the standard

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® TOTAL PROTEIN reagent is intended for the in vitro quantitative determination of total protein with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: The quantitation of the interrelationship of total protein concentration to albumin and globulin fractions aids in the diagnosis of multiple myeloma, sarcoidosis, dehydration, hepatic malfunction, renal disease, malnutrition, third degree burns, and water intoxication.

PRINCIPLES OF REAGENT SYSTEM: In an alkaline solution, cupric ions form a violet-colored complex with protein, and the intensity of the color produced is directly proportional to protein concentration. This color reaction is the basis for the biuret test.[1] See Figure 1.

The method used by the optimized DART TOTAL PROTEIN reagent is a modified Gornall method.[1]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Cupric Sulfate	24 mmol/L
Sodium Hydroxide	500 mmol/L
Potassium Sodium Tartrate	85 mmol/L
Potassium Iodide	24 mmol/L
Stabilizer	

CAUTION: Reagent contains sodium hydroxide and is CORROSIVE, causing severe burns on skin and eyes. Wash affected areas thoroughly with water for 15 min after contact and consult a physician.

PACKAGE CONTENTS:

DART TOTAL PROTEIN Reagent 20 x 25.5 mL

REAGENT PREPARATION: DART TOTAL PROTEIN reagent is supplied as a single reagent and is in ready-to-use form.

STABILITY AND STORAGE: Store unopened vials of DART TOTAL PROTEIN reagent, tightly capped, in subdued light at controlled room temperature. Consult expiration date on vial label for shelf life.

Do not use if the reagent has any precipitate, this may indicate reagent deterioration. Do not use if the reagent blank has an absorbance greater than 0.250 measured at 550 nm. The reagent blank absorbance of a mixture of 2.0 mL reagent and 1.2 mL DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges of DART LIQUITROL or DACOS CONTROL LEVEL I and II while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: Assay freshly drawn serum to avoid possible specimen contamination. Serum not promptly assayed may be stored at 2 to 8° C in a stoppered container for approximately one month without appreciable change in total protein concentration.[2] See the Interferences and Limitations section in this package insert.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[3]

EXPECTED VALUES: Determined with samples from an ambulatory population.

General Population = 6.2 to 8.4 g/dL

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 0 to 16 g/dL

PERFORMANCE CHARACTERISTICS: This is typical data produced by one or more DACOS chemistry analyzers.

1. PRECISION: (Three samples per run)

A. Within-Run:

No. of Runs	MEAN (g/dL)	S.D. (g/dL)	C.V. (%)
20	3.21	0.04	1.3
20	6.16	0.05	0.9
20	8.79	0.07	0.8

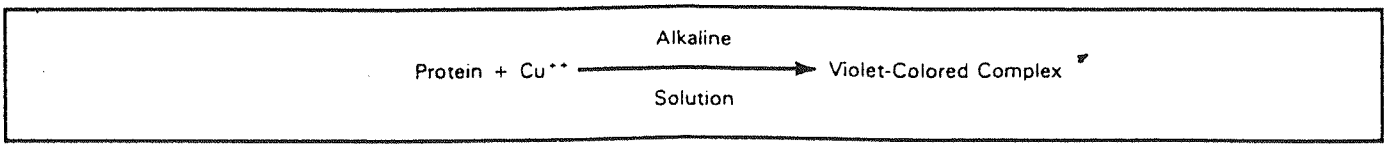

Figure 1 Sequence of Reaction

DART® CREATININE A + R

(KINETIC JAFFE METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® CREATININE reagent is intended for the in vitro quantitative determination of creatinine with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: The determination of serum creatinine is an aid in diagnosing renal disease and dysfunction.[1]

PRINCIPLES OF REAGENT SYSTEM: The formation of a reddish creatinine-picrate complex, which is proportional to the amount of creatinine present, is the basis for the creatinine determination. See Figure 1.

The method used by the DART CREATININE reagent is a modification of the kinetic Jaffe method.[2]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Reagent A	
Sodium Borate	26.2 mmol/L
Sodium Phosphate Dibasic	52.8 mmol/L
Sodium Hydroxide	537.4 mmol/L
Stabilizer and Surfactant	
Reagent B	
Picric Acid	57.2 mmol/L

CAUTION: Reagent A contains sodium hydroxide which may cause irritation or burns to skin and eyes. Flush contact surface with water. If taken internally or eye contact occurs consult a physician. Use with adequate ventilation. Reagent B contains picric acid; contact with skin should be avoided. Flush contact surface with water. If Reagent B is permitted to evaporate to dryness, the resulting crystals are explosive. Wash all containers thoroughly before allowing to dry.

PACKAGE CONTENTS:

DART CREATININE Reagent A	10 x 16.8 mL
DART CREATININE Reagent B	10 x 16.8 mL

REAGENT PREPARATION: DART CREATININE Reagents A and B are supplied in a ready-to-use form.

STABILITY AND STORAGE: Store unopened DART CREATININE reagent vials at a controlled room temperature in subdued light. DO NOT REFRIGERATE. If exposed to extreme cold, crystals can appear; allow to stand at room temperature with occasional mixing to dissolve crystals. Refer to the expiration dates listed on the vial labels for shelf life. Reagents are stable for at least 72 h at 15°C after being opened, but should be kept tightly capped when not in use.

Do not use if the reagent blank has an absorbance greater than 0.060 measured at 520 nm. The reagent blank absorbance of a mixture of 800 µL of Reagent A and 800 µL of Reagent B and 1.2 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges for DART LIQUITROL or DACOS CONTROL LEVELS I AND II, while using DACAL® I, II, and III calibrators to calibrate might indicate reagent deterioration.

SPECIMEN HANDLING: Fresh serum should be used. If samples are to be shipped, serum should be frozen immediately after separation. Samples which have been frozen tend to give slightly lower values.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[3]

EXPECTED VALUES:

General Population = 0.8 to 1.6 mg/dL

Sex	Age (m = months, y = years)	Range (mg/dL)
Male	1 m – 99 y	1.0 – 1.7
Female	1 m – 99 y	0.8 – 1.4

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 0 to 25 mg/dL

Creatinine + Picrate ⟶ Red Colored Creatinine – Picrate Complex

Figure 1 Sequence of Reaction

DART® AST (GOT)

(MODIFIED IFCC METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® AST (GOT) reagent is intended for the in vitro quantitative determination of asparate aminotransferase (AST) activity in serum with the DACOS® and the DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: The quantitation of elevated levels of AST is an aid in diagnosing heart and liver diseases. AST activity rises within the first 18 h after myocardial infarction, reaching its highest level within 48 h.[1,2]

PRINCIPLES OF REAGENT SYSTEM: Serum aspartate aminotransferase (AST) catalyzes the transformation of 2-oxoglutarate to L-glutamate with simultaneous deamination of L-aspartate to oxaloacetate. AST activity is measured as oxaloacetate, which is reduced to malate by malate dehydrogenase (MD), and an equimolar amount of NADH is oxidized to NAD in proportion to AST activity. AST activity is determined spectrophotometrically by measuring the decrease in absorbance at 340 nm. Lactate dehydrogenase (LD) is included in the formulation to eliminate any pyruvate present in the samples. See Figure 1.

The method used by the optimized DART AST (GOT) reagent is a modification of the method recommended by the International Federation of Clinical Chemistry (IFCC).[3]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before dilution of the reagents by the DACOS chemistry analyzer.

2-Oxoglutarate (α-ketoglutarate)	40 mmol/L
L-Aspartate	825 mmol/L
Reduced Nicotinamide Adenine Dinucleotide (NADH)	0.75 mmol/L
Malate Dehydrogenase (E.C.1.1.1.37, MD)	1925 U/L
Lactate Dehydrogenase (E.C.1.1.1.27, LD)	1650 U/L
Tris (Hydroxymethyl) Aminomethane Buffer	275 mmol/L
Sodium Azide	0.025%
Stabilizers	

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

FOR IN VITRO DIAGNOSTIC USE

PACKAGE CONTENTS:

DART AST (GOT) Reagent 20 x 10 mL

REAGENT PREPARATION: Gently tap each vial of DART AST (GOT) reagent several times to loosen contents from the sides of the container. To each 10 mL vial add 10.0 mL of water, which meets or exceeds the specifications of NCCLS Type II water.[4] Mix by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened DART AST (GOT) reagent vials in subdued light at 2 to 8°C. Refer to expiration date on vial label for shelf life. The reconstituted reagent is stable for at least six days when refrigerated at 2 to 8°C, or 72 h at 15°C.

Do not use if the dry reagent appears moist, or if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance less than 1.2 measured at 340 nm. The reagent blank absorbance of a mixture of 1.2 mL reconstituted reagent and 1.8 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within expected ranges for DART LIQUITROL or DACOS CONTROL LEVEL I and LEVEL II while using DACAL® I, II and III Calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: The use of fresh or refrigerated serum is recommended. If not assayed promptly, freeze samples rapidly and as needed, thaw to room temperature with thorough mixing. Do not use hemolyzed samples.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Reference Manual.[5]

ANALYTICAL RANGE: From 0 to 1000 U/L at 37°C

INTERFERENCES AND LIMITATIONS:

1. Microbial contamination of water used for reconstitution may produce an apparent elevation of AST activity by the introduction of pyridoxal phosphate (PyP).
2. Hemolyzed sera may interfere with AST determination, since erythrocytes contain AST.
3. For a comprehensive review of interfering substances, consult Young, DS et al.: 1975. "Effects of Drugs on Clinical Laboratory Tests."[6]

EXPECTED VALUES:

General Population = 7 to 39 U/L at 37°C

This range was determined from an apparently healthy, fasting, adult, male and female population, using nonparametric analysis. This range has been verified on the DACOS chemistry analyzer.

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

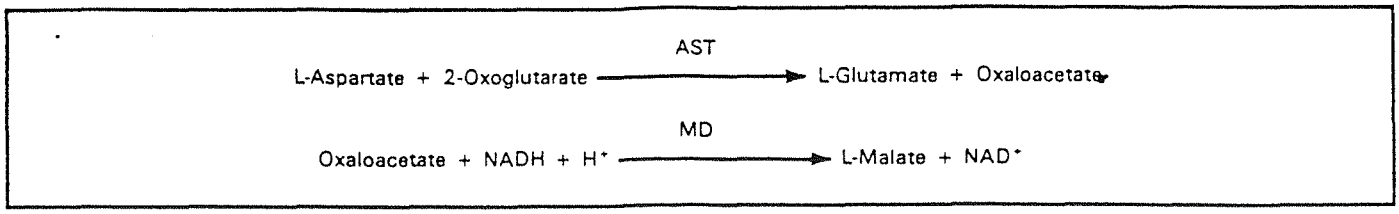

Figure 1 Sequence of Reactions

DART® UREA NITROGE

(MODIFIED TALKE AND SCHUBERT METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® UREA NITROGEN reagent is intended for the in vitro quantitative determination of urea nitrogen with the DACOS® and DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: The quantitation of urea is useful in diagnosing disorders associated with renal and prerenal diseases, dehydration, severe GI hemorrhage, infections, diabetes mellitus and some neoplastic diseases.[1,2]

PRINCIPLES OF REAGENT SYSTEM: In the presence of water and urease, urea is hydrolyzed to carbon dioxide and ammonia. Glutamate dehydrogenase (GLD) catalyzes the reaction of ammonia, 2-oxoglutarate, and reduced nicotinamide adenine dinucleotide (NADH) to produce L-glutamate and NAD. See Figure 1.

While NADH has a high absorbance at 340 nm, NAD has virtually no absorbance at that wavelength. Over the analytical range of the reagent, the amount of NADH oxidized, and the subsequent decrease in absorbance at 340 nm, is proportional to the urea concentration of the sample.

This method used by the optimized DART UREA NITROGEN reagent is based on a modification of the Talke and Schubert method.[3]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagents are diluted by the DACOS chemistry analyzer.

Urease (E.C.3.5.1.5)	2400 U/L
2-Oxoglutarate (α-ketoglutarate)	12.8 mmol/L
Reduced Nicotinamide Adenine Dinucleotide (NADH)	0.6 mmol/L
Glutamate Dehydrogenase (E.C.1.4.1.3, GLD)	48,000 U/L
Tris (Hydroxymethyl) Aminomethane Buffer	128 mmol/L
Sodium Azide	0.016%
Filler and Stabilizers	

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

PACKAGE CONTENTS:

DART UREA NITROGEN Reagent 20 x 20 mL

REAGENT PREPARATION: Gently tap each vial of reagent several times to loosen contents from the sides of the container. To each 20 mL vial, add 20.0 mL of ammonia-free water which meets or exceeds the specifications for NCCLS Type II water.[4] Immediately mix by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened DART UREA NITROGEN reagent vials in subdued light at 2 to 8°C. Refer to the expiration date on the vial label for the shelf life. The reconstituted reagent is stable for at least six days when refrigerated (2 to 8°C) or 72 h at 15°C.

Do not use if the dry reagent appears moist or if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance less than 2.4 measured at 340 nm. The reagent blank absorbance of a mixture of 2.0 mL of reconstituted reagent and 1.2 mL of DACOS DILUENT can be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) that are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges of DART LIQUITROL or DACOS CONTROL LEVEL I and II, while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: It is preferable to use fresh serum. Serum that has been stored refrigerated can be used. Materials used for sample collection should be ammonia-free.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[5]

EXPECTED VALUES:

General Population = 7 to 21 mg/dL

Sex	Age (m = months, y = years)	Range (mg/dL)
Both	1 m	3 — 14
Both	2 m — 1 y	5 — 15
Both	2 y — 14 y	5 — 16
Male	15 y — 44 y	8 — 19*
Female	15 y — 44 y	7 — 16*
Male	45 y — 74 y	7 — 21
Female	45 y — 74 y	7 — 19
Both	75 y — 99 y	7 — 29

Ranges have been extrapolated from the literature. References are available upon request.

*These ranges have been verified on the DACOS chemistry analyzer.

Coulter strongly recommends that each laboratory determines its own normal ranges based upon its geographical location and other population characteristics.

$$\text{Urea} + H_2O \xrightarrow{\text{Urease}} 2NH_3 + CO_2$$

$$NH_3 + \text{2-Oxoglutarate} + \text{NADH} + H^+ \xrightarrow{\text{GLD}} \text{L-Glutamate} + NAD^+ + H_2O$$

Figure 1 Sequence of Reactions

Reagents Applications, Inc.

RAICHEM™

MAGNESIUM REAGENT

Product No. 85207

INTENDED USE

This reagent is intended for the quantitative determination of magnesium in serum or plasma.

For *in vitro* diagnostic use only.

TEST SUMMARY

Older methods for determination of magnesium were based on precipitation in the form of magnesium ammonium phosphate, followed by determination of phosphate in the precipitate. Complexometric techniques using EDTA have been employed. Fluorometric methods have been presented, one of which has been automated. The definitive method is by neutron activation analysis, while the procedure of choice uses atomic absorption (1). Direct magnesium determinations employing spectrophotometric methods without deproteinization of the samples have been described. These use calmagite, methylthymol blue, Titan yellow.

The sodium salt of Xylidyl Blue I (Magon sulfonate-CAS registry number: 14936-97-1) is 4-hydroxy-3-[2-hydroxy-3-(2, 4-dimethylphenyl amino carbonyl)-1-naphthylazo] benzene sulfonic acid (2) and is used in our procedure. This compound forms a red complex in alkaline solution with magnesium. The absorbance at 520 nm of the red Xylidyl Blue I: magnesium complex is proportional to the concentration of magnesium in the sample. Interference by calcium is prevented by the use of EGTA [ethylenebis (oxyethylene nitrilo) tetraacetic acid].

REAGENT COMPOSITION

Component	Approximate Concentration
Xylidyl Blue I	0.14 mmol/L
EGTA	0.1 mmol/L
TRIS	200 mmol/L
Na_2CO_3	100 mmol/L

A magnesium standard is provided with the reagent.

REAGENT PREPARATION

The reagent is in liquid form, ready for use.

REAGENT STORAGE AND STABILITY

The reagent in the unopened containers is stable at 2°C-25°C until the expiration date indicated on the container.

PRECAUTIONS

Do not use the reagent if it becomes turbid or fails to recover known serum control values.

Avoid contamination of the reagents. Magnesium is present in a number of products used as detergents, in tap water, etc.

The reagent is alkaline; avoid contact with skin and mucous membranes. If contact occurs, wash affected area with copious quantities of water. Use an eye wash if the eyes are involved.

INTERFERING SUBSTANCES

Any substance which either chelates magnesium or contains magnesium will interfere with the assay.

Young, et al. (3) have published a comprehensive list of drugs and substances which may interfere with *in vitro* diagnostic assays, including that for serum magnesium.

SPECIMEN COLLECTION, PREPARATION AND STORAGE

The assay may be performed using serum or heparinized plasma. Do not use anticoagulants which are also metal complexing agents, such as oxalate, fluoride or citrate. Separate the serum or plasma from the formed elements of blood as soon as possible to minimize transferral of magnesium from the cells through the cell membranes. Do not use hemolyzed samples as red cells contain a much higher level of magnesium than plasma.

Magnesium in serum or plasma is stable for several days refrigerated. For long term storage, samples should be kept in a freezer.

MATERIALS REQUIRED BUT NOT PROVIDED

1. Spectrophotometer capable of acccurate readings at 520 nm.
2. Matched cuvets.
3. Distilled or deionized water.
4. Accurate pipettes to measure water, reagent and standard.

MATERIAL PROVIDED

1. Magnesium Reagent in liquid form.
2. Magnesium Standard: Concentration reported on vial label.

CALIBRATION:

The assay requires the use of a magnesium standard. Use the standard provided with the reagent or other commercially available standards or calibrators.

REAGENTS APPLICATIONS, INC.
8225 Mercury Court • San Diego, California 92111 • (619) 569-8009 • 800-482-3914 • 800-438-6100 (CA Only)

DART® CK(CPK)-NAC

(MODIFIED OLIVER-ROSALKI METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® CK (CPK)-NAC reagent is intended for the in vitro quantitative determination of creatine kinase (CK) activity with the DACOS® and the DACOS XL chemistry analyzer.

CLINICAL SIGNIFICANCE: The determination of creatine kinase is an aid in diagnosing muscular dystrophy and other diseases of the skeletal muscles, myocardial infarction, hypothyroidism, and renal disease and/or dysfunction.[1]

PRINCIPLES OF REAGENT SYSTEM: CK catalyzes the conversion of creatine phosphate and ADP to creatine and ATP. The ATP and glucose are converted to ADP and glucose-6-phosphate by hexokinase (HK) in the second reaction. In the final reaction, glucose-6-phosphate dehydrogenase (G-6-PD) oxidizes the glucose-6-phosphate and reduces the nicotinamide adenine dinucleotide (NAD). The rate of increase in NADH concentration is proportional to the CK activity. See Figure 1.

This method used by the DART CK (CPK)-NAC reagent is based on that of Oliver and Rosalki.[2,3] The reagent includes AMP and diadenosine pentaphosphate to suppress adenylate kinase activity.[4] N-acetylcysteine (NAC) acts as a CK stabilizer and activator.[5]

ACTIVE INGREDIENTS: The values listed are the vial concentrations before the reagent is diluted by the DACOS chemistry analyzer.

D-Glucose	62.5 mmol/L
Magnesium $^{++}$	16.25 mEq/L
Adenosine-5'-Monophosphate (AMP)	12.5 mmol/L
N-Acetylcysteine (NAC)	50 mmol/L
Creatine Phosphate	75 mmol/L
Adenosine-5'-Diphosphate (ADP)	6.3 mmol/L
Nicotinamide Adenine Dinucleotide	5.8 mmol/L
Glucose-6-Phosphate Dehydrogenase (E.C.1.1.1.49, G-6-PD)	3750 U/L
Hexokinase (E.C.2.7.1.1, HK)	5000 U/L
EDTA	5 mmol/L
Diadenosine 5'-pentaphosphate	26.5 µmol/L
Sodium Azide	0.025%
Buffers and Stabilizers	

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form a highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

PACKAGE CONTENTS:

DART CK (CPK)-NAC Reagent 20 x 10 mL

REAGENT PREPARATION: Gently tap each vial of DART CK (CPK)-NAC reagent several times to loosen contents from the sides of the container. To each 10 mL vial, add 10.0 mL of water which meets or exceeds the specifications for NCCLS Type II water.[6] Mix immediately by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened DART CK (CPK)-NAC reagent vials in subdued light, at 2 to 8°C. Refer to expiration date on vial label for shelf life. The reconstituted reagent is stable for at least six days at 2 to 8°C or 72 h at 15°C.

Do not use if the dry reagent appears moist or if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance greater than 0.400 measured at 340 nm. The reagent blank absorbance of a mixture of 2.0 mL of reconstituted reagent and 3.0 mL of DACOS DILUENT can be measured in a spectrophotometer against water in a 1 cm light path cuvet. Inability to recover results within the expected ranges for DART LIQUITROL or DACOS CONTROL LEVELS I and II might indicate reagent deterioration.

SPECIMEN HANDLING: If serum is not assayed immediately, it should be kept in a stoppered container and refrigerated. Avoid exposure to bright light. If samples are to be shipped or stored for longer then two days, freeze immediately after separation. Hemolyzed samples should not be used, although slight hemolysis can be tolerated. See the Interferences and Limitations section in this package insert.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[7]

EXPECTED VALUES:

General Population = 16 to 206 U/L at 37°C*

*These ranges have been verified on the DACOS chemistry analyzer.

Exercise or trauma can cause an elevation in CK values. Coulter strongly recommends that each laboratory determines its own normal ranges based upon its geographical location and other characteristics.

ANALYTICAL RANGE: From 0 to 2000 U/L at 37°C

PERFORMANCE CHARACTERISTICS: This is data produced by one or more DACOS chemistry analyzers.

1. PRECISION: (Three samples per run)

A. Within-Run:

No. of Runs	MEAN (U/L)	S.D. (U/L)	C.V. (%)
10	95.4	3.3	3.5
10	324.2	4.7	1.4
10	635.9	5.4	0.8

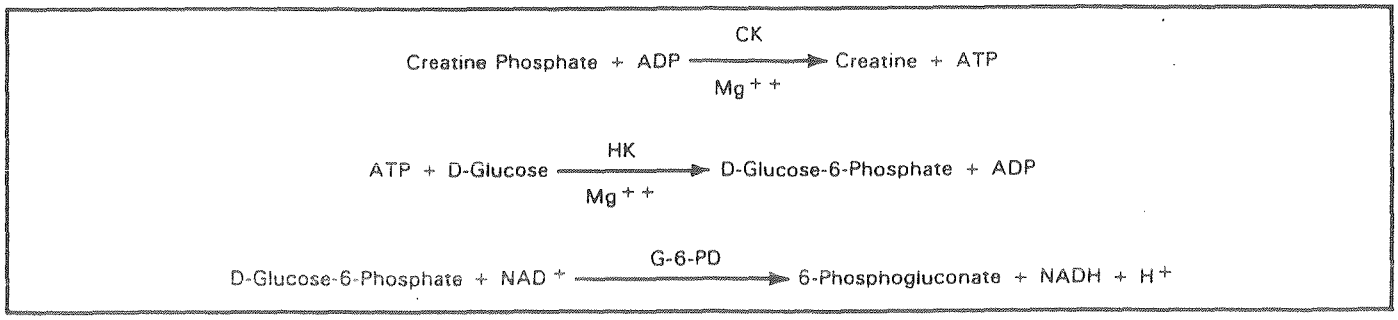

Figure 1 Sequence of Reactions

DART® ALBUMIN

(MODIFIED DOUMAS METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® ALBUMIN reagent is intended to be used for the in vitro quantitative determination of albumin with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: Observation of serum albumin level is useful as an aid in diagnosing disease states of the liver and kidneys, intestinal malabsorption, and water intoxication.[1]

PRINCIPLES OF REAGENT SYSTEM: The method used by the DART ALBUMIN reagent is based on that of Doumas.[2] At a controlled pH, bromcresol green forms a colored complex with albumin. The intensity of color at 630 nm is directly proportional to albumin content. The instantaneous initial absorbance is obtained as suggested by Webster.[3] See Figure 1.

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Bromcresol Green	0.36 mmol/L
Succinic Acid	125.8 mmol/L
Sodium Hydroxide	43.8 mmol/L
Sodium Azide	2.6 mmol/L
Brij 35, 30%	6.7 mL/L
Ethanol (denatured)	3.9 mL/L

CAUTION: Contains sodium azide; may form explosive metallic salt with lead or copper plumbing. If flushed down drain, use copious amounts of water. Normal operation of the DACOS chemistry analyzer provides sufficient water for flushing.

PACKAGE CONTENTS:

DART ALBUMIN Reagent 20 x 25.1 mL

REAGENT PREPARATION: DART ALBUMIN reagent is supplied as a single reagent and is in ready-to-use form.

STABILITY AND STORAGE: Store unopened DART ALBUMIN reagent vials in subdued light at a controlled room temperature; opened reagent is stable for at least 72 h at 15°C. Refer to expiration date on vial label for shelf life. Do not use if the reagent blank has an absorbance outside the range of 0.150 to 0.450 measured at 630 nm. The reagent blank absorbance of a mixture of 3.0 mL of reagent and 1.2 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges of DART LIQUITROL or DACOS CONTROL LEVEL I and LEVEL II while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: Serum stored at room temperature for up to one week may be used, provided it remains clear. When refrigerated, serum protein is stable for one month.[4]

TEST PROCEDURE DEFINITION: Refer to the test preprogrammed definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[5]

EXPECTED VALUES: Determined with samples from an ambulatory population.

General Population = 3.4 to 4.7 g/dL

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 0 to 6 g/dL

PERFORMANCE CHARACTERISTICS: This is data produced by one or more DACOS chemistry analyzers.

1. PRECISION: (Three samples per run)

   A. Within-Run:

No. of Runs	MEAN (g/dL)	S.D. (g/dL)	C.V. (%)
10	1.93	0.04	2.1
10	3.60	0.05	1.3
10	5.05	0.04	0.7

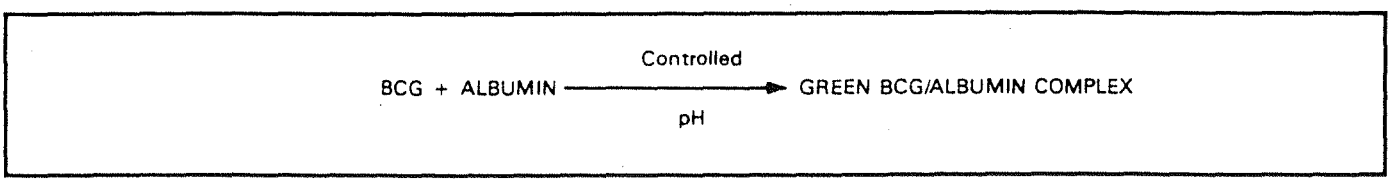

Figure 1 Sequence of Reaction

DART® ALP (ALK PHOS) A+

(MODIFIED BOWERS AND McCOMB METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® ALP (ALK PHOS) reagent system is intended for the in vitro quantitative determination of alkaline phosphatase enzyme in serum with the DACOS® and DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: The quantitation of alkaline phosphatase (ALP) is an aid in diagnosing bone, liver, nutritional and intestinal disorders. Elevated serum ALP is found in women during their third trimester of pregnancy and in children.

PRINCIPLES OF REAGENT SYSTEM: ALP, in the presence of 2-amino-2-methyl-1-propanol (AMP buffer) and magnesium ions (Mg^{++}, activator), hydrolyzes p-nitrophenyl phosphate to produce p-nitrophenol and phosphate. The rate of increase in absorbance at 420 nm is directly proportional to the ALP activity in the sample. See Figure 1.

The method used by the DART ALP (ALK PHOS) reagent is a modified Bowers and McComb system optimized for use with the DACOS chemistry analyzer.[1]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Reagent A	
2-Amino-2-Methyl-1-Propanol Buffer	1.6 mol/L
Reagent B	
p-Nitrophenyl Phosphate, Tris Salt	32 mmol/L
Magnesium (Mg^{++})	0.8 mEq/L
Sodium Azide	0.016%
Filler and Stabilizer	

CAUTION: Do not pipet reagent by mouth. The reaction end product (p-nitrophenol) is hazardous to health; use caution when handling.

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

FOR IN VITRO DIAGNOSTIC USE

PACKAGE CONTENTS:

DART ALP (ALK PHOS) Reagent A	1 x 425 mL
DART ALP (ALK PHOS) Reagent B	20 x 20 mL

REAGENT PREPARATION: Gently tap each vial of DART ALP reagent B several times to loosen the contents from the sides of the vial. To each 20 mL vial of reagent B, add 20.0 mL of reagent A. Mix by gently swirling and inverting, to avoid foaming, until contents are completely dissolved. Refer to Interferences and Limitations.

STABILITY AND STORAGE: Store unopened DART ALP reagents A and B at 2 to 8°C in subdued light. Refer to expiration date on vial label for shelf life. Reconstituted reagent B is stable for at least six days when refrigerated at 2 to 8°C or 72 h at 15°C. Keep reagent A tightly sealed.

Do not use reagent B if its contents appear moist. Do not use if the reagent blank has an absorbance greater than 0.2, measured at 420 nm. The reagent blank absorbance of a mixture of 2.0 mL of reconstituted reagent and 1.2 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the DACOS chemistry analyzer test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within expected ranges for DART LIQUITROL or DACOS CONTROL LEVEL I and LEVEL II while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: Assay of fresh serum is recommended. If not assayed promptly, serum should be refrigerated at 2 to 8°C. If storage is to exceed 2 to 3 days, serum should be frozen and stored at −20°C.[2] Note that ALP activity recovers slowly after thawing of frozen serum. Before assaying, thawed serum should stand for 24 h at 2 to 8°C.[3]

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Reference Manual.[4]

ANALYTICAL RANGE: From 0 to 2400 U/L at 37°C

INTERFERENCES AND LIMITATIONS:

1. Serum free from hemolysis is preferred; slightly hemolyzed samples may be used.
2. Anticoagulants such as oxalate, citrate and EDTA inhibit alkaline phosphatase activity.[1]
3. Reagents A and B supplied in this package should not be interchanged and used with reagents having different lot numbers.
4. For a comprehensive review of interfering substances, consult Young, DS et al.: 1975. "Effects of Drugs on Clinical Laboratory Tests."[5]

EXPECTED VALUES:

General Population = 41 to 133 U/L at 37°C

This range was determined from an apparently healthy, fasting, adult, male and female population, using nonparametric analysis. This range has been verified on the DACOS chemistry analyzer.

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

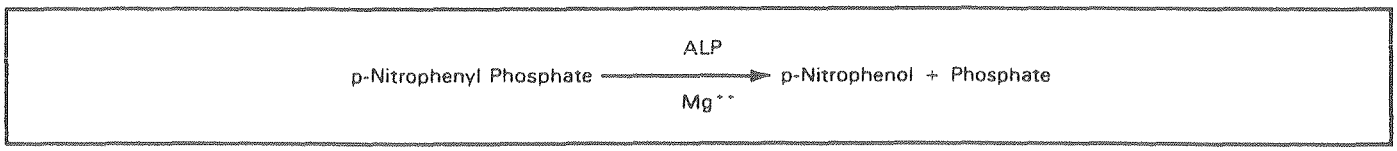

Figure 1 Sequence of Reaction

DART® ALT (GPT)

(MODIFIED IFCC METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® ALT (GPT) reagent is intended for the in vitro quantitative determinations of alanine aminotransferase (ALT) activity with the DACOS® and the DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: The quantitation of elevated levels of ALT is an aid in diagnosing liver damage, both primary and secondary.[1]

PRINCIPLES OF REAGENT SYSTEM: Alanine aminotransferase accelerates the simultaneous transformation of the amino group from L-alanine to 2-oxoglutarate with formation of L-glutamate and pyruvate. Pyruvate is then reduced to lactate in the presence of the enzyme lactate dehydrogenase (LD) with corresponding oxidation of reduced nicotinamide adenine dinucleotide. ALT activity can be determined spectrophotometrically by measuring the decrease in absorbance at 340 nm caused by the oxidation of NADH. Lactate dehydrogenase also eliminates interference by pyruvate in the sample. See Figure 1.

The method used by the optimized DART ALT (GPT) reagent is a modification of the method recommended by the International Federation of Clinical Chemistry (IFCC).[2]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

2-Oxoglutarate (α-ketoglutarate)	40 mmol/L
L-Alanine	1375 mmol/L
Reduced Nicotinamide Adenine Dinucleotide (NADH)	0.75 mmol/L
Lactate Dehydrogenase (E.C.1.1.1.27,LD)	2750 U/L
Tris (Hydroxymethyl) Aminomethane Buffer	277.5 mmol/L
Sodium Azide	0.025%

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

PACKAGE CONTENTS:

DART ALT (GPT) Reagent 20 x 10 mL

REAGENT PREPARATION: Gently tap each vial of DART ALT (GPT) reagent several times to loosen contents from sides of container. To each 10 mL vial, add 10.0 mL of water which meets or exceeds the specification for NCCLS Type II water.[3] Immediately mix by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened DART ALT (GPT) reagent vials in subdued light at 2 to 8°C . Refer to expiration date on vial label for shelf life. Reconstituted reagent is stable for at least six days when refrigerated at 2 to 8°C or for 36 h at 15°C.

Do not use if the dry reagent appears moist or if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance less than 1.3 measured at 340 nm. The reagent blank absorbance of a mixture of 1.2 mL of reconstituted reagent and 1.8 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges for DART LIQUITROL or DACOS CONTROL LEVEL I and LEVEL II while using DACAL® I, II, and III Calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: It is recommended that fresh serum be assayed. If storage and/or shipment of specimen is necessary, refrigerate or freeze. Do not use hemolyzed samples.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[4]

EXPECTED VALUES:

General Population = 2 to 54 U/L at 37°C

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 0 to 1000 U/L at 37°C

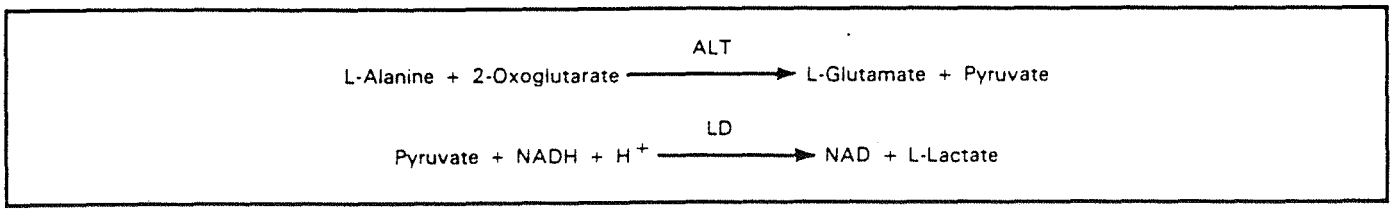

Figure 1 Sequence of Reactions

DART® CHLORID

(MODIFIED SCHOENFELD AND LEWELLEN METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® CHLORIDE reagent is intended for the in vitro quantitative determination of chloride with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: Chloride is a principal serum anion essential in maintaining normal acid/base equilibrium and water balance in human metabolism; its determination is well documented in literature.[1] Quantitation of serum chloride is also useful in conjunction with additional electrolyte determinations in diagnosing cases of uremia and respiratory, metabolic, or diabetic acidosis and alkalosis.

PRINCIPLES OF REAGENT SYSTEM: DART CHLORIDE reagent uses the colored complex which results from the reaction between iron (+3) and thiocyanate, the latter having been displaced from mercury (+2) thiocyanate by the chloride in serum.[2] This method is a modification of the assay described by Schoenfeld and Lewellen.[3] See Figure 1.

The color intensity of the complex formed is proportional to the chloride concentration when measured at 520 nm using the DACOS® chemistry analyzer.

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Ferric Nitrate Nonahydrate	50 mmol/L
Mercuric Thiocyanate	2 mmol/L
Nitric Acid	103 mmol/L
Surfactant	

CAUTION: DART CHLORIDE reagent contains an acid and a mercury compound and is both CORROSIVE and TOXIC. It may cause irritation to skin and eyes. Call a physician if taken internally or if eye contact has occurred, and flush contact surface with water.

PACKAGE CONTENTS:

DART CHLORIDE Reagent 20 x 28 mL

REAGENT PREPARATION: DART CHLORIDE reagent is supplied as a single reagent and is in ready-to-use form.

CALIBRATION PROCEDURE: It is recommended that DART CHLORIDE reagent be calibrated with DART Carbon Dioxide/Chloride Standard and Control Kit (Coulter PN 7546901, CMS PN 233-056).

STABILITY AND STORAGE: Store unopened vials of DART CHLORIDE reagent at controlled room temperature. Refer to expiration date on vial label for shelf life. Opened vials of reagent are stable for at least 72 h at 15°C.

Do not use if the reagent blank has an absorbance greater than 0.450, measured at 520 nm. The reagent blank absorbance of a mixture of 3.0 mL of reagent and 1.2 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are preprogrammed in its test definition for the DACOS chemistry analyzer. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges for DART LIQUITROL or DACOS CONTROL LEVELS I and II while using prescribed calibrators may indicate reagent deterioration.

SPECIMEN HANDLING: Collect whole blood by venipuncture and allow to clot. Centrifuge and remove serum from clot as soon as possible.

Do not use hemolyzed specimens. Assay of fresh serum is recommended. If storage or shipment of specimens is necessary, separate serum from clot and keep refrigerated at 2 to 8°C or freeze.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[4]

EXPECTED VALUES: Determined with samples from an ambulatory population.

General Population = 98 to 110 mmol/L*

Sex	Age (y = years)	Range (mmol/L)
Male	18 y – 39 y	98 – 107*
Female	18 y – 59 y	99 – 111*

*These ranges have been verified on the DACOS chemistry analyzer.

No ranges are quoted for populations outside the above age/sex groups. Samples used were from apparently healthy, ambulatory individuals.

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 70 to 130 mmol/L

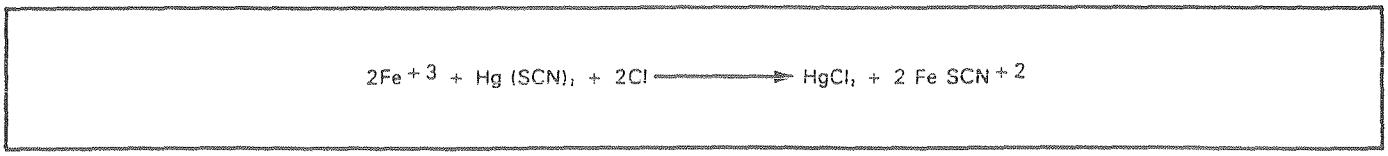

Figure 1 Sequence of Reaction

DART® BILIRUBIN (A+C)+(B)

(MODIFIED WALTERS AND GERARDE)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® BILIRUBIN reagent system is intended for the in vitro quantitative determination of Total and Direct Bilirubin with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: The quantitation of bilirubin is a useful diagnostic indicator for hepatobiliary disorders.

PRINCIPLES OF REAGENT SYSTEM: Bilirubin forms a water soluble azo dyestuff with diazotized sulfanilic acid. Sulfanilic acid forms a diazonium chloride with sodium nitrite in a strongly acidic solution. See Figure 1.

The formation of the diazo dye is different depending on which of the following three bilirubin derivatives is involved (monoglucuronide, diglucuronide, or unconjugated bilirubin).

The optimized DART BILIRUBIN reagent system is a modification of the Walters and Gerarde method.[1]

The bilirubin reactions are as follows:

1. Direct Bilirubin — bilirubin diglucuronides and a part of the bilirubin monoglucuronides give the direct reaction.
2. Total Bilirubin — includes unconjugated bilirubin, bilirubin monoglucuronides, and bilirubin diglucuronides.

Dimethyl sulfoxide (DMSO) is used to solubilize (or accelerate the reaction) of unconjugated bilirubin.

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Reagent A	
Hydrochloric Acid	835 mmol/L
Sulfanilic Acid	34.5 mmol/L
Reagent B	
Dimethyl Sulfoxide	12.6 mol/L
Reagent C	
Sodium Nitrite	348 mmol/L

CAUTION: Reagent A contains hydrochloric acid which is CORROSIVE and may cause irritation or burns to skin and eyes. Flush contact surfaces with water. Call a physician if taken internally.

PACKAGE CONTENTS:

Direct Bilirubin (A + C):	
DART BILIRUBIN Reagent A	19 x 12 mL
DART BILIRUBIN Reagent C	1 x 7 mL
*Total Bilirubin (B):	
DART BILIRUBIN Reagent B	20 x 25 mL

*Total Bilirubin determination also requires the purchase of the Direct Bilirubin (A + C) reagents.

REAGENT PREPARATION: The reagent A + C solution is unstable and must be freshly prepared daily. Transfer 0.36 mL (7 drops) of reagent C into the reagent A vial. Swirl to mix. Reagent B is ready to use.

STABILITY AND STORAGE: Store uponend vials of DART BILIRUBIN reagents A, B, and C at controlled room temperature in subdued light. Refer to expiration dates listed on vial labels for shelf life. The A + C working solution is stable for 24 h at 15°C.

There are no indications of instability and/or deterioration in reagents B and C. However, in reagent A and in the A + C mixture, the formation of a yellow color indicates deterioration; do not use if this occurs. Do not use if the reagent blank has an absorbance greater than 0.043, measured at 550 nm. The reagent blank absorbance of a mixture of 400 µL A + C working solution, 1.0 mL reagent B, and 600 µL DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems. Inability to recover bilirubin results within expected ranges of DART LIQUITROL or DACOS CONTROL LEVEL I and II, while using DACAL® I, II, and III calibrators to calibrate, may indicate reagent deterioration.

SPECIMEN HANDLING: Samples should be analyzed soon after collection, and should not be exposed to direct light.

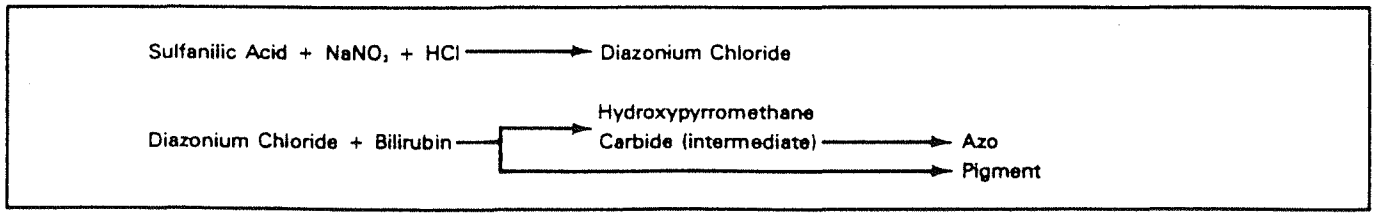

Figure 1 Sequence of Reactions

INTERFERENCES AND LIMITATIONS: (Cont'd)

7. DACAL calibrators are assayed with DART BILIRUBIN (Total) reagent system to obtain good agreement between its results on the DACOS chemistry analyzer and other methodologies. Nonserum based commercial calibrators and controls may exhibit a slight positive bias.

8. It is recommended that patient sera with extreme protein abnormalities, as in the case of multiple myeloma, not be run with this methodology. Positively biased Direct and/or Total Bilirubin results may be produced with these samples, which could also result in Direct Bilirubins reading higher than Total Bilirubin.

9. Direct Bilirubin sera with values higher than the analytical range should be diluted with a protein based solution such as bovine sera, albumin (6% solution), or low human sera.

10. For a comprehensive review of interfering substances, consult Young, DS, et al.: 1975. "Effects of Drugs on Clinical Laboratory Tests."[4]

BIBLIOGRAPHY:

1. Walters M and Gerarde H: 1970. An Ultramicro-Method for the Determination of Conjugated and Total Bilirubin in Serum or Plasma. Microchem J 15: 231.

2. DACOS® Analyzer Product Reference Manual, PN 4235049, PN 4235543, or PN 4235794, Coulter Electronics, Inc., Hialeah, Florida.

3. Publication #PSEP-3: September 1979. Protocol for Establishment of Performance Claims for Clinical Chemical Methods — Replication Experiments. National Committee for Clinical Laboratory Standards, 771 E. Lancaster Ave., Villanova, PA.

4. Young DS, Pestaner LC, and Gibberman V: 1975. Effects of Drugs on Clinical Laboratory Tests. Clin Chem 21(5).

PRODUCT AVAILABILITY:

DART BILIRUBIN Reagent Systems

Direct Bilirubin (A + C)

Reagent A 19 x 12 mL
Reagent C 1 x 7 mL

COULTER #7546926 CMS #257-489

*Total Bilirubin (B)

Reagent B 20 x 25 mL

COULTER #7546927 CMS #257-490

*Total Bilirubin determination also requires the purchase of the Direct Bilirubin (A + C) reagents.

Manufactured by:
COULTER DIAGNOSTICS,
a division of COULTER ELECTRONICS, INC.,
Hialeah, FL 33014

Distributed by:
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DART® PHOSPHORUS A+B

(MODIFIED DALY AND ERTINGSHAUSEN METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® PHOSPHORUS reagent is intended for the in vitro quantitative determination of inorganic phosphorus with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: Observation and quantitation of phosphorus is useful as an aid in the diagnosis of kidney disease, hypoparathyroidism, and some bone diseases.[1]

PRINCIPLES OF REAGENT SYSTEM: In the test reaction, inorganic phosphate complexes with molybdate to form unreduced phosphomolybdate with an absorption maximum at 340 nm. The increase in absorbance is directly proportional to the amount of inorganic phosphorus in the sample. See Figure 1.

The method used by the DART PHOSPHORUS reagent is a modification of the Daly and Ertingshausen method.[2]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagents are diluted by the DACOS chemistry analyzer.

Reagent A
Surfactant and Preservative

Reagent B

Ammonium Molybdate	0.84 mmol/L
Sulfuric Acid	0.32 mol/L

CAUTION: Reagent A is FLAMMABLE; use caution in handling and avoid any open flame. Reagent B contains sulfuric acid and is CORROSIVE. It may cause irritation or burns upon contact with skin and eyes. Flush contact surface with water. Consult a physician if taken internally or if eye contact occurs.

PACKAGE CONTENTS:

DART PHOSPHORUS Reagent A	1 x 6 mL
DART PHOSPHORUS Reagent B	19 x 15 mL

REAGENT PREPARATION: Add five drops of reagent A into a vial of reagent B. Mix thoroughly by gently swirling.

STABILITY AND STORAGE: Store unopened DART PHOSPHORUS Reagents A and B vials in subdued light at controlled room temperature. Refer to expiration date on the vial label for shelf life. The working reagent mixture is stable for at least 72 h when refrigerated at 15°C.

Do not use if the reagent blank has an absorbance outside of the range of 0.0500 to 0.3000 measured at 340 nm. The reagent blank absorbance of a mixture of 2.5 mL reagent and 1.5 mL DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges of DART LIQUITROL or DACOS CONTROL LEVELS I and II, while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: Assay of freshly drawn serum is recommended. If not assayed promptly, or if shipment is required, serum may be stored at room temperature for 8 h, overnight at 2 to 8°C, or frozen for up to one year.[3] Do not use hemolyzed serum. Refer to the Interferences and Limitations section of this package insert.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[4]

EXPECTED VALUES:

General Population = 2.2 to 4.5 mg/dL

Coulter strongly recommends that each laboratory determines its own normal range based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 0 to 15 mg/dL

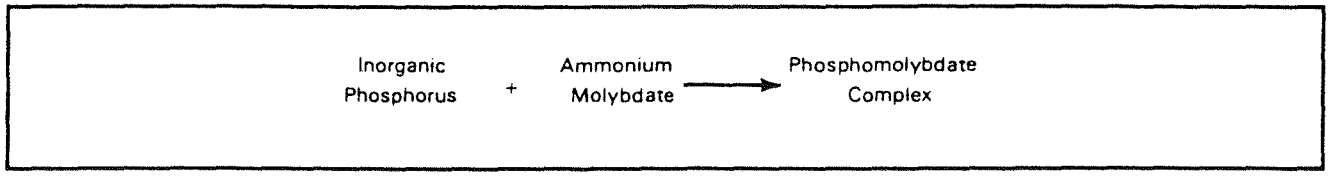


Figure 1 Sequence of Reaction

DART® CALCIU

(MODIFIED CONNERTY AND BRIGGS)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® CALCIUM reagent system is intended for the in vitro quantitative determination of calcium with the DACOS® chemistry analyzer.

CLINICAL SIGNIFICANCE: The quantitation of calcium is useful in diagnosing disorders associated with parathyroid and renal functions. Several other conditions also influence calcium levels including multiple myeloma and leukemia.

PRINCIPLES OF REAGENT SYSTEM: In alkaline solutions, calcium forms a colored complex with o-cresolphthalein complexone proportional to the amount of calcium present. 8-Quinolinol suppresses magnesium interference and a buffer is incorporated to maintain a constant pH. See Figure 1.

The reagent system is based on a modification of the method of Connerty and Briggs.[1]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagents are diluted by the DACOS chemistry analyzer.

Reagent A	
O-Cresolphthalein Complexone	80.2 µmol/L
8-Quinolinol	17.2 mmol/L
Solvent and acid	
Reagent B	
Monoethanolamine	865 mmol/L
Ethylenediamine	879 mmol/L
Surfactant	

CAUTION: Reagent A contains 8-Quinolinol, solvent, and acid. Do not breathe vapor. Avoid contact with skin. Flush contact surface with water. Call a physician if taken internally. 8-Quinolinol is reportedly capable of causing cancer in animals.

PACKAGE CONTENTS:

DART CALCIUM Reagent A	10 x 19 mL
DART CALCIUM Reagent B	10 x 24 mL

REAGENT PREPARATION: DART CALCIUM reagents A and B are supplied in a ready-to-use form.

STABILITY AND STORAGE: Store unopened vials of DART CALCIUM reagents at controlled room temperature in subdued light. Refer to expiration date on vial label for shelf life. Reagents are stable for at least 72 h at 15°C after being opened.

Do not use if the reagent blank has an absorbance greater than 0.3500 measured at 575 nm. The reagent blank absorbance of a mixture of 1.5 mL of Reagent A, 2.0 mL of Reagent B, and 0.4 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges of DART LIQUITROL or DACOS CONTROL LEVELS I and II, while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: Specimens should be serum, free from hemolysis, separated from the clot as soon as possible, and within 2 h of collection. Calcium is not affected in specimens stored at room temperature for up to 8 h, refrigerated overnight, or frozen at −12°C for 1 year. Calcium chelating agents such as EDTA, oxalate, and citrate interfere with calcium assays.[2]

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[3]

EXPECTED RANGE:

General Population = 8.8 to 11.1 mg/dL*

Sex	Age (y = years)	Range (mg/dL)
Male	18 y – 42 y	9.1 – 11.1*
Female	18 y – 43 y	8.6 – 10.9*

*These ranges have been verified on the DACOS chemistry analyzer. No ranges are quoted for populations outside the above age/sex groups. Samples used were from apparently healthy, ambulatory individuals.

Coulter strongly recommends that each laboratory determines its own normal ranges based upon its geographical location and other population characteristics.

ANALYTICAL RANGE: From 4 to 14.0 mg/dL

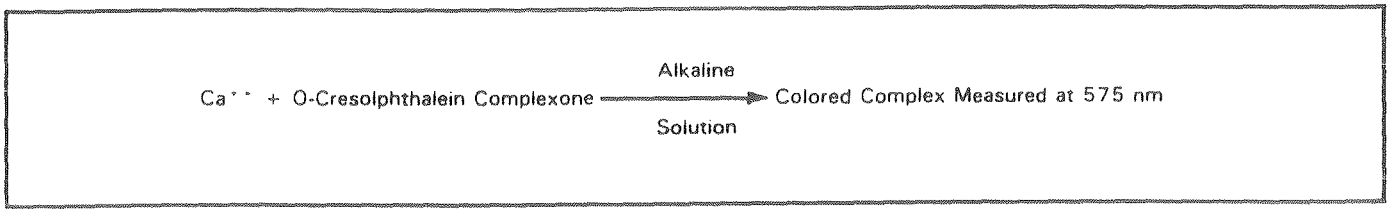


Figure 1 Sequence of Reaction

DART® CARBON DIOXIDE

(ENZYMATIC PEPC METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® CARBON DIOXIDE reagent system is intended for the in vitro quantitative determination of total carbon dioxide with the DACOS® and DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: The quantitation of total carbon dioxide (CO_2) is useful in the evaluation of acid-base status. High total CO_2 may be observed in compensated respiratory acidosis (retention of CO_2) as well as in metabolic alkalosis (increase in bicarbonate). A low total CO_2 may be observed in compensated respiratory alkalosis (loss of CO_2 due to hyperventilation) or in metabolic acidosis (decrease of bicarbonate). Use of additional laboratory tests, such as pH, can differentiate between metabolic and respiratory conditions.[1]

PRINCIPLES OF REAGENT SYSTEM: Serum CO_2 (shown in Figure 1 as bicarbonate, HCO_3^-) and phosphoenol-pyruvate are converted to oxalacetate and phosphate catalyzed by the enzyme phosphoenolpyruvate carboxylase (PEPC). The oxalacetate formed is then reduced to malate with an equimolar amount of NADH being oxidized to NAD^+, catalyzed by the enzyme malate dehydrogenase (MD). The quantitation of total CO_2 can be determined spectrophotometrically by measuring the proportional decrease in absorbance at 340 nm.[1,3,4] The DART CARBON DIOXIDE method is optimized for the DACOS chemistry analyzer.

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Phosphoenol-pyruvate Carboxylase (E.C.4.1.1.31, PEPC)	184 U/L
Malate Dehydrogenase (E.C.1.1.1.37, MD)	2240 U/L
Phosphoenol-pyruvate	3.28 mmol/L
Reduced Nicotinamide Adenine Dinucleotide (NADH)	1.07 mmol/L
Tris (hydroxymethyl) Aminomethane Buffer	80 mmol/L

PACKAGE CONTENTS:

DART CARBON DIOXIDE Reagent	20 x 10 mL

REAGENT PREPARATION: Gently tap each vial of DART CARBON DIOXIDE reagent several times to loosen the contents from the sides of the vial. To each vial add 10.0 mL of water, which meets or exceeds the specifications for NCCLS Type II water.[5] Mix by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened vials of DART CARBON DIOXIDE reagent at 2 to 8°C in subdued light. Refer to expiration date on vial label for shelf life. Reconstituted reagent is stable for 8 h at 15°C, open vial.

Do not use if the reagent blank has an absorbance less than 1.1, measured at 340 nm. The reagent blank may be prepared manually by adding equal volumes of working reagent with DACOS DILUENT, measured on a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are preprogrammed in its test definition for the DACOS chemistry analyzer. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges for control material may indicate reagent deterioration.

SPECIMEN HANDLING: The use of fresh serum is recommended. Evacuated blood collection tubes should be filled completely. The sample should be handled with limited exposure to air. Ammonium hydroxide and tert-butylamine have been recommended as additives for alkalinization of sera to minimize gas exchange; however, do not use preserved sera if the preservative interferes with additional testing.[7,8]

CALIBRATION AND QUALITY CONTROL PROCEDURES: It is recommended that DART CARBON DIOXIDE reagent be calibrated with DART Carbon Dioxide/Chloride Standard and Control Kit (Coulter PN 7546901, CMS PN 233-056). The 10 mmol/L, 25 mmol/L, and 35 mmol/L standards are to be used as calibrators; the 20 mmol/L and 30 mmol/L standards are to be used as controls.

For proper utilization procedures, refer to the DACOS® Analyzer Product Reference Manual.[6]

ANALYTICAL RANGE: From 0 to 40 mmol/L.

TEST PROCEDURE DEFINITION: Refer to the test definition preprogrammed in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Product Reference Manual.[6]

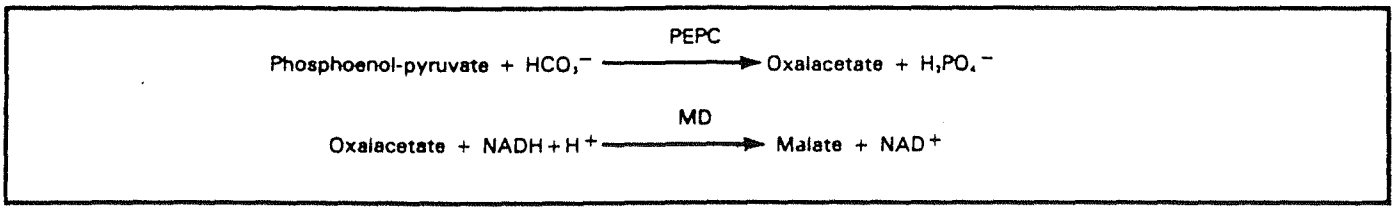


Figure 1 Sequence of Reactions

DART® CHOLESTERO

(ENZYMATIC METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® CHOLESTEROL reagent is intended for use in the in vitro quantitative determination of total serum cholesterol with the DACOS® and DACOS XL analyzers.

CLINICAL SIGNIFICANCE: Although wide fluctuation in total serum cholesterol concentration may occur in some healthy individuals,[1] the quantitation of cholesterol in conjunction with the concentrations of other lipid components is useful in diagnosing hypoproteinemia, hypothyroidism, obstructive jaundice, nephrosis, diabetes mellitus, lipemia, atherosclerosis, malabsorption, malnutrition,[2,3] and normal pregnancy.[4,5]

PRINCIPLES OF REAGENT SYSTEM: In this reaction cholesterol is oxidized and simultaneously hydrogen peroxide is formed. The oxidative coupling of 4-aminoantipyrine and 3,5-dichloro-2-hydroxybenzenesulfonic acid in the presence of hydrogen peroxide and peroxidase produces a chromogenic quinoneimine dye. The absorbance of the chromogen at 520 nm is directly proportional to the concentration of total cholesterol in the sample. See Figure 1.

Richmond developed an enzymatic procedure which used cholesterol oxidase to oxidize serum cholesterol to Δ 4-cholesten-3-one and hydrogen peroxide.[6] Allain et al. later developed a totally enzymatic technique in which hydrogen peroxide formed during the oxidation of cholesterol is used in conjunction with peroxidase, 4-aminoantipyrine and phenol to form a quinoneimine dye.[7] The method used by the DART CHOLESTEROL reagent employs 3,5-dichloro-2-hydroxybenzenesulfonic acid, in place of phenol, to produce a quinoneimine dye with greater absorbance at 520 nm.

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS analyzer.

4-Aminoantipyrine	1.3 mmol/L
3,5-Dichloro-2-Hydroxybenzenesulfonic Acid Na_2	11.2 mmol/L
Sodium Cholate	10.5 mmol/L
Peroxidase	96,000 U/L
Cholesterol Esterase	1040 U/L
Cholesterol Oxidase	224 U/L
Buffers	480 mmol/L

CAUTION: Contains 3,5-dichloro-2-hydroxybenzenesulfonic acid; do not pipet reconstituted reagent by mouth as the effects are unknown.

PACKAGE CONTENTS:

DART CHOLESTEROL Reagent	20 x 20 mL

REAGENT PREPARATION: Gently tap each vial several times to loosen contents from the sides of the container. To each 20-mL vial of reagent, add 20.0 mL of water (room temperature 25°C and above) which meets or exceeds the specifications of NCCLS Type II water.[8] ***Immediately mix each vial by gently swirling and inverting, to avoid foaming, until completely dissolved. Failure to dissolve the reagent as directed may result in an incompletely dissolved reagent and an irreversible precipitate.***

STABILITY AND STORAGE: Store unopened DART CHOLESTEROL reagent vials in subdued light at 2 to 8°C. Refer to expiration date on vial label for shelf life. Reconstituted reagent is stable for at least 96 h when refrigerated at 2 to 8°C or 72 h at 15°C.

If the dry reagent appears moist, or any color other than white or off-white, the product may have deteriorated. Do not use if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance greater than 0.150 measured at 520nm. The reagent blank absorbance of a mixture of 2.0 mL of reconstituted reagent and 1.2 mL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges for DART LIQUITROL or DACOS CONTROL LEVEL I and II, while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: It is recommended that fresh serum be assayed. However, frozen samples are stable for five years at −20°C.[9] Mix refrigerated or frozen samples thoroughly prior to assay.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® or DACOS XL Analyzer Product Reference Manual.[10]

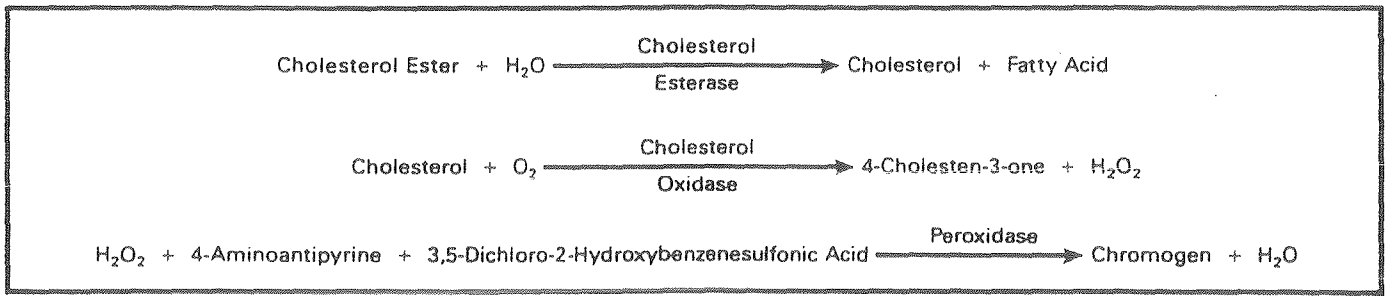


Figure 1 Sequence of Reactions

DART® GAMMA-GT A+B

(MODIFIED SZASZ METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® GAMMA-GT reagent system is intended for the in vitro quantitative determination of gamma-glutamyl transpeptidase (GGT) enzyme activity in serum with the DACOS® and the DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: Elevated levels of GGT have been reported in serum from patients with disease of the liver, biliary tract, and pancreas, and with certain neurological diseases and burns.[1,2] Alcohol and certain other drugs, such as barbiturates, cause GGT elevation.[3] Elevated GGT levels also have been observed in patients with myocardial infarction and diabetes mellitus.[4]

PRINCIPLES OF REAGENT SYSTEM: The enzyme gamma-glutamyl transpeptidase catalyzes the transfer of glutamyl from L-gamma-glutamyl-p-nitroanilide to glycylglycine. As the glutamyl combines with glycylglycine, an equimolar amount of p-nitroaniline is generated. GGT activity is measured as the rate of absorbance change at 420 nm. See Figure 1.

This optimized DART GAMMA-GT method is a modification of Szasz's method.[5]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Reagent A	
Glycylglycine	908 mmol/L
Sodium Azide	0.040%
Tris (Hydroxymethyl) Aminomethane Buffer	
Reagent B	
L-Gamma-Glutamyl-p-Nitroanilide	12.2 mmol/L

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

FOR IN VITRO DIAGNOSTIC USE

PACKAGE CONTENTS:

DART GAMMA-GT Reagent A	10 x 7 mL
DART GAMMA-GT Reagent B	10 x 14 mL

REAGENT PREPARATION: Gently tap each vial of DART GAMMA-GT reagent several times to loosen contents from the sides of the container. To each vial of reagent A add 7.0 mL of water, and to each vial of reagent B add 14.0 mL of water which meets or exceeds the specifications of NCCLS Type II water.[6] Immediately mix each vial by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened vials of DART GAMMA-GT reagents A and B in subdued light at 2 to 8°C. Refer to expiration dates on vial labels for shelf life. Reconstituted reagent solutions are stable for at least six days when stored at 2 to 8°C and three days when stored at 15°C.

Do not use if the dry reagent appears moist or if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance greater than 0.850 measured at 420 nm. The reagent blank absorbance of a mixture of 800 µL of reagent A and 2.0 mL of reagent B and 400 µL of DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges for DART LIQUITROL or DACOS CONTROL LEVELS I and II, while using DACAL® I, II and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: Test specimens should be sera, collected in the usual manner for enzyme analysis. The stability of GGT activity in serum has not been well characterized; however, GGT activity loss is minimized by refrigerated storage for up to seven days. Frozen storage minimizes loss for longer periods.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Reference Manual.[7]

ANALYTICAL RANGE: From 0 to 1300 U/L at 37°C

INTERFERENCES AND LIMITATIONS:

1. Administration of phenobarbitone, phenytoin, methaqualone, amylobarbitone, dichloroalphenazone, phenazone, quinalbarbitone and nitrazepam can cause a false elevation in GGT activity in serum.
2. Heavy alcohol consumption can cause a false elevation of GGT activity in serum.
3. Hemolysis of 500 mg/dL (red cell lysate) can cause a reduction in the recovery of results which can exceed 10%.
4. Bilirubin up to 20 mg/dL (crystalline) does not cause a clinically significant interference.
5. Heavy turbidity up to 8.0 absorbance, measured at 700 nm, does not interfere with GGT determinations.
6. For a comprehensive review of interfering substances, consult Young, DS et al.: 1975. "Effects of Drugs on Clinical Laboratory Tests."[8]

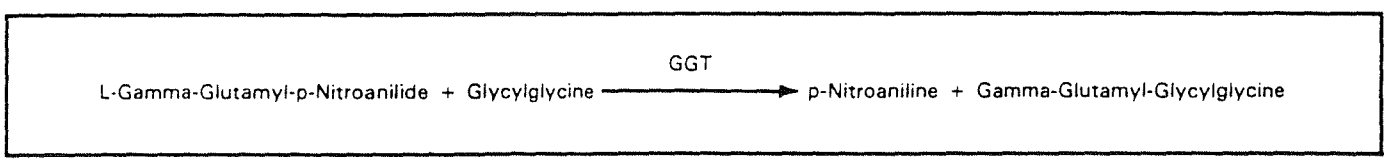


Figure 1 Sequence of Reaction

DART® GLUCOS

(MODIFIED CDC NATIONAL REFERENCE METHOD)

FOR IN VITRO DIAGNOSTIC USE

INTENDED USE: Coulter DART® GLUCOSE reagent is intended for the in vitro quantitative determination of glucose in serum with the DACOS® and the DACOS XL chemistry analyzers.

CLINICAL SIGNIFICANCE: The quantitation of glucose is chiefly used to detect diabetes mellitus. Elevated glucose levels can also result from adrenal, pituitary, or thyroid hyperactivity, and pheochromocytoma. Abnormally low glucose levels (hypoglycemia) can result from excessive insulin administration, pancreatic or other tumors, liver disease, and adrenal, pituitary, or thyroid hypoactivity. [1,2]

PRINCIPLES OF REAGENT SYSTEM: Hexokinase (HK) catalyzes the reaction of glucose with adenosine-5'-triphosphate (ATP) to produce D-glucose-6-phosphate and adenosine-5'-diphosphate (ADP). D-glucose-6-phosphate is then oxidized by glucose-6-phosphate dehydrogenase (G-6-PD) to 6-phosphogluconate with the reduction of nicotinamide adenine dinucleotide (NAD^+). This increase in absorbance at 340 nm is proportional to the glucose concentration in the sample. See Figure 1.

The optimized DART GLUCOSE reagent method is a modified Hexokinase/Glucose-6-Phosphate Dehydrogenase procedure, a National Glucose Reference method.[3]

ACTIVE INGREDIENTS: The values listed are the vial concentrations obtained before the reagent is diluted by the DACOS chemistry analyzer.

Magnesium (Mg^{++})	3.4 mEq/L
Adenosine-5' -Triphosphate (ATP)	1440 µmol/L
Oxidized Nicotinamide Adenine Dinucleotide (NAD^+)	2219 mmol/L
Hexokinase (E.C.2.7.1.1, HK)	1440 U/L
Glucose-6-Phosphate Dehydrogenase (E.C.1.1.1.49, G-6-PD)	1440 U/L
Tris (Hydroxymethyl) Aminomethane Buffer	160 mmol/L
Sodium Azide	0.016%
Stabilizers	

WARNING

Contains sodium azide. Sodium azide may react with lead and copper plumbing to form highly explosive metal azides. On disposal, flush with a large volume of water to prevent azide build-up.

FOR IN VITRO DIAGNOSTIC USE

PACKAGE CONTENTS:

DART GLUCOSE Reagent	20 x 24 mL

REAGENT PREPARATION: Gently tap each vial of DART GLUCOSE reagent several times to loosen contents from sides of container. Add 24.0 mL of water which meets or exceeds the NCCLS specifications for Type II water.[4] Immediately mix by gently swirling and inverting, to avoid foaming, until contents are completely dissolved.

STABILITY AND STORAGE: Store unopened DART GLUCOSE reagent vials in subdued light at 2 to 8°C. Refer to the expiration date on the vial label for shelf life. The reconstituted reagent is stable for at least six days at 2 to 8°C, or 72 h at 15°C.

Do not use if the dry reagent appears moist or if the reconstituted reagent becomes turbid. Do not use if the reagent blank has an absorbance greater than 0.150, measured at 340 nm. The reagent blank absorbance of a mixture of 2.0 mL reconstituted reagent and 1.5 mL DACOS DILUENT may be measured in a spectrophotometer against water in a 1 cm light path cuvet. This reagent blank absorbance check is an independent procedure. Therefore, its limits are not always identical to the absorbance limits of the reagent blank (first level calibrator) which are programmed in the test definition. This check is provided as a means to separate reagent problems from instrument problems.

Inability to recover results within the expected ranges of DART LIQUITROL or DACOS CONTROL LEVEL I and LEVEL II while using DACAL® I, II, and III calibrators to calibrate may indicate reagent deterioration.

SPECIMEN HANDLING: The use of fresh serum is recommended. To avoid loss of glucose by glycolysis, the sample should be separated from the clot immediately. The requests of the physician (for example, fasting, postprandial, glucose tolerance) must be strictly adhered to for the results to be of diagnostic value.

TEST PROCEDURE DEFINITION: Refer to the preprogrammed test definition located in the system for this reagent. For operating instructions, refer to the DACOS® Analyzer Reference Manual.[5]

ANALYTICAL RANGE: From 0 to 800 mg/dL

INTERFERENCES AND LIMITATIONS:

1. All materials which come in contact with reagent and samples should be kept clean and free of contamination by heavy metals, detergents and other chemicals.
2. No interference in recovery of values from hemolysis up to 500 mg/dL.
3. No interference in recovery of values from total bilirubin up to 20 mg/dL or direct bilirubin up to 10 mg/dL.
4. No interference in recovery of values from turbidity up to an absorbance of 8, measured at 700 nm.

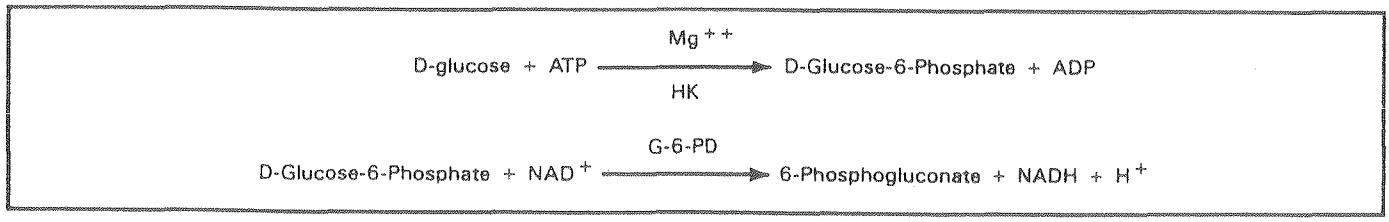


Figure 1 Sequence of Reactions

STAT PROCEDURE FOR DART® GLUCOSE

INTENDED USE: When used with DART GLUCOSE reagent on the DACOS chemistry analyzer with the DART GLUCOSE reagent test definition, STAT procedure (PN 7595155), this procedure is intended for a faster in vitro quantitative determination of glucose in serum.

PRINCIPLES OF STAT TEST DEFINITION: By using fewer data collection points than the standard procedure, results can be available faster.

PROCEDURE: Refer to the preprogrammed STAT test definition in the system for this reagent. The STAT procedure requires subordinate calibration from the standard procedure. For operating instructions, refer to the DACOS Analyzer Reference Manual.[5]

The STAT procedure uses subordinate calibration and fewer data points. Therefore, the Parent test definition (Standard procedure) must be calibrated before the Subordinate test definition (STAT procedure) is run. We recommend that tests be calibrated (F2) before samples are run.

PERFORMANCE CHARACTERISTICS: The performance characteristics of the STAT procedure are equivalent to those of the standard method with the following exceptions:

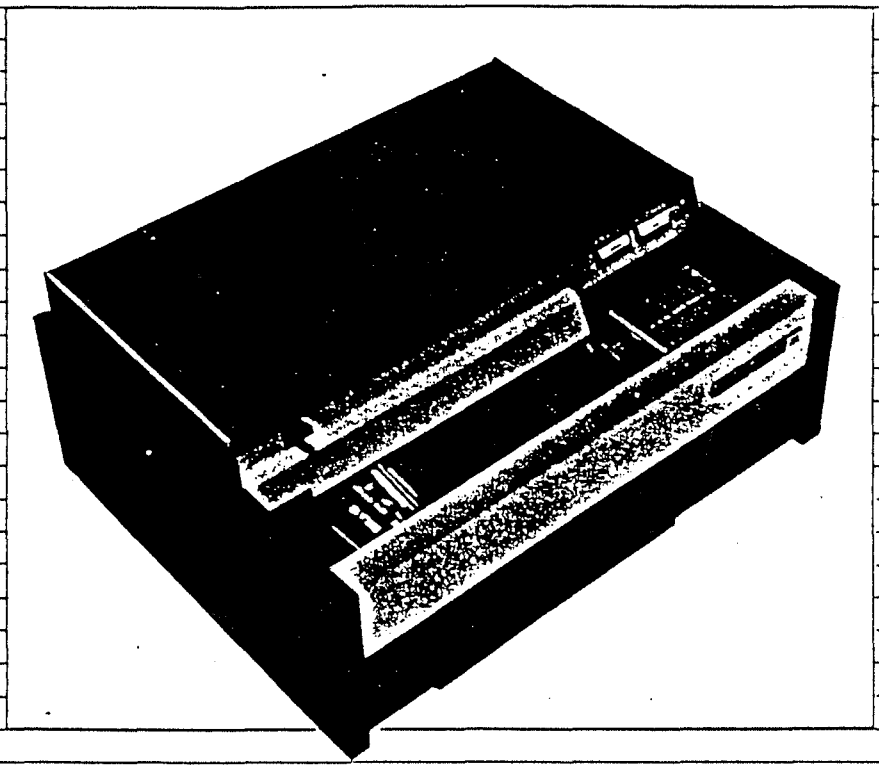
ANALYTICAL RANGE: From 0 to 400 mg/dL

CORRELATION TO CURRENT TEST DEFINITION:

DART STAT GLUCOSE (Y axis) vs current DART GLUCOSE (X axis); performed on DACOS chemistry analyzer.

No. of Samples = 155
Correlation Coefficient(r) = 0.998
Linear Relationship by Least Squares:
Slope = 0.985
Intercept = 0.95 mg/dL
Test Range:
Current DART GLUCOSE = 54 – 357 mg/dL (Mean = 58.17)
DART STAT GLUCOSE = 54 – 353 mg/dL (Mean = 57.38)

HEMA-TEK®
Slide Stainer



for automated differential staining

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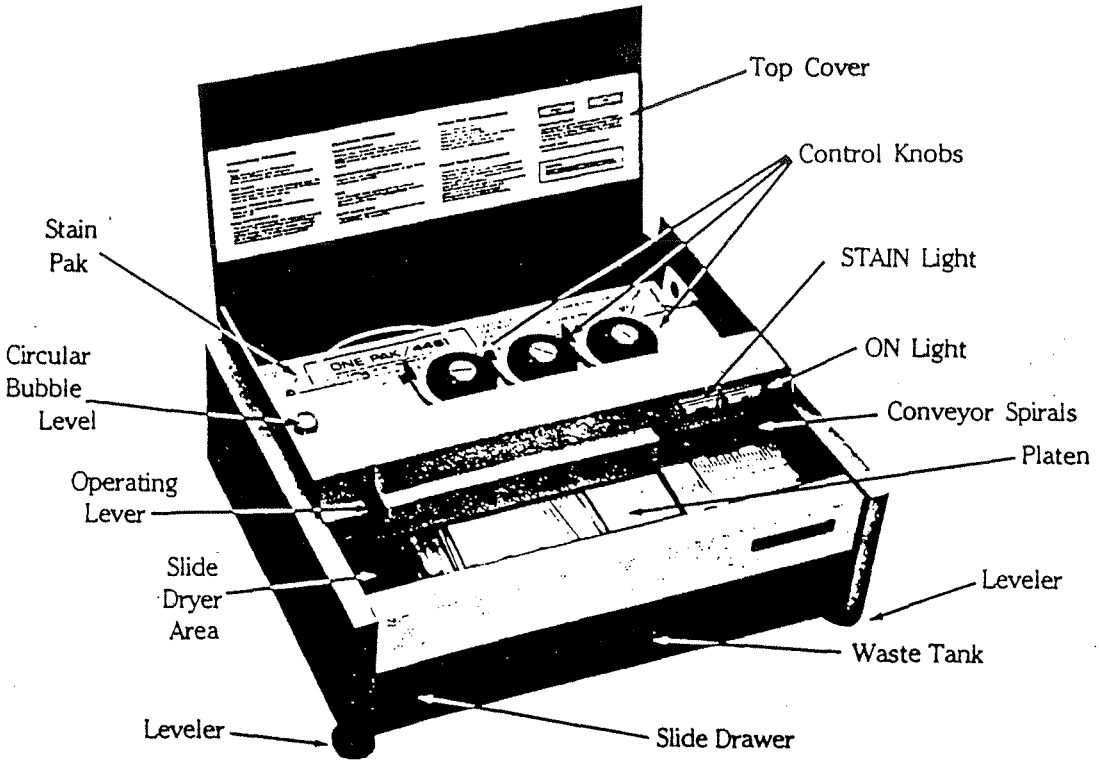


The automated Hema-Tek® Slide Stainer is designed to continuously and economically produce stained blood films of high quality using Hema-Tek Stain Pak at a rate of one slide per minute. Consistent staining, with virtually no waste, is achieved by the proper dispersal of measured volumes of stain, buffer and rinse. Hema-Tek Slide Stainer is simple and convenient consisting of two slide conveyor spirals, a stain platen and three controlled solution pumps. The spirals move slides from the slide-loading area across the length of the platen. The slides undergo staining, buffering, rinsing and air drying, and are finally delivered into a slide drawer as finished stained slides, ready to use. All solutions, controls, waste collection, and functions are self-contained, eliminating the mess of manual staining techniques.

Conveyor Spirals

Two gear driven conveyor spirals rotate in opposite directions while maintaining proper rotational phase. The slides are held first in a vertical plane and then moved horizontally across the platen.

Platen

The platen is located between the conveyor spirals and forms part of the conveyor system. Raised edges on the platen support the slides at all times during the staining process. The platen is precision formed to maintain a precise capillary volume for various solution introductions and provides a mixing system for the stain and buffer. The platen edges extend past the staining area to allow drying of the slides before they are collected in the slide drawer. A drain trough removes used solutions from the platen to a waste tank below for convenient disposal.

Solution Pumps

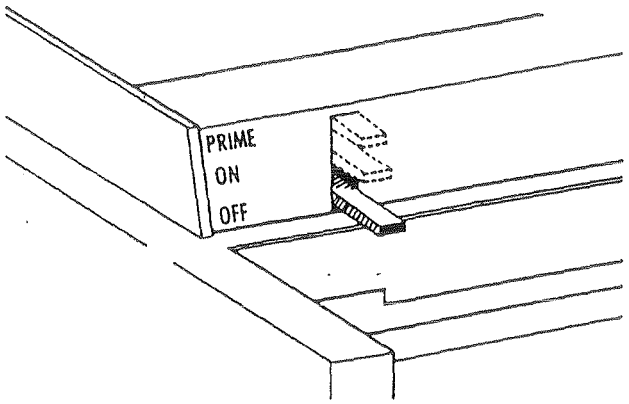
The volume control knobs for three peristaltic solution pumps are accessible when the top cover of the instrument is open. The pumps are interchangeable with each other. The volume of solution being delivered may be varied by rotating the black pump control knob. The blue line on the aluminum hub serves as a reference for pump settings. Rotating the knob in the plus (+) direction increases the volume; rotating in the minus (-) direction decreases the volume.

Pump Control System

The pumps are synchronized to slide position by cam operated switches inside of the right end panel. Connected in series with each cam switch is a sensing switch with a finger projecting into the rear gutter of the platen. As a slide moves along the platen, it operates this sensing switch which in turn energizes the cam switch. After the slide passes, the sensing switch returns to its normally off position until another slide comes along. There is one sensing switch and one cam switch for each pump. The sensing switches are located at the beginning of the platen areas they control.

Operating Lever

This is a multiple function black lever at the left on the instrument. Three positions of the lever control the Slide Stainer as follows:



(1) *OFF Position.* When the lever is in the lower position, the instrument is electrically turned off. The pump arms are pulled away from the pump rotors and the pump tubes are free of compression. When the instrument is off, solutions in the pump tubes siphon back into the Stain Pak.

(2) *ON Position.* The middle position of the lever turns the machine ON for normal operation. In the ON position the pump arms compress the tubing against the pump rotors.

(3) *PRIME Position.* In the top position all normal functions continue except that the pumps run continuously to prime the solutions to the platen area. By holding the operating lever in this position all air bubbles are expelled in the tubing. When this is completed and the lever is released, it returns to the ON position for normal use.

ON Light

The ON light glows as soon as the operating lever is moved to the ON or PRIME positions. It indicates that electrical power is applied and the machine is running.

STAIN Light

The STAIN light glows when the Stain Pak contains an adequate stain supply. When the Stain Pak needs replacement, the STAIN light goes off. Enough reserve stain remains to process approximately 20 slides before the solutions become exhausted.

Waste Tank

A waste tank collects the used solutions which drain from the platen. This tank should be emptied daily and at replacement of each Hema-Tek Stain Pak. The waste tank slides out from the front of the instrument.

Slide Drawer

This drawer receives the finished slides from the platen. It is located at the lower left of the instrument and slides out from the front of the instrument. When removing, it should be kept level so as not to spill the slides.

Levelers

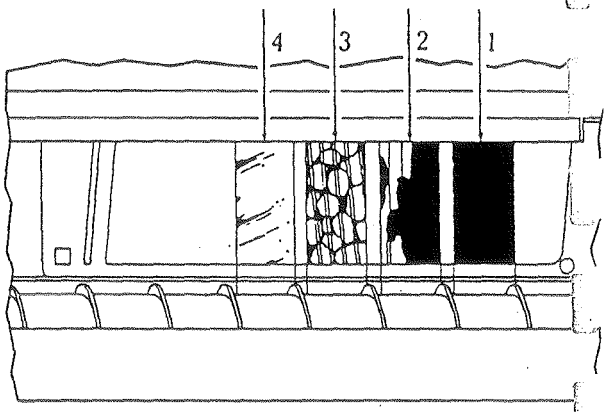
Two grooved knobs or levelers located below e[illegible] front corner of the instrument may be adjusted to r[illegible] or lower the instrument to a level position. The ci[illegible]ular bubble level (under top cover, to left of volume control knobs) will indicate when the levelers h[illegible] been properly adjusted and the instrument is leve[illegible]

Stain-Pak

Hema-Tek Stain Pak consists of three bottles cont[illegible] ing a polychrome methylene blue stain, buffer and rinse solutions. One Stain Pak provides enough solutions to stain and fix 1000 blood film preparations. Stain Pak is inserted in the well at the rear of [illegible] instrument. It rests on a spring-loaded tray which activates a switch connected to the stain light. As long [illegible] there is an adequate supply of Stain Pak solutions, [illegible] stain light glows.

INSTRUMENT FUNCTION

The operation of Hema-Tek Slide Stainer is simp[illegible]. Two conveyor spirals are utilized to convey 25 slides face down over a platen. Three sensing switch[illegible] trigger sequentially to activate three solution pum[illegible] which meter and deliver a special stain, buffer and rinse into the capillary space between the blood film and platen. The diagram shows this progression.



Zone 1 - Slide properly in contact with stain.
Zone 2 - Introduction of buffer to stain; mixing begins.
Zone 3 - Mixing action continues.
Zone 4 - Mixing action completed. Slide properly contacting stain-buffer mixture.

When the lid of the instrument is raised, the thr[illegible] volume control knobs are accessible. The volume of solution being delivered can be adjusted (i.e. increas[illegible] or decreased) by rotating the respective control kn[illegible] clockwise (+ toward blue line) or counterclockwise (- toward blue line). High-quality staining results wi[illegible] be assured if the pump volumes are correct since t[illegible] time phases are constant. A small change in the stai[illegible] buffer ratio can lighten or darken staining. A stain/buffer ratio of not less than 1 part stain to 2 parts buff[illegible] (i.e. 1:2 stain/buffer) has been found to provide t[illegible] proper ratio needed for optimum staining perfor[illegible] mance. In addition, rinse solution volume is approximately 1 ml/slide.

Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
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PROTOCOLS FOR MEASURING MIXED FUNCTION OXYGENASES OF FISH LIVER

P.V. Hodson, P.J. Kloepper-Sams, K.R. Munkittrick, W.L. Lockhart, D.A. Metner, P.L. Luxon, I.R. Smith, M.M. Gagnon, M. Servos and J.F. Payne

Physical and Chemical Sciences Branch
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1991

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M. Servos[3] and J.F. Payne[7]

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ABSTRACT

Hodson, P.V., P.J. Kloepper-Sams, K.R. Munkittrick, W.L. Lockhart, D.A. Metner, L. Luxon, I.R. Smith, M.M. Gagnon, M. Servos and J.F. Payne. 1991. Protocols for measuring mixed function oxygenases of fish liver. Can. Tech. Rep. Fish. Aquat. Sci. 1829: 49 p.

This document was prepared in response to requirements for protocols under Environmental Effects Monitoring (EEM) Programs proposed as part of revisions to Canada's Pulp and Paper Effluent Regulations of the Federal Fisheries Act (1991). Field research programs in Scandinavia and North America consistently demonstrated that activity of liver mixed function oxygenase (MFO) enzymes of fish reflected exposure to chemical inducers associated with effluents from pulp mills using chlorine bleaching. Induction of activity was strongly correlated to other important effects on fish and fish populations. Since the measurement of MFO activity was a logical addition to EEM programs, a workshop sponsored by the Department of Fisheries and Oceans and by Environment Canada was convened at the Freshwater Institute, Winnipeg, Manitoba, in November, 1990 to review the theoretical and practical aspects of MFO measurements. The participants agreed that measurements of MFO activity were suitable and useful indicators of chemical contamination from pulp mills using chlorine bleaching, and that a practical protocol could be prepared. This protocol is the direct result of that workshop and is intended for use by biologists with laboratory experience in biochemistry. This protocol should not be used in isolation, but should be an integral part of EEM programs, as an early step in tier-testing to direct further studies of chemical contamination and biological impacts.

RÉSUMÉ

Hodson, P.V., P.J. Kloepper-Sams, K.R. Munkittrick, W.L. Lockhart, D.A. Metner, L. Luxon, I.R. Smith, M.M. Gagnon, M. Servos and J.F. Payne. 1991. Protocols for measuring mixed function oxygenases of fish liver. Can. Tech. Rep. Fish. Aquat. Sci. 1829: 49 p.

Ce document a été préparé pour le Programme de Surveillance des Effets sur l'Environnement des rejets d'usines de pâte et papier. Ce programme a été entrepris lors du processus de révision des Règlements sur les Effluents de Pâte et Papier de la Loi Fédérale sur les Pêches (1991). Différents programmes de recherche, en Scandinavie et en Amérique du Nord, ont démontré fréquemment et sans exception une augmentation de l'activité des enzymes hépatiques d'oxydase de fonction multiple (OFM) chez les poissons exposés aux effluents d'usine de pâte et papier avec blanchiment au chlore. Cette induction de l'activité enzymatique est fortement associée à d'autres effets importants chez les poissons et les populations de poissons. Comme la mesure de l'activité des OFMs est une composante logique d'un programme de surveillance des rejets de pâte et papier, le Ministère des Pêches et des Océans et Environnement Canada ont organisé un atelier ayant comme objectif d'examiner de façon critique les aspects théoriques et pratiques des mesures d'activité des OFMs. Cet atelier a eu lieu à l'Institut des Eaux Douces, à Winnipeg, en Novembre 1990. Les participants ont reconnu l'utilité et la pertinence des mesures de l'activité des OFMs comme indicateurs de la contamination par des effluents de pâte et papier avec blanchiment au chlore et ont proposé de préparer un protocole décrivant les méthodes de mesure des OFMs. Ce protocole est donc un résultat direct de cet atelier. Il a été conçu pour être utilisé par des biologistes avec de l'expérience de laboratoire en biochimie. Ce protocole ne devrait pas être utilisé comme unique méthode de surveillance mais devrait constituer une étape préliminaire au sein d'un programme complet de surveillance de la contamination chimique et des impacts biologiques.

1.0 INTRODUCTION

Monitoring the effects of industrial wastes in receiving waters includes monitoring the responses of fish. Fish are present in most Canadian surface waters and their welfare is relevant to the public, to environmental control, and to sports and commercial fisheries. The measurement of the activity of fish liver detoxication enzymes, the mixed function oxygenases (MFOs), has been proposed as a tool for monitoring the environmental effects of marine petroleum pollution (Addison and Payne 1986). MFO activity has been tested as an indicator of the presence of chemical contamination from urban and industrial development in over 30 field trials (Payne *et al.* 1987), and has been included in the North Sea Monitoring Master Plan (Addison 1991). This document describes the measurement of fish liver MFO activity as a tool for monitoring chemical contamination associated with effluent from pulp mills using chlorine bleaching (Bleached Kraft Mill Effluent or BKME). It includes the biochemistry, toxicology and measurement of the MFO enzymes in fish and it identifies what data should be collected, how they should be collected, and how positive and negative responses should be interpreted.

1.1 Theory

Mixed function oxygenases (also called mixed function oxidases, MFOs, cytochrome P-450s, polysubstrate multifunction oxygenases, PSMOs) are a family of membrane-bound enzymes which increase the water solubility of aromatic and lipophilic compounds (White and Coon 1980). Natural substrates for MFOs include endogenous compounds such as steroid hormones and fatty acids, although they also aid in drug metabolism and the breakdown and excretion of other exogenous compounds (Lu and West 1980; Ryan *et al.* 1979). MFO activity includes various reactions which add molecular oxygen to lipophilic compounds. The terminal oxidase enzyme of the MFO system is the iron-containing hemoprotein cytochrome P-450 (Blumberg 1978); the '450' refers to the wavelength absorption maximum of the reduced form of the cytochrome after complexation with carbon monoxide. One group of cytochrome P-450s, called P-450IA, is 'induced' by the presence of several foreign compounds. That is, in the presence of these foreign compounds, animals synthesize new amounts of P-450IA proteins and enzyme activity is measurably increased.

Induction is initiated when a foreign compound binds to a specific cellular receptor (Poland *et al.* 1976; Perdew and Poland 1988), often called the Aryl hydrocarbon or Ah receptor. Binding triggers the expression of the gene coding for P-450IA leading to increased RNA transcription (Gonzalez *et al.* 1984; Israel and Whitlock 1984) and eventual synthesis of new P-450IA protein. Induction can be detected by measures of several components in the chain of cellular events: P-450IA mRNA, P-450IA protein, or P-450IA enzymatic activity (Nebert and Gonzalez 1987).

While most studies of P-450IA originally concerned mammals, the system is also inducible in fish. Experimental treatments with pure compounds have established that some polynuclear aromatic hydrocarbons (PAH: benzo(a)pyrene, 3-methylcholanthrene) and some chlorinated

aromatic hydrocarbons (co-planar PCBs, chlorinated dibenzodioxins and dibenzofurans) induce liver P-450IA in several species (James *et al.* 1979; James and Bend 1980; Förlin 1980; Gooch *et al.* 1989; Law and Addison 1981; Vodicnik *et al.* 1981; Addison *et al.* 1982; Van der Weiden *et al.* 1990a; 1990b; Muir *et al.* 1990). The ability to induce MFO activity appears to be related to molecular shape, i.e. the co-planarity of connected aromatic rings and the distribution of substituents such as chlorine atoms. Complex mixtures such as Aroclors, petroleum oils, and BKME also have inducing properties (Förlin and Lidman 1981; Melancon *et al.* 1981; Addison *et al.* 1982; Melancon and Lech 1983; Payne *et al.* 1988; Walton *et al.* 1978; Walton *et al.* 1983; Andersson *et al.* 1988; Thomas *et al.* 1989), probably because these mixtures contain specific inducers.

1.2 Interpretation

Induction of P-450 enzymes reliably indicates exposure to compounds with inducing properties. Field studies of P-450IA in fish have focused on oil spills, PAH contamination of sediments and, more recently, BKME (Payne 1976; Elskus and Stegeman 1989; Dunn 1980; Johnson *et al.* 1988; James and Bend 1980; Van Veld *et al.* 1990; Andersson *et al.* 1988; Rogers *et al.* 1989). Scandinavian and Canadian studies of fish captured near sources of BKME have shown dramatic induction of P-450IA-related enzymatic activities when compared with fish from reference sites (Andersson *et al.* 1988; Lindström-Seppä and Oikari 1989; Rogers *et al.* 1989, Sodergren 1989; Munkittrick *et al.* 1991a; Smith *et al.* 1991; Hodson *et al.* 1991; Servos *et al.* 1991). Studies in Canada were of effluents from five bleached kraft mills discharging to Lake Superior, Thunder Bay (Lake Superior), the Athabasca River, the Spanish River and the St. Maurice River. Since PAHs and PCBs are not commonly found in pulp mill effluents, MFO induction may indicate exposure to dioxins and furans, and both have been measured in effluents and the tissues of induced fish (Rogers *et al.* 1989; Hodson *et al.* 1991).

Recent experiments suggest that other compounds in bleached and unbleached mill effluents may also be responsible for induction, but the evidence so far is circumstantial and the identities of the inducing agents are as yet unknown. For example, Munkittrick *et al.* (1991b) observed that inducton in fish caught near a bleached kraft mill disappeared when the plant temporarily ceased operations, suggesting the discharge of an inducer that was not persistent, in contrast to dioxins and furans. Payne and Fancey (1981) observed low levels of induction in both liver and gill of rainbow trout exposed to shavings of wood bark floating in aquaria and they speculated that some turpenoid hydrocarbons may be inducers.

Studies of mills not using chlorine bleaching are lacking in Canada and results of such studies in Scandinavia are conflicting. Swedish studies of mills not using chlorine bleaching indicate no induction (Larsson *et al.* 1988), whereas a recent Finnish study showed the opposite (Lindström-Seppä *et al.* 1991). Since dioxin discharges from pulp mills have been associated in the past with the use of chlorophenolic-treated wood chips, the presence of dioxins in these studies cannot be discounted without analyses of both fish and effluents, and the question of other inducing agents remains open. Nevertheless, detection of MFO induction in fish from areas

contaminated by BKME is a strong argument for surveys of chemicals typical of BKME exposure, in particular for dioxins and furans in fish tissues. Chemical surveys of sediment and fish tissue will help to determine whether the pulp mill is the source of contamination and whether induction was due to the presence of PAHs from combustion or to PCBs from electrical equipment.

The biological significance of P-450IA induction is not completely known. Induction is an adaptive response and can result in the metabolism and excretion of exogenous substrates. Studies demonstrating increases in P-450IA activity have also documented changes in fish performance, including altered steroid hormone profiles, changes in thyroxine and vitamin A metabolism, impairment of the reproductive and immune system, and an increased prevalence of diseases (e.g. Munkittrick *et al.* 1991a; Larsson *et al.* 1988). There has not yet been a demonstration of causal links between altered P-450IA activity and other biochemical responses of fish (e.g. altered hormone profiles); one hypothesis is that both MFO induction and hormone effects are the result of binding by the contaminants to the Ah or other receptors, but are not otherwise related.

The simultaneous occurrance of adverse effects and MFO induction indicates that measures of MFO induction justify further studies of biological impacts. The area in which P-450IA activity is altered is assumed to represent the zone of direct influence of the effluent on fish physiology and performance. The philosophy behind using P-450IA for monitoring populations subject to BKME is one of simple prudence. Induction is one of the easiest and most sensitive responses to detect. If induction can be avoided, presumably other Ah-associated biological responses will also be avoided. If induction is detected, more detailed studies are needed of the survival, growth, reproduction, and bioaccumulation of inducers by the local fish community. It must be recognized, however, that lack of induction does not mean 'no effect' - other effects may be produced by biochemical actions independent of the Ah receptor. Measurement of MFO induction signals only an increased probability of a suite of associated responses.

Induction without measureable levels of chlorinated compounds ('false positive') is also possible if fish have been exposed to PAHs from other industries. In this case, the enzyme activity will reduce levels of PAHs in fish tissues to 'non-detectable' and chemical analysis of sediments will be required to confirm that contamination does not come from the pulp mill, particularly in areas where many industries discharge to the same water body.

In summary, the P-450IA enzyme system is a consistent, simple and economical indicator of exposure to inducing contaminants; its response in fish signals the need for surveys of chemical contamination and more detailed biological studies of effects on fish.

1.3 Caveats

The induction of MFO activity represents a chain of cellular events that includes binding of the inducing compound to the Ah receptor, production of messenger RNA to initiate synthesis of new enzyme proteins, and the action of the enzymes on various substrates. Each step of the chain can now be measured, with varying degrees of difficulty. Currently, the simplest is the measurement of enzyme activity, as described in the appendices to this protocol. However, since this is the last step in the chain, it is the most sensitive to interference; with more steps in a chain, there is a greater possibility of an interference. There are many labs developing methods to measure the quantity of the protein enzyme and of the messenger RNA. Refinement of these techniques could lead to future 'kit' methods that are more sensitive, more reliable, faster and less expensive than the methods described here.

Studies of various species (Table 1) consistently demonstrate that MFO induction reflects chemical exposure. However, species differences in the magnitude of the response are found, and both biological variables (sex, age, spawning status, size, genetic strain) and habitat variables (temperature) may influence the response (Stegeman and Chevion 1980; Koivusaari *et al.* 1981; Luxon *et al.* 1987; Lindström-Seppä 1985; Pedersen *et al.* 1976; Jimenez and Burtis 1989).

The most important biological factor affecting activity is reproduction. While there is little difference between the sexes for immature fish, mature females have slightly lower MFO activities than males, a difference accentuated during spawning when hormones such as estradiol vary dramatically in their concentrations in serum (Förlin and Haux 1985). While differences among treated and control sites can still be seen, increased variability and lower activities may obscure statistical significance. Each species should be sampled during its inter-spawning interval, at least two to six months before spawning, and fish must be carefully selected for a similar size, stage of development, age, sex and feeding activity.

Age and life stage are important co-variates of sexual maturation. They influence the distribution of fish and their diet, and hence their exposure to pulp mill effluent. For example, spawning migrations may control the time spent in the effluent and whether the fish are truly representative of the region in which they are caught. There are also very large species differences in the induction measured during field studies, which may be due to variations in exposure, accumulation or sensitivity to inducers. In a responsive species such as longnose sucker, a five-fold induction is not equivalent to a five-fold induction in species which are less responsive, such as lake whitefish or walleye.

Temperature is an important environmental variable, since the activity of enzyme molecules declines with temperature; less energy is available to drive chemical reactions. Since acclimation or thermal compensation requires time and is species-dependent, temperature may affect both inducibility and MFO activity.

Methods of fish capture, tissue handling and analysis of enzyme activity are potential sources of analytical error, so these factors must be standardized among sites. There appears to be no

Table 1. Species of fish showing MFO induction. This list is restricted to those species reported in papers listed in Section 9.0, References.

	COMMON NAME	LATIN NAME
FRESHWATER		
	Rainbow trout	*Oncorhynchus mykiss*
	Chinook salmon	*Oncorhynchus tshawytscha*
	Lake trout	*Salvelinus namaycush*
	Brook trout	*Salvelinus fontinalis*
	Lake whitefish	*Coregonus clupeaformis*
	Vendace	*Coregonus albinus*
	Carp	*Cyprinus carpio*
	White sucker	*Catostomus commersoni*
	Longnose sucker	*Catostomus catostomus*
	Bluegill	*Lepomis macrochirus*
	European Perch	*Perca fluviatilis*
	Walleye	*Stizostedion vitreum*
BRACKISH		
	Killifish	*Fundulus heteroclitus*
	European Perch	*Perca fluviatilis*
MARINE		
	Scup	*Stenotomus chrysops*
	Cunner	*Tautogolabrus adspersus*
	Winter flounder	*Pseudopleuronectes americanus*
	English sole	*Parophrys vetulus*
	Spot	*Leiostomus xanthurus*

obvious effects of partial suffocation (e.g. by gill netting), electroshocking or capture stress on MFO activity (L.L. Luxon and P.V. Hodson, unpublished data). Prolonged stress may contribute to water retention and enlarged livers, which would bias activity expressed as 'per gram of tissue'. However, measurement of specific activity (i.e. activity per mg of protein in liver extracts) ensures a reliable measurement. An uneven distribution of enzyme activity within livers can contribute to analytical error; either the entire liver must be minced and mixed before analysis to avoid heterogeneity, or subsamples must be taken from the same area of liver in each animal sampled. Other effects due to dissection, tissue storage and assay procedures are alluded to in the detailed methods, and a quality control program is outlined.

The methods presented here have been widely used in research and in pilot monitoring programs. A ring test among ten laboratories using the fluorometric ethoxyresorufin-o-deethylase (EROD)

method (Appendix B) demonstrated that all could separate six induced from six un-induced fish with no overlap or errors, although measures of absolute activities for each fish varied among labs. Therefore, it appears that all labs could identify responses of fish to pulp mill effluent, should they occur (Munkittrick *et al.* 1991c).

In summary, confounding variables such as temperature, fish size, sex, maturity and season must be standardized as much as possible among contaminated and reference sites. Sampling programs should avoid the spawning period of the target species or increase the number of fish sampled. Using these designs in field studies and the specific procedures outlined for each analytical method, the MFO system can successfully detect specific chemical exposures and can indicate whether more costly chemical analyses are needed.

2.0 SAMPLE COLLECTION AND STORAGE

2.1 Study design and choice of fish species

Sampling should include two species, at least one benthivore and one pelagic predator. MFO activity of the benthivore will reflect sediment contamination and MFO activity of the predator will reflect accumulation of inducing compounds through the food chain. Sample size should be based on study design and requirements, but a minimum of 10 to 12 fish per site must be taken and 15 are recommended. Sequential statistical analyses of liver aryl hydrocarbon hydroxylase (AHH) activities of 20 fish showed that running means and standard deviations stabilized only when sample sizes were 10 or more (P.V. Hodson, unpublished data). It is not always possible to collect adequate numbers of both sexes of fish at all field sites, during all seasons. Since there may be differences between sexes for most species, this should be taken into consideration during study design, possibly by restricting sampling to male fish.

Sampling must always include a minimum of one contaminated site and one uncontaminated reference site, but two reference sites are preferable, with one immediately 'upstream' of the source. The reference sites should be chosen to decrease the influence of fish movements and migration. Sampling at two reference sites may not be required if a) fish are prevented by barriers from moving between the upstream and downstream sites, or b) sufficient data are available from other sources to validate the data from one reference site. Where more than one test site is possible, they may be positioned to demonstrate the spread of the effluent in a lake or ocean, or exposure gradients caused by distance or by dilution from tributaries.

There are areas where studies on free-ranging wild fish may not be possible, especially where pulp mills are located adjacent to one another. One solution is to cage fish, with cages distributed among contaminated and reference sites. A number of studies have found that caging fish in pulp mill effluents for periods of up to 30 days does not induce MFO activity to the same extent as in native fish, although induction is often evident (Lindström-Seppä and Oikari 1989). The cause of the difference has not been defined.

2.2 Field sampling procedures

There are several alternatives for sampling: samples may be processed entirely in the field, partially processed in the field and completed in the laboratory, or processed entirely in the laboratory. Although it is possible to conduct the entire assay under field conditions (see Addison and Payne 1986), this is not always necessary or practical. The samples can be stored until transferred to the laboratory, but storage conditions are critical. Freezing and thawing samples cause the loss of 30-40% of the original activity, but the loss of activity is uniform among sites (i.e. that the exposed site will show the same relative induction). Methods for collecting, processing and storing liver samples must be standardized among sites.

Liver must be collected from live fish; MFO activity decreases and variability increases within 15 min of death, depending on external temperature. There are several ways to process samples in the field. Livers must be removed carefully, avoiding the rupture of the gall bladder and contact with bile. Sub-samples taken from one area of the liver or whole livers may be removed intact, and frozen immediately, or rinsed in 0.15 M KCl and minced prior to freezing on dry ice or liquid nitrogen. The advantages of mincing the liver are that the mix represents the average MFO activity throughout the liver, since the activity can vary by < 2 - 3 fold among various parts of the liver. A third alternative is to homogenize directly in the field with a buffer containing glycerol and to freeze the homogenate for lab analysis. EROD activity has been compared between homogenates prepared in the lab and field from portions of the same livers. There was consistently lower activity with field homogenates but the same relative order of activity (M.M. Gagnon, unpublished data; A-M. Prud'homme and J. Bureau, Environment Canada, personal communication; K.R. Munkittrick, unpublished data).

There are reports of MFO inhibition or interference with fluorescence readings and P-450 spectra if traces of bile or blood are present. As a simple precaution after dissection and weighing, the liver must be rinsed immediately with cold 0.15 M KCl to remove traces of blood and bile. For an animal with a simple liver, the severed blood vessels provide a convenient entry for irrigation through the tip of a squeeze bottle. For a multi-lobed liver, the best alternative is external washing. K.R. Munkittrick (unpublished data) found no effects of mincing the liver of white sucker, or of the position within the liver (anterior versus middle or posterior lobes) on EROD activity. However, when the liver was minced prior to freezing, there was a decrease in activity unless the sample was rinsed in KCl.

For tissue storage, all samples must be quick-frozen in liquid Nitrogen or dry ice and stored at -60°C or lower; storage at -20°C is not acceptable, even for a very short period of time. Livers homogenized in the field require more liquid Nitrogen to freeze a given weight of liver due to dilution by buffer. Freezing is most efficient for small portions, e.g. as 2.0 g aliquots in cryovials.

In the laboratory, frozen tissue is thawed, homogenized and centrifuged to separate MFO enzymes from cell debris. The first stage is a low-speed (9000 x g) centrifugation that gives a 'post-mitochondrial supernatant (PMS)', also called S-9 fraction. The second stage is a centrifugation of the S-9 fraction at 100,000 x g, which separates the enzyme in a pellet of microsomes (membrane fragments). Although some authors prefer the use of the microsomal preparation for MFO assays, there is a very strong correlation between MFO activity determined in the S-9 fraction and in the more highly purified microsomes (r^2>0.99). Even though the fluorescence from a microsomal preparation is 3 - 4 x higher than from S-9, the relative amount of induction is similar (K.R. Munkittrick, unpublished data). The lower centrifuge speeds required for S-9 preparations allow production of test material with portable centrifuges. Thus, a fourth alternative is to prepare S-9 fractions in the field from fresh livers, freeze the supernatant in liquid Nitrogen, and analyse enzyme activity in the laboratory. This approach requires more work and equipment in the field but may reduce the loss of activity associated with freezing minced tissues or homogenates.

Microsomal preparations may be frozen at -80°C by resuspension in homogenizing buffer containing 20 % glycerol. Activity remains constant for at least a year and repetitive analyses of multiple frozen aliquots of the same homogenate provides an internal standard as a check on the precision of the chosen method. The amount required per aliquot is the pellet derived from preparing 1 - 2 g of liver.

Details of these procedures are given in Appendix A, Preparation of S-9 fractions and microsomes.

3.0 CHOICE OF MFO ASSAY

There are several methods available for measuring cytochrome P-450IA in fish (details are presented in Appendices B-E). Recent developments include P-450IA protein and mRNA measurement and will be discussed briefly below. The most common methods employ catalytic assays, using substrates that are metabolized in specific ways by the P-450IA enzyme. P-450IA belongs to a gene superfamily (Nebert and Gonzalez 1987) and often shares overlapping substrate specificities with other forms, so substrates other than those described in this protocol must be chosen with care and with knowledge of substrate specificities.

Substrates for P-450IA include benzo(a)pyrene and 2,5-diphenyloxazole (aryl hydrocarbon hydroxylase or AHH assays) and ethoxyresorufin (ethoxyresorufin-o-deethylase or EROD assays). For each substrate, various methods exist, the major ones being radiometric, fluorometric and spectrophotometric. The appendices describe methods used frequently by the authors, although many variants have been published in the literature. For example, the spectrofluorometric EROD assay of Pohl and Fouts (1980) is described, but the version by Lake (1987) gives equivalent results (P. Martel, Pulp and Paper Research Institute of Canada, 570 St. John's Boulevard, Pointe Claire, Québec H9R 3J9, personal communication). Users are encouraged to consult the original references cited for further information on this assay. The choice of assay method depends on each laboratory, considering substrate source (e.g. purity), assay cost, ease and speed of analysis, sensitivity and reliability of the assay. Regardless of the method chosen, certain aspects must be controlled and understood for each species examined to obtain consistent and credible results. These include protein concentration, NADPH concentration, substrate concentration and incubation temperature. Whichever enzymatic analysis is chosen, the limits of detection must be recorded, and the limits will vary among samples according to their protein contents. While detection limits are not as important for high activity samples, they are crucial for samples at or near the limits of detection. As part of quality assurance and quality control (QA/QC), high and low activity "reference" samples must be run to assure consistency in results obtained with unknown samples. QA/QC issues are discussed in section 5.0.

3.1 Other techniques for measuring P-450 expression

Besides enzymatic analysis, other techniques for measuring P-450IA expression include direct protein quantitation and mRNA analysis. Analysis of mRNA is somewhat unwieldy and inappropriate for routine analysis; current technology requires RNA purification and use of a ^{32}P-labelled cDNA probe. However, P-450IA mRNA measurement is essential in situations when enzyme inhibition and/or degradation is suspected at the same time as gene activation (e.g. after high doses of co-planar PCBs). The P-450IA protein measurement is relatively quick and easy in experienced hands. It is inherently more robust than assays of enzyme activity (e.g. it works well even with degraded samples), but requires specific antibodies. An excellent "reagent" antibody exists which is highly specific for P-450IA and which it can detect in mammals, birds, reptiles, and fish (Park *et al.* 1986; Kloepper-Sams *et al.* 1987). Unfortunately, this specific

anitbody is not commercially available, although antibodies against rat P-450IA1 and oligonucleotide probes for rat P-450IA1 RNA are sold by OXYGENE, a company in Dallas, Texas. These reagents have not been tested in studies of MFO induction in fish exposed to pulp mill effluents.

4.0 DATA

4.1 Data requirements - field

MFO measurements are not made in isolation. Aside from associated environmental measurements described in other protocols (e.g. temperature, alkalinity, pH), there are several measurements and samples that must be collected from each fish during the necropsy. These include: total body weight (g), gutted carcass weight (weight (g) after removal of intestines and gonads), gonad weight (g), liver weight (g), fork length (cm), sex, and age (y). In immature fish, sex can be determined histologically from a thin section of gonad preserved in buffered formalin. Age is measured by counting annuli in hard structures such as otoliths and cross-sections of fin rays, cleithra or opercular bones, depending on the species. Use of scales is not recommended for fish greater than 5 y of age.

From these measurements, the condition factor (CF= 100 x (total weight - gonad weight)/length^3), gonadosomatic index (GSI = 100 x (gonad weight/gutted weight)) and liver somatic index (LSI = 100 x liver weight/gutted weight) are calculated. Condition factor is based on gonad-free weight to remove bias due to variations in sexual maturation, and GSI and LSI are based on gutted weight to remove bias due to variable levels of fat in gonads and intestines and variable gonad weight. Correlations should be calculated between enzyme activity and sex, CF, LSI, GSI, weight and age to identify possible bias in MFO results. These factors can help to identify differences in exposure to inducers as a result of sexual maturation and habitat selection by different sizes of fish. Bias would indicate the need for stratified sampling and factorial analyses of variance to compare activity among sites.

Other important observations are unusual coloration or lumps in the liver, or other obvious pathology in other tissues. These measurements are the bare minimum, and if there are associated studies on fish population structure, many more could be added.

Where *post-hoc* confirmation of MFO induction by chemical analyses is possible, samples should be taken of sediments and fish tissue (usually whole carcass and liver) and they should be deep frozen as quickly as possible in contaminant-free plastic bags or aluminum foil rinsed in ultra-pure hexane. Analyses for trichloroguaiacols (ug.kg^{-1}) and chlorinated dioxins and furans (ng.kg^{-1}) would reflect exposure to BKME and the presence of chemical gradients, and would help to confirm that responses were due to pulp mills and not to other industrial effluents.

4.2 Protein content of the liver

Since measurements of MFO activity are an expression of the catalytic activity of protein molecules, it is expressed as 'specific activity', i.e. activity per mg of protein in the microsomal or S-9 preparation. The total protein content of either the microsomal fraction or the S-9

fraction, whichever is used for the MFO determinations, must be measured using established protein assays with bovine serum albumin as a standard.

An option is to measure the amount of P-450 protein (Appendix F) to calculate the 'turnover number', i.e. activity per nmol P-450 protein or the ratio of substrate molecules metabolized per molecule of enzyme. Turnover numbers may be misleading since P-450s are a family of proteins that include many different enzymes. Since some inducers may inhibit P-450IA, induce other P-450 enzymes, or change the protein or lipid content of liver, the turnover number may not reflect induction. However, a comparison of specific activities and turnover numbers among sites may help to identify mechanisms of toxicity. Total cytochrome P-450 content can be measured using a scanning spectrophotometer (Appendix E).

The total capacity for liver MFO metabolism can be calculated by multiplying the specific activity by the mg of microsomal protein per g of liver (protein yield) to give activity per gram of liver. Activity per liver (activity per gram multiplied by the total weight of the liver) can also be calculated, but it is subject to bias caused by differences in fish size among sites, unless fish are selected for a uniform weight or a correction is applied for relative liver weight by normalizing fish weights to a common value.

4.3 Statistics

Assuming that at least five fish have been caught at each site (10-15 is the ideal), the data must be analyzed statistically following the study design. It is a general phenomenon that biological data are not distributed normally, but are skewed towards higher values. All data must be tested for normality and homogeneity of variance before applying statistical tests appropriate for the study design. One simple indicator of non-linearity is that variance is proportional to the mean. Data that fail these tests can usually be normalized by a log transformation so that all statistical analyses are carried out on transformed data. Means should be re-transformed to their original units to facilitate the interpretation of the results. An alternative is non-parametric statistical analysis.

The appropriate analysis for comparing responses among sites where sex or some other variable may also have an effect, and where sample sizes are often unequal, is analysis of variance (ANOVA) following the general linear model. The sex effect on MFO activity is seasonal. If it is non-significant during the inter-spawning interval, it may be omitted from the model to give more power to the ANOVA.

Where ANOVAs have been applied, differences among sites should be tested with an appropriate multiple range test such as Tukey's Test. A more sensitive alternative is to apply a priori contrast tests (Hoke *et al.* 1990). These are fixed comparisons (e.g. control vs test sites) built into the ANOVAs to test specific hypotheses about increased MFO activity downstream of a suspected source of inducers. All differences and effects should be tested at a 95% probability level. If preliminary estimates of variance are available, the minimum sample size to detect a

given difference (usually doubling of enzyme activity) and the probability of failing to detect a real difference (Type II error) should be calculated in advance as an aid to the study design. Where activity is significantly elevated above reference levels, the degree of induction must be calculated as the ratio of mean activities at treated sites to that at the reference site.

4.4 Definition of a response

There are no absolute or 'correct' values for MFO activity of fish. The AHH and EROD activities of white sucker from reference sites are usually less than 1.5 FU.mg^{-1} protein in a 20 minute incubation for AHH and less than 10 pmol.mg protein^{-1}.min^{-1} for EROD in the S-9 fraction or 30 pmol.mg protein^{-1}.min^{-1} for the microsomal fraction. In contrast, these values may encompass the activities of induced fish of other species. Therefore, the best basis for judging the influence of an effluent is not the absolute activity, but the pattern of responses among contaminated and reference sites. Assuming that sufficient fish have been captured and analyzed at a minimum of one reference and two or more contaminated sites, an MFO response will be significant if criterion (a) and either criteria (b) or (c) are met:

a. Activity is significantly higher at contaminated sites relative to reference sites ($p<0.05$). Induction of activity by 10 to 40-fold is not uncommon when contaminated sites are compared to reference sites.

b. There is a decrease in activity with distance from the source of the effluent, suggesting an 'exposure-response' relationship due to dilution or transformation of the inducer. A difference could be seen within a short distance if there is dilution by a major tributary or if the effluent enters an open lake, estuary or marine ecosystem (e.g. Munkittrick *et al.* 1991a). In a river with no major tributaries, the minimum distance downstream between stations should be about 30 km or below a major obstruction to fish migration (e.g. Hodson *et al.* 1991). For shorter distances, the gradient may be so shallow that it is difficult to detect.

c. The MFO response is consistent between sexes of the same species, consistent among two or more species, or consistent among repeated surveys.

4.5 Presentation

All raw data must be presented along with means, standard deviations, sample sizes, and results of all statistical tests of comparisons among sites and correlations among variables. Where reference samples have been analyzed as an internal standard, the mean and standard deviation of the current results must be presented and compared with previous assays. Presentations of means and standard deviations in bar charts, showing reference and contaminated sites, are very helpful in understanding the results. The data must also be summarized in writing and any

difficulties with sample collection and analysis must be described and interpreted, as well as any unusual observations or results. Where other measurements have been made (e.g. temperature or chemical concentrations in sediments), it is important to compare them with the fish measurements as a way of explaining or eliminating possible causes of observed responses.

5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Most of the difficulties in interpretation are associated with verifying that a negative response equals 'no induction', and not poor enzyme assays. There are several aspects to QA/QC which must be incorporated into every report. These include the results of assays of blanks, replicates, and standards, and the repeatability of the assay.

5.1 Blanks and replicates

Blanks are simply reaction mixtures without enzyme activity. Activity may be prevented by omitting an essential component such as NADPH or tissue extract, or by inhibiting the enzyme with a solvent such as methanol or acetone; appropriate balns are described in each protocol. Blank values are normally very consistent but both blanks and tests must be run in triplicate when there are fewer than 24 samples. For larger numbers of samples, the numbers per sample may be reduced.

There have been several problems reported with blanks. If disposable tubes are used for fluorometric assays, there are differences in background fluorescence among and within batches of tubes. Some types and brands of disposable tubes show some natural fluorescence. If the laboratory is using reusable tubes, there may be persistent contamination and high blank values. Tubes must be carefully checked for consistency and low background fluorescence before each batch of samples is assayed.

5.2 Standards

There are two types of standards to run with most catalytic assays: internal and external (positive) controls. For internal controls, there is a significant amount of variability in the quality of substrates such as ethoxyresorufin and resorufin among suppliers and batches. Careful consideration must be given to procedures for monitoring batch-to-batch variability. For example, stock solutions of 7-ethoxyresorufin must be made up to a consistent peak absorbance (i.e. dissolved in DMSO until absorbance at 461.5 nm = 1.6 to 1.7).

Instrument checks must be made by diluting standards used for the standard curve in methanol. One high and one low standard must be run with each batch of samples to check instrument response. For example, in the spectrofluorometric EROD assay (Appendix B) these may be 0.0005 and 0.02 mg mL^{-1} resorufin standards diluted 10 µl into 2.5 mL of methanol.

It is essential that a laboratory reporting a negative response (no induction) assures that the assay was capable of detecting induction, if it was present. There are several ways to confirm or validate negative responses:

i) External positive controls to show induction was measurable:

a) Some laboratories induce MFO activity in fish by exposing a number of laboratory rainbow trout to an intraperitoneal injection of 0.5 $mg.kg^{-1}$ ß-naphthoflavone for a 2 - 5 d period. Livers are collected, homogenized, pooled and centrifuged to yield a large batch of homogenous microsomes. The microsomes may be divided into small aliquots and stored at -80°C for extended periods of time. A sample is thawed and run with each test batch to ensure consistency of measurements. Livers from fish sampled at reference and contaminated sites can be used in the same way.

b) It is possible to buy liver S-9 (such as rat liver preparations commonly used for Ames testing) and to use this as a consistent, positive, external control. This method has not been validated.

ii) Measurement of the P-450 protein:

For samples showing no induction, at least one sample from the contaminated site should be analyzed for P-450 content to ensure that the enzyme has not degraded during storage or handling. During degradation, the P-450 enzymes are reduced to P-420 forms, detectable through spectrophotometric analyses (Appendix E).

iii) Background data:

All assays must report protein levels, levels of reagents and incubation time to ensure that quenching or loss of substrate did not play a role in depressing activity.

iv) Protein:

Quality control standards are available commercially and must be included with each batch of protein assays.

5.3 Equipment

A variety of equipment is available for all aspects of MFO studies. For fluorometry, instruments range from simple filter fluorometers with relatively wide band widths to sophisticated spectrofluorometers with monochromators, narrow band widths, and continuously adjustable excitation and emission wavelengths. A comparison of several machines illustrated that, for the spectrofluorometric EROD assay, there were few differences among a Turner 112 filter fluorometer, Rayonics-Nova spectrofluorometer and Perkin Elmer spectrofluorometer in standard curves for resorufin and ethoxyresorufin (B. Kirner and P. Martel, Pulp and Paper Research Institute of Canada, 570 St. John's Boulevard, Pointe Claire, Québec H9R 3J9, personal

communication). Results of EROD assays on fish livers were virtually identical, except when staining of the flow cell on the Perkin Elmer machine caused elevated readings. This was eliminated through methanol rinses between samples. To ensure that equipment used for MFO assays gives high quality results, laboratories should periodically participate in inter-laboratory exchanges of samples and must use quality control standards as described in Section 5.2.

6.0 SUMMARY

This document has described several aspects of the application of MFO assays to monitoring the environmental effects of BKME. A number of options have been presented as well as factors that can affect the quality of data and the conclusions that may be drawn from results. It is obvious that the number and complexity of tests and study designs is large and that those who apply these techniques in biomonitoring programs will have to make some choices, depending upon their specific goals and circumstances. As a minimum, any monitoring program must have test and reference sites, some measure of MFO activity in a reasonable number of fish, and measures of a few associated variables to ensure that major biases have been accounted for. This minimum program is outlined in a flow diagram of a typical study (Figure 1), and it identifies where in this document supporting information can be found. The minimum measurements described in this protocol are also listed in Table 2. With this minimum program, the spatial variation of MFO activity can be described and the following questions answered:

- Is the MFO activity of fish at contaminated sites induced relative to that of fish at reference sites?
- Does the pattern of induction suggest that the source of inducers is the pulp mill?
- Does the intensity of induction suggest the need for more chemical and biological studies of contamination and effects on fish?

As indicated in earlier sections, additional numbers and types of measurements will aid the understanding of both the nature and causes of the observed changes.

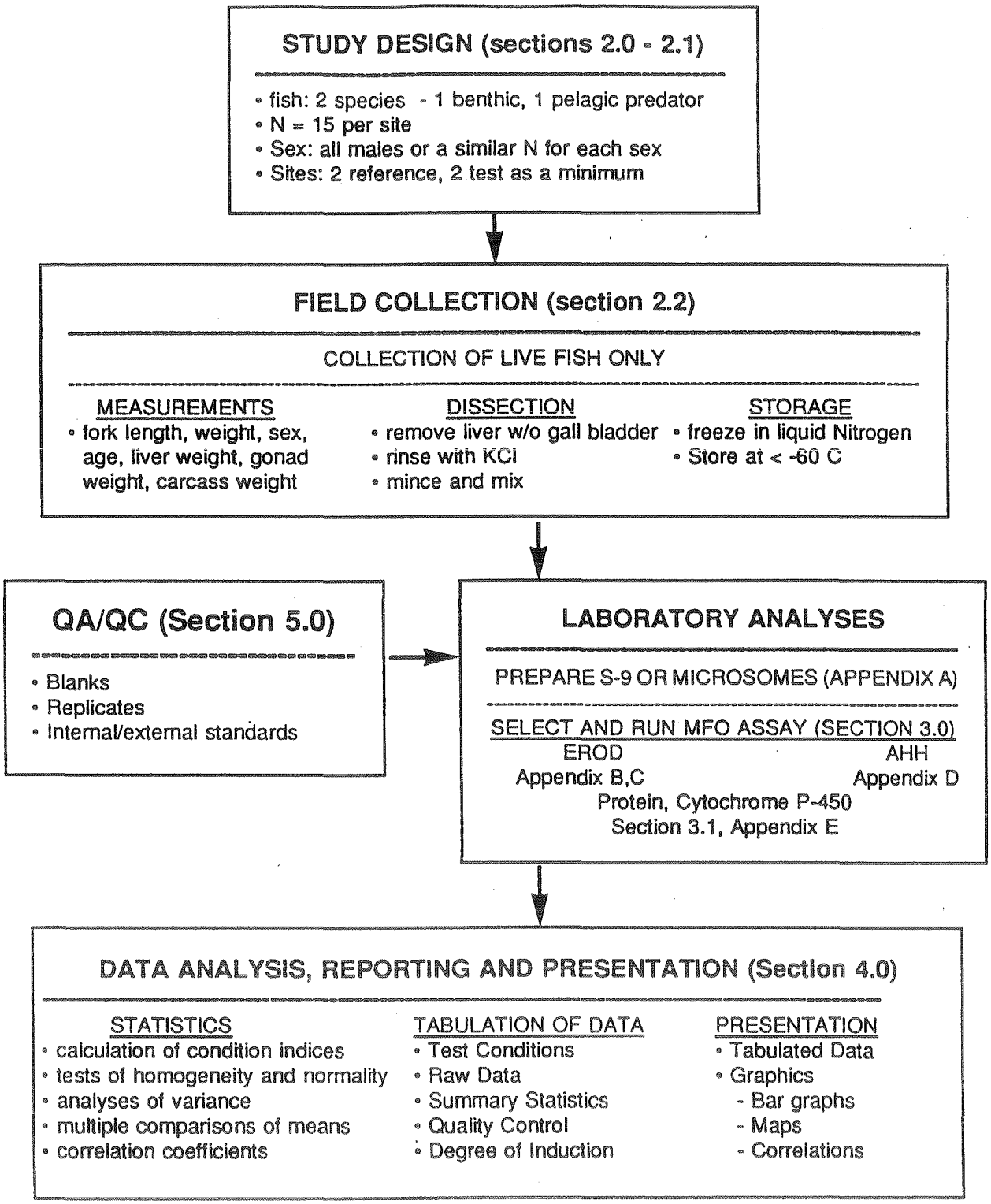

Figure 1. Components of a study of MFO induction in fish

Table 2. Measurements required as part of a survey of fish liver MFO activities.

ACTIVITY	MEASUREMENT	MINIMUM NUMBER PER SITE AND SPECIES	PRECISION
WATER ANALYSIS	Temperature	1 depth profile	1°C
	pH	1, surface	0.1 units
	conductivity	1, surface	2% of working range
FISH SAMPLING	Total Weight	15	1 g
	Gutted weight (carcass)	15	1 g
	Fork Length	15	0.1 cm
	Sex	15[1]	-
	Liver weight	15	0.1 g
	Gonad weight	15	0.1 g
	Age	15	1 year
	Condition Factor	15	calculated
	Gonad Somatic Index	15	calculated
	Liver Somatic Index	15	calculated
ENZYME ANALYSIS (EROD)	Ethoxyresorufin - absorbance of stock solution	once	1.0 fluorescent units
	Resorufin standard curve	once, 5 points	'r' for standard curve[2] regression > 0.90
	Fluorescence of tests	15 in triplicate	1.0 fluorescent unit
	Protein standard curve	once, 5 points	'r' for standard curve[2] regression > 0.90
	Protein in test solutions	15 in triplicate	0.005 abs. units
	Calculated activity	15	0.5 pmoles resorufin. min^{-1}.mg $protein^{-1}$
	Blanks	15 in triplicate	
	Activity of 'Standard' microsomes[3]	2 in triplicate	0.5 pmoles resorufin min^{-1}.mg $protein^{-1}$

[1] Since sex can affect the activity of MFO enzymes, there should be roughly the same number of each sex at each site.

[2] 'r' is the correlation coeffcient for the regression of fluorescence on concentration.

[3] 'Standard' microsomes are those prepared in bulk from a large volume of liver and deep-frozen in aliquots for repeated analysis.

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9.0 APPENDICES - DETAILED METHODS

As indicated in Section 3.0, there are many methods and variations on methods for measuring MFO activities. The methods in these Appendices are those used by one or more of the authors of this report, and are presented because they have proved useful in field studies of fish MFO activity.

APPENDIX A. Preparation of S-9 fractions and microsomes

All subsequent methods test extracts of whole liver. The S-9 fraction is the supernatant generated by centrifuging a liver homogenate at 9,000 x g. Microsomes are precipitated by a 100,000 x g centrifugaton of the S-9 fraction.

A.1 Reagents and solutions

a) Potassium chloride - HEPES buffer (0.15 M KCl; 0.02 M HEPES; pH 7.5) (HEPES = N-2-Hydroxyethylpiperazine-N'-2-ethanesulphonic acid)
b) Glycerol buffer - 0.05 M tris-(hydroxymethyl)methylamine (tris), 1 mM ethylenediaminetetraacetic acid (EDTA), 1 mM dithiothreitol, and 20 % glycerol; pH 7.4.

A.2 Equipment

a) refrigerated ultracentrifuge and appropriate rotor
b) refrigerated superspeed centrifuge and appropriate rotors
c) motorized glass-teflon tissue homogenizer (Potter-Elvejhem type)
d) balance
e) tissue mincer (scissors or chopper of some sort)

A.3 Precautions

The steps described in this procedure must be carried out in a cold room at 1 - 4°C. Alternatively, all reagents, equipment and samples should be held on ice. Do not warm up the tissues by hand contact or by friction during homogenization. If subsamples of frozen specimens are desired, remove a portion while the specimen is still frozen and immediately return the unused part to the freezer. Under no circumstances should the sample be allowed to thaw and refreeze. Microsomes which are resuspended in KCl-HEPES must be kept in a refrigerator or immersed in ice until use.

A.4 Procedure

1) Subsample 1 - 2 g of frozen liver and transfer to a pre-weighed and pre-chilled petri dish. Immediately return the unused part of the liver to the freezer.

2) Weigh the liver and dish and calculate the weight of liver.

3) Allow the tissue to thaw or semithaw in a cold room at 1 - 4°C or on ice; the tissue must be soft enough to be cut up.

4) Mince the tissue with scissors or some other device and transfer to a prechilled tissue homogenizer. Conical tipped homogenizers of about 15 mL capacity work well.

   Note: For tissues minced and frozen in the field at the time of capture, pre-weigh an ice-cold homogenizing tube and transfer a semi-thawed portion of the sample to the tube for weighing.

5) Add 4 mL of cold KCl-HEPES per gram of tissue and homogenize with 5 - 7 passes of a motor driven teflon pestle (Potter-Elvejhem homogenizer)

6) Transfer the homogenate to polycarbonate tubes and centrifuge at 9000 x g for 30 min at 2 - 4°C. The post-mitochondrial supernatant (S-9 fraction) produced in this step may be analyzed directly if microsomes are not required. The supernatant is collected with a Pasteur or Eppendorf pipet, taking care to avoid the pellet and the floating lipid layer.

7) Transfer the cold supernatant to ultracentrifuge tubes. Keep them ice-cold while filling and balancing.

8) Centrifuge at 100,000 x g for 75 min at 2 - 4°C.

9) Remove the supernatant and wash the pellet 3 times with cold KCl-HEPES.

10) Using a glass-teflon tissue homogenizer, resuspend the pellet in sufficient cold KCl-HEPES to give a final protein concentration of 5 - 15 mg mL^{-1}.

11) Store the suspension in an ice bath or fridge and proceed to the enzyme assay. Assays should be completed within several hours. Frozen storage of microsomes resuspended in KCl-HEPES is not recommended. If microsomes are to be frozen they should be washed and resuspended in glycerol buffer. Use liquid nitrogen for freezing the microsomes.

   Note: Samples lose less activity during long-term storage (months) if frozen as a microsomal preparation than when frozen as whole tissue.

APPENDIX B. Ethoxyresorufin-o-deethylase (EROD) - spectrofluorometric analysis

This procedure is based on the method of Pohl and Fouts (1980), and has been the most commonly used in studies of BKME. There are two approaches to the estimation of EROD activity. The first is to follow the reaction as it occurs in the cuvette of a spectrofluorometer, measuring the appearance of resorufin, the product of the reaction (Prough *et al.* 1978). This technique requires a temperature-controlled cuvette and a recording device such as a chart recorder or computer graphics software. The advantages of this technique are those of simplicity and the ability to recognize immediately if the reaction is non-linear due to substrate or co-factor depletion. This method is not currently used by the authors but is a very suitable alternative. It is described in detail by Addison and Payne (1986).

The alternate technique, used when temperature control of the sample cuvette is not possible, requires a reaction in a water bath for a fixed and accurate time (Pohl and Fouts 1980). Methanol is used to stop the reaction and causes the denaturation and precipitation of proteins, so that separation of protein from the reaction solution is necessary before spectrofluorometry to prevent turbidity and interference. The first approach is obviously the simplest and is preferable, but may be limited by the availability of equipment. Both techniques give equivalent results, and the fixed-time method has been most frequently used in studies of pulp mill effluents.

B.1 Reagents and solutions

a) HEPES buffer (pH 7.8, 0.1 M) (HEPES = N-2-Hydroxyethylpiperazine -N'-2-ethanesulphonic acid)
b) magnesium sulphate (154 $mg.mL^{-1}$)
c) NADPH (0.5 mM or 27.5 $mg.L^{-1}$) (NADP = nicotinamide adenine dinucleotide phosphate; the 'H' refers to the reduced form)
d) 7-ethoxyresorufin (0.03 - 0.06 $mg.mL^{-1}$ in dimethyl sulphoxide) - see notes
e) BSA (bovine serum albumin) (40 $mg.mL^{-1}$)
f) Resorufin (see discussion on standards)
g) S-9 or microsomal preparation, as described in Appendix A

Notes:

a) Reagents a, b, and d may be prepared in bulk and stored in a refrigerator or cold room.
b) NADPH solutions should be prepared fresh immediately before use. The working time is 30 minutes.
c) There have been some problems with the concentration of ethoxyresorufin from different preparations of the purified compound. Klotz *et al.* (1984) describe methods for checking the purity of the ethoxyresorufin. Analysts should be aware of possible purity problems and take appropriate precautions.
d) 7-ethoxyresorufin is stored in a light-proof bottle at room temperature.

e) Since NADPH is very unstable, with a working life in solution of about one-half hour, an alternative is to use a biochemical system for generating NADPH. This requires the addition of 10 µL of each of the following solutions in place of the 30 µL of NADPH:
   f) NADP (98.4 mg mL^{-1})
   g) sodium isocitrate (193.58 mg mL^{-1})
   h) isocitrate dehydrogenase (usually purchased in solution and used as supplied - store in the refrigerator)

B.2 Instrumentation

a) fluorometer (spectrofluorometer recommended)
b) recording device for fluorometer output
c) Eppendorf pipettes (repeaters and adjustable)
d) vortex mixer
e) temperature-controlled water bath
f) high speed centrifuge and appropriate rotor (centrifugation to 100,000 x g)
g) stopwatch

B.3 Standards

Aliquots of 10 µl of resorufin standards (0.0005 to 0.02 $mg.mL^{-1}$ in dimethyl sulphoxide) are spiked into killed reaction mixtures (described below) and the fluorescence determined along with the fluorescence of a reaction mixture blank. Standard fluorescence is corrected for blank fluorescence and a response factor ($nmol.FU^{-1}$) in the reaction mixture (3.75 mL) is calculated and used in determining the amount of resorufin present in the unknowns. The preparation of standards is critical since the fluorescence produced is quite sensitive to the proportions of alcohol and water in the mixture being measured. Re-standardization may be required if instrument sensitivity changes or changes in reagents are made which affect the response.

These stock standards are stored in light-proof bottles at room temperature. Stability should be checked periodically if they are to be re-used. Klotz *et al.* (1984) discuss procedures for checking the purity of the resorufin preparation.

B.4 Procedure - fixed time assay

Three replicate assays and three blanks are recommended for each sample (6 tubes per sample). Procedures are the same for the assay tubes and the blank tubes up to step 5. Also, protect ethoxyresorufin and resorufin from exposure to strong laboratory lighting.

1) Into corex glass centrifuge tubes pipet the following reagents:
   - 1100 µl of HEPES buffer
   - 10 µl of $MgSO_4$
   - 50 µl BSA
   - 30 µl of NADPH

Note: The alternative method of generating NADPH from an enzyme system requires the addition of 10 µl of NADP, 10 µl of sodium isocitrate and 10 µl of isocitrate dehydrogenase (1.0 unit) in place of the 30 µl of NADPH. If the volume of isocitrate dehydrogenase required for one unit is greater than 10 µl, the volume necessary for one unit (to the nearest 10 µl) should be added and the volume of buffer reduced accordingly. The incubation mixture volume should be kept constant for comparability with the standards. Mix on a vortex mixer and allow the samples to stand for at least 10 minutes to ensure that sufficient NADPH is produced for the EROD reaction.

3) Add 50 µl of the S-9 or microsome preparation to each tube.

4) Incubate the tubes for at least 5 min in a water bath at an appropriate temperature (25°C for fish).

The following 2 steps (5, 6) apply to actual assay tubes only (not blanks).

5) Add 10 µl of ethoxyresorufin substrate to each tube and incubate for exactly 2 minutes in the water bath at the appropriate temperature. Use a stopwatch for timing.

6) After incubation, kill the reaction by adding 2.50 mL of methanol to each reaction tube and mix well. For very low activity samples, the incubation time may be increased by several minutes to allow for more conversion of substrate. Conversely, for very high activity samples, care should be taken that serious substrate depletion does not occur.

7) To prepare the blanks, add 2.50 mL of methanol to each tube to destroy the enzyme activity. Add 10 µl of ethoxyresorufin substrate solution. Precise timing is not required for these additions.

8) Centrifuge samples at 23,000 - 25,000 x g for 5 min to pellet the precipitated protein.

Note: When EROD reactions are stopped by adding methanol to the reaction mixture, proteins are precipitated and must be removed. This requires either a short centrifugation or a filtration through 0.8 µm glass fibre filters in a multi-port vacuum filtration system (e.g. Burdick and Jackson 12 or 24-port filtration unit, Canlab). A 24-port system allows filtration of up to 80 samples per hour. The advantages of filtration over centrifugation are those of speed and of low contamination. Pipetting the supernatant from centrifuge tubes risks contamination from the precipitated protein, whereas filtrates can be collected automatically, ready for fluorometry.

9) Transfer the clear supernatant to the fluorometer cuvette, taking care not to transfer any particulate matter, and measure the fluorescence at an excitation wavelength of 530 nm and an emission wavelength of 585 nm. Record the responses.

10) The protein content of the tissue preparation must be determined by accepted methods such as the Lowry, Biuret or BIORAD procedures.

11) Calculate the enzyme activity using the formula below.

activity = (f x pk)/((p x 0.050) x t)

where:

activity = enzyme activity ($nmol.min^{-1}.mg^{-1}$)

f = instrument response factor in n $mol.FU^{-1}$ for the reaction volume of 3.75 mL as determined from the standards.

pk = sample fluorescence corrected for blank fluorescence (FU).

p = protein concentration of the tissue preparation in $mg.mL^{-1}$.

t = incubation time in min.

B.5 Discussion

Activity increases linearly with protein concentrations up to 1 $mg.mL^{-1}$ in the reaction mixture. Care must be taken if the enzyme activity is very high to ensure that serious substrate depletion does not occur over the course of the assay. This may occur if high concentrations of very active protein are used.

The sensitivity of the method will depend on the instrumentation used. The absolute sensitivity is about 0.5 pmol of resorufin in the reaction mixture when using a spectrofluorometer.

APPENDIX C. Ethoxyresorufin-o-deethylase - spectrophotometric analysis

Ethoxyresorufin (7-ER) is an artificial substrate whose de-ethylation is catalyzed by a specific, inducible cytochrome P-450 (P-450IA). Original methods described a direct fluorometric technique for the measurement of the product (Burke and Mayer 1974). In the spectrophotometric assay, the generation of the product resorufin is monitored continuously at 572 nm (Klotz *et al.* 1984). Resorufin formation is dependent on the presence of enzyme, substrate and co-factor (NADPH). Temperature control is necessary during both pre-incubation and analysis.

In the spectrophotometric EROD assay, the formation of the product resorufin (pink) due to cleavage of the substrate (orange) by P-450IA is followed spectrally at 572 nm. The assay is a modification of the original fluorometric EROD assay. This assay has advantages over other methods in terms of substrate type since ethoxyresorufin is not a known carcinogen, as is benzo(a)pyrene. It uses a visible spectrophotometer rather than a fluorometer and the assay is easier. Interpretation is simpler - as a continuous assay, linearity is known and replicates can be added as needed immediately, rather than as later repetitions necessary in batch incubation assays. In addition, the daily blanks and standard curves needed for fluorometric and radiometric methods are not necessary with this procedure. However, some optimization may be necessary to gain the desired sensitivity for the very low activity expected in some cold water, unexposed fish. Although daily blanks are not needed for the spectrophotometric EROD assay, they should be run occasionally (e.g. all components minus NADPH, or minus enzyme). This is especially important if the assay indicates activity (increase in A_{572}), but no pink colour is formed, even after standing overnight. If pink colour (resorufin) is not present, it is likely that the change in A_{572} is NADPH and/or substrate independent, and overestimates true EROD activity. The original paper describing the method (Klotz *et al.* 1984) should be read by anyone setting up these assays. This protocol follows the Klotz method and describes some aspects not included in that reference.

C.1 Reagents and solutions

a) Ethoxyresorufin (Molecular Probes Inc. Eugene, Oregon)
b) HPLC-grade Methanol
c) NADPH (Sigma): 25 $mg.mL^{-1}$ in resuspension buffer. Make fresh daily or thaw a frozen aliquot
d) EROD Buffer (0.1 M Tris-HCl, pH 8.0, 0.1 M NaCl)
e) Resuspension Buffer (50 mM Tris-HCl, pH 7.4, 1 mM dithiothreitol, 1 mM EDTA, 20% glycerol v/v)
f) S-9 or microsomal preparation, as described in Appendix A.

C.2 Equipment

a) Recording Visible Spectrophotometer (e.g. Shimadzu, Beckman, Perkin-Elmer)
b) Glass cuvettes (1 cm)

c) Water Bath. Circulating water baths can also be used with thermally-regulated cell holders in most spectrophotometers, to obtain temperature controlled preincubation as well as temperature-controlled cuvettes. Otherwise, a standing or shaking water bath can be used, if the spectrophotometer has its own built-in temperature control.

C.3 Preparation of 7-ER/EROD solution and sample 7-ER calculation

Calculate the amount of substrate needed as follows:

In a total assay volume of 500 µl, there will be:

a) 10 µL of microsomes (add more or dilute sample as needed, see Appendix C.4, Step 5 below)
b) 10 µL of 25 $mg.mL^{-1}$ NADPH (in resuspension buffer), and
c) 480 µL of 7-ER in EROD buffer

A saturated solution of 7-ER in methanol has an approximate concentration of 400 µM. A final concentration of 2 µM is needed. Thus, 2/400 or 0.005 times the total volume is desired. For 480 µL per run, this is 2.4 µL per run.

If 12 samples are to be assayed, assume 3 replicates (12 x 3 = 36) and add a few spares to make enough 7-ER mixture for 45 assays. For 45 samples:

NADPH:	45 assays x 10 µL/assay	= 450 µL at 25 $mg.mL^{-1}$
7-ER:	45 assays x 2.4 µL/assay	= 108 µL 7-ER
EROD buffer:	45 assays x 480 µL/assay	= 21.6 mL EROD buffer

Therefore, add 108 µl of 7-ER to 21.6 mL EROD buffer to approach the target of 2 µM. Zero the spectrophotometer at 482 nm with EROD buffer alone in both the reference and sample cuvettes. Then measure the Absorbance at 482 nm of the 7-ER/EROD buffer mixture versus the "zeroed" straight EROD buffer. The extinction coefficient of 7-ER is 22.5 $mM^{-1}.cm^{-1}$, and the 7-ER/EROD mixture will comprise only 480 of the final volume of 500 µL. Thus, the actual final concentration of 7-ER in the assay is calculated as:

Concentration of 7-ER (µM) = $(A_{482}/0.0225)$ x (480/500)

If this number is 2.0 $\pm$ 0.1, use it. BUT:

1) If the 7-ER concentration is too low, use this correction:

New total volume of 7-ER = (2/(calculated uM)) x (original 7-ER volume)

Subtract the original volume of 7-ER used and add this amount. Re-measure the new substrate, mix, and reiterate as necessary.

Example: A_{482} = 0.040, then

Concentration of 7-ER = (0.040/0.0225) x (480/500) = 1.70 uM

New total volume of 7-ER = (2/1.7) x 108 = 126.5 µL

Amount of 7-ER to add = (126.5 - 108) = 18.5 µL

2) If the 7-ER concentration is too high, use a similar correction, but now for buffer volume:

New buffer volume = ((Calculated uM)/2 uM) x (original buffer volume)

Subtract the original buffer volume and add this amount. Remeasure the new substrate mix and reiterate as needed.

Example: A_{482} = 0.053, then

Concentration of 7 -ER = (0.053/0.0225) x (480/500) = 2.26 µM

New Buffer volume = (2.26/2) x 21.6 = 24.4 mL

EROD buffer to add = (24.4 - 21.6) = 2.8 mL

It may take some adding of both or either component(s) to achieve the correct concentration of 7-ER in EROD buffer, but this becomes easier with time as the operator learns what the desired solution looks like.

C.4 Procedure

1) Set the water bath for preincubation to the optimum temperature determined for the test species, but keep the spectrophotometer at room temperature until the substrate is prepared and read at 482 nm. Prepare samples for analysis according to the method for microsome or S-9 preparations (Section 7).

2) Make substrate: dissolve a crystal of 7-ethoxyresorufin (7-ER) in 0.5 mL HPLC-grade MeOH. Place the test tube in hot water to aid dissolution. Let the solution cool to room temperature. 7-ER dissolved in MeOH will degrade with time, so a fresh sample must be prepared daily. Calculate the number of samples to be run and make a sufficient volume of 7-ER in EROD buffer. Check the concentration of 7-ER at 482 nm and adjust as needed to a final concentration of 2 µM (see example under "Preparation of 7-ER/EROD Solution" (Appendix C.3)). Keep the 7-ER/EROD buffer mixture on ice until used.

3) Change the wavelength from 482 nm (for the 7-ER reading) to 572 nm to measure the resorufin formation. Prepare the spectrophotometer for time-course parameters, and bring the cuvettes to a proper temperature. Circulate water if a water bath is used to

control cuvettes, or set the cuvette holders to the same temperature as the preincubation bath if a separate system is used. Pipette 480 µL 7-ER/EROD mixture into a few small test tubes, to bring the substrate to room temperature and to reduce the time lag for bringing it to the assay temperature.

4) Add microsomes (try 10 µL first) to 480 µL 7-ER/EROD solution and pre-incubate in the water bath for 2-3 minutes.

5) Remove the tube from the bath and quickly add 10 µL NADPH to initiate the reaction. Transfer the solution to the sample cuvette and record the change in absorbance at 572 nm against EROD buffer in the reference cuvette. Because this is a kinetic assay, temperature control is important. The rate of resorufin formation should be linear for at least 3 min. Bubbles or settling may initially obscure the observable rate of change in absorbance at 572 nm. It is not necessary to always begin recording the change in absorbance at the same interval after NADPH addition, but note that the enzyme is not stable in EROD buffer and will start to degrade over time, losing activity. Thus, extremely long pre-incubations and run times should be avoided.

   If the change in absorbance is too fast or too slow, repeat the assay with less or more sample. Dilute microsomes in resuspension buffer or use more microsomal volume, respectively.

   Note: If the total assay volume is changed significantly, recalculate the 7-ER concentration to assure it is still 2.0 ± 0.1 µM.

6) Run replicates of each sample. To save time, pre-incubate the next sample in the water bath while first one is being monitored.

7) Using the linear change in absorbance, calculate the EROD activity. This calculation is based on the observed change in absorbance per min at 572 nm, the extinction coefficient of resorufin at 572 nm (73 $mM^{-1}.cm^{-1}$, Klotz *et al.* 1984), a correction factor, and the total assay volume and volume of enzyme added. A dilution factor is needed if samples have been diluted for the run. To obtain an activity per unit volume, calculate the following:

   nmol resorufin formed.$min^{-1}.ml^{-1}$ = (delta A_{572}/min) x (mmol/73 L) x (10^6 nmol/mmol) x (1/1000 mL) x (500/10) x dilution)

8) To determine the EROD specific activity (nmol.min^{-1}.mg $protein^{-1}$), divide by mg.mL^{-1} protein.

9) To calculate the EROD turnover number (nmol resorufin.min^{-1}.$nmol^{-1}$ P-450), divide the specific activity by the P-450 specific content (nmol.mg^{-1}), or divide the original value (nmol.min^{-1}.mL^{-1}) by the P-450 content per volume (nmol P-450.L^{-1}). P-450 content is determined by spectral analysis as described in Appendix E.

Example:

Total Volume =	480 µL (7 ER + buffer)	+	10 µL (sample at 1:5 dilution)	+ 10 µL (NADPH)	=	500 µL,

If the measured delta $A_{572}.min^{-1}$ = 0.0108, then:

Activity = 0.0108 x 1000/73 x 500 µL/10 µL x 5 = 36.99 $nmol.min^{-1}.mL^{-1}$

If the protein concentration is 24.3 $mg.mL^{-1}$, then:

Activity = 36.99/24.3 = 1.52 $nmol.min^{-1}.mg^{-1}$ protein;

If the P-450 content is 0.37 $nmol.mg^{-1}$, then:

Activity = 1.52/0.37 = 4.11 $nmol.min^{-1}.nmol^{-1}$ P-450.

APPENDIX D. Aryl hydrocarbon hydroxylase (AHH)

Arylhydrocarbon hydroxylase (AHH) encompasses many enzyme systems, two of which use Benzo(a)pyrene (BaP) as a substrate or diphenyloxazole (PPO). There are published methods for BaP hydroxylase which use a radio-labelled BaP substrate (Nebert and Gelboin 1968a; 1968b; Binder and Stegeman 1980). The water-soluble product is extracted at the end of the assay and measured by standard scintillation counting. The advantage of this technique is that the product of the reaction is known and standards are available for quality control and for accurately estimating enzyme activity in terms of product generated. The major disadvantage of the technique is the use of a substrate that is highly carcinogenic and the use of solvent-based fluors for beta-counting. While this method may be quite suitable for surveys of BKME effects, details are not given because it is not currently used in the authors' laboratories due to its inherent hazards. A method is described by Addison and Payne (1989).

The PPO assay estimates the activity of aryl hydrocarbon hydroxylase (AHH) by measuring the appearance of a NaOH-extractable fluorescing metabolite of diphenyloxazole when incubated with enzymes extracted from liver tissue under standard conditions.

In comparing the PPO assay with the BaP hydroxylase assay there are a number of advantages and disadvantages. The AHH assay was modified from Nebert and Gelboin (1968a) using 2,5-diphenyloxazole (PPO) as a substrate because it is less carcinogenic than BaP. The PPO substrate is stable and the assay is faster and simpler than the BaP assay. The major drawback of the PPO assay is that the metabolism of PPO generates an unknown product; therefore, sample results must be compared in relative units only. The assay also produces lower AHH activities than BaP by about one-third because the S-9 supernatant is used instead of microsomes. Despite these simplifications in the method, the relative values of AHH activities from different sampling locations and from repeated sampling over several years at one site demonstrated significant and consistent trends in AHH activity (Hodson *et al.* 1989). Quality control in the PPO assay is derived by the use of known fluorescing compounds for calibrating the fluorometer and by repeated assays of livers with previously measured and known activities.

The EROD assay, by comparison, is safer than the PPO assay because solvents such as hexane are not used. The EROD sensitivity is also greater and specific activity in nmol product. $min^{-1}.mg^{-1}$ protein can be determined.

D.1 Reagents and solutions

a) PPO - (2,5-Diphenyloxazole): Treat this toxic chemical with respect. Wear personal protective equipment. Prepare PPO fresh for each AHH assay.

452 uM PPO - Dissolve 2 $mg.mL^{-1}$ using spectro-grade methanol.

To the PPO powder, add 1.0 mL of methanol at a time and carefully dissolve and transfer the solution into a labelled test tube. If more than 1.0 mL methanol is added to the weigh boat, it will be lost due to rapid evaporation. Vortex the solution. Add 50 µL PPO solution/AHH sample.

b) NADPH - 4 mM: Prepare fresh for each day's work. Dissolve 3.33 $mg.mL^{-1}$ of assay buffer. Transfer to a labelled test tube and then Vortex. Add 100 µL NADPH solution/ AHH sample (0.4 mM).
c) Assay Buffer: Dissolve 7.459 g of Tris buffer (pH 7.5) and 0.6095 g (3 mM) $MgCl_2$ in 1000 mL distilled water.
d) Quinine sulphate standard: Add 3.7335 mg Quinine sulphate to 100 mL of 0.1 N H_2SO_4
e) GC-grade hexane
f) S-9 preparation, as described in Appendix A.

D.2 Equipment

a) Shaking water bath with clips to hold 25 mL Erlenmeyer flasks
b) Turner fluorometer, Model 110, with emission filters 2A and 3, and excitation filter 7-60.
c) Vortex mixer
d) Micropipets

D.3 Procedure

1) Into three erlenmeyer flasks (25 mL, duplicate samples plus a blank) add:
   - 350 µL assay buffer
   - 100 µL NADPH
   - 500 µL liver supernatant

   Vortex the sample for every flask. The remaining supernatant is used for protein determination by the Biuret or Lowry method with bovine serum albumin (BSA) as a standard.

2) Ensure that the water bath is at 27°C. Place and secure flasks into the waterbath and restart the shaker.

3) Add 50 µL of PPO in methanol to the samples, leaving exactly 30 s between each flask. Time this action with a stopwatch. Incubate for 20 min.

4) Making sure there are no air bubbles in the repipettors, add to the blanks:
   - 1.0 mL acetone, swirl by hand
   - 3.25 mL hexane, vortex for 10 s
   - 50 µL of PPO, swirl by hand

   Set the blanks to one side for readings.

5) After the 20 min incubation, one has 30 s to process each flask one at a time, as follows:
   - add 1.0 mL acetone, swirl by hand for several seconds
   - add 3.25 mL hexane and vortex for 10 s

   Avoid spillage! Use a stopwatch to ensure that samples are processed in exact 30 s intervals.

6) Carefully decant the top hexane layer into a test tube.

7) Carefully transfer 2.0 mL of the sample into the next row of test tubes with an Eppendorf pipet. To prevent the hexane solution from dripping, pipet 1.0 mL and release it back into the original sample test tube. This will coat the pipet tip.

8) To the 2.0 mL samples, add 5.0 mL 1N NaOH and vortex for 30 s. Avoid spillage.

9) Allow the samples to settle into two phases.

10) Remove the bottom phase and transfer it to the last row of test tubes with a Pasteur pipet.

D.4 Fluorometer readings

1) Warm up a Turner 110 fluorometer for 30 min.

2) Standardize the fluorometer with emission filter No. 2A and excitation filter 7-60. Zero the machine with distilled water. Take a reading of the quinine sulphate standard. Readings must be consistent from day-to-day to ensure no drift.

3) Sample readings: Replace filter No. 2A with filter No. 3. Zero the machine with a sample blank. Read each sample. If a sample reading is greater than 100, dilute with 1N NaOH, ensuring that the total volume is 4.0 mL. Vortex the original sample when making the dilutions.

4) Calculate specific activity by dividing the reading of fluorescence units (FU) by the protein concentration, correcting for dilution if necessary. Specific activity is expressed as $FU.min^{-1}.mg\ protein^{-1}$. One FU is equivalent to a reading on a 1x scale of the fluorometer with quinine sulphate used to ensure no drift from day-to-day.

> Note: Alternate method: A spectrofluorometer may be substituted for a fluorometer, using an excitation wavelength of 345 nm and an emission wavelenth of 510 nm (Ahokas 1976).

APPENDIX E. Spectral P-450 analysis

The potential for protein denaturation exists for all samples, particularly for field samples which are shipped to laboratories for further analysis. Hence, the catalytic competence of representative samples must be proven occasionally by spectral scanning for total P-450 content. If the scan reveals a single peak at about 450 nm, the sample is intact and activity results are accurate (barring inhibition). If the scan reveals a significant peak at about 420 nm, the sample is degraded and activity is underestimated. If there is a peak present at 420 nm but not at 450, true activity will be absent. Cytochrome b5 can sometimes be induced by P-450 inducers, and its reductase activity may interact with other P-450 activities. If present, it can be observed during spectral analysis by following step 2 below.

Spectral analysis requires more sample volume than the spectrophotometric EROD assay and some training in practice and interpretation of results. However, if no activity or low activity is observed at all sites, this analysis is necessary. For convenience, 2 representative samples per site (e.g. with representative enzyme activities) should be analyzed for total spectral P-450 to determine enzyme competence.

E.1 Reagents and solutions

a) NADH (5 $mg.mL^{-1}$ in resuspension buffer)
b) CO (e.g. training bottle)
c) sodium dithionite crystals (Na_2SO_4)
d) resuspension buffer (see EROD spectrophotometric protocol)
e) S-9 or microsomal preparation, as described in Appendix A.

E.2 Equipment

a) scanning spectrophotometer, dual or single beam
b) glass cuvettes, 1 cm, with lids

E.3 Procedure

To determine TOTAL P-450 content, a reduced, CO-bound difference spectrum is measured. The following protocol is based on Stegeman *et al.* (1979). If cytochrome b5 values are desired, follow the method below. If cytochrome b5 is not needed, add 10 µl NADH to the diluted sample and skip step 2.

1) Dilute microsomes (or post-mitochondrial supernatant) in resuspension buffer to a final volume of about 0.7 to 0.8 mL for dual beam determinations, half that for single beam. Dilutions of microsomes prepared at a resuspension ratio of 1 mL $buffer.g^{-1}$ of liver should generally be diluted 1/20.

2) For dual beam determinations, divide the sample evenly between two cuvettes and record a baseline spectrum between 500 and 400 nm. Add 5 µL NADH to the sample cuvette and scan between 450 and 400 nm. Cytochrome b5 will show as a peak at about 424 and a trough at about 409 nm. This difference is used to determine the concentration of b5 using the extinction coefficient of 185 $mM^{-1}.cm^{-1}$ (see below). Combine the sample from both cuvettes and add an additional 5 µL NADH to reduce the b5 from the "reference" sample.

   For single beam determinations, run a baseline with the entire sample in the sample cuvette and store it, then run the NADH-reduced sample versus the stored baseline.

3) Bubble the sample with CO in a hood for about 30 s. Re-divide the sample between the reference and sample cuvettes and cover. Record a baseline spectrum at 500 to 400 nm as before. Some settling may occur; if so, wait and run the baseline again until stable. Add a few crystals of sodium dithionite to the sample cuvette and scan from 500 to 400 nm. As it may take 10-20 min for complete reduction, scan again until peaks are stable. Determine the P-450 concentration using 91 mM^{-1} cm^{-1} as the extinction coefficient, as shown below.

   For single beam determinations, establish a baseline with the CO-bubbled sample and store it, then run the dithionite-reduced sample against the saved CO bubbled baseline run.

4) Wash out the cuvettes, making sure all traces of dithionite are removed. Repeat the analysis with the next sample.

5) Calculations assuming a 1 cm path length:

   Cytochrome b5 ($nmol.mL^{-1}$) = $A_{(424-409)}$ x mmol/185 L x 10^6 nmol/mmol x (1 L/10^3 mL) x dilution

   Cytochrome P-450 ($nmol.mL^{-1}$) = $A_{(490-449)}$ x mmol/91 L x 10^6 nmol/mmol x (1 L/10^3 mL) x dilution

   Divide these results by the protein concentration ($mg.mL^{-1}$) to get specific contents, or $nmol.mg^{-1}$ protein.

   Note:

   a) Upwards skewing (towards the 400 nm end) of the P-450 spectrum often occurs if too much dithionite is added. Add only a few crystals, let the sample reduce, and add more if you suspect that not enough dithionite was added. Ideal P-450 scans will run flat from 500 to 470 nm before the peak starts to rise, and drop below zero by 400 nm. Calculations may be adjusted according to the scan obtained. In the calculation above, 490 is taken as the representative "zero"and 449 as the peak P-450 value. If the baseline is not flat, correct for this in calculating the P-450 value.

b) This analysis is usually run at room temperature. For most species, you can thaw a sample of microsomes, dilute it in resuspension buffer and let it sit on ice for a few hours until analysis. In fact, it may remain stable even after freezing overnight at -20 degrees; of course catalytic activity is reduced or eliminated. Stability should be tested for each species. For example, run one portion of a sample immediately after thawing and compare it to another portion left on ice for a few hours; let a fully-reduced sample sit in the cuvettes, scan over time, and observe whether a P-420 peak develops.

c) Dithionite will be "exhausted" quickly in a humid room. Store dithionite aliquots in a dessicator and use each aliquot only for one day. During humid conditions, change dithionite more frequently. Strong odour and/or "cling" indicate exhaustion of the chemical.

d) Remember to clear the CO lines of air by bubbling into water or buffer before CO bubbling the first sample of the day.

e) This assay measures TOTAL P-450, of which P-450IA may be a minor component. Therefore, changes in spectral hepatic P-450 are an inconsistent marker of exposure to inducing chemicals. This assay will give indirect information on P-450IA. For example, turnover numbers for catalytic activity will indicate whether the portion of P-450IA has increased. However, the most important function for spectral P-450 analysis is to check the overall functional capacity of the P-450 proteins. If there is more than a shoulder at 420, beware of catalytic results!

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BILE FLUORESCENCE AND SOME EARLY BIOLOGICAL EFFECTS IN FISH AS INDICATORS OF POLLUTION BY XENOBIOTICS

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Abstract—Simple measurement of bile fluorescence in fish has been proposed as a means for determining exposure to certain waterborne chemicals. This proposal was based on the data obtained by chemical determination of metabolites of compounds to which fish were exposed. Because exposures to most of these compounds cause some profound biological effects in fish, we studied the correlation between the increase in bile fluorescence, the induction of liver benzo[*a*]pyrene monooxygenase (BaPMO) activity, and the increase in the potential of liver to bioactivate promutagenic benzo[*a*]pyrene to *Salmonella typhimurium* TA100 mutagens. Carp exposed to diesel-2 oil, crude oil, or to a flow of polluted river water simultaneously increased severalfold the levels of all three parameters in a dose- and time-dependent manner. During the recovery from exposure, the levels of bile fluorescence and the BaPMO activity declined and by day 15 reached their natural, preexposure levels. The level of bioactivation potential, however, remained at the higher, induced level throughout the recovery period of 15 d. Seven fish species living in polluted Sava River (near Zagreb, Croatia) revealed severalfold increased levels of these parameters, as compared to their levels in fish living in the reference Korana River (near Karlovac, Croatia) or to their levels in control carp. These results give qualitatively new support to the idea of using simple measurements of fluorescence of diluted bile as a rapid and cheap complementary investigative tool for monitoring and assessment studies.

Keywords—Bile fluorescence Carp Diesel-2 oil Crude oil Polluted river water

INTRODUCTION

The analysis of fish bile for xenobiotics and/or their metabolites and conjugates was proposed as a useful monitoring aid for certain waterborne chemicals [1,2]. It was based on data obtained by exposure of fish to radiolabeled xenobiotics. Subsequently, it was shown by chemical analyses, using HPLC, GLC, and nuclear magnetic resonance (NMR), that conjugates of metabolites of several compounds to which fish were exposed could be found in bile [3–9]. Recently Hellou and Payne [10] demonstrated that simple measurement of fluorescence of diluted crude bile samples could be used to detect metabolites of petroleum hydrocarbons in trout exposed to No. 2 fuel oil. These authors supplemented these fluorescence data with NMR spectroscopy of bile as a more definitive proof of hydrocarbon contamination. In another study Payne et al. [11] noted that the accumulation of metabolites in bile of winter flounder approached the sensitivity of the induction of mixed-function oxygenase (MFO) enzymes for assessing hydrocarbon bioavailability from petroleum-contaminated sediments. Similar correlation between the activity of MFO and fluorescent aromatic compounds (FACs) in bile was found in English sole exposed to environmental contaminants [12]. The demonstration of the validity of crude bile fluorescence as a biomarker of exposure to environmental contamination, and its correlation with the induction of such pathobiological effects like the induction of monooxygenase activity, offer a qualitatively new combination of fast, simple, and inexpensive tools in environmental monitoring.

In this work, attempts were made to correlate the induction and persistence of crude bile fluorescence in carp experimentally exposed to crude oil, diesel-2 oil, or polluted river waters, and in fish living in polluted and unpolluted river waters, with the induction and persistence of liver benzo[*a*]pyrene monooxygenase activity, as well as with the induction and persistence of another profound biological effect—the liver potential for bioactivation of promutagens to ultimate mutagens.

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BILE FLUORESCENCE
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MATERIALS AND METHODS

Chemicals

3-Methylcholanthrene (3-MC), 7,8-benzoflavone, β-glucuronidase (*Helix pomatia*, type H-1), and chemicals used in the Ames test were from Sigma Chemical Co., Munich, Germany; benzo[*a*]pyrene (BaP) was from Roth, Germany; and all other chemicals were from Kemika, Croatia. Millex-HA® 0.45-μm filter units and Millex-GA® 0.22-μm filter units were from Millipore S.A. France. *Salmonella typhimurium* strains TA 98 and TA 100 were obtained from Dr. B.N. Ames, Department of Biochemistry, University of California, Berkeley; 3-hydroxy-benzo[*a*]pyrene (BaPOH) was donated by Dr. Gelboin, National Institutes of Health (NIH), Bethesda, Maryland. Crude oil was of Panonian oil type, from the Bizovec-3 well. This oil belongs to the "mixed base" type of oils. Its density was 0.852 g/cm^3, and its paraffin content was 10.5%. Diesel-2 oil was from INA refinery, Rijeka, Croatia, its origin unknown.

Fish stocks

One year-old specimens of carp, *Cyprinus carpio* (weighing 20 to 30 g, obtained from fish farm Draganići, near Zagreb, Croatia) served as experimental animals. Carp were adapted for one week in 400-L basins in a flow of dechlorinated, well-aerated water, at 13°C and a density of 400 specimens per cubic meter. The flow rate was two total changes of water volume per day. Carp were given no food during the adaptation, exposure, and recovery periods. Groups of carp were exposed to experimentally polluted waters in 50-L glass tanks with a flow of 70 ml of tap water per minute (two volume exchanges per day) for different periods of time.

Natural fish specimens

Fish from the polluted Sava River at Zagreb, Croatia, and from the unpolluted Korana River upstream from Karlovac, Croatia, were caught in the middle of June 1991 by sport fishermen by angling. The quality of water from each of these rivers was defined by its load of industrial and domestic waste, expressed in population equivalents (p.e.) (Sava River = 2,400,000 p.e. and Korana River = 5,000 p.e.), as well as by the average benzo[*a*]pyrene monooxygenase (BaPMO) activity (in picomoles BaP-hydroxide per milligram of protein per minute) in the livers of fishes living in these waters: Sava = 20 ± 17; Korana = 3.4 ± 1.8 [13,14]. High-resolution capillary GC coupled with MS analysis identified > 200 specific organic compounds in Sava River waters, including several polynuclear aromatic hydrocarbons at concentrations of 10 to 100 ng/L, like phenanthrenes, anthracene, C_1 phenanthrenes, and C_2 phenanthrenes [15]. Fish species were barbel (*Barbus barbus*), "plotica" (Croatian) (*Rutilus pigus virgo*), chub (*Leuciscus cephalus*), nose crap (*Chondrostoma nasus*), roach (*Rutilus rutilus*), bleak (*Alburnus alburnus*), and bream (*Abramis brama*). The liver and gall bladder were separated immediately after the catch and transported in an ice box at −20°C to the laboratory. Bile was sucked from the gall bladder using a needle and syringe, transferred to sterile plastic Nunc tubes, and stored at −20°C until analysis. Liver was used immediately for measurement of BaPMO or for the preparation of S9 fraction.

Exposure to crude oil

Twenty-five grams of crude oil was extracted with 1,000 ml of tap water in a separatory funnel, according to the method described by Gordon et al. [16]. One hundred milliliters of water-soluble fraction was added to water in 50-L glass tanks, reaching a petroleum hydrocarbon concentration of 36 μg of Kuwait oil equivalents per liter. During the experimental period of 18 d, freshly prepared water-soluble fractions of crude oil were added to experimental tanks daily to maintain the fluorescence level of water at the beginning of exposure.

Exposure to diesel-2 oil

Saturation of water in the tank with diesel-2 oil was achieved by passing the inflow of tap water (70 ml/min) through a vertical glass tube (diameter 4 cm) filled with a layer of diesel-2 oil (50 ml) and mounted in the middle of the 50-L glass tank. Next day the fluorescence of water was determined and the exposure of carp started. The concentration of diesel-2 oil hydrocarbons in water of the experimental tank was 50 μg of Kuwait oil equivalents per liter. On day 12, a group of carp was transferred to a 50-L tank of clean tap water for recovery. Groups of four fish were collected on days 2, 5, 10, and 15 of recovery. Control groups of fish maintained in tap water were sampled at each period simultaneously with experimental fish throughout the duration of the experiment.

Exposure of carp to Sava River water

A group of carp was exposed for 29 d in a 50-L tank to a flow of polluted Sava River water, at a rate of five water-volume exchanges per day, at the cooling water pumping station of the power plant Zagreb II. On day 15 a group of exposed carp was

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transferred to a tank with tap water for recovery. These exposures were done during three consecutive periods: September/October 1990, February/March 1991, and March/April 1991.

Measurement of the oil hydrocarbon concentration

The concentration of petroleum hydrocarbons in the water extracts was determined after purification and separation of water samples through an acid alumina column, according to the standard Intergovernmental Oceanographic Commission method [17], as modified by Picer [18]. The concentrations of hydrocarbons in three separate water extracts of crude oil were 17.7, 16.7, and 18.3 ppm of Kuwait oil equivalents, or 2.5, 3.0, and 3.2 ppm of chrysene equivalents. Fluorescence of water in the tanks polluted with either crude oil or diesel-2 oil was measured in a Zeiss PMQ-3 spectrofluorometer at an excitation wavelength of 365 nm (Zeiss filter 365) and emission at 520 nm. The fluorescence of a solution of 1 μg of quinine sulfate per milliliter of 0.1 N H_2SO_4 was used for the standardization of the instrument at 1,000 fluorescence units. The water fluorescence was expressed arbitrarily in these fluorescence units.

Preparation of postmitochondrial fraction and measurement of BaPMO activity

One gram of liver tissue was homogenized in three volumes of 0.15 M KCl in a glass Potter-Elvehjem homogenizer with a Teflon® pestle. The homogenate was centrifuged at 9,000 *g* for 10 min at 2°C. An aliquot of the supernatant was stored in liquid nitrogen and used as S9 fraction for the preparation of S9 mix in the mutagenicity testing. BaPMO activity was measured immediately in another aliquot of the supernatant, according to the method of Nebert and Gelboin [19], as modified by Payne and Penrose [20]. The inhibitory effect of 10^{-4} M of 7,8-benzoflavone on the BaPMO activity [21] was measured in each sample in parallel. Carp treated intraperitoneally (i.p.) with 3-MC (50 mg/kg) served as a positive control [13,14]. The activities were expressed in picomoles of BaPOH per milligram of protein per minute. Proteins were determined according to the method of Lowry et al. [22].

Measurement of bile fluorescence

Aliquots of bile (5 μl) were diluted in 4 ml of 1 N NaOH, and the fluorescence of the solution was measured in a Zeiss PMQ-3 spectrofluorometer at an excitation wavelength of 365 nm (Zeiss filter 365) and emission at 520 nm. This procedure was chosen because it closely imitates the conditions occurring in the last step of the method of Nebert and Gelboin [19] for determination of BaP metabolites in hexane extracts of incubation media for the determination of BaPMO activity. The fluorescence of a solution of 1 μg of quinine sulfate per milliliter of 0.1 N H_2SO_4 was used for the standardization of the instrument at 1,000 fluorescence units. The bile fluorescence was expressed in these fluorescence units.

Mutagenicity testing of bile

Bile samples from carp exposed to crude oil, diesel-2 oil, or polluted Sava River water, as well as bile samples from natural fish species, were assayed by the plate incorporation Ames test [23], using the *S. typhimurium* TA 100 and TA 98 strains, with and without S9 mix. Aliquots of bile (50 μl) were added to 2 ml of top agar, followed by 500 μl of S9 mix and 100 μl of the tester strains culture, quickly mixed, and plated. The presence of glucuronidated mutagenic metabolites in bile was determined by addition of β-glucuronidase solution (*H. pomatia* type H-1, 2000 U per plate in 0.2 M sodium acetate buffer, pH 4.5) to the S9 mix. The postmitochondrial fraction of liver from immature carp induced by i.p. injection of 3-MC (50 mg/kg) served as the activation system (S9) [24]. Immediately before mutagenicity testing, the S9 fractions were passed through membrane filters (0.45-μm and 0.22-μm filter units) to remove any contaminating microorganisms. Each sample was tested in triplicate. The number of *his*+ revertants was counted manually.

Potential for bioactivation of procarcinogens

The potential of liver postmitochondrial fractions from experimentally exposed carp or from natural fish specimens for bioactivation of procarcinogen BaP was measured by a modified Ames test [25]. Bioactivation potential was expressed as the net increase in the number of revertants activated from BaP (10 μg per plate) by fish liver S9 (2 mg protein per plate) over the spontaneous number of *S. typhimurium* TA 100 revertants. The potential of S9 preparations from experimentally exposed fish was expressed as the *n*-fold increase over the potential of S9 fraction from control carp.

RESULTS

In order to follow the correlations between the induction, persistence, and decline in the BaPMO activity; the potential to bioactivate BaP; and the bile fluorescence, we exposed carp to water exper-

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imentally contaminated either with diesel-2 or with crude oil for a certain period of time. Subsequently, carp were transferred to unpolluted water for a period of recovery.

The level of bile fluorescence in carp exposed to water saturated with diesel-2 oil (50 ppb) increased within 3 d to a level 5.8-fold higher than the natural fluorescence level in unexposed carp. Twelve days' exposure increased the fluorescence to a saturation level (12-fold increase). Prolonged exposure (18 d) did not increase the fluorescence further (Fig. 1A). Fluorescence of the bile in fish exposed to crude oil (36 ppb) almost reached the saturation level (6.2-fold the natural fluorescence) after a 3-d exposure (Fig. 1B).

The level of BaPMO activity in fish exposed either to crude oil or to diesel-2 oil was increased about fivefold after 3 d of exposure (Fig. 1A,B). These levels of induction were near the maximum inductions (about sixfold) obtained on day 18 of exposure either to diesel-2 or to crude oil (Fig. 1A,B). 7,8-Benzoflavone at 10^{-4} M inhibited all these induced BaPMO activities by 57 to 73% (not shown). The fast increase in the BaPMO activity in the liver of fish exposed to either of the pollutants was accompanied by an increase in the potential for bioactivation of BaP in the *Salmonella* TA 100 assay (Fig. 1A,B).

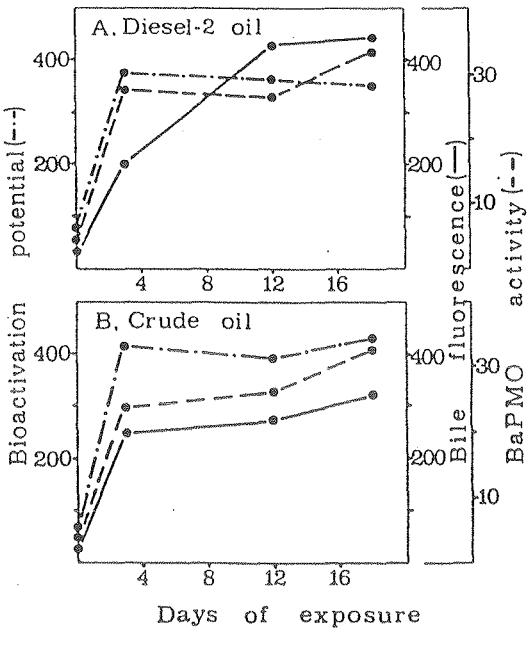

Fig. 1. Bile fluorescence, benzo[*a*]pyrene monooxygenase (BaPMO) activity, and bioactivation potential in the liver of carp exposed to (A) diesel-2 oil (50 ppb) and (B) crude oil (36 ppb). Bile fluorescence is expressed in arbitrary units; BaPMO activity is expressed in pmoles of BaPOH/mg/min; bioactivation potential is expressed in the net increase in the number of revertants activated from BaP (10 μg/plate) by fish liver S9 (2 mg protein/plate) over the spontaneous number (145 ± 5) of *Salmonella typhimurium* TA 100 revertants. Each point represents the mean from determinations in four specimens. The SD was <11%.

Bile from unexposed carp contained neither direct, indirect, nor glucuronidated *S. typhimurium* TA 100 or TA 98 mutagens. Exposure to diesel-2 or to crude oil for 12 d slightly increased the count of TA 98 (41 and 46, respectively) and TA 100 (67 and 74, respectively) colonies in the bile in the presence of S9 fraction. No direct mutagens were detected. Longer exposure (18 d) did not further increase the number of revertants of these *Salmonella* strains. Interestingly, β-glucuronidase treatment increased the number of TA 98 (50%) and TA 100 (78%) promutagens only in the bile of carp exposed to diesel-2 oil.

It is known that the induction of BaPMO in fish exposed to crude oil causes a dose-dependent response [26–29]. In order to elucidate whether bile fluorescence and the potential for bioactivation in carp exposed to crude oil respond also in a dose-dependent mode, we exposed groups of carp to different concentrations of crude oil for a constant exposure time of 12 d.

The results of these experiments (Fig. 2) revealed that whereas exposure to low (8 ppb) and medium (18 ppb) concentrations of crude oil caused only slight induction of BaPMO (61 and 52%, respectively), the increase in bile fluorescence, as well as the increase in the potential to bioactivate BaP into TA 100 mutagens, was more than fourfold after exposure to the lowest concentration of crude oil. This finding demonstrated that the sensitivity of bile fluorescence, or of the potential for bioactivation of BaP to TA 100 mutagens, was an even more sensitive detector of the exposure to low concentrations of crude oil than was the induction of BaPMO. Exposure to the highest concentration of crude oil (36 ppb), however, increased simultaneously the fluorescence of bile (5.5-fold), the activity of BaPMO (5.1-fold), and the bioactivation potential (11-fold). Differences between values of BaPMO and bile fluorescence in control fish and their values in fish at all three concentrations of exposure were statistically significant, at $P < 0.05$ or less. Simultaneously, the net number of both TA 98 (20, 30, and 50, respectively) and TA 100 (71, 74, and 99, respectively) revertants in the bile was proportional to the dose (8, 18, and 36 ppb) of crude oil (not shown).

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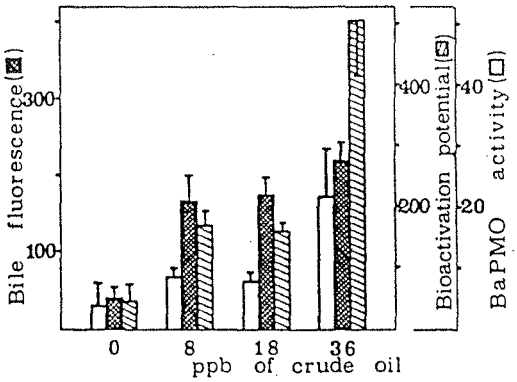

Fig. 2. Bile fluorescence, benzo[*a*]pyrene monooxygenase (BaPMO) activity, and bioactivation potential in carp exposed for 12 d to crude oil with petroleum hydrocarbon concentrations of 8, 18, and 36 μg of Kuwait oil equivalent/L. Bile fluorescence is expressed in arbitrary units; BaPMO activity is expressed in pmoles of BaPOH/mg/min; bioactivation potential is expressed in the net increase in the number of revertants activated from BaP (10 μg/plate) by fish liver S9 (2 mg protein/plate) over the spontaneous number (142 ± 8) of *Salmonella typhimurium* TA 100 revertants. Each column represents the mean and the SD from determinations in four specimens. Differences between values of BaPMO and bile fluorescence in control fish and their values in fish at all three concentrations of exposure were statistically significant at $P < 0.05$ or less, as determined by Student's *t* test.

Similarly to the results obtained in a time-dependent experiment, neither of these promutagens was glucuronidated.

These results demonstrated that the increase in bile fluorescence caused by exposure to crude and diesel-2 oil was correlated with the increase in both biological responses caused by this exposure, that is, the BaPMO activity and the potential for bioactivation, as well as with the mutagenicity of bile as detected by strains TA 98 and TA 100 in the presence of S9 fraction. In the case of exposure to diesel-2 oil, part of the promutagenic metabolites was glucuronidated.

Before any possible application of these findings to real environmental samples, it was important to explore how long the observed changes would hold after the cessation of exposure, for example, after the disappearance of the oil slick in the real environment. In order to obtain this information, we followed, for a 15-d recovery period, the dynamics of changes in values of these parameters in fish previously exposed for 12 d to a water saturated with diesel-2 oil. During the recovery period, the bile fluorescence steadily decreased and reached an almost natural level of fluorescence on day 15 (Fig. 3). On day 15 the bile was negative with respect to the presence of TA 98 promutagens or glucuronidated promutagens. The activity of BaPMO decreased during the recovery in a time-dependent way to almost the natural level at day 15 (Fig. 3). However, the induced potential for bioactivation of BaP using the TA 100 strain was maintained at the same high level throughout the recovery period (Fig. 3), demonstrating the difference between the nature of BaPMO enzyme and the enzymes responsible for bioactivation of BaP to TA 100 mutagens.

To test the applicability of bile fluorescence measurements as a parameter indicating the presence of xenobiotics in water, as well as a parameter indicating their biological effects under natural, in-the-field conditions, the response of these parameters was measured, first, in the experimental carp exposed to a flow of polluted Sava River waters and, second, in a population of fish living either in the polluted Sava River or in the reference Korana River. The exposure of experimental juvenile carp to Sava River water for 29 d resulted in the increase in either bile fluorescence (5.1-fold), liver BaPMO activity (9.5-fold), or liver potential to bioactivate BaP using the TA 100 strain (fourfold) (Fig. 4). The BaPMO activities at days 11 and 25 were readily inhibited (by 67 and 76%, respectively) in the presence of 10^{-4} M 7,8-benzoflavone. On day 15 of exposure, the bile of carp became mutagenic: the

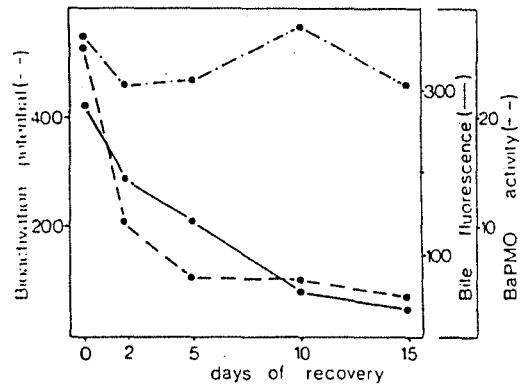

Fig. 3. Bile fluorescence, benzo[*a*]pyrene monooxygenase (BaPMO) activity, and bioactivation potential in carp during recovery after a 12-d exposure to diesel-2 oil (50 ppb). Bile fluorescence is expressed in arbitrary units; BaPMO activity is expressed in pmoles of BaPOH/mg/min; bioactivation potential is expressed in the net increase in the number of revertants activated from BaP (10 μg/plate) by fish liver S9 (2 mg protein/plate) over the spontaneous number (144 ± 7) of *Salmonella typhimurium* TA 100 revertants. Each point represents the mean from determinations in four specimens. The SD was <9%.

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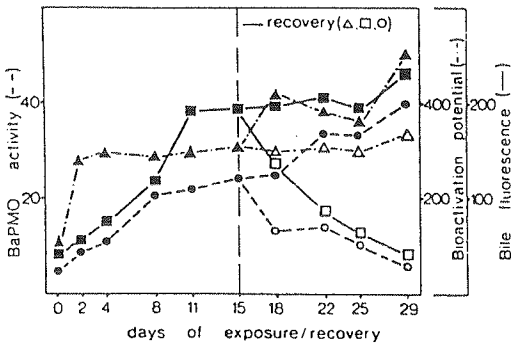

Fig. 4. Bile fluorescence, benzo[*a*]pyrene monooxygenase (BaPMO) activity, and bioactivation potential in carp during exposure to Sava River water (closed symbols) and during the recovery period (open symbols). Bile fluorescence is expressed in arbitrary units; BaPMO activity is expressed in pmoles of BaPOH/mg/min; bioactivation potential is expressed in the net increase in the number of revertants activated from BaP (10 μg/plate) by fish liver S9 (2 mg protein/plate) over the spontaneous number (140 ± 9) of *Salmonella typhimurium* TA 100 revertants. Each point represents the mean from determinations in four specimens. The SD was <7%.

net number of *S. typhimurium* TA 98 revertants was 51 + 10 (six bile samples), and treatment with β-glucuronidase increased the mutagenicity for 29%. The transfer of carp, previously exposed to polluted Sava River waters for 15 d, to clean water resulted in a rapid fall of BaPMO activity and bile fluorescence, whereas the potential for bioactivation remained at the same induced level throughout the 14-d recovery period (Fig. 4). Similar results were obtained during exposures in September/October 1990 and February/March 1991. Thus, the behavior of these parameters was concordant with their behavior found in the exposure/recovery experiment with diesel-2 oil.

Seven fish species native to the polluted Sava River, caught in the middle of June 1991, when compared to untreated juvenile carp revealed a general increase in bile fluorescence (1.5- to 4.5-fold), BaPMO activity (four- to 21-fold), and potential to bioactivate BaP to TA 100 mutagens (87–498 revertants) (Table 1). However, there were considerable species-specific differences in responses with regard to these parameters. In *B. barbus, L. cephalus, R. pigus virgo*, and *A. brama*, there was a good correlation between bile fluorescence, BaPMO activity, and bioactivation potential. Indeed, the correlation between BaPMO and bile fluorescence was statistically significant ($P < 0.05$). In *C. nasus*, however, the bile fluorescence did not correlate with BaPMO activity and bioactivation potential. The BaPMO activities in all Sava fish livers were inhibited with 10^{-4} M 7,8-benzoflavone by 55 to 69%. Simultaneously, six fish species from the reference Korana River, also caught in the middle of June 1991, did not reveal an increase in bile fluorescence,

Table 1. The bile fluorescence, benzo[*a*]pyrene monooxygenase (BaPMO) activity, and bioactivation potential in livers of fish living in the polluted Sava River and the reference Korana River (Croatia)[a]

	n[b]		Bile fluorescence (arbitrary units)		BaPMO (pmol/mg/min)		Bioactivation potential[c] (no. of TA 100 revertants)	
Fish species	Sava	Korana	Sava	Korana	Sava	Korana	Sava	Korana
"Plotica" (*Rutilus pigus virgo*)	5	5	74 ± 20[d]	25 ± 11	17.2 ± 3.8[d]	6.9 ± 1.8	331 ± 9	12 ± 7
Chub (*Leuciscus cephalus*)	4	4	89 ± 23[d]	28 ± 4	36.3 ± 9.8[d]	9.0 ± 1.5	200 ± 11	52 ± 26
Barbel (*Barbus barbus*)	9	5	103 ± 29[d]	44 ± 18	29.5 ± 9.5[d]	13.7 ± 2.5	348 ± 17	40 ± 12
Nose carp (*Chondrostoma nasus*)	3	4	37 ± 28	25 ± 7	69.7 ± 9.8	9.8 ± 0.9	498 ± 10	47 ± 17
Roach (*Rutilus rutilus*)	4	9	43 ± 13	25 ± 13	14.4 ± 4.5	6.0 ± 4.5	87 ± 6	20 ± 26
Bleak (*Alburnus alburnus*)	8	7	42 ± 15	18 ± 6	17.4 ± 2.2	3.5 ± 1.4	126 ± 6	23 ± 7
Bream (*Abramis brama*)	6	NA[e]	114 ± 21[d]	NA	31.3 ± 9.3[d]	NA	229 ± 10	NA
Control untreated carp	14		25 ± 3		3.3 ± 1.2		25 ± 6	
3-MC treated carp	12		226 ± 63		38.8 ± 2.6		868 ± 23	

[a]Fish were caught in the middle of June 1991.
[b]Numbers of examined specimens from each source.
[c]Bioactivation potential was expressed in the net increase in the number of revertants activated from BaP (10 μg/plate) by fish liver S9 (2 mg protein/plate) over the spontaneous number (137 ± 16) of TA 100 revertants.
[d]Difference from control values (untreated carp) was statistically significant, at $P < 0.05$.
[e]NA = not available.

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in comparison to bile fluorescence in untreated experimental juvenile carp (Table 1). Their liver BaPMO activities, however, were one- to fourfold higher than those in control carp, whereas their potential to bioactivate BaP to TA 100 mutagens never doubled the number of spontaneous revertants (Table 1). 7,8-Benzoflavone (10^{-4} M) inhibited the BaPMO activities in livers of Korana fish between 0 and 18%. Bile from Sava or Korana fish contained neither TA 98 promutagens nor glucuronidated promutagens.

DISCUSSION

The choice of experimental design was based on the following rationale: (a) diesel-2 and crude oil induce in fish, including carp, severalfold enhancements of both the BaPMO activity [26,27,30,31] and the potential to bioactivate procarcinogens like BaP to *S. typhimurium* mutagens [13,24]; (b) these pollutants are complex mixtures of thousands of diverse organic compounds, including FACs [10]; (c) FACs are eliminated from the organism via the bile, where their concentration can be measured as the increase in bile fluorescence [10,7]; (d) exposure conditions closely simulate the conditions as they may naturally occur beneath an oil slick [32], hence increasing the environmental relevance of the results; (e) a recovery period allows the determination of the persistence and/or time-dependent decline in the level of impacted parameters after the cessation of exposure.

Exposures of carp to either pollutant resulted in rapid simultaneous increases in the activity of BaPMO, the potential for bioactivation of BaP to mutagens, and the level of bile fluorescence. The responses of all three parameters were in a dose-dependent mode, as revealed in 12-d exposures to three different concentrations of crude oil.

It is worthwhile to note that all these changes were caused at concentrations that closely simulate conditions as they might occur beneath an oil slick: concentrations in our basin with experimental oil spill (36 ppb of Kuwait oil equivalents) were similar to those reported to occur 10 m beneath, and several hours after the initiation of, the experimental oil slick (20–80 ppb; 8–11 h after discharge) [32].

During the 15-d recovery after exposure to diesel-2, both the bile fluorescence and the BaPMO activity steadily decreased and reached an almost natural level on day 15. In contrast, the potential of carp liver S9 fraction for bioactivation of BaP into mutagens remained at the same induced level throughout the 15-d recovery. This behavior of bioactivation potential may explain the lag in the formation of liver diesel-2- or crude oil-related DNA adducts formed in carp exposed to diesel-2 or crude oil found under conditions similar to those described here: there the formation of petroleum-DNA adducts proceeded well after the cessation of exposure [33]. Thus it seems that the increase in bile fluorescence observed in carp exposed to diesel-2 or crude oil may be correlated with the increase in the formation of DNA adducts only during the exposure period. In wild fish living in chemically contaminated rivers, that is, in steadily exposed fish, bile fluorescence correlates well with the level of pollution-related DNA adducts [34].

Exposure of carp to a flow of polluted Sava River water resulted in a similar simultaneous increase in all three parameters. The indication that levels of biliary fluorescence may be as sensitive an indicator of contamination with polycyclic aromatic hydrocarbons as the induction of MFO activity was recently demonstrated in winter flounder exposed to sediment contaminated with a range of Venezuelan crude oil concentrations [11] and in English sole exposed to a complex mixture of contaminants extracted from a sediment collected from a polluted area of Puget Sound, Washington [12]. During the recovery from the exposure to polluted Sava River water, both the bile fluorescence and the BaPMO activity steadily decreased and on day 15 of recovery almost reached the natural, preexposure level. Similar decline in the activity of aryl hydrocarbon hydroxylase also was observed in English sole captured from a reference site in Puget Sound and held in captivity for 28 d [12]; however, under these conditions bile fluorescence was shown to increase. This difference from our results may be explained, besides by the difference in fish species, by different feeding status of carp and English sole during the experiments. Similarly to carp exposed to oils, the potential of carp exposed to Sava River water for bioactivation remained at the same induced level throughout the recovery period. Thus during the experimental laboratory exposures to diesel-2 or crude oil, as well as during the exposure to Sava River water, the increase in fluorescence of bile coincided with the enhancement in important molecular responses, like the induction of BaPMO activity and the induction of the potential to bioactivate BaP to mutagens. This demonstrated that, alone, simple measurement of bile fluorescence in fish exposed to polluted waters may indicate the presence of even unknown xenobiotics causing profound molecular response.

Finally, seven fish species native to polluted Sava River waters generally revealed a simultaneous in-

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crease in bile fluorescence, BaPMO activity, and potential to bioactivate BaP. However, a complex physiology of bile formation and its secretion may influence its natural level of fluorescence. Nevertheless, it seems that enhanced fluorescence in fish from the Sava River may indicate the presence of unknown xenobiotics causing profound pathophysiological and molecular responses, as simultaneous analyses of six fish species native to the reference Korana River did not reveal an increase in bile fluorescence, in comparison to bile fluorescence in untreated experimental juvenile carp. Their BaPMO activities and their potentials for bioactivation were slightly higher than corresponding activities in unexposed experimental carp. These values, however, may well be the normal values of BaPMO activities in these native fish species, as the non- or low-inhibiting effect of 10^{-4} M 7,8-benzoflavone [21,14], shows.

Previous study of BaPMO activity in the population of fish living in the polluted Sava River and fish living in two less polluted rivers, the Kupa and Krka, showed high correlation between the level of pollution by communal and industrial waste and the level of BaPMO induction [14]. Simultaneously, in no instance were neoplasms detected in the fish populations from the Sava River [35,13]. Interestingly, recent ^{32}P-postlabeling analyses of DNA adducts in chub, bream, and barbel from the Sava and Korana rivers failed to show any pollution-related DNA adducts [36], demonstrating that the level of pollution in the Sava was under the threshold level needed for the formation of pollution-related DNA adducts.

Thus in addition to already established correlations between bile fluorescence and the content of aromatic compounds in the bile of fish exposed to xenobiotics, bile fluorescence in exposed fish correlates well with the induction of important physiological and pathobiological effects, like the induction of BaPMO; the induction of the potential for bioactivation of BaP to mutagens; and, at certain levels of pollution, the formation of pollution-related DNA adducts.

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YOUR INFORMATION ONLY

APPENDIX VI

BENTHIC INVERTEBRATE QA/QC - SORTING EFFICIENCY TEST

SUNCOR PROJECT-Oct. 1995 Benthic Invertebrate Samples

Sorting efficacy test on a random set from 63 total benthic samples.
Initial sorting conducted by ABA, Inc., Corvallis, OR
Sorting efficacy check involved a complete resort of each sample by another technician at ABA.
The 9 randomly selected samples all passed the 95% sorting efficacy test.

Sampler	Sample	Total initial sort	Number missed initial sort	Adjusted total	Percent missed %
Ekman	AB007-B076	47	1	48	2.08
Ekman	AB010-B105	30	0	30	0
Ekman	AB001-B015	127	3	130	2.31
Artificial substrate	AB010-B102	534	4	538	0.74
Artificial substrate	AB004-B042	539	5	544	0.92
Artificial substrate	AB012-B121	462	1	463	0.22
Artificial substrate	AB003-B033	544	15	559	2.68
Hess	SB002-B021	342	16	358	4.47
Hess	SB003-B021	188	5	193	2.59

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BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN

RESULTS OF SORTING EFFICIENCY (QA/QC) TESTS)

Taxon	Site-Replicate		
	S4-3	17-1	55-5
Enchytraeidae	1	0	0
Naididae	0	1	4
Hydrachnidia	3	1	3
Baetis	1	1	0
Plecoptera	1	0	0
Perlidae	1	0	0
Orthocladiinae	2	2	5
Corynoneura	1	1	0
Tanypodinae	0	1	0
Chironomini	3	2	2
Tanytarsini	1	0	3
Initial Total/Sample	286	259	515
Adjusted Total	300	268	532
Number Missed	14	9	17
% Missed	4.7	3.4	3.2
Sorting Efficiency	95.3	96.6	96.8

BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN

RESULTS OF INVERTEBRATE RE-IDENTIFICATIONS (QA/QC)

Taxon	Site-Replicate			
	17-1 Taxonomist 1	17-1 Taxonomist 2	30-2 Taxonomist 1	30-2 Taxonomist 2
Nematoda	7	6	5	5
Enchytraeidae	0	0	3	2
Naididae	22	22	12	16
Tubificidae	2	1	26	24
Pisidium	1	0	0	0
Sphaerium	1	2	0	0
Hydrachnidia	30	30	12	11
Cyclopoida	2	2	0	0
Baetis	5	4	14	13
Baetis pygmaeus	8	6	0	0
Ephemerella	0	0	1	1
Heptageniidae	4	6	0	0
Heptagenia	12	9	1	1
Stenonema	2	10	0	0
Stenacron	2	1	0	0
Leptophlebia	1	1	0	0
Ophiogomphus	0	0	1	1
Plecoptera	1	0	1	1
Chloroperlidae	1	1	4	4
Zapada	1	1	0	0
Skwala	0	0	1	1
Perlodidae	0	0	0	1
Callicorixa	0	0	4	4
Glossosomatidae	0	0	1	1
Hydropsyche	0	0	3	3
Oecetis	1	1	0	0
Ptilostomis	1	0	0	0
Optioservus l	0	0	1	1
Diptera p	1	1	0	0
Bezzia	1	1	0	0
Chironomidae p	1	1	0	0
Diamesinae	0	0	1	0
Orthocladiinae	6	5	2	1
Corynoneura	0	0	5	5
Tanypodinae	21	25	2	2
Chironomini	18	10	1	2
Tanytarsini	71	70	0	1
Chelifera	4	0	1	1
Hemerodromia	29	29	2	1
Pericoma	1	1	0	0
Hexatoma	2	2	0	0
Terrestrial	0	0	5	5
Total	259	248	109	108
% Similarity	92		93	

NOTE: Data shown are numbers per sample

APPENDIX VII

SUMMARY OF WATER QUALITY DATA

TABLE VII-1

WATER QUALITY OF THE ATHABASCA RIVER

Parameter	Units	Athabasca River upstream Ft.McMurray (1985-1995)*												Athabasca R. upstream Lease 19 (1995)			Athabasca R. downstream Lease 25 (1995)	
		Spring			Summer			Fall			Winter			Spring	Summer	Fall	Spring	Summer
		Range	Median	n	Range	Median	n	Range	Median	n	Range	Median	n	AW004-C001	AW004-C002	AW004-C003	AW009-C001	AW009-C002
Conventional Parameters and Major Ions																		
Bicarbonate	mg/L	114 - 216	141	24	114-128	118	14	144-193	155	12	162-267	212	23	119	108	116	127	110
Calcium - Dissolved	mg/L	26 - 56	39	35	29-35	31	18	33.4-42	36.9	14	39-74	52	25	30.7	32.5	27	33.6	33.5
Carbon - Particulate Total	mg/L	<0.02 - 2.9	0.05	16	0.12-3.6	2.7	5	0.25-1.68	0.97	2	<0.02-0.27	0.03	3					
Carbon - Total Organic	mg/L	7.5 - 19	8.85	6	3.2-16	6.1	4	5.4-10.7	6.8	4	5.7-9	7.6	12					
Carbon - Dissolved Organic	mg/L	5.2 - 17.2	7.6	19	1-14.7	3.9	10	2.7-10.7	5.2	8	5.7-9	7.3	15	7.1	16.7	9.2	7.6	16.1
Carbon - Dissolved Inorganic	mg/L	43 - 44	44	3					24	1								
Carbonate - Dissolved	mg/L	<0.5 - 7	0.1	15	<0.5-0.1	<0.5	13	<0.5-0.1	<5	11	<0.05-10	0.1	21					
Chloride - Dissolved	mg/L	<1.0 - 9.0	4	18	0.5-4.6	1.9	9	1.9-7.2	3.2	7	2.7-14	6.3	13	9.6	3.1	14.8	7.1	2.6
Colour True	Rel. units	10.0 - 80.0	24	19	<5-70	27	9	<5-50	16	7	<5-30	20	15					
Fluoride	mg/L	0.08-0.18	0.12	18	0.08-0.16	0.1	9	0.08-0.18	0.12	7	0.12-0.19	0.13	13	0.12			0.14	
Hydrocarbons, Recoverable	mg/L													< 1	1	< 1	< 1	< 1
Magnesium - Dissolved	mg/L	6.2-17	9.5	18	6-8.11	7.7	14				11.1-21	15	23	8.4	8	7.9	8.9	8.2
Non-Filterable Residue (TSS)	mg/L	<1-415	30	17	11-326	55	10	1-84.3	6	8	<0.4-92	2.3	14	19	624	4	23	676
pH	units	7.2 - 8.53	8	31	7.44-8.5	8.1	17	7.76-8.4	8.1	14	6.9-8.5	7.85	25	7.81	7.63	7.82	7.94	7.63
Potassium - Dissolved	mg/L	0.9-2.65	1.5	18	0.61-1.13	0.8	9	0.85-1.4	1	7	1.1-2.1	1.8	13	1.2	0.9	1.2	1.2	0.7
Sodium - Dissolved	mg/L	4.0-23	11.7	18	4.5-8.2	5	9	6-13.8	11.8	7	14-25	18	13	13.6	8.6	16.6	11.5	8.3
Specific Conductance	µS/cm	216 - 482	301	31	209-260	234	15	253-345	317	13	267-530	436	25	253	200	268	249	205
Sulphate - Dissolved	mg/L	14-57	27	18	14.4-24	19.6	9	16-38	32	7	33-58	51	13	18.3	13.1	20.3	19.2	14.2
Sulphur - Total	mg/L													6.6			7.3	
Total Alkalinity (as CaCO3)	mg/L	94 - 177	122	18	94-111	98	9	118-158	127	7	133-231	174	13	97.4	88.2	94.8	104	90.3
Total Cyanide	mg/L		<0.001	3										< 0.001	< 0.001	0.005	0.1	< 0.001
Total Dissolved Solids	mg/L	117 - 314	223	29	117-159	127	14	139-196	181	9	187-319	251	15	141	120	146	145	123
Total Hardness (as CaCO3)	mg/L	90-210	134	35	102-120.3	105.3	18	122-153	130	14	143-271	192	26	111	114	100	121	118
Total Phenolics	mg/L	<0.001-0.007	0.004	17	<0.001-0.004	<0.001	10	<0.001-0.002	<0.002	7	<0.001-0.007	<0.001	13	0.001	0.001	< 0.001	0.002	0.001
Nutrients																		
Nitrite plus Nitrate Nitrogen	mg/L	<0.001-0.231	0.187	22	<0.001-0.05	<0.001	9	<0.001-0.032	<0.003	7	0.005-0.19	0.14	15	0.015	0.11	0.007	0.003	0.1
Total Ammonia Nitrogen	mg/L	<0.01-0.06	0.02	21	<0.01-0.02	0.02	9	<0.01-0.02	0.003	7	<0.01-0.08	0.05	15	< 0.01	0.04	< 0.01	< 0.01	0.04
Total Phosphorus	mg/L	0.01-0.304	0.064	28	0.02-0.24	0.05	17	0.009-0.12	0.016	13	<0.003-0.18	0.02	26	0.048	0.39	0.028	0.04	0.44
Metals (Total)																		
Aluminum	mg/L	<0.005-1.44	0.02	15	0.11-2.5	0.6	7	<0.005-0.76	0.377	5	<0.01-0.07	0.05	11	0.17	8.64	0.11	0.15	10.1
Antimony	mg/L													< 0.0002	0.0002	< 0.0002	< 0.0002	0.0003
Arsenic	mg/L	0.0003-0.0019	0.0004	13	0.0004-0.0012	0.0008	7	0.0003-0.0019	0.0008	4	0.0004-0.0007	0.0005	5	0.0006	0.007	0.0005	0.0008	0.007
Barium	mg/L	0.06-0.121	0.083	14	0.06-0.15	0.08	6	0.07-0.08	0.07	4	0.08-0.12	0.08	6	0.05	0.2	0.04	0.06	0.21
Beryllium	mg/L	<0.001-0.001	<0.001	3	<0.001-0.003	<0.001	2		<0.001	8		<0.001	2	< 0.001	0.004	< 0.001	< 0.001	0.004
Boron	mg/L		0.04	1		0.04	1		0.04	1	0.01-0.05	0.03	2	0.05	0.05	0.09	0.03	0.05
Cadmium	mg/L	<0.0002-0.002	0.001	14	<0.0002-0.001	<0.001	6		<0.001	4	<0.001-0.003	0.001	6	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Chromium	mg/L	<0.001-0.009	0.003	12	0.004-0.032	0.004	6	<0.001-0.007	0.003	5	<0.002-0.006	0.003	10	< 0.002	0.003	< 0.002	< 0.002	< 0.002
Cobalt	mg/L	<0.001-0.005	0.001	14	<0.001-0.004	<0.001	6		<0.001	4	<0.001-0.004	<0.001	6	< 0.003	< 0.003	< 0.003	0.006	0.005
Copper	mg/L	<0.001-0.009	0.002	18	0.002-0.014	0.003	9	<0.001-0.004	<0.001	7	<0.001-0.007	0.002	14	< 0.001			0.004	
Iron	mg/L	0.101-7.51	0.221	15	0.25-10.7	0.6	6	0.19-2.42	1.3	4	0.13-0.25	0.2	6	0.43	17.9	0.91	0.43	19.4
Lead	mg/L	<0.002-0.006	<0.002	14	<0.002-0.003	<0.003	5	<0.002-<0.003	<0.002	4	<0.002-0.009	<0.002	10	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lithium	mg/L		<0.005	1		0.014	1		0.017	1	<0.005-0.02	<0.005	2	0.006	0.014	0.006	0.006	0.019
Manganese	mg/L		0.011	2	0.03-0.26	0.04	7	0.013-0.073	0.017	6	<0.004-0.12	0.007	9	0.04	0.509	0.033	0.044	0.534
Mercury	µg/L	<0.1-0.2	<0.1	18	<0.05-<0.1	<0.1	9	<0.05-<0.1	<0.05	7	<0.05-<0.1	<0.05	13	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	mg/L	<0.001-0.007	0.002	16	<0.001-0.005	<0.001	6	<0.001-0.018	0.002	4	<0.001-0.007	0.001	5	< 0.003	< 0.003	< 0.003	0.004	< 0.003
Nickel	mg/L	<0.001-0.013	0.004	15	0.004-0.014	0.009	6	0.002-0.005	0.004	4	0.001-0.009	0.005	6	0.005	< 0.005	< 0.005	< 0.005	0.009
Selenium	mg/L	<0.0001-0.0003	<0.0001	13	<0.0001-0.0004	<0.0002	6	<0.0001-0.0004	<0.0001	4	<0.0001-0.0002	<0.0002	5	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Silicon	mg/L													2.12			1.85	
Silver	mg/L		<0.001	1		<0.001	1		<0.001	1		<0.001	3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Strontium	mg/L		0.18	1		0.22	1		0.22	1	0.32-0.36	0.34	2	0.19	0.229	0.171	0.21	0.248
Titanium	mg/L													0.004	0.085	0.007	0.005	0.056
Uranium	mg/L													< 0.5			< 0.5	
Vanadium	mg/L	<0.002-0.015	0.002	14	<0.002-0.016	0.007	7	<0.002-0.005	0.002	4	<0.001-0.009	0.004	6	< 0.002	0.009	0.003	0.004	0.015
Zinc	mg/L	<0.001-0.025	0.007	19	0.005-0.038	0.008	10	<0.001-0.03	0.01	6	0.001-0.034	0.01	14	0.019	0.085	0.017	0.019	0.095
Bacteria																		
Total Coliforms	No/100 mL	4.0 - 250	68	11	12-240	24	3	4.0-84	44	2								
Fecal Coliforms	No/100 mL	<4 - 8.0	2	11	<4-76	8	4	<4-24	<4	2								
Detectable Trace Organic Compounds																		
Naphthalene	mg/L																0.02	
Methyl Naphthalene	mg/L																0.03	
Naphthenic Acids	mg/L													< 1	< 1	< 1	< 1	< 1

NOTES

* Median values; Data from NAQUADAT for Site 00AL07CC0600(1985-1995)

Historical trace organics data are not shown

TABLE VII-2

WATER QUALITY OF ATHABASCA RIVER TRIBUTARIES IN 1995

Parameter	Units	McLean Cr. at Mouth			Wood Cr. at Mouth			Leggett Cr. at Mouth	
		Spring	Summer	Fall	Spring	Summer	Fall	Summer	Fall
		AW005-S001	AW005-S002	AW005-S003	AW006-S001	AW006-S002	AW006-S003	AW014-S002	AW014-S003
Conventional Parameters and Major Ions									
pH		7.73	8.15	7.96	7.86	8.18	8.08	7.6	7.4
Specific Conductance	µS/cm	572	291	307	544	319	368	293	336
Total Dissolved Solids	mg/L	339	156	167	328	191	207	167	188
Non-Filterable Residue (TSS)	mg/L	46	17	1	9	87	5	10	211
Dissolved Organic Carbon	mg/L	12	21.9	21.4	12.3	27.5	23	25.7	26.2
Calcium - Dissolved	mg/L	53.3	38.5	38.8	60	51.7	47.7	50.1	49.5
Magnesium - Dissolved	mg/L	13.8	10.1	11	18.4	13.6	13.6	11.3	12.4
Sodium - Dissolved	mg/L	61.3	11	13.5	47.7	16.3	18.9	8.6	10.5
Potassium - Dissolved	mg/L	2.1	0.92	1.4	2.2	0.6	1.3	0.68	1.3
Chloride - Dissolved	mg/L	56.9	8	10.5	29.2	7	9.1	1.2	3.7
Sulphate - Dissolved	mg/L	53.2	7.3	11	25.4	5.8	7.8	5.3	8.4
Total Alkalinity (as CaCO3)	mg/L	162	132	133	238	157	178	148	168
Bicarbonate	mg/L	197	161	162	290	191	217	180	205
Total Hardness (as CaCO3)	mg/L	190	138	142	226	185	175	172	175
Fluoride	mg/L	0.17			0.24				
Total Cyanide	mg/L	< 0.001	0.003	< 0.001	0.025	< 0.001	< 0.001	0.003	< 0.001
Sulphur - Total	mg/L	17.3			8.8				
Total Phenolics	mg/L	0.002	0.003	< 0.001	0.002	0.001	< 0.001	0.004	< 0.001
Hydrocarbons, Recoverable	mg/L	< 1	1	< 1	< 1	9	< 1	< 1	< 1
Nutrients									
Nitrite plus Nitrate Nitrogen	mg/L	0.019	< 0.03	0.004	0.012	0.1	0.005	< 0.03	< 0.003
Total Ammonia Nitrogen	mg/L	0.03	0.05	< 0.01	0.01	< 0.01	< 0.01	0.03	0.03
Total Phosphorus	mg/L	0.048	0.033	0.014	0.037	0.049	0.021	0.019	0.196
Metals (Total)									
Aluminum	mg/L	0.29	0.28	0.06	0.06	1.12	0.09	0.14	1.89
Antimony	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0002	< 0.0002	0.0003	< 0.0002
Arsenic	mg/L	0.0002	0.0003	0.0008	0.0003	0.0015	0.0003	0.0005	0.0012
Barium	mg/L	0.04	0.03	0.02	0.05	0.03	0.03	0.04	0.07
Beryllium	mg/L	< 0.001	0.001	< 0.001	< 0.001	0.004	< 0.001	0.002	< 0.001
Boron	mg/L	0.09	0.12	0.08	0.13	0.11	0.08	0.05	0.1
Cadmium	mg/L	< 0.003	0.003	0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Chromium	mg/L	< 0.002	0.008	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cobalt	mg/L	0.005	< 0.003	< 0.003	0.004	< 0.003	< 0.003	< 0.003	0.004
Copper	mg/L	0.002			0.002				
Iron	mg/L	0.89	0.77	0.41	0.64	2.22	0.38	0.76	4.81
Lead	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lithium	mg/L	0.016	0.006	0.007	0.02	0.008	0.011	0.011	0.016
Manganese	mg/L	0.061	0.045	0.02	0.053	0.053	0.017	0.088	0.21
Mercury	µg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	mg/L	< 0.003	< 0.003	0.004	< 0.003	< 0.003	< 0.003	< 0.003	0.004
Nickel	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.012
Selenium	mg/L	< 0.0002	0.0003	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Silicon	mg/L	2.93			3.76				
Silver	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Strontium	mg/L	0.18	0.103	0.096	0.21	0.143	0.143	0.15	0.163
Titanium	mg/L	0.006	< 0.003	0.007	< 0.003	< 0.003	0.008	< 0.003	0.046
Uranium	mg/L	< 0.5			< 0.5				
Vanadium	mg/L	< 0.002	0.007	< 0.002	< 0.002	< 0.002	< 0.002	0.006	0.008
Zinc	mg/L	0.023	0.066	0.024	0.032	0.043	0.023	0.038	0.035
Naphthenic Acids	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

NOTES

Trace organic compounds were not detected in 1995

TABLE VII-3

WATER QUALITY OF POPLAR CREEK

Parameter	Units	Historical Data (1980-84)*												1995 Data		
		Spring			Summer			Fall			Winter			Spring	Summer	Fall
		Range	Median	n	Range	Median	n	Range	Median	n	Range	Median	n	AW008-S001	AW008-S002	AW008-S003
Conventional Parameters and Major Ions																
pH		7.2-8.5	7.8	17	7.28-8.44	8.1	12	7.28-8.3	7.96	10	7.52-8.44	8.01	8	7.88	8.33	8
Colour True	Rel. Units.	50-100	80	5		125	1	25-100	62.5	4	35-150	70	5			
Turbidity	NTU	3.4-22.5	8.5	7	7-73	40	2	3.5-12	4.2	3	3.8-16	6.2	4			
Specific Conductance	µS/cm	220-6640	484	19	294-686	541.5	14	240-1290	537	14	340-4400	895	11	457	354	363
Total Dissolved Solids	mg/L	126-3814	270	12	177-391	253	7	192-672	259	11	210-2412	471	5	273	203	206
Non-Filterable Residue (TSS)	mg/L	1.6-22	9.2	11	2.4-146	6	8	3.2-61.2	5.6	7	3.6-46.8	8.3	6	2	4	117
Residue Filterable	mg/L	146-3984	307	12	191-450	347.5	8	208-709	363	8	252-2860	471	6			
Residue Fixed Filterable	mg/L	107-2630	201	7	140-299	207	3	143-500	227	4	174-2002	391	5			
Residue Fixed Nonfilterable	mg/L	<0.4-16	4.5	7	5-118	14	3	2.4-54.4	6.2	4	2-41.2	4.6	5			
Residue Total	mg/L		617	1					408.4	1						
Dissolved Organic Carbon	mg/L	12-34	20.9	9	22-29.5	26.6	4	23.9-29	27.4	4	24-29.5	26.8	4	21.9	22.5	25.3
Dissolve Carbon Inorganic	mg/L	43.4-52.7	48.05	2		32.7	1	38.2-42.2	40.2	2						
Carbon Particulate Total	mg/L	0.45-1.24	0.845	2		1.38	1		0.98	1						
Carbon Organic Total	mg/L	13-36.5	21.1	11	22-29.5	24.55	8	21.6-29.5	27	7	23-29.5	25.5	6			
Calcium - Dissolved	mg/L	15.5-161	30.5	15	24.8-36.4	31	10	25-47.7	31.06	11	30.2-106	44.9	6	39.4	30.6	30.5
Magnesium - Dissolved	mg/L	6.1-93	10.6	13	8-15.1	12.3	9	9.8-20.3	11.4	9	10.9-51	16.2	6	13.2	10.9	11.2
Sodium - Dissolved	mg/L	25.5-1185	65	13	29.2-101	63	9	35-190	66	9	35-800	98	6	55	39.6	38.3
Potassium - Dissolved	mg/L	1.5-8.1	2	10	0.1-2.02	1.4	6	0.1-2.3	1	9	0.1-5.6	1.9	5	2.4	1.8	2
Chloride - Dissolved	mg/L	17.7-1780	41.5	13	12.6-102	60	7	18.8-232	56.5	9	24.3-1050	99.8	6	40.6	11.3	13.2
Sulphate - Dissolved	mg/L	6.9-86	20.3	13	8.8-22.7	16	9	9.1-24	15.6	9	13.6-62	29.2	6	13.6	11.1	15.2
Chlorophyll A	mg/m^3	8.6-13.1	10.85	2		9.5	1	4.1-6.4	5.25	2						
Chlorophyll A Epilithic	mg/m^2	0.199-31.566	15.84	2		0.85	1	11.27-50.31	30.79	2						
Total Alkalinity (as CaCO3)	mg/L	77-834	168	13	124-202	182	9	137-259	193	9	144-562	227	6	179	160	156
Carbonate	mg/L		0.1	11	0.1-0.7	0.1	8	0-0.1	0.1	8	0.1-6.7	0.1	6			
Bicarbonate	mg/L	94-1016.4	204.5	13	151-246	222	9	166.8-315.5	227.35	10	175-685	276	6	218	189	190
Coliforms Fecal	No./100 mL	0-18	2.5	12	0-160	16	8	0-17	1	9		0	5			
Coliforms Total	No./100 mL	0-770	10.5	12	16-2400	111	8	2-710	33	9	0-22	0	5			
Total Hardness (as CaCO3)	mg/L	63.8-784.9	118.2	15	95-153	128	10	103.6-202.7	123	11	120.3-474.6	178.6	6	153	121	122
Fluoride	mg/L	0.14-0.16	0.15	2		0.14	1	0.13-0.15	0.14	2				0.64		
Total Cyanide	mg/L	0.002-0.01	0.005	11	0.002-0.01	0.01	8	0.004-0.008	0.007	7	0.003-0.008	0.005	5	0.025	<0.001	<0.001
Sulphide - Dissolved	mg/L		<0.01	10	<0.01-0.16	<0.01	8	<0.01-0.18	<0.01	3		<0.01	3			
Sulphur - Total	mg/L													5.2		
Dissolved Oxygen	mg/L	7.4-13.7	9.6	6	7.4-12	9.65	6	5.8-18.3	8.8	5	1.5-14.4	8	2			
Biochemical Oxygen Demand	mg/L		2.5	1												
Chemical Oxygen Demand	mg/L	27-80	47.5	6	50-88.6	60	3		62.6	1	56-65	61	2			
Silica Reactive	mg/L	1.7-17.9	3.9	12	1.6-6.78	3.75	8	4.6-6.8	5.4	8	2.9-13.8	7.7	6			
Total Phenolics	mg/L	0.002-0.01	0.0055	12	0.003-0.01	0.01	8	0.003-0.015	0.005	9	0.003-0.02	0.008	6	0.003	<0.001	0.005
Oil and Grease	mg/L	<0.1-3.4	0.4	13	0.1-4.3	0.4	9	0.1-2.1	0.6	9	0.6-3.2	1.3	6			
Hydrocarbons (alkanes)	mg/L	<0.1-0.6	<0.1	11		<0.1	7	<0.1-0.1	<0.1	7	<0.1-0.2	<0.1	5			
Hydrocarbons, Recoverable	mg/L													<1	<1	<1
Nutrients																
Nitrite plus Nitrate Nitrogen	mg/L	<0.003-14.1	0.015	14	0.004-0.06	0.02	9	0.005-0.112	0.028	9	0.03-0.468	0.118	6	0.012	<0.03	0.023
Total Ammonia Nitrogen	mg/L													0.02	0.07	0.02
Nitrogen Total	mg/L	0.623-15.05	1.035	9	1.09-1.44	1.195	4	0.768-1.179	1.103	4	1.47-1.968	1.77	4			
Nitrogen Total Kjeldahl	mg/L	0.6-2.74	0.95	9	1.06-1.42	1.185	4	0.76-1.1	1.06	4	1.2-1.84	1.53	4			
Nitrogen Particulate Total	mg/L	0.14-0.17	0.155	2					0.09	1						
Nitrate Dissolved	mg/L	<0.003-0.026	0.011	11	0.004-0.05	0.015	8	<0.003-0.093	0.019	7	0.024-0.45	0.111	6			
Nitrogen Dissolved Ammonia	mg/L	0.01-1.14	0.053	13	0.01-0.13	0.05	9	0.018-0.161	0.054	9	0.04-0.28	0.17	6			
Nitrogen Dissolved Nitrite	mg/L	<0.003-0.035	0.005	13	<0.003-0.01	0.003	9	<0.003-0.019	0.006	9	0.004-0.018	0.006	6			
Phosphorus Particulate	mg/L	0.042-0.064	0.053	2		0.03	1	0.002-0.028	0.015	2						
Phosphorus Total Dissolved	mg/L	<0.002-0.018	0.01	2		0.03	1	0.021-0.039	0.03	2						
Dissolved Orthophoshate	mg/L	0.004-0.034	0.011	13	0.01-0.02	0.01	9	0.006-0.039	0.011	9	0.015-0.037	0.026	6			
Total Phosphorus	mg/L	0.03-0.077	0.051	13	0.03-0.17	0.04	9	0.023-0.059	0.041	9	0.033-0.064	0.04	6	0.031	0.023	0.043
Metals (Total)																
Aluminum	mg/L	<0.01-0.74	0.065	10	0.13-0.19	0.16	4	<0.01-0.4	0.049	5	0.05-0.3	0.27	4	0.03	0.1	0.31
Antimony	mg/L													<0.0002	0.0002	<0.0002
Arsenic	mg/L	0.0007-0.0012	0.00095	2		0.0018	1	0.0006-0.0008	0.0007	2				0.0005	0.0005	0.0005
Barium	mg/L													0.04	0.03	0.04
Beryllium	mg/L		<0.001	2		<0.001	1		<0.001	2				<0.001	0.002	<0.001
Boron	mg/L													0.19	0.19	0.14
Cadmium	mg/L	<0.001-0.001	<0.001	9		<0.001	4		<0.001	4		<0.001	4	<0.003	<0.003	0.003
Chromium	mg/L	<0.001-0.004	0.0025	2		0.004	1		0.003	2				<0.002	0.017	<0.002
Chromium hexavalent	mg/L	<0.003-0.006	0.003	6	<0.003-0.003	<0.003	3	0.003-<0.005		2	<0.001-0.006	<0.003	4			
Cobalt	mg/L	<0.001-0.003	<0.001	8	<0.001-0.004	<0.001	4		<0.001	4		<0.001	4	<0.003	0.003	<0.003
Copper	mg/L	<0.001-0.003	<0.001	13	<0.001-0.005	<0.001	9	<0.001-0.004	<0.001	9	<0.001-0.008	0.002	6	0.002		
Iron	mg/L	0.14-1.3	0.66	13	0.32-4.7	0.71	9	0.67-1.96	0.96	9	0.26-2.00	0.72	6	0.42	0.71	1.1
Lead	mg/L	<0.001-0.016	0.003	13	<0.002-0.014	0.002	9	<0.001-0.004	0.002	9	<0.002-0.009	0.004	6	<0.02	<0.02	<0.02
Lithium	mg/L													0.02	0.018	0.02
Manganese	mg/L	0.03-6.55	0.127	13	0.01-0.19	0.06	9	0.032-0.28	0.094	9	0.08-1.29	0.21	6	0.07	0.032	0.101
Mercury	µg/L	<0.0001-0.0005	<0.0001	13	<0.0001-0.0002	<0.0001	9	<0.0001-0.0003	<0.0001	9	<0.0001-0.0002	<0.0001	6	<0.05	<0.05	<0.05
Molybdenum	mg/L		<0.001	2		<0.001	1		<0.001	2				<0.003	<0.003	<0.003
Nickel	mg/L	<0.001-0.003	<0.001	13	<0.001-0.01	0.002	9	<0.001-0.003	0.002	9	<0.001-0.005	0.002	6	<0.005	<0.005	0.014
Selenium	mg/L		<0.0002	1					<0.0002	2				<0.0002	<0.0002	<0.0002
Silicon	mg/L													1.23		
Silver	mg/L													<0.002	<0.002	<0.002
Strontium	mg/L													0.2	0.168	0.167
Titanium	mg/L													<0.003	<0.003	0.013
Uranium	mg/L													<0.5		
Vanadium	mg/L	<0.001-0.004	0.001	12	<0.001-0.011	0.001	9	<0.001-0.003	0.001	8	<0.001-0.002	<0.001	6	<0.002	<0.002	0.004
Zinc	mg/L	<0.001-0.012	0.004	13	0.002-0.02	0.003	9	<0.001-0.093	0.009	9	<0.001-0.013	0.006	6	0.012	0.08	0.038
Naphthenic Acids	mg/L													6	<1	<1

NOTES

Trace organic compounds were not detected in 1995

* Median values; Data from NAQUADAT for Site 00AL07DA0840

TABLE VII-4

WATER QUALITY OF THE STEEPBANK RIVER IN 1995

Parameter	Units	Steepbank River at Lease 19 Border		
		Spring AW001-S001	Summer AW001-S002	Fall AW001-S003
Conventional Parameters and Major Ions				
pH		7.42	7.69	7.67
Specific Conductance	µS/cm	200	159	201
Total Dissolved Solids	mg/L	111	87	115
Non-Filterable Residue (TSS)	mg/L	< 0.4	4	< 0.4
Dissolved Organic Carbon	mg/L	15.7	23.3	22.6
Calcium - Dissolved	mg/L	22.3	22.5	18.5
Magnesium - Dissolved	mg/L	6.7	6.4	7
Sodium - Dissolved	mg/L	12.6	7.5	13
Potassium - Dissolved	mg/L	1.5	0.63	1.1
Chloride - Dissolved	mg/L	3.7	< 0.5	0.8
Sulphate - Dissolved	mg/L	4.8	1.6	9.5
Total Alkalinity (as CaCO3)	mg/L	98	79.7	106
Bicarbonate	mg/L	120	97.2	129
Total Hardness (as CaCO3)	mg/L	83.3	82.6	75.1
Fluoride	mg/L	0.14		
Total Cyanide	mg/L		0.005	0.003
Sulphur - Total	mg/L	2.2		
Total Phenolics	mg/L	< 0.001	0.003	< 0.001
Hydrocarbons, Recoverable	mg/L	1	2	< 1
Nutrients				
Nitrite plus Nitrate Nitrogen	mg/L	0.003	< 0.03	0.004
Total Ammonia Nitrogen	mg/L	0.02	0.07	0.03
Total Phosphorus	mg/L	0.057	0.041	0.038
Metals (Total)				
Aluminum	mg/L	< 0.01	0.05	0.02
Antimony	mg/L	< 0.0002	0.0002	< 0.0002
Arsenic	mg/L	0.0004	0.0004	< 0.0002
Barium	mg/L	0.03	0.03	0.02
Beryllium	mg/L	< 0.001	0.003	< 0.001
Boron	mg/L	0.14	0.07	0.07
Cadmium	mg/L	< 0.003	0.005	< 0.003
Chromium	mg/L	< 0.002	0.005	0.003
Cobalt	mg/L	< 0.003	< 0.003	< 0.003
Copper	mg/L	< 0.001		
Iron	mg/L	0.81	0.74	0.57
Lead	mg/L	< 0.02	< 0.02	< 0.02
Lithium	mg/L	0.006	0.006	0.009
Manganese	mg/L	0.028	0.046	0.014
Mercury	µg/L	< 0.05	< 0.05	< 0.05
Molybdenum	mg/L	< 0.003	< 0.003	< 0.003
Nickel	mg/L	< 0.005	< 0.005	< 0.005
Selenium	mg/L	< 0.0002	0.0002	< 0.0002
Silicon	mg/L	1.29		
Silver	mg/L	< 0.002	< 0.002	< 0.002
Strontium	mg/L	0.094	0.083	0.073
Titanium	mg/L	< 0.003	< 0.003	0.005
Uranium	mg/L	< 0.5		
Vanadium	mg/L	0.004	0.004	< 0.002
Zinc	mg/L	0.162	0.029	0.012
Naphthenic Acids	mg/L	< 1	< 1	< 1

NOTE

Trace organic compounds were not detected

TABLE VII-5

WATER QUALITY OF THE STEEPBANK RIVER NEAR ITS MOUTH

Parameter	Units	Steepbank River (1990-1999)*									Steepbank River at Mouth (1995)**		
		Spring			Summer			Winter			Spring	Summer	Fall
		Range	Median	n	Range	Median	n	Range	Median	n	AW010-S001-3	AW010-S004-6	AW010-S007-9
Conventional Parameters and Major Ions													
pH		8.1-8.2	8.15	2		6.6	1	7.4-8.3	7.81	5	7.87	7.88	7.81
True Colour	Rel.Units		95	1					42	1			
Turbidity	NTU		5.3	1				6.8-7.8	7.2	3			
Specific Conductance	µS/cm	576-610	593	2		138	1	474-704	480	5	232	178	219
Total Dissolved Solids	mg/L		342	1				327-383	355	2	134	99.7	127
Non-Filterable Residue (TSS)	mg/L							4.8-6	5.4	2	<0.4-11	3	<0.4-1
Residue Fixed Nonfilterable	mg/L							<0.4-1.2	<0.4-1.2	2			
Residue Filterable	mg/L							326-436	381	2			
Residue Fixed Filterable	mg/L							212-320	266	2			
Dissolved Organic Carbon	mg/L		12.6	1				11.5-13.1	12.5	3	16.3	23.1	23.4
Carbon Particulate Total	mg/L		0.72	1					0.99	1			
Carbon Total Organic	mg/L							11.5-12.5	12	2			
Carbonate	mg/L								0.1	2			
Calcium - Dissolved	mg/L		62	2				64.4-76	70.2	2	27.8	25.6	26.5
Coliforms Fecal	No./100 mL								0	2			
Coliforms Total	No./100 mL							0-12	6	2			
Magnesium - Dissolved	mg/L		22	1				20-24	22	2	8.7	7.1	8.7
Sodium - Dissolved	mg/L		46	1				42-52	42.5	3	15.1	9	13
Potassium - Dissolved	mg/L		2	1				1.8-2.3	2.1	2	0.9	0.46	0.8
Chloride - Dissolved	mg/L		7.8	1				6.5-6.7	6.5	3	3	0.8	1.9
Sulphide - Dissolved	mg/L								<0.01	2			
Sulphate - Dissolved	mg/L		10	1				11-15.8	13.7	3	5.9	0.1	9.4
Biochemical Oxygen Demand	mg/L		0.8	1					1.3	1			
Dissolved Oxygen	mg/L	12.9-13.18	13.18	3		6.3	1	13.14-13.8	13.39	3			
Total Chemical Oxygen Demand	mg/L		27	1				25-37	33	3			
Total Alkalinity (as CaCO3)	mg/L		318	1				293-347	320	2	120	89.7	109
Bicarbonate	mg/L		388	1				356.9-422.3	389.6	2	146	109	133
Total Hardness (as CaCO3)	mg/L		245	1							105	93.3	102
Total Hardness (calculated)	mg/L		245	1				243.1-288.6	265.9	2			
Oil and Grease	mg/L							0.3-0.4	0.35	2			
Silica Reactive	mg/L		13.1	1				13.2-15.8	14.5	2			
Fluoride	mg/L		0.26	1							0.15		
Total Cyanide	mg/L										<0.001-0.025	0.04	0.003
Sulphur - Total	mg/L										2.1		
Total Phenolics	mg/L		0.004	1				<0.001-0.005	<0.001	3	0.004	<0.001-0.005	<0.001
Hydrocarbons, Recoverable	mg/L										<1-1	<1	<1
Nutrients													
Nitrite plus Nitrate Nitrogen	mg/L		0.35	1				0.24-0.32	0.29	3	<0.003-0.005	< 0.03	<0.003-0.034
Total Ammonia Nitrogen	mg/L		0.06	1				0.04-0.195	0.058	3	<0.01-0.01	0.08	<0.01-0.02
Nitrogen Dissolved Nitrite	mg/L		0.004	1				0.004-0.006	0.005	2			
Nitrogen Particulate Total	mg/L		0.03	1					0.04	1			
Nitrogen Total Kjeldahl	mg/L		0.7	1				0.6-1.64	0.7	3			
Nitrogen Total	mg/L		1.05	1				0.89-1.88	1.02	3			
Nitrate Dissolved	mg/L							0.236-0.31	0.273	2			
Total Phosphorus Dissolved	mg/L		0.0138	1									
Dissolved Ortho Phosphate	mg/L							0.03-0.069	0.0495	2			
Total Phosphorus	mg/L		0.0593	1				0.035-0.0762	0.074	3	0.038	0.03	0.043
Metals (Total)													
Aluminum	mg/L		0.013	1				0.05-0.08	0.065	2	< 0.01	0.03	0.05
Antimony	mg/L										< 0.0002	<0.0002-0.0002	< 0.0002
Arsenic	mg/L		0.0006	1							0.0003	0.0004	<0.0002-0.0002
Barium	mg/L		0.073	1							0.04	0.03	0.03
Beryllium	mg/L										< 0.001	0.001	< 0.001
Boron	mg/L										0.12	0.08	0.1
Cadmium	mg/L		0.002	1							<0.003-0.003	<0.003-0.003	< 0.003
Chromium	mg/L		0.005	1							<0.002-0.002	<0.002-0.011	0.011
Cobalt	mg/L		0.001	1							<0.003-0.003	< 0.003	< 0.003
Copper	mg/L		0.002	1				<0.001-0.016	<0.001-0.016	2	<0.001-0.002		
Iron	mg/L		0.83	1				0.7-0.91	0.805	2	0.43	0.65	0.71
Lead	mg/L		<0.002	1				0.005-0.011	0.008	2	< 0.02	< 0.02	< 0.02
Lithium	mg/L										0.01	0.007	0.009
Manganese	mg/L		0.018	1				0.031-0.034	0.0325	2	0.035	0.032	0.015
Mercury	µg/L		<0.0001	1					<0.0001	2	< 0.05	< 0.05	< 0.05
Molybdenum	mg/L		0.003	1							< 0.003	< 0.003	< 0.003
Nickel	mg/L		0.005	1					<0.001	2	<0.005-0.005	< 0.005	<0.005-0.01
Selenium	mg/L		<0.0001	1							< 0.0002	< 0.0002	< 0.0002
Silicon	mg/L										1.18		
Silver	mg/L										< 0.002	<0.002-0.003	< 0.002
Strontium	mg/L										0.11	0.089	0.094
Titanium	mg/L										< 0.003	< 0.003	0.006
Uranium	mg/L										< 0.5		
Vanadium	mg/L		0.005	1					<0.001	2	<0.002-0.003	0.004	<0.002-0.003
Zinc	mg/L		0.012	1				0.003-0.017	0.01	2	0.042	0.038	0.015
Naphthenic Acids	mg/L										< 1	< 1	< 1
Detectable Trace Organic Compounds													
Naphthalene	µg/L												0.02

NOTES

* Median values; Data from NAQUADAT for Sites 00AL07DA1075, 00AL07DA1150, 00AL07DA1200

** Mean of three measurements or range

TABLE VII-6

WATER QUALITY OF THE LEASE 25 WETLAND, 1995

Parameter	Units	Lease 25 Wetland Outlet		
		Spring AW007-S001	Summer AW007-S002	Fall AW007-S003
Conventional Parameters and Major Ions				
pH		7.59	7.8	7.56
Specific Conductance	µS/cm	446	338	353
Total Dissolved Solids	mg/L	268	190	196
Non-Filterable Residue (TSS)	mg/L	30	2	79
Dissolved Organic Carbon	mg/L	25.5	25.4	25.6
Calcium - Dissolved	mg/L	58.1	48.2	47.2
Magnesium - Dissolved	mg/L	11.8	11.4	11.8
Sodium - Dissolved	mg/L	32.3	16.2	15
Potassium - Dissolved	mg/L	3.5	1.47	1.8
Chloride - Dissolved	mg/L	26.6	8	8.5
Sulphate - Dissolved	mg/L	18.2	6.6	7.8
Total Alkalinity (as CaCO3)	mg/L	192	161	170
Bicarbonate	mg/L	234	196	207
Total Hardness (as CaCO3)	mg/L	194	167	167
Fluoride	mg/L	0.2		
Total Cyanide	mg/L	< 0.001	0.004	0.003
Sulphur - Total	mg/L	5.2		
Total Phenolics	mg/L	0.005	0.003	< 0.001
Hydrocarbons, Recoverable	mg/L	< 1	1	< 1
Nutrients				
Nitrite plus Nitrate Nitrogen	mg/L	0.005	< 0.03	0.021
Total Ammonia Nitrogen	mg/L	0.06	0.06	0.03
Total Phosphorus	mg/L	0.075	0.03	0.102
Metals (Total)				
Aluminum	mg/L	0.3	0.03	1.09
Antimony	mg/L	< 0.0002	0.0002	< 0.0002
Arsenic	mg/L	0.0018	0.0008	0.001
Barium	mg/L	0.09	0.04	0.06
Beryllium	mg/L	< 0.001	0.001	< 0.001
Boron	mg/L	0.1	0.1	0.08
Cadmium	mg/L	0.003	< 0.003	< 0.003
Chromium	mg/L	0.009	0.007	< 0.002
Cobalt	mg/L	< 0.003	< 0.003	< 0.003
Copper	mg/L	0.051		
Iron	mg/L	3.28	1.16	3.29
Lead	mg/L	0.03	< 0.02	< 0.02
Lithium	mg/L	0.014	0.01	0.011
Manganese	mg/L	0.32	0.054	0.212
Mercury	µg/L	< 0.05	< 0.05	< 0.05
Molybdenum	mg/L	0.003	< 0.003	< 0.003
Nickel	mg/L	0.005	< 0.005	< 0.005
Selenium	mg/L	< 0.0002	< 0.0002	< 0.0002
Silicon	mg/L	1.28		
Silver	mg/L	< 0.002	< 0.002	< 0.002
Strontium	mg/L	0.16	0.137	0.14
Titanium	mg/L	0.006	< 0.002	0.027
Uranium	mg/L	< 0.5		
Vanadium	mg/L	0.002	0.002	< 0.002
Zinc	mg/L	0.047	0.051	0.039
Naphthenic Acids	mg/L	< 1	< 1	< 1

TABLE VII-7

WATER QUALITY OF THE MUSKEG RIVER

Parameter	Units	Muskeg River at Mouth, 1995*			Muskeg River upstream Stanley Cr.															
					1995 Data		Historical Data (1980-81)**													
		SPRING	SUMMER	FALL	SPRING	SUMMER	SPRING			SUMMER			FALL			WINTER				
		P90WTQL004 P30WTQL005	U30WTQL002 U90WTQL003	F30WTQL002 F90WTQL003	P36WTQL005	U36WTQL006	Range	Median	n	Range	Median	n	Range	Median	n	Range	Median	n		
Conventional Parameters and Major Ions																				
pH		7.95	8.01	7.9	6.93	7.36	6.7-7.9	7.42	19	7.35-7.95	7.55	9	7.26-7.55	7.32	4	7.13-8.47	7.67	5		
Specific Conductance	µS/cm	300	270	284	333	277	107-578	310	21	160-479	395	10	210-500	242.5	6	220-567	477.5	6		
Total Dissolved Solids	mg/L	167	151	169	187	147	109-311	181	11	198-266	212	5	124-277	130	3	152-309	283	3		
Non-Filterable Residue (TSS)	mg/L	< 0.4	<0.4-6	2	2	1	3-17	4.4	11	3.2-7.2	5.2	5	0.4-24.8	5.6	3	4.4-16.4	16.4	4		
Fixed Non-Filterable Residue	mg/L						<0.4-6.5	0.4	11	<0.4-3.2	1.6	5	<0.4-20	1.2	3	1.8-9.2	9.6	4		
Filterable Residue	mg/L						128-339	225	11	226-311	244	5	154-309	171	3	188-385	354.5	4		
Fixed Filterable Residue	mg/L						80-241	143	11	167-209	177	5	111-207	126	3	133-278	262	4		
Turbidity	NTU						1.7-21	8.3	11	4-6.5	4.5	5	0.7-1.2	0.95	2	3.2-18	16	3		
Colour	Rel. Units						15-100	65	11	'60-70	70	5	50-100	100	3	35-100	50	4		
Oxygen - Total COD	mg/L						23-69	37	8	50-70	68	5					73	1		
Oxygen - Dissolved	mg/L						0-9.8	6.4	9	2-7.2	5.2	5	3.9-5.8	5.6	3	6.5-6.5	6.45	2		
Biochemical Oxygen Demand	mg/L	17		0.6																
Coliforms - Total	No./100mL						0-113	38	11	13-117	33	5	2-8	4	3	0-100	11	4		
Coliforms - Fecal	No./100mL						<0-92	1	11	3-36	9	5	0-4	2	3		0	4		
Chlorophyll A	mg/L			< 0.001			<0.001-0.006	<0.001	7		0.008	1		<0.001	1		<0.001	1		
Dissolved Organic Carbon	mg/L	15.9	25	24.1	16.8	23.3	14-24.5	18	11	21.5-31.3	24.5	5	24.5-25	24.75	2	19.5-24	23	3		
Carbon-Total Organic							14-24.5	18	11	21.5-31.3	25	5	24.5-33.7	26	3	20-24.5	22.75	4		
Calcium - Dissolved	mg/L	44.3	39.8	41.7	50.3	39.9	27.2-75.8	45.1	11	46.9-75.3	58.1	5	29-57.8	31	3	37-81.6	75.85	4		
Magnesium - Dissolved	mg/L	9.6	9.9	10.7	12.7	11.5	7.1-26.8	11.8	11	12.6-18.2	14.1	5	9.3-14.3	11.5	3	10.6-26.6	18.7	4		
Sodium - Dissolved	mg/L	10.4	10.3	11	6.8	5	3.1-13.5	8.3	11	5.6-20.5	10.1	5	4.5-29.5	8.3	3	9.5-16	12	4		
Potassium - Dissolved	mg/L	1.8	0.4	1	2.1	0.6	0.85-2.6	1.2	11	0.3-1.1	0.7	5	0.3-1.7	0.35	3	0.45-1.3	1.1	3		
Chloride - Dissolved	mg/L	4.2	2.9	2.7	1.8	0.5	1-4.6	2.1	11	1.6-8.1	3.4	5	1.1-13	1.7	3	2.3-5.09	3.4	4		
Sulphate - Dissolved	mg/L	4.9	1.5	10.2	3.3	0.6	2.4-5.3	4.6	11	4.3-6	4.8	5	4.5-6.8	5.4	3	3.5-6	4.3	4		
Sulphide - Dissolved	mg/L							<0.01	5	<0.01-0.15	<0.01	3	<0.01-0.17	<0.09	2		<0.01	3		
Total Alkalinity (as CaCO3)	mg/L	152	142	150	181	146	103.7-322	176	11	196-266	204	5	118-256	127	3	144-308	288	4		
Bicarbonate	mg/L	185	173	183	221	178	126.2-392.3	214.3	11	238.7-324	248.4	5	143.6-311.8	154.6	3	175.3-375.2	343.6	4		
Total Hardness (as CaCO3)	mg/L	151	140	148	178	147	97.1-297.6	156.3	11	169-263	206.1	5	110.7-203.2	124.8	3	136-313.3	286.35	4		
Fluoride	mg/L	0.17		0.12	0.16															
Fluoride-Dissolved	mg/L							0.61	1											
Total Cyanide	mg/L	0.025	< 0.001	0.003			0.001-0.005	0.002	9	0.002-0.007	0.005	3	0.002-0.004	0.003	3	0.003-0.006	0.004	4		
Sulphur - Total	mg/L	1.1		0.6	7.9															
Total Phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003-0.009	0.005	11	0.002-0.006	0.002	5	0.004-0.007	0.005	3	0.004-0.005	0.004	4		
Oil and Grease	mg/L						<0.1-2.4	0.8	11	0.7-12.9	1.8	5	0.5-1.6	1.3	3	0.5-1.7	1.2	4		
Hydrocarbons, Alkanes	mg/L							<0.1	7		<0.1	2	<0.1-0.2	<0.15	2		<0.1	4		
Hydrocarbons, Recoverable	mg/L	3	< 1	< 1	< 1	< 1														
Nutrients																				
Nitrogen - Total Kjeldahl	mg/L						0.52-1.42	0.94	11	0.8-1.29	1.21	5	1-1.26	1.13	2	1-1.5	1.02	3		
Nitrogen - Total N	mg/L						0.569-1.438	0.982	11	0.805-1.293	1.217	5	1.003-1.263	1.133	2	1.01-1.52	1.056	3		
Nitrite plus Nitrate Nitrogen	mg/L	< 0.003	< 0.03	0.015	< 0.003	0.09														
Dissolved Nitrate & Nitrite Nitrogen	mg/L						0.003-0.093	0.02	11	0.003-0.059	0.005	5	0.003-0.027	0.003	3	0.01-0.041	0.028	4		
Nitrate - Dissolved	mg/L						<0.003-0.083	0.016	11	<0.003-0.055	0.005	5	<0.003-0.019	<0.003	3	0.006-0.035	0.0215	4		
Total Ammonia Nitrogen	mg/L	< 0.01	< 0.01	0.04																
Dissolved Ammonia Nitrogen	mg/L						0.017-0.8	0.073	11	0.077-0.81	0.097	5	0.017-3.9	0.065	3	0.023-0.48	0.3	4		
Dissolved Nitrite Nitrogen	mg/L						0.003-0.01	0.006	11	<0.003-0.004	0.003	5	0.003-0.008	0.003	3	0.004-0.007	0.006	4		
Total Phosphorus	mg/L	0.034	0.027	0.022	0.034	0.095	0.024-0.138	0.058	11	0.035-0.078	0.063	5	0.025-0.069	0.025	3	0.025-0.113	0.0835	4		
Dissolved Ortho Phosphate	mg/L						0.005-0.054	0.016	11	0.007-0.023	0.012	5	0.008-0.012	0.01	3	0.014-0.068	0.0265	4		
Metals (Total)																				
Aluminum	mg/L	<0.01-0.01	0.09	0.08	< 0.01	0.1	<0.01-0.69	0.06	11	0.04-0.12	0.07	5	0.08-0.12	0.1	2	0.03-0.2	0.04	3		
Antimony	mg/L	< 0.0002	< 0.0002	< 0.0002																
Arsenic	mg/L	0.0002	0.0002	0.0002																
Barium	mg/L	0.03	0.03	0.03	0.05	0.04														
Beryllium	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001														
Boron	mg/L	0.06	0.1	0.1	0.06	0.03														
Cadmium	mg/L	< 0.003	< 0.003	<0.003-0.003	< 0.003	< 0.003		<0.001	9		<0.001	3		<0.001	2		<0.001	3		
Chromium	mg/L	< 0.002	< 0.002	0.007	0.008	0.014														
Chromium-Hexavalent							<0.003-0.008	<0.003	11	<0.003-0.004	<0.003	5		<0.003	2	<0.003-0.007	0.005	3		
Cobalt	mg/L	< 0.003	< 0.003	0.006	< 0.003	0.005		<0.001	9	<0.001-0.001	<0.001	3		<0.001	2		<0.001	3		
Copper	mg/L	0.001		<0.001-0.001	< 0.001		<0.001-0.002	<0.001	11		<0.001	5	<0.001-0.001	<0.001	3	<0.001-0.001	<0.001	4		
Iron	mg/L	0.53	0.84	1.14	1.95	0.91	0.17-3.25	1.5	11	0.73-1.81	1.32	5	0.41-0.92	0.45	3	1.05-3.25	3.02	4		
Lead	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.002-0.004	<0.002	11	<0.002-0.008	0.003	5	<0.002-0.004	0.003	3	<0.002-0.006	<0.002	4		
Lithium	mg/L	0.008	0.008	0.008	0.007	0.006														
Manganese	mg/L	0.032	0.036	0.051	0.072	0.032	0.03-0.575	0.09	11	0.03-0.54	0.12	5	0.02-0.15	0.02	3	0.08-1.17	0.565	4		
Mercury	µg/L	< 0.05	< 0.05	< 0.05			<0.0001-0.0004	<0.0001	11		<0.0001	5	<0.0001-0.0001	<0.0001	3		<0.0001	4		
Molybdenum	mg/L	<0.003-0.004	< 0.003	<0.003-0.005	0.004	< 0.003														
Nickel	mg/L	< 0.005	< 0.005	<0.005-0.015	< 0.005	0.006	<0.001-0.009	<0.001	11	<0.001-0.002	<0.001	5		<0.001	3		<0.001	4		
Selenium	mg/L	< 0.0002	< 0.0002	< 0.0002																
Silicon	mg/L	1.66		3.78	2.93															
Silica - Reactive	mg/L						2.4-17.3	7	11	7.1-15.3	10	5	7.8-9.8	8.1	3	8.7-18.7	15.4	4		
Silver	mg/L	< 0.002	< 0.002	0.003	< 0.002	< 0.002	<0.001-0.002	0.001	7		<0.001	1		<0.001	2	<0.001-0.008	<0.001	3		
Strontium	mg/L	0.092	0.097	0.097	0.108	0.094														
Titanium	mg/L	< 0.003	<0.003-0.005	0.006	< 0.003	0.009														
Uranium	mg/L	< 0.5		< 0.5	< 0.5															
Vanadium	mg/L	< 0.002	<0.002-0.006	<0.002-0.002	0.003	< 0.002	<0.001-0.004	<0.001	11		<0.001	5	<0.001-0.001	<0.001	3	<0.001-0.002	<0.001	4		
Zinc	mg/L	0.007	0.048	0.021	0.054	0.025	0.002-0.009	0.005	11	0.003-0.05	0.007	5	<0.001-0.013	0.002	3	<0.001-0.014	0.0025	4		
Naphthenic Acids	mg/L	< 1	< 1	< 1	< 1	< 1														

NOTES

Trace organic compounds were not detected in 1995 and were not measured in 1980-81

* Mean of two measuements or range

** Median values; Data from NAQUADAT for Sites 00AL07DA1800 and 00AL07DA1850

TABLE VII-8

WATER QUALITY OF TRIBUTARIES OF THE MUSKEG RIVER, 1995

Parameter	Units	North Muskeg Creek			Jackpine Creek at Mouth			Muskeg Creek at Mouth			Stanley Creek at Mouth		lyinimin Creek		Blackfly Creek	
		SPRING	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING	SUMMER	SUMMER	FALL	SUMMER	FALL
		P09WTQL001	U09WTQL004	F09WTQL004	P17WTQL002	U17WTQL001	F17WTQL001	P50WTQL007	U50WTQL008	F50WTQL008	P60WTQL006	U60WTQL007	U08WTQL009	F08WTQL009	U55WTQL010	F55WTQL010
Conventional Parameters and Major Ions																
pH		6.85	7.01	7.13	7.19	7.57	7.58	7.14	7.39	7.45	6.78	7.02	7.32	7.55	7.69	7.61
Specific Conductance	µS/cm	177	151	166	210	196	212	223	330	291	225	274	129	170	193	221
Total Dissolved Solids	mg/L	97	84	96	116	109	127	124	169	166	125	143	69	102	108	135
Non-Filterable Residue (TSS)	mg/L	< 0.4	6	< 0.4	< 0.4	24	< 0.4	1	15	3	< 0.4	2	171	< 0.4	77	2
Biochemical Oxygen Demand	mg/L				2.3		0.6									
Chlorophyll A	mg/L	0.006					< 0.001									
Dissolved Organic Carbon	mg/L	19.8	23.8	22.6	17.8	28.1	26.7	19.9	26.9	24	10.6	23.5	35.4	26.8	33.2	29.6
Calcium - Dissolved	mg/L	21.8	17.6	20.8	25.8	26	28.1	24.5	40.3	43.7	35.7	44.1	17.5	22.1	21.2	25.9
Magnesium - Dissolved	mg/L	6.5	6.1	6.8	6.4	7.3	8	7.3	10.1	12.9	8.4	9	5.6	7.7	7	9.2
Sodium - Dissolved	mg/L	9.3	9.9	10.2	12.3	11	12.1	15.8	10.6	6	2.8	1.6	6.8	8.7	16.7	17.4
Potassium - Dissolved	mg/L	1.2	0.6	0.8	1.9	0.5	0.9	2.1	0.8	1.1	1.3	1.3	< 0.02	0.4	0.3	0.7
Chloride - Dissolved	mg/L	0.8	0.8	0.5	2.9	1.7	2.1	2.5	4.4	1.3	< 0.5	< 0.5	0.9	0.8	1.1	1.4
Sulphate - Dissolved	mg/L	6	3	6.6	4.9	1.3	9.8	4.9	0.8	6.9	2.6	< 0.5	4.2	9.2	4.9	10.6
Total Alkalinity (as CaCO3)	mg/L	84	75.3	82.7	102	100	109	110	168	155	121	143	55	87.2	92.6	115
Bicarbonate	mg/L	102	91.8	101	124	122	133	134	205	189	147	174	67	106	113	140
Total Hardness (as CaCO3)	mg/L	81.3	69.1	80	90.8	95	103	91.3	142	162	124	147	66.8	86.9	81.8	103
Fluoride	mg/L	0.19		0.07	0.16		0.1	0.12		0.12	0.16			0.07		0.1
Total Cyanide	mg/L				0.05	< 0.001	< 0.001									
Sulphur - Total	mg/L	1.6		1.3	1.3		0.6	2.2		0.2	0.5			0.8		0.9
Total Phenolics	mg/L	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hydrocarbons, Recoverable	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1
Nutrients																
Nitrite plus Nitrate Nitrogen	mg/L	0.009	< 0.03	0.008	< 0.003	< 0.03	< 0.003	< 0.003	< 0.03	0.014	< 0.003	< 0.03	< 0.03	< 0.003	< 0.03	0.003
Total Ammonia	mg/L	< 0.01			0.01	< 0.01	0.01									
Total Phosphorus	mg/L	0.03	0.022	0.022	0.051	0.034	0.01	0.025	0.024	0.043	0.033	0.215	0.042	0.04	0.033	0.041
Metals (Total)																
Aluminum	mg/L	0.05	0.09	< 0.01	0.05	0.2	0.04	0.04	0.07	0.04	0.02	0.06	1.13	0.07	1.2	0.1
Antimony	mg/L				0.001	< 0.0002	< 0.0002									
Arsenic	mg/L				0.0008	0.0004	0.0002									
Barium	mg/L	0.02	0.02	0.02	0.04	0.02	0.02	0.02	0.03	0.04	0.04	0.06	0.03	0.02	0.02	0.02
Beryllium	mg/L	0.002	< 0.001	< 0.001	0.003	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.07	0.06	0.06	0.07	0.1	0.03	0.11	0.07	0.02	0.05	0.12	0.08	0.06	0.19	0.09
Cadmium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.003
Chromium	mg/L	< 0.002	0.01	< 0.002	< 0.002	0.004	0.012	0.004	< 0.002	0.011	< 0.002	< 0.002	0.002	0.002	< 0.002	< 0.002
Cobalt	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.009	< 0.003	< 0.003	0.006	< 0.003	< 0.003	< 0.003	0.005	< 0.003	0.004
Copper	mg/L	0.003		< 0.001	0.003		< 0.001	< 0.001		< 0.001	< 0.001			0.001		< 0.001
Iron	mg/L	0.35	0.21	0.13	0.77	0.87	0.58	0.72	0.7	1.74	0.56	1.43	2.69	0.91	2.45	0.76
Lead	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	0.05	< 0.02	0.02
Lithium	mg/L	0.007	0.005	0.005	0.011	0.008	0.009	0.008	0.01	0.007	0.005	0.006	0.002	0.005	0.006	0.008
Manganese	mg/L	0.037	0.012	0.012	0.034	0.051	0.021	0.048	0.106	0.092	0.038	0.224	0.103	0.016	0.064	0.011
Mercury	µg/L				< 0.05	< 0.05	< 0.05									
Molybdenum	mg/L	0.004	< 0.003	< 0.003	0.006	< 0.003	0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.006	< 0.003	0.005
Nickel	mg/L	< 0.005	< 0.005	0.011	0.011	< 0.005	< 0.005	< 0.005	0.01	0.01	< 0.005	0.006	< 0.005	0.013	< 0.005	0.01
Selenium	mg/L				< 0.0002	< 0.0002	< 0.0002									
Silicon	mg/L	1.29		2.31	1.23		2.9	1.1		3.74	3.08			2.89		2.46
Silver	mg/L	< 0.002	< 0.002	0.002	< 0.002	< 0.002	0.005	< 0.002	< 0.002	0.003	< 0.002	< 0.002	< 0.002	0.004	< 0.002	< 0.002
Strontium	mg/L	0.06	0.051	0.061	0.082	0.089	0.094	0.084	0.102	0.089	0.067	0.089	0.039	0.059	0.051	0.072
Titanium	mg/L	0.005	< 0.003	0.004	0.007	0.003	0.008	< 0.003	0.01	0.007	< 0.003	0.009	0.006	0.009	< 0.003	0.007
Uranium	mg/L	< 0.5		< 0.5	< 0.5		< 0.5	< 0.5		< 0.5	< 0.5			< 0.5		< 0.5
Vanadium	mg/L	0.005	0.003	< 0.002	0.011	0.005	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.007	0.002
Zinc	mg/L	0.016	0.1	0.018	0.009	0.433	0.186	0.025	0.015	0.007	0.127	0.03	0.031	0.027	0.039	0.024
Naphthenic Acids	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

TABLE VII-9

WATER QUALITY OF KEARL LAKE

Parameter	Units	SUMMER 1995	FALL 1995	HISTORICAL DATA* (1983, 1988, Open Water Season)		
		U80WTQL005	F80WTQL005	Range	Median	n
Conventional Parameters and Major Ions						
pH		7.87	7.56	7.5-8.4	8.15	4
Specific Conductance	µS/cm	171	169	166-258	227	4
Total Dissolved Solids	mg/L	93	98	95-142	104	6
Non-Filterable Residue (TSS)	mg/L	1	1			
Dissolved Organic Carbon	mg/L	21.2	23.1	25.3-31.8	28.6	2
Carbon-Dissolved Inorganic	mg/L				32.4	1
Carbonate-Dissolved	mg/L				<5	1
Carbon- Particulate	mg/L				1.54	1
Calcium - Dissolved	mg/L	20.2	21.8	14.68-30	16.96	6
Magnesium - Dissolved	mg/L	6.6	7	6-10	7	3
Sodium - Dissolved	mg/L	10.5	10.7	11-14	13	3
Potassium - Dissolved	mg/L	0.6	1	1-1.4	1	3
Chloride - Dissolved	mg/L	0.7	1		<1	3
Sulphate - Dissolved	mg/L	2.8	6.2	6-8	6	3
Total Alkalinity (as CaCO3)	mg/L	84.5	82.2	87-132	100	3
Bicarbonate	mg/L	103	100	106.1-160.9	118	3
Total Hardness (as CaCO3)	mg/L	77.7	83.3	66-116.1	67.1	6
Fluoride	mg/L		0.09	0.08-0.1	0.09	3
Sulphur - Total	mg/L		1.4			
Turbidity	NTU			1.3-2.2	1.75	2
Colour-True	Rel. Units			70-76	73	2
Chlorophyll a	mg/L			0.0009-0.0052	0.00305	2
Total Phenolics	mg/L			0.013-0.014	0.0135	2
Recoverable Hydrocarbons	mg/L	< 1	< 1			
Nutrients						
Nitrite plus Nitrate Nitrogen	mg/L	< 0.03	< 0.003	<0.001-<0.05	0.005	3
Total Phosphorus	mg/L	0.016	0.03	0.0159-0.04	0.0234	4
Total Dissolved Phosphorus	mg/L				0.0096	1
Ammonia-Dissolved	mg/L			0.011-0.217	0.014	3
Nitrite-Dissolved	mg/L			<0.001-<0.05	0.002	3
Nitrogen-Total	mg/L			0.924-1.65	1.325	3
Nitrogen-Total Kjeldahl	mg/L			0.923-1.6	1.32	3
Metals (Total)						
Aluminum	mg/L	< 0.01	< 0.01	<0.02-0.023	0.0215	2
Arsenic	mg/L				<0.0002	2
Barium	mg/L	0.01	0.02	0.011-0.024	0.0175	2
Beryllium	mg/L	< 0.001	< 0.001			
Boron	mg/L	0.05	0.06			
Cadmium	mg/L	< 0.003	< 0.003		<0.001	2
Chromium	mg/L	< 0.002	< 0.002		<0.001	2
Cobalt	mg/L	< 0.003	< 0.003		<0.001	2
Copper	mg/L		< 0.001		<0.001	2
Iron	mg/L	0.08	0.11	0.1-0.53	0.2	3
Lead	mg/L	< 0.02	< 0.02	<0.003-0.009	<0.006	2
Lithium	mg/L	0.002	0.006			
Manganese	mg/L	0.017	0.011	0.035-0.074	0.0545	2
Mercury	mg/L				<0.0001	2
Molybdenum	mg/L	< 0.003	0.003		<0.001	2
Nickel	mg/L	< 0.005	0.005	<0.001-0.002	<0.0015	2
Selenium	mg/L				<0.0002	2
Silicon	mg/L		2.3			
Silver	mg/L	< 0.002	0.003			
Strontium	mg/L	0.049	0.062			
Titanium	mg/L	< 0.003	0.004			
Uranium	mg/L		< 0.5			
Vanadium	mg/L	< 0.002	< 0.002		<0.002	2
Zinc	mg/L	0.016	0.011	<0.001-0.002	<0.0015	2
Naphthenic Acids	mg/L	< 1	< 1			

NOTE

* Data from NAQUADAT for Sites 01AL07DA3700 and 01AL07DA3701

TABLE VII-10

SEDIMENT QUALITY OF THE ATHABASCA RIVER

Parameter	Units	At TID, Right Bank* AW015-S002 (Fall)	At TID, Left Bank AW016-S002 (Fall)	Above TID, Left Bank AW017-S002 (Fall)
Total Organic Carbon	weight %	0.49	1.02	1.39
Hydrocarbons, Recoverable	mg/kg	450	703	2160
Metals				
Aluminum	µg/g	3730	4890	3910
Antimony	µg/g	< 0.2	< 0.2	< 0.2
Arsenic	µg/g	0.9	1	0.6
Barium	µg/g	83	117	100
Beryllium	µg/g	0.3	0.4	0.4
Boron	µg/g	< 1	< 1	< 1
Cadmium	µg/g	0.6	0.5	< 0.3
Calcium	µg/g	21100	18400	19700
Chromium	µg/g	11.1	12.4	13.9
Cobalt	µg/g	3.8	5.8	4.4
Copper	µg/g	3.6	6.5	4.6
Iron	µg/g	9820	13100	11000
Lead	µg/g	5	5	4
Lithium	µg/g	6.6	8.1	6.8
Magnesium	µg/g	4840	5180	5840
Manganese	µg/g	240	304	255
Mercury	µg/kg	36	30	25
Molybdenum	µg/g	0.4	0.5	< 0.3
Nickel	µg/g	11.8	15.6	13.8
Phosphorus	µg/g	446	484	410
Potassium	µg/g	587	668	552
Selenium	µg/g	< 0.2	0.3	0.2
Silicon	µg/g	915	1250	993
Silver	µg/g	0.4	0.4	0.3
Sodium	µg/g	78	97	101
Strontium	µg/g	37.8	46.7	40.6
Titanium	µg/g	85.4	70.4	75
Uranium	µg/g	< 50	< 50	< 50
Vanadium	µg/g	12.8	14.5	14.7
Zinc	µg/g	27.6	39.6	29.9
Detectable Trace Organic Compounds				
Benzo(a)anthracene/Chrysene	µg/g		0.01	0.03
Benzo(b&k)fluoranthene	µg/g	0.01	0.02	
C2 sub'd B(a)A/chrysene	µg/g			0.04
C2 sub'd B(b&k)F/B(a)P	µg/g			0.04
C2 sub'd dibenzothiophene	µg/g			0.03
C2 sub'd naphthalene	µg/g			0.02
C2 sub'd phenanthrene/anth.	µg/g			0.04
C3 sub'd dibenzothiophene	µg/g			0.06
C3 sub'd phenanthrene/anth.	µg/g	0.03	0.03	0.07
C4 sub'd phenanthrene/anth.	µg/g	0.03	0.03	0.09
Methyl B(a)A/chrysene	µg/g			0.03
Methyl B(b&k)F/B(a)P	µg/g			0.05
Methyl fluoranthene/pyrene	µg/g			0.05
Methyl naphthalene	µg/g		0.01	0.02
Methyl phenanthrene/anthracene	µg/g		0.02	0.05
Naphthalene	µg/g		0.01	0.02
Phenanthrene	µg/g			0.01
Quinoline	µg/g			0.01

NOTES

* TID = Tar Island Dyke; right bank facing downstream

TABLE VII-11

SEDIMENT QUALITY OF THE STEEPBANK RIVER

Parameter	Units	Steepbank River at Lease 19 Border		Steepbank River at Mouth	
		Spring AW002-S001	Fall AW002-S002	Spring AW011-S003	Fall AW011-S006
Total Organic Carbon	weight %	1.36	2.17	2.12	3.51
Hydrocarbons, Recoverable	mg/kg	154	247	5720	17833
Metals					
Aluminum	µg/g	3950	4990	3333	2330
Antimony	µg/g	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic	µg/g	1.1	1.7	1	1.2
Barium	µg/g	49	52	40	31
Beryllium	µg/g	0.2	0.5	0.2	0.3
Boron	µg/g	3	7	< 1	3
Cadmium	µg/g	< 0.3	< 0.3	0.3	< 0.3
Calcium	µg/g	3740	9620	4403	2067
Chromium	µg/g	13.4	17.7	7.1	7.9
Cobalt	µg/g	2.9	4.7	3	2.9
Copper	µg/g	3.4	5.7	3.7	2.3
Iron	µg/g	10400	12600	10237	7280
Lead	µg/g	2	4	3	4
Lithium	µg/g	6.4	8.8	5.6	3.5
Magnesium	µg/g	1900	3440	2253	1107
Manganese	µg/g	296	238	173	98
Mercury	µg/kg	< 20	28	< 20	< 20
Molybdenum	µg/g	< 0.3	1	< 0.3	0.9
Nickel	µg/g	10.5	14.6	8.9	7.2
Phosphorus	µg/g	330	440	227	187
Potassium	µg/g	650	740	613	467
Selenium	µg/g	< 0.2	< 0.2	< 0.2	< 0.2
Silicon	µg/g	890	1900	832	1098
Silver	µg/g	< 0.2	0.2	< 0.2	< 0.2
Sodium	µg/g	110	110	<20-30	< 20
Strontium	µg/g	17.2	28.6	15.3	10.8
Titanium	µg/g	126	87.7	82.2	54.6
Uranium	µg/g	< 50	< 50	< 50	< 50
Vanadium	µg/g	13	15.4	13	12.1
Zinc	µg/g	22.8	30.5	24.2	15.7
Detectable Trace Organic Compounds					
Acenaphthene	µg/g				0.04
Benzo(a)anthracene/Chrysene	µg/g				1.9
Benzo(a)pyrene	µg/g				0.21
Benzo(b&k)fluoranthene	µg/g				0.47
Benzo(ghi)perylene	µg/g				0.21
C2 sub'd B(a)A/chrysene	µg/g				3.3
C2 sub'd B(b&k)F/B(a)P	µg/g				0.63
C2 sub'd biphenyl	µg/g				0.13
C2 sub'd dibenzothiophene	µg/g			0.23	5.1
C2 sub'd fluorene	µg/g			0.1	1.56
C2 sub'd phenanthrene/anth.	µg/g			0.1	7.4
C3 sub'd dibenzothiophene	µg/g			0.29	5
C3 sub'd naphthalene	µg/g			<0.02-0.03	0.31
C3 sub'd phenanthrene/anth.	µg/g			0.11	8.4
C4 sub'd dibenzothiophene	µg/g			0.09	6.4
C4 sub'd naphthalene	µg/g			0.09	1.27
C4 sub'd phenanthrene/anth.	µg/g			0.03	4.8
Dibenzo(a,h)anthracene	µg/g				0.1
Dibenzothiophene	µg/g				0.04
Fluoranthene	µg/g				0.12
Fluorene	µg/g				0.03
Indeno(c,d-123)pyrene	µg/g				0.15
Methyl acenaphthene	µg/g				0.14
Methyl B(a)A/chrysene	µg/g				2.7
Methyl B(b&k)F/B(a)P	µg/g				1.32
Methyl biphenyl	µg/g				<0.02-0.02
Methyl dibenzothiophene	µg/g			0.08	1.15
Methyl fluoranthene/pyrene	µg/g				1.07
Methyl fluorene	µg/g			<0.02-0.05	0.31
Methyl naphthalene	µg/g				<0.01-0.01
Methyl phenanthrene/anthracene	µg/g			0.05	2.6
Naphthalene	µg/g				<0.01-0.02
Phenanthrene	µg/g			<0.01-0.02	0.31
Pyrene	µg/g				0.2

TABLE VII-12

POREWATER QUALITY OF THE ATHABASCA RIVER, 1995

Parameter	Units	At TID, Right Bank* AW015-P002 (Fall)	At TID, Left Bank AW016-P002 (Fall)	Above TID, Left Bank AW017-P002 (Fall)
Conventional Parameters and Major Ions				
pH		7.53	7.28	7.63
Specific Conductance	µS/cm	2930	458	5480
Total Dissolved Solids	mg/L	1730	259	3220
Dissolved Organic Carbon	mg/L	182	22.6	31.7
Calcium - Dissolved	mg/L	85.2	64.7	38.2
Magnesium - Dissolved	mg/L	68	17.4	18.4
Sodium - Dissolved	mg/L	423	12.8	1210
Potassium - Dissolved	mg/L	11.3	1.8	7.6
Chloride - Dissolved	mg/L	396	4.5	1320
Sulphate - Dissolved	mg/L	407	20.2	150
Total Alkalinity (as CaCO3)	mg/L	565	226	778
Bicarbonate	mg/L	689	275	948
Total Hardness (as CaCO3)	mg/L	493	233	171
Fluoride	mg/L	0.57	0.24	0.5
Total Cyanide	mg/L	0.003	0.003	0.003
Sulphur - Dissolved	mg/L	125	6.2	48.1
Hydrocarbons, Recoverable	mg/L	< 1	< 1	< 1
Total Phenolics	mg/L	< 0.001	0.001	0.001
Nutrients				
Nitrite plus Nitrate Nitrogen	mg/L	0.009	0.003	0.003
Total Ammonia Nitrogen	mg/L	0.59	0.58	0.78
Total Phosphorus	mg/L	1.85	0.22	1.75
Metals (Dissolved)				
Aluminum	mg/L	< 0.01	< 0.01	1.19
Antimony	mg/L	< 0.0002	< 0.0002	0.0003
Arsenic	mg/L	0.0008	0.0004	0.0009
Barium	mg/L	0.04	0.26	0.12
Beryllium	mg/L	0.001	0.002	0.003
Boron	mg/L	1.53	0.05	2.03
Cadmium	mg/L	0.0006	0.0005	0.0006
Chromium	mg/L	< 0.002	< 0.002	< 0.002
Cobalt	mg/L	0.0012	0.0011	0.0005
Copper	mg/L	< 0.001	< 0.001	< 0.001
Iron	mg/L	< 0.01	0.03	0.56
Lead	mg/L	< 0.0003	< 0.0003	0.0003
Lithium	mg/L	0.143	0.007	0.117
Manganese	mg/L	0.002	0.828	0.045
Mercury	µg/L	< 0.05	0.13	< 0.05
Molybdenum	mg/L	< 0.003	< 0.003	< 0.003
Nickel	mg/L	0.0336	0.0124	0.0091
Selenium	mg/L	< 0.0002	< 0.0002	0.0005
Silicon	mg/L	2.72	4.15	6.25
Silver	mg/L	< 0.0002	< 0.0002	< 0.0002
Strontium	mg/L	0.905	0.372	0.574
Titanium	mg/L	< 0.003	< 0.003	0.025
Uranium	mg/L	0.0003	0.0003	0.0032
Vanadium	mg/L	< 0.002	< 0.002	0.003
Zinc	mg/L	0.003	0.006	0.022
Detectable Trace Organic Compounds				
C2 sub'd phenanthrene/anth.	µg/L			0.04
Naphthenic Acids	mg/L	< 1	< 1	17

NOTES

* TID = Tar Island Dyke; right bank facing downstream

TABLE VII-13

POREWATER QUALITY OF THE STEEPBANK RIVER

Parameter	Units	Steepbank River at Lease 19 Border		Steepbank River near Lot 3		Steepbank River at Mouth	
		Spring AW001-P001	Fall AW001-P002	Spring AW003-P001	Fall AW003-P002	Spring AW012-P001-3	Fall AW012-P004-6
Conventional Parameters and Major Ions							
pH		6.87	7.62	7.4	7.61	7.04	7.31
Specific Conductance	µS/cm	335	250	2470	21200	503	493
Total Dissolved Solids	mg/L	228	125	1370	14500	292	287
Dissolved Organic Carbon	mg/L	137	36.6	166	19.4	19.1	55.5
Calcium - Dissolved	mg/L	47.2	23.8	113	74.6	73.7	75.1
Magnesium - Dissolved	mg/L	11.1	7.4	40.4	110	14.9	17.1
Sodium - Dissolved	mg/L	26.1	11.5	380	5120	23.9	13.4
Potassium - Dissolved	mg/L	1.9	1.2	4.1	22.8	1.6	2
Chloride - Dissolved	mg/L	1.4	1.5	550	7800	3.3	2.2
Sulphate - Dissolved	mg/L	24.7	6.9	5.2	21	5.3	11
Total Alkalinity (as CaCO3)	mg/L	190	119	447	2150	278	272
Bicarbonate	mg/L	232	145	545	2630	339	332
Total Hardness (as CaCO3)	mg/L	164	90	449	639	245	258
Fluoride	mg/L	0.23	0.14	0.25	0.67	0.32	0.31
Total Cyanide	mg/L	< 0.001	0.003	< 0.001	< 0.001	<0.001-0.063	0.003
Sulphur - Dissolved	mg/L	3.7	1.2	2	2.3	1.8	2.9
Hydrocarbons, Recoverable	mg/L	1	< 1	138	3	<1-16	5
Total Phenolics	mg/L	0.001	< 0.001	0.003	< 0.001	0.003	< 0.001
Nutrients							
Nitrite plus Nitrate Nitrogen	mg/L	0.024	0.016	0.007	0.039	0.044	0.011
Total Ammonia Nitrogen	mg/L	0.06	0.03	0.5	3.01	0.55	0.47
Total Phosphorus	mg/L	0.14	0.062	0.102	5.1	0.072	0.07
Metals (Dissolved)							
Aluminum	mg/L	0.11	< 0.01	< 0.01	0.23	< 0.01	<0.01-0.02
Antimony	mg/L	0.0002		< 0.0002		< 0.0002	
Arsenic	mg/L	0.0009	< 0.0002	0.0008	< 0.0002	0.0007	0.0004
Barium	mg/L	0.22	0.03	0.53	1.33	0.12	0.11
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	0.006	< 0.001	< 0.001
Boron	mg/L	0.25	0.04	0.49	4.06	0.23	0.08
Cadmium	mg/L	< 0.003	< 0.0002	< 0.003	< 0.0002	<0.003-0.012	< 0.0002
Chromium	mg/L	< 0.002	< 0.002	0.003	0.01	< 0.002	0.008
Cobalt	mg/L	< 0.003	0.0005	0.004	0.0015	<0.003-0.007	0.0013
Copper	mg/L	0.005	< 0.001	0.002	< 0.001	0.009	<0.001-0.001
Iron	mg/L	0.56	0.04	< 0.01	0.31	0.31	0.43
Lead	mg/L	< 0.02	< 0.0003	< 0.02	< 0.0003	<0.02-0.05	< 0.0003
Lithium	mg/L	0.018	0.011	0.077	0.635	0.023	0.019
Manganese	mg/L	0.033	0.014	0.37	0.094	1.5	1.271
Mercury	µg/L	< 0.05	< 0.05	0.34	0.28	< 0.05	<0.05-0.05
Molybdenum	mg/L	< 0.003	< 0.003	< 0.003	0.008	< 0.003	< 0.003
Nickel	mg/L	< 0.005	0.0081	0.011	0.0174	0.015	0.0119
Selenium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Silicon	mg/L	5.02	2.16	4.7	5.76	5.61	5.23
Silver	mg/L	< 0.002	< 0.0002	0.002	< 0.0002	<0.002-0.011	0.0003
Strontium	mg/L	0.16	0.096	0.809	4.52	0.291	0.31
Titanium	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	<0.003-0.005	<0.003-0.003
Uranium	mg/L	< 0.5	< 0.0002	< 0.5	< 0.0002	< 0.5	<0.0002-0.0009
Vanadium	mg/L	0.002	< 0.002	< 0.002	0.008	0.012	<0.002-0.003
Zinc	mg/L	0.035	0.003	0.031	0.004	0.013	0.014
Detectable Trace Organic Compounds							
Acenaphthene	µg/L				0.04		
Acetone	µg/L	35000		41000		250	
Biphenyl	µg/L			0.04			
C2 sub'd B(a)A/chrysene	µg/L			0.06			
C2 sub'd biphenyl	µg/L			0.42			
C2 sub'd dibenzothiophene	µg/L			3.7	0.16		0.13
C2 sub'd fluorene	µg/L			2.8	0.12		
C2 sub'd phenanthrene/anth.	µg/L			1.7	0.08		0.08
C3 sub'd dibenzothiophene	µg/L			8.7	0.17		0.23
C3 sub'd naphthalene	µg/L			0.06	0.08		
C3 sub'd phenanthrene/anth.	µg/L			2.7	0.11		0.13
C4 sub'd dibenzothiophene	µg/L			7.1			0.06
C4 sub'd naphthalene	µg/L			2.4	0.21		0.09
C4 sub'd phenanthrene/anth.	µg/L			1.7	0.05		0.09
Fluorene	µg/L				0.03		
Methyl dibenzothiophene	µg/L			0.91	0.06		
Methyl fluoranthene/pyrene	µg/L			0.46			
Methyl fluorene	µg/L			0.43	0.05		
Methyl naphthalene	µg/L			0.08			0.03
Methyl phenanthrene/anthracene	µg/L			0.4	0.05		
Naphthalene	µg/L	0.03		0.09			
Naphthenic Acids	mg/L	5	< 1	3	16	3	< 1

TABLE VII-14

POREWATER QUALITY IN THE MUSKEG RIVER BASIN, 1995

Parameter	Units	Muskeg River at Mouth F30PW001	Jackpine Creek FS4PW001
Conventional Parameters and Major Ions			
pH		7.62	7.96
Specific Conductance	µS/cm	230	290
Total Dissolved Solids	mg/L	130	168
Dissolved Organic Carbon	mg/L	24.5	43.2
Calcium - Dissolved	mg/L	29.9	44
Magnesium	mg/L	8.1	10.4
Sodium - Dissolved	mg/L	11	10.5
Potassium - Dissolved	mg/L	0.8	0.9
Chloride - Dissolved	mg/L	1.6	2.7
Sulphate - Dissolved	mg/L	6.2	4.4
Total Alkalinity (as CaCO3)	mg/L	118	155
Bicarbonate	mg/L	144	189
Total Hardness (as CaCO3)	mg/L	108	153
Fluoride	mg/L	0.13	0.15
Total Cyanide	mg/L	0.003	0.003
Sulphur - Dissolved	mg/L	1.2	0.9
Total Phenolics	mg/L	< 0.001	< 0.001
Hydrocarbons, Recoverable	mg/L	< 1	< 1
Nutrients			
Nitrite plus Nitrate Nitrogen	mg/L	0.03	0.044
Total Ammonia Nitrogen	mg/L	< 0.01	0.01
Total Phosphorus	mg/L	0.051	0.078
Metals (Dissolved)			
Aluminum	mg/L	0.06	< 0.01
Antimony	mg/L	< 0.0002	< 0.0002
Arsenic	mg/L	0.0002	0.0002
Barium	mg/L	0.06	0.03
Beryllium	mg/L	0.001	0.001
Boron	mg/L	0.03	0.03
Cadmium	mg/L	0.0005	0.0006
Chromium	mg/L	0.005	0.007
Cobalt	mg/L	0.0003	0.0004
Copper	mg/L	0.001	< 0.001
Iron	mg/L	0.16	0.2
Lead	mg/L	< 0.0003	< 0.0003
Lithium	mg/L	0.008	0.008
Manganese	mg/L	0.01	0.002
Mercury	µg/L	< 0.05	< 0.05
Molybdenum	mg/L	0.003	< 0.003
Nickel	mg/L	0.0049	0.0076
Selenium	mg/L	< 0.0002	0.0002
Silicon	mg/L	3.03	3.26
Silver	mg/L	< 0.0002	< 0.0002
Strontium	mg/L	0.096	0.104
Titanium	mg/L	< 0.003	< 0.003
Uranium	mg/L	< 0.0002	< 0.0002
Vanadium	mg/L	0.002	0.004
Zinc	mg/L	< 0.001	< 0.001
Naphthenic Acids	mg/L	< 1	< 1

APPENDIX VIII

QA REVIEW OF WATER QUALITY DATA BY EVS

TABLE OF CONTENTS

1.0 INTRODUCTION

This report consists of two parts:

1. A quality assurance review of chemical analyses of surface water, groundwater, soil, sediment, porewater, and benthic tissue samples; and
2. A field and documentation audit.

1.1 QUALITY ASSURANCE REVIEW INTRODUCTION

This section of the report documents the results of a quality assurance review of data from chemical analyses of surface water, groundwater, soil, sediment, porewater, and benthic tissue samples. Data validation procedures were based on quality control criteria and data quality objectives established in the Steepbank Mine EIA: Quality Assurance Needs and Database Management Plan (QAPP) (Golder, 1995). Overall usability of the data was assessed according to U.S. Environmental Protection Agency (U.S. EPA) data usability guidelines for remedial response activities (U.S. EPA, 1987).

Analytical data for the samples are of good quality and satisfy the data use category Level III (U.S. EPA, 1987), which is suitable for conducting risk assessments and assessing environmental impacts.

Data qualifiers were assigned, as necessary, during the quality assurance reviews in accordance with the above documents. The following laboratory deliverables were reviewed during the data validation process:

- Results of all available laboratory quality control check results, including surrogate compounds, laboratory control samples, matrix spikes, and duplicate analyses;
- Instrument and sample detection limits for all target analytes and compounds;
- Sample holding times; and
- Field blanks and field replicates associated with the sampling event.

All data met the data quality objectives for this project, except for the exceedances discussed below.

2.0 SUMMARY OF QUALIFIED DATA

During the quality assurance review, several surface water and porewater results were qualified as undetected (*U*) because of field blank contamination. The affected sample results are shown in Table 1. For surface water, 17 dissolved potassium results, 7 total aluminum results, 20 total boron results, 1 total iron result, 14 total titanium results, 20 total zinc results, 5 silicon results, 2 total recoverable hydrocarbon results, 2 naphthalene results, and 1 methyl naphthalene result were qualified as undetected (*U*). For porewater, 1 dissolved potassium result, 1 dissolved calcium result, 11 dissolved zinc results, 1 total zinc result, 10 cyanide results, 2 total recoverable hydrocarbon results, 1 acetone result, 2 naphthalene results, 1 methyl naphthalene result, 2 methyl dibenzothiophene results, and 5 total phenol results were qualified as undetected (*U*). For groundwater, 6 chromium results, 9 copper results, and 11 zinc results were qualified as undetected (*U*).

3.0 DATA QUALITY ASSESSMENT

The results of the quality control procedures employed in the analyses of the field samples are discussed below, including completeness, holding times, analytical methods, accuracy, and precision. Data quality was assessed according to requirements specified in the Quality Assurance Needs and Database Management Plan (QAPP) (Golder, 1995).

3.1 COMPLETENESS

The results reported by the laboratory were 100 percent complete. No data were rejected during the quality assurance review.

3.2 HOLDING TIMES

Analytical holding time constraints were met for all samples.

3.3 ANALYTICAL METHODS

All analyses were performed using the methods specified in the QAPP (Golder, 1995).

3.4 ACCURACY

The accuracies of the analytical results have been evaluated in terms of analytical bias (based on surrogate compound, matrix spike, and laboratory control sample recoveries) and precision (based on matrix duplicates).

3.4.1 SURROGATE COMPOUND RECOVERIES

The recoveries reported by the laboratory for the surrogate compounds added to all field samples met the criteria for acceptable performance, with the exception of total phenolic compounds for

surface water, porewater, and groundwater. Two of the three surrogate recoveries for total phenolic compounds frequently fell below the acceptance criteria stated in the QAPP. However, phenolic compounds were not detected in the affected samples; therefore, no data were qualified based on this exceedance.

3.4.2 MATRIX SPIKE RECOVERIES

Reported matrix spike recoveries for all analyses met the control criteria specified in the QAPP, with the exception of volatile organic compounds in surface water and porewater. Two of the seven matrix spike compounds for volatile organic analyses exceeded the control limits of 85 to 115 percent recovery specified in the QAPP (1,1-dichloroethene with 66 percent recovery and trichloroethene with 73 percent recovery). No data were qualified for these exceedances since all other volatile organic matrix spike compound recoveries were within the specified control limits and since the matrix spike recovery exceedances for 1,1 -dichloroethene and trichloroethene were within the limits set forth in the U.S. Environmental Protection Agency's Contract Laboratory Program (U.S. EPA) (61 to 145 percent for 1,1-dichloroethene and 71 to 120 percent for trichloroethene).

3.4.3 LABORATORY CONTROL SAMPLE RECOVERIES

All laboratory control sample results met the criteria for acceptable performance.

3.5 PRECISION

The reported results for all matrix duplicate analyses met the criteria for acceptable performance.

3.6 FIELD QUALITY ASSURANCE

Although validation guidelines were not established for field quality control samples, the results are useful in identifying possible problems as a result of sample collection and/or sample processing in the field.

3.6.1 FIELD BLANKS

Field blanks are useful in assessing whether or not the samples could have been contaminated during sample collection. Field blanks were collected for the surface water, porewater, and groundwater components of this investigation.

Several analytes and compounds were detected in the field blanks at concentrations exceeding twice the limit of detection. All sample results which fell below 5 times the concentration found in the field blank were qualified as undetected (*U*) during the quality assurance review. The affected sample results are listed in Table 1. For surface water, 17 dissolved potassium results, 7 total aluminum results, 20 total boron results, 1 total iron result, 14 total titanium results, 20 total zinc results, 5 silicon results, 2 total recoverable hydrocarbon results, 2 naphthalene results, and 1 methyl naphthalene result were qualified as undetected (*U*) during the quality assurance review. For porewater, 1 dissolved potassium result, 1 dissolved calcium result, 11 dissolved zinc results, 1 total zinc result, 10 cyanide results, 2 total recoverable hydrocarbon results, 1 acetone result, 2 naphthalene results, 1 methyl naphthalene result, 2 methyl dibenzothiophene results, and 5 total phenol results were qualified as undetected (*U*) during the quality assurance review. For groundwater, 6 chromium results, 9 copper results, and 11 zinc results were qualified as undetected (*U*) during the quality assurance review. Chloroform was detected in one of the groundwater blanks at a concentration of 14 µg/L; however, chloroform was not detected in any of the associated sample results.

3.6.2 FIELD REPLICATES

Field replicates provide information that is useful in assessing sample heterogeneity and variability of contaminant concentrations in the field. Field triplicates were collected for the surface water investigation and field duplicates were collected for the groundwater investigation. The relative standard deviations of the field triplicate results for surface water ranged from zero to 48 percent. The relative percent difference of the field duplicates results for groundwater ranged from zero to 67 percent. These results indicate that the surface water and groundwater samples were relatively homogeneous.

Table 1 **Sample results qualified as undetected (*U*) during the data validation review because of field blank results**

Sample Number	Sample Results Affected (qualified *U*)
Surface Water	
AW001-S001	Total recoverable hydrocarbons and dissolved potassium
AW001-S003	Dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW004-C001	Dissolved potassium, total boron, and total zinc
AW004-C003	Dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW005-S001	Dissolved potassium, total boron, and total zinc
AW005-S003	Dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW006-S001	Dissolved potassium, total boron, and total zinc
AW006-S003	Dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW007-S001	Total silicon, total boron, and total zinc
AW007-S003	Total boron, total titanium, and total zinc
AW008-S001	Dissolved potassium, total silicon, total boron, and total zinc
AW008-S003	Total boron, total titanium, and total zinc
AW009-C001	Naphthalene, methyl naphthalene, dissolved potassium, total boron, and total zinc
AW010-S001	Dissolved potassium, total silicon, total boron, and total zinc
AW010-S002	Dissolved potassium, total silicon, total boron, and total zinc
AW010-S003	Total recoverable hydrocarbons, dissolved potassium, total silicon, total boron, total zinc
AW010-S007	Dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW010-S008	Naphthalene, dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW010-S009	Dissolved potassium, total aluminum, total boron, total titanium, and total zinc
AW014-S003	Dissolved potassium, total boron, and total zinc
AW018-C001	Total boron, total iron, and total zinc

Sample Number	Sample Results Affected (qualified *U*)
Porewater	
AW001-P001	Total recoverable hydrocarbons, naphthalene, and total phenols
AW001-P002	Total cyanide and dissolved zinc
AW003-P001	Naphthalene, methyl naphthalene, and total phenols
AW003-P002	Methyl dibenzothiophene and dissolved zinc
AW012-P001	Acetone, dissolved potassium, total cyanide, total phenols, and dissolved zinc
AW012-P002	Total recoverable hydrocarbons, total phenols, and total zinc
AW012-P003	Total cyanide, total phenols, and dissolved zinc
AW012-P004	Total cyanide and dissolved zinc
AW012-P005	Total cyanide and dissolved zinc
AW012-P006	Total cyanide and dissolved zinc
AW015-P002	Total cyanide and dissolved zinc
AW016-P002	Total cyanide and dissolved zinc
AW017-P002	Total cyanide and dissolved zinc
AW019-P002	Methyl dibenzothiophene, dissolved calcium, total cyanide, and dissolved zinc
Groundwater - Summer	
L97-P95-2-L	Total copper
L97-P95-8-BA	Total chromium and total copper
L97-P95-OB-2	Total copper
L97-P95-OB-4	Total chromium
L97-P95-3-BA	Total chromium and total copper
L97-P95-OB-3	Total chromium and total copper
FL7-BRDG-4	Total chromium and total copper
L97-P95-OB-5	Total copper
FL3-P95-13-BA	Total chromium and total copper
FL3-P95-6-BA	Total copper

Sample Number	Sample Results Affected (qualified *U*)
Groundwater - Fall	
FL3-P95-13-BA	Total zinc
FL3-P95-6-BA	Total zinc
FL7-BRDG-4	Total zinc
L97-P94-2-L	Total zinc
L97-P95-1-BA	Total zinc
L97-P95-3-BA	Total zinc
L97-P95-8-BA	Total zinc
L97-P95-OB-1	Total zinc
L97-P95-OB-2	Total zinc
L97-P95-OB-3	Total zinc
L97-P95-OB-4	Total zinc
L97-P95-OB-5	Total zinc

4.0 AUDIT INTRODUCTION

An audit was conducted in two parts for the Suncor Steepbank Mine Environmental Impact Assessment. A field audit was conducted for the fish inventory/biomarker sampling conducted on September 28, 1995, and a documentation audit was conducted for the water and sediment sampling and the fish inventory and vegetation surveys. The audit consisted of reviewing project-specific standard operating procedures and sample collection and documentation practices.

The following sections summarize the results of the field and documentation audits. There is more detailed information relating to the audit contained in the field notes, which are on file at EVS. The field section covers the sampling stations, type of sampling, observations, and recommendations. The documentation section covers observations and recommendations for the various sampling activities and surveys associated with this project.

5.0 FIELD AUDIT

The field audit was conducted on September 28, 1995. Sampling activities were observed for the fish inventory/biomarker surveys of Stations AF006, AF005, AF015, and AF019.

In general, the standard operating procedures for the EIA were followed in the field. All sampling personnel were familiar with their tasks and knowledgeable regarding the type of sampling being performed. Overall, the quality of the data collected was retained throughout the sampling event. Measurements were cross checked by other individuals on the sampling team to ensure that transcription errors did not occur.

6.0 DOCUMENTATION AUDIT

The documentation associated with the EIA activities were reviewed October 10 through October 12, 1995. The documentation audit consisted of spot checking and cross referencing field collection forms, chain-of-custody forms, and field logbooks.

6.1 OBSERVATIONS AND RECOMMENDATIONS

Overall, the sampling collection efforts for this project were thoroughly and consistently documented. Minor deficiencies are discussed below.

Observation

In general, the field logbooks documented the samples collected, the analyses required, and where the samples were being sent. However, sometimes the types of analyses or where the samples were being sent were omitted.

Recommendation

For each site entry in the logbook it would be helpful to have a standard table which includes spaces for the above information.

Observation

Individuals involved in the sampling efforts did not sign the first page of the field logbooks.

Recommendation

The first page of the field logbook should include the signature and corresponding initials of each individual recording information in the logbook. This can then be used as a key to identify the individuals who initialled corrections and made any entries throughout the logbook.

Observation

Some of the corrections in the logbooks were overwritten or obliterated and initialled. In some cases corrections were made with white-out.

Recommendation

To ensure that there is no confusion in interpreting the corrections, all errors should be crossed out with a single line, dated, and initialled with the correction clearly indicated nearby. White-out should never be used.

Observation

The time of sample receipt was not always recorded on the chain-of-custody forms.

Recommendation

It is important to document the time that samples were released and received. Otherwise the chain-of-custody for the samples can not be traced as accurately and consequently the custody (and potentially the integrity) of the samples becomes questionable.

Observation

The form of shipment and corresponding air bill number was not always identified on the chain-of-custody forms.

Recommendation

To maintain custody of the samples, the form of shipment should be entered in the appropriate place on the chain-of-custody forms. The air bill number for the shipper is also important to include on the chain-of-custody forms. Knowing the shipper and the air bill number enables tracking of the sample through the shipping process if needed. If the samples are being hand-couriered by one of the sampling crew, then their name must be entered as the shipper and their signature should appear in the "Relinquished by:" box on the chain-of-custody form.

7.0 REFERENCES

Golder Associates. 1995. Suncor Steepbank Mine EIA: Quality Assurance Needs and Database Management Plan. Submitted to Suncor Inc., Fort. McMurray, AB, by Golder Associates, Calgary, AB.

U.S. EPA. 1987. Data Quality Objectives for Remedial Response Activities. Volume 1. EPA 540/G-87/003A. U. S. Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, Washington, DC, USA.

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APPENDIX IX

BENTHIC INVERTEBRATE RAW DATA

Athabasca and Steepbank Rivers

Station 1, October 14, 1995, AB001

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS001

IDENTIFICATION CODE	B011	B012	B014
SUBSAMPLING CORRECTION	1	1.2	4.3
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Naididae	0	0	4.3	1.4	2.5	0.14
Acari	0	1.2	0	0.4	0.7	0.04
TOTAL: NON INSECTS	0	1.2	4.3	1.8	2.2	0.18
Baetis tricaudatus	6	22.8	154.8	61.2	81.5	6.13
Centroptilum	0	2.4	0	0.8	1.4	0.08
Ephemerella inermis/infrequens	9	7.2	167.7	61.3	92.1	6.14
Heptageniidae-early instar	0	4.8	25.8	10.2	13.7	1.02
Heptagenia	7	15.6	21.5	14.7	7.3	1.47
Rhithrogena	7	3.6	30.1	13.6	14.4	1.36
Ameletus	0	1.2	0	0.4	0.7	0.04
TOTAL: EPHEMEROPTERA	29	57.6	399.9	162.2	206.4	16.23
Capniidae-early instar	4	31.2	137.6	57.6	70.6	5.77
Claassenia sabulosa	1	0	0	0.3	0.6	0.03
Isogenoides	0	3.6	12.9	5.5	6.7	0.55
Isoperla	0	100.8	825.6	308.8	450.4	30.91
Taenionema	10	22.8	103.2	45.3	50.5	4.54
Taeniopteryx	1	0	0	0.3	0.6	0.03
TOTAL: PLECOPTERA	16	158.4	1079	417.9	577.2	41.83
Brachycentrus americanus	0	0	4.3	1.4	2.5	0.14
Brachycentrus occidentalis	1	0	0	0.3	0.6	0.03
Cheumatopsyche	3	0	17.2	6.7	9.2	0.67
Hydropsyche	5	1.2	51.6	19.3	28.1	1.93
?Nectopsyche	1	0	0	0.3	0.6	0.03
TOTAL: TRICHOPTERA	10	1.2	73.1	28.1	39.2	2.81
Ceratopogoninae	0	1.2	0	0.4	0.7	0.04
Hemerodromia	0	0	4.3	1.4	2.5	0.14
Simulium	17	46.8	240.8	101.5	121.5	10.16
TOTAL: DIPTERA	17	48	245.1	103.4	123.7	10.35
Chironomini-early instar	0	0	4.3	1.4	2.5	0.14
Heterotrissocladius	0	2.4	0	0.8	1.4	0.08
Micropsectra	10	147.6	301	152.9	145.6	15.30
Orthocladiinae-early instar	0	3.6	0	1.2	2.1	0.12
Orthocladius Complex	1	3.6	17.2	7.3	8.7	0.73
Pentaneurini-early instar	3	0	12.9	5.3	6.8	0.53
Polypedilum	0	0	4.3	1.4	2.5	0.14
Rheotanytarsus	1	9.6	17.2	9.3	8.1	0.93
Stempellinella	0	2.4	0	0.8	1.4	0.08
Thienemannimyia	1	2.4	4.3	2.6	1.7	0.26
Tvetenia	1	19.2	288.1	102.8	160.8	10.29
TOTAL: CHIRONOMIDAE	17	190.8	649.3	285.7	326.7	28.60
GRAND TOTAL	89	457.2	2451	999.1	1270.8	100.00

Non-benthic invertebrates

Corixidae (Sigara)	67	57	17
Cladocera (Daphnia)		12	

Station 1, October 14, 1995, AB001

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 998.9	EPT abundance	= 608.0
Total number of taxa	= 34	Number EPT taxa	= 18
Hilsenhoff Biotic Index	= 3.82	Brillouin H	= 2.23

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	2	1.8	0.18
Odonata	0	0.0	0.00
Ephemeroptera	7	162.2	16.24
Plecoptera	6	417.8	41.83
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	5	28.0	2.80
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	3	103.3	10.34
Chironomidae	11	285.8	28.60

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	6	319.0	31.93
Parasite	1	0.4	0.04
Collector-gatherer	11	391.5	39.19
Collector-filterer	4	136.8	13.69
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	3	38.5	3.85
Shredder	1	57.6	5.77
Xylophage	0	0.0	0.00
Omnivore	6	49.0	4.91
Unknown	2	6.1	0.61

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	308.8	30.91
Micropsectra	152.9	15.30
Tvetenia	102.8	10.29
Simulium	101.5	10.16
Ephemerella inermis/infreq	61.3	6.14
SUBTOTAL 5 DOMINANTS	727.3	72.80
Baetis tricaudatus	61.2	6.13
Capniidae-early instar	57.6	5.77
Taenionema	45.3	4.54
Hydropsyche	19.3	1.93
Heptagenia	14.7	1.47
TOTAL 10 DOMINANTS	925.4	92.64

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	0.8	0.08
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	2	7.0	0.70
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	0.8	0.08
K Tolerant midges	0	0.0	0.00
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 1, October 14, 1995, AB001
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 2.13
Hydropsychidae/Total Trichoptera	= 0.93
Baetidae/Total Ephemeroptera	= 0.38

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.28
Scraper/(Scraper + C.-filterer)	= 0.22
Shredder/Total organisms	= 0.06

Biotic Condition Index

Community Tolerance Quotient (a)	= 74.59
Community Tolerance Quotient (d)	= 74.82

DIVERSITY MEASURES

Shannon H (loge)	= 2.28
Shannon H (log2)	= 3.29
Evenness	= 0.65
Simpson D	= 0.15

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	267.8	26.80
Univoltine	729.1	73.00
Semivoltine	2.0	0.20

Station 3, October 15, 1995, AB003

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS003

IDENTIFICATION CODE	B031	B033	B034
SUBSAMPLING CORRECTION	1	10	6
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Nematoda	1	0	30	10.3	17.0	0.36
Hyalella azteca	1	0	0	0.3	0.6	0.01
Acari	2	0	0	0.7	1.2	0.02
TOTAL: NON INSECTS	4	0	30	11.3	16.3	0.39
Baetis tricaudatus	6	180	54	80.0	89.9	2.75
Caenis	0	0	12	4.0	6.9	0.14
Ephemerella inermis/infrequens	3	110	18	43.7	57.9	1.50
Heptageniidae-early instar	2	40	0	14.0	22.5	0.48
Heptagenia	4	120	48	57.3	58.6	1.97
Rhithrogena	0	10	0	3.3	5.8	0.11
Leptophlebia	1	20	30	17.0	14.7	0.58
Ameletus	0	0	6	2.0	3.5	0.07
Tricorythodes minutus	0	10	0	3.3	5.8	0.11
TOTAL: EPHEMEROPTERA	16	490	168	224.7	242.0	7.73
Capniidae-early instar	3	80	0	27.7	45.3	0.95
Isogenoides	0	0	6	2.0	3.5	0.07
Isoperla	45	460	192	232.3	210.4	7.99
Taenionema	1	120	0	40.3	69.0	1.39
TOTAL: PLECOPTERA	49	660	198	302.3	318.6	10.40
Brachycentrus occidentalis	0	10	0	3.3	5.8	0.11
Cheumatopsyche	0	0	6	2.0	3.5	0.07
Hydropsyche	0	0	12	4.0	6.9	0.14
Ceraclea	0	10	0	3.3	5.8	0.11
Neureclipsis	0	10	0	3.3	5.8	0.11
TOTAL: TRICHOPTERA	0	30	18	16.0	15.1	0.55
Simulium	22	660	90	257.3	350.4	8.85
Dicranota	2	0	24	8.7	13.3	0.30
TOTAL: DIPTERA	24	660	114	266.0	344.2	9.15
Brillia	0	0	18	6.0	10.4	0.21
Diamesa	3	30	0	11.0	16.5	0.38
Diamesinae-early instar	0	0	18	6.0	10.4	0.21
Dicrotendipes	0	60	0	20.0	34.6	0.69
Eukiefferiella	0	30	0	10.0	17.3	0.34
Micropsectra	234	2190	1932	1452.0	1062.7	49.93
Orthocladiinae-early instar	17	30	42	29.7	12.5	1.02
Orthocladius Complex	3	60	0	21.0	33.8	0.72
Parametriocnemus	17	100	60	59.0	41.5	2.03
Polypedilum	3	0	0	1.0	1.7	0.03
Rheotanytarsus	3	0	0	1.0	1.7	0.03
Stempellinella	7	0	0	2.3	4.0	0.08
Tanytarsini-early instar	7	0	0	2.3	4.0	0.08
Thienemanniella	3	60	0	21.0	33.8	0.72
Thienemannimyia	3	60	102	55.0	49.7	1.89
Tvetenia	47	980	144	390.3	513.0	13.42
TOTAL: CHIRONOMIDAE	347	3600	2316	2087.7	1638.5	71.79
GRAND TOTAL	440	5440	2844	2908.0	2500.6	100.00

Non-benthic invertebrates

Corixidae (Sigara)	1	6
Cladocera (Daphnia)		6

Station 3, October 15, 1995, AB003

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 2907.7	EPT abundance	= 542.8
Total number of taxa	= 39	Number EPT taxa	= 18
Hilsenhoff Biotic Index	= 5.74	Brillouin H	= 1.91

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	3	11.3	0.39
Odonata	0	0.0	0.00
Ephemeroptera	9	224.6	7.71
Plecoptera	4	302.3	10.40
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	5	15.9	0.54
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	2	266.0	9.15
Chironomidae	16	2087.6	71.78

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	5	301.3	10.36
Parasite	2	11.0	0.38
Collector-gatherer	16	2160.3	74.28
Collector-filterer	4	264.3	9.09
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	3	74.6	2.56
Shredder	2	33.7	1.16
Xylophage	0	0.0	0.00
Omnivore	5	57.9	1.98
Unknown	2	4.6	0.16

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	1452.0	49.93
Tvetenia	390.3	13.42
Simulium	257.3	8.85
Isoperla	232.3	7.99
Baetis tricaudatus	80.0	2.75
SUBTOTAL 5 DOMINANTS	2411.9	82.94
Parametriocnemus	59.0	2.03
Heptagenia	57.3	1.97
Thienemannimyia	55.0	1.89
Ephemerella inermis/infreq	43.7	1.50
Taenionema	40.3	1.39
TOTAL 10 DOMINANTS	2667.2	91.72

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	3	24.3	0.83
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	2.0	0.07
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	20.0	0.69
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 3, October 15, 1995, AB003
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 0.26
Hydropsychidae/Total Trichoptera	= 0.38
Baetidae/Total Ephemeroptera	= 0.36

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.28
Scraper/(Scraper + C.-filterer)	= 0.22
Shredder/Total organisms	= 0.01

Biotic Condition Index

Community Tolerance Quotient (a)	= 81.21
Community Tolerance Quotient (d)	= 80.12

DIVERSITY MEASURES

Shannon H (loge)	= 1.93
Shannon H (log2)	= 2.79
Evenness	= 0.53
Simpson D	= 0.28

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	1639.8	56.40
Univoltine	1264.5	43.49
Semivoltine	3.3	0.11

Station 4, October 17, 1995, AB004

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS004

IDENTIFICATION CODE	B042	B043	B044
SUBSAMPLING CORRECTION	7.5	1	4.3
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Naididae	15	1	8.6	8.2	7.0	0.39
TOTAL: NON INSECTS	15	1	8.6	8.2	7.0	0.39
Ophiogomphus	7.5	0	0	2.5	4.3	0.12
TOTAL: ODONATA	7.5	0	0	2.5	4.3	0.12
Baetis tricaudatus	143	10	47.3	66.6	68.3	3.19
Centroptilum	7.5	0	0	2.5	4.3	0.12
Ephemerella inermis/infrequens	165	24	73.1	87.4	71.6	4.18
Heptageniidae-early instar	0	0	4.3	1.4	2.5	0.07
Heptagenia	150	34	64.5	82.8	60.1	3.97
Rhithrogena	15	3	0	6.0	7.9	0.29
Leptophlebia	30	15	38.7	27.9	12.0	1.34
Isonychia	15	2	0	5.7	8.1	0.27
Ameletus	0	6	8.6	4.9	4.4	0.23
TOTAL: EPHEMEROPTERA	525	94	237	285.2	219.6	13.66
Capniidae-early instar	158	11	103	90.6	74.1	4.34
Chloroperlidae	0	0	4.3	1.4	2.5	0.07
Claassenia sabulosa	0	1	0	0.3	0.6	0.02
Isogenoides	0	1	4.3	1.8	2.3	0.08
Isoperla	1260	129	443	610.6	583.9	29.25
Pteronarcys dorsata	0	6	8.6	4.9	4.4	0.23
Taenionema	67.5	14	17.2	32.9	30.0	1.58
Taeniopteryx	165	34	47.3	82.1	72.1	3.93
TOTAL: PLECOPTERA	1650	196	628	824.6	746.7	39.50
Hydropsyche	135	16	25.8	58.9	66.1	2.82
Limnephilidae-early instar	0	1	0	0.3	0.6	0.02
Neureclipsis	0	1	4.3	1.8	2.3	0.08
TOTAL: TRICHOPTERA	135	18	30.1	61.0	64.3	2.92
Chelifera	0	1	0	0.3	0.6	0.02
Hemerodromia	22.5	1	0	7.8	12.7	0.38
Simulium	180	7	25.8	70.9	94.9	3.40
TOTAL: DIPTERA	203	9	25.8	79.1	107.2	3.79
Dicrotendipes	0	1	0	0.3	0.6	0.02
Micropsectra	608	37	477	373.9	299.0	17.91
Orthocladiinae-early instar	30	2	43	25.0	21.0	1.20
Orthocladius Complex	15	5	98.9	39.6	51.6	1.90
Paracladopelma	30	3	17.2	16.7	13.5	0.80
Paratrissocladius	15	2	0	5.7	8.1	0.27
Pentaneurini-early instar	60	5	0	21.7	33.3	1.04
Polypedilum	0	1	8.6	3.2	4.7	0.15
Potthastia Longimana Gr.	0	0	8.6	2.9	5.0	0.14
Rheotanytarsus	97.5	10	151	86.0	71.0	4.12
Tanytarsini-early instar	45	0	0	15.0	26.0	0.72
Thienemanniella	15	0	8.6	7.9	7.5	0.38
Thienemannimyia	82.5	1	8.6	30.7	45.0	1.47
Tvetenia	450	12	133	198.4	226.1	9.51
TOTAL: CHIRONOMIDAE	1448	79	955	827.0	693.1	39.62
GRAND TOTAL	3983	397	1883	2087.6	1801.5	100.00

Non-benthic invertebrates

Corixidae (Sigara)	60	176	198

Station 4, October 17, 1995, AB004

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 2087.5	EPT abundance	= 1170.8
Total number of taxa	= 39	Number EPT taxa	= 20
Hilsenhoff Biotic Index	= 4.03	Brillouin H	= 2.47

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	8.2	0.39
Odonata	1	2.5	0.12
Ephemeroptera	9	285.2	13.66
Plecoptera	8	824.6	39.50
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	3	61.0	2.92
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	3	79.0	3.80
Chironomidae	14	827.0	39.63

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	9	657.2	31.49
Parasite	0	0.0	0.00
Collector-gatherer	14	851.2	40.78
Collector-filterer	4	221.5	10.61
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	3	90.2	4.33
Shredder	1	90.6	4.34
Xylophage	0	0.0	0.00
Omnivore	4	123.1	5.89
Unknown	4	53.7	2.58

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	610.6	29.25
Micropsectra	373.9	17.91
Tvetenia	198.4	9.51
Capniidae-early instar	90.6	4.34
Ephemerella inermis/infreq	87.4	4.18
SUBTOTAL 5 DOMINANTS	1360.9	65.19
Rheotanytarsus	86.0	4.12
Heptagenia	82.8	3.97
Taeniopteryx	82.1	3.93
Simulium	70.9	3.40
Baetis tricaudatus	66.6	3.19
TOTAL 10 DOMINANTS	1749.3	83.80

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	2	30.4	1.46
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	2.9	0.14
K Tolerant midges	2	17.0	0.82
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 4, October 17, 1995, AB004
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 1.42
Hydropsychidae/Total Trichoptera	= 0.97
Baetidae/Total Ephemeroptera	= 0.24

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.41
Scraper/(Scraper + C.-filterer)	= 0.29
Shredder/Total organisms	= 0.04

Biotic Condition Index

Community Tolerance Quotient (a)	= 75.31
Community Tolerance Quotient (d)	= 77.32

DIVERSITY MEASURES

Shannon H (loge)	= 2.51
Shannon H (log2)	= 3.62
Evenness	= 0.69
Simpson D	= 0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	687.7	32.94
Univoltine	1392.1	66.69
Semivoltine	7.7	0.37

Station 5, October 17, 1995, AB005

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS005

IDENTIFICATION CODE	B052	B053	B054
SUBSAMPLING CORRECTION	7.5	5	1
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Nematoda	0	10	0	3.3	5.8	0.17
Enchytraeidae	7.5	0	0	2.5	4.3	0.13
Naididae	7.5	10	4	7.2	3.0	0.37
Sphaeriidae	0	5	0	1.7	2.9	0.09
TOTAL: NON INSECTS	15	25	4	14.7	10.5	0.75
Baetis tricaudatus	90	40	19	49.7	36.5	2.54
Ephemerella inermis/infrequens	75	95	16	62.0	41.1	3.17
Heptageniidae-early instar	0	25	1	8.7	14.2	0.44
Heptagenia	105	60	8	57.7	48.5	2.95
Rhithrogena	0	5	0	1.7	2.9	0.09
Leptophlebia	0	5	0	1.7	2.9	0.09
TOTAL: EPHEMEROPTERA	270	230	44	181.3	120.6	9.27
Capniidae-early instar	195	105	32	110.7	81.6	5.66
Chloroperlidae	7.5	0	0	2.5	4.3	0.13
Isogenoides	0	0	2	0.7	1.2	0.03
Isoperla	682.5	740	191	537.8	301.7	27.50
Pteronarcys dorsata	7.5	0	1	2.8	4.1	0.14
Taenionema	105	80	26	70.3	40.4	3.60
Taeniopteryx	7.5	0	0	2.5	4.3	0.13
TOTAL: PLECOPTERA	1005	925	252	727.3	413.6	37.19
Brachycentrus occidentalis	7.5	15	0	7.5	7.5	0.38
Cheumatopsyche	7.5	0	0	2.5	4.3	0.13
Hydropsyche	0	10	0	3.3	5.8	0.17
Hydroptilidae-early instar	15	0	0	5.0	8.7	0.26
Neureclipsis	7.5	0	1	2.8	4.1	0.14
TOTAL: TRICHOPTERA	37.5	25	1	21.2	18.5	1.08
Simulium	60	50	6	38.7	28.7	1.98
TOTAL: DIPTERA	60	50	6	38.7	28.7	1.98
Chironomini-early instar	15	20	2	12.3	9.3	0.63
Micropsectra	1238	565	139	647.2	553.8	33.09
Nanocladius	0	0	2	0.7	1.2	0.03
Orthocladiinae-early instar	97.5	20	12	43.2	47.2	2.21
Orthocladius Complex	97.5	90	12	66.5	47.3	3.40
Paracladopelma	0	10	14	8.0	7.2	0.41
Rheotanytarsus	15	0	2	5.7	8.1	0.29
Tanytarsini-early instar	15	60	2	25.7	30.4	1.31
Thienemanniella	15	0	0	5.0	8.7	0.26
Thienemannimyia	45	0	2	15.7	25.4	0.80
Tvetenia	157.5	240	31	142.8	105.3	7.30
TOTAL: CHIRONOMIDAE	1695	1005	218	972.7	739.0	49.73
GRAND TOTAL	3083	2260	525	1955.8	1305.6	100.00

Non-benthic invertebrates			
Corixidae (Sigara)	135	110	9
Cladocera (Daphnia)		30	7

Station 5, October 17, 1995, AB005

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 1956.1	EPT abundance	= 929.9
Total number of taxa	= 34	Number EPT taxa	= 18
Hilsenhoff Biotic Index	= 4.44	Brillouin H	= 2.10

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	4	14.7	0.76
Odonata	0	0.0	0.00
Ephemeroptera	6	181.5	9.28
Plecoptera	7	727.3	37.19
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	5	21.1	1.08
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	38.7	1.98
Chironomidae	11	972.8	49.73

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	5	559.5	28.60
Parasite	1	3.3	0.17
Collector-gatherer	13	1042.5	53.31
Collector-filterer	4	50.2	2.57
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	1	5.0	0.26
Scraper	3	68.1	3.48
Shredder	1	110.7	5.66
Xylophage	0	0.0	0.00
Omnivore	4	83.1	4.25
Unknown	2	33.7	1.72

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	647.2	33.09
Isoperla	537.8	27.50
Tvetenia	142.8	7.30
Capniidae-early instar	110.7	5.66
Taenionema	70.3	3.60
SUBTOTAL 5 DOMINANTS	1508.8	77.15
Orthocladius Complex	66.5	3.40
Ephemerella inermis/infreq	62.0	3.17
Heptagenia	57.7	2.95
Baetis tricaudatus	49.7	2.54
Orthocladiinae-early insta	43.2	2.21
TOTAL 10 DOMINANTS	1787.9	91.42

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	1.7	0.09
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	2.5	0.13
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	8.0	0.41
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 5, October 17, 1995, AB005
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 0.96
Hydropsychidae/Total Trichoptera	= 0.27
Baetidae/Total Ephemeroptera	= 0.27

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 1.36
Scraper/(Scraper + C.-filterer)	= 0.58
Shredder/Total organisms	= 0.06

Biotic Condition Index

Community Tolerance Quotient (a)	= 77.44
Community Tolerance Quotient (d)	= 78.55

DIVERSITY MEASURES

Shannon H (loge)	= 2.14
Shannon H (log2)	= 3.09
Evenness	= 0.61
Simpson D	= 0.20

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	776.8	39.71
Univoltine	1168.2	59.72
Semivoltine	11.2	0.57

Station 6, October 18, 1995, AB006

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS006

IDENTIFICATION CODE	B062	B063	B064
SUBSAMPLING CORRECTION	1	1.2	1
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Naididae	0	1.2	0	0.4	0.7	0.09
TOTAL: NON INSECTS	0	1.2	0	0.4	0.7	0.09
Baetis tricaudatus	11	15.6	12	12.9	2.4	3.03
Ephemerella inermis/infrequens	8	20.4	2	10.1	9.4	2.39
Heptageniidae-early instar	4	0	1	1.7	2.1	0.39
Heptagenia	42	64.8	28	44.9	18.6	10.58
Rhithrogena	0	3.6	0	1.2	2.1	0.28
Stenonema	0	1.2	0	0.4	0.7	0.09
Leptophlebia	5	4.8	8	5.9	1.8	1.40
Isonychia	0	1.2	0	0.4	0.7	0.09
Ameletus	1	1.2	4	2.1	1.7	0.49
TOTAL: EPHEMEROPTERA	71	112.8	55	79.6	29.8	18.75
Capniidae-early instar	9	13.2	7	9.7	3.2	2.29
Isogenoides	0	6	0	2.0	3.5	0.47
Isoperla	92	122.4	38	84.1	42.7	19.81
Taenionema	16	30	40	28.7	12.1	6.75
Taeniopteryx	3	22.8	6	10.6	10.7	2.50
TOTAL: PLECOPTERA	120	194.4	91	135.1	53.3	31.83
Hydropsyche	1	4.8	0	1.9	2.5	0.46
TOTAL: TRICHOPTERA	1	4.8	0	1.9	2.5	0.46
Simulium	0	24	5	9.7	12.7	2.28
TOTAL: DIPTERA	0	24	5	9.7	12.7	2.28
Chironomini-early instar	9	2.4	1	4.1	4.3	0.97
Micropsectra	221	172.8	49	147.6	88.7	34.76
Orthocladiinae-early instar	22	2.4	3	9.1	11.1	2.15
Orthocladius Complex	6	2.4	8	5.5	2.8	1.29
Paracladopelma	0	2.4	0	0.8	1.4	0.19
Rheotanytarsus	9	0	1	3.3	4.9	0.79
Thienemanniella	0	0	1	0.3	0.6	0.08
Thienemannimyia	0	7.2	1	2.7	3.9	0.64
Tvetenia	25	24	24	24.3	0.6	5.73
TOTAL: CHIRONOMIDAE	292	213.6	88	197.9	102.9	46.60
GRAND TOTAL	484	550.8	239	424.6	164.2	100.00

Non-benthic invertebrates

Corixidae (Sigara)	1

Station 6, October 18, 1995, AB006

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 424.4	EPT abundance	= 216.6
Total number of taxa	= 26	Number EPT taxa	= 15
Hilsenhoff Biotic Index	= 4.55	Brillouin H	= 2.10

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	0.4	0.09
Odonata	0	0.0	0.00
Ephemeroptera	9	79.6	18.74
Plecoptera	5	135.1	31.82
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	1	1.9	0.46
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	9.7	2.28
Chironomidae	9	197.7	46.60

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	3	88.8	20.92
Parasite	0	0.0	0.00
Collector-gatherer	11	222.3	52.38
Collector-filterer	4	15.3	3.62
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	4	48.2	11.34
Shredder	1	9.7	2.29
Xylophage	0	0.0	0.00
Omnivore	2	39.3	9.25
Unknown	1	0.8	0.19

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	147.6	34.76
Isoperla	84.1	19.81
Heptagenia	44.9	10.58
Taenionema	28.7	6.75
Tvetenia	24.3	5.73
SUBTOTAL 5 DOMINANTS	329.6	77.63
Baetis tricaudatus	12.9	3.03
Taeniopteryx	10.6	2.50
Ephemerella inermis/infreq	10.1	2.39
Capniidae-early instar	9.7	2.29
Simulium	9.7	2.28
TOTAL 10 DOMINANTS	382.6	90.12

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	2	6.3	1.49
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	0.8	0.19
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 6, October 18, 1995, AB006
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 1.10
Hydropsychidae/Total Trichoptera	= 1.00
Baetidae/Total Ephemeroptera	= 0.16

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 3.15
Scraper/(Scraper + C.-filterer)	= 0.76
Shredder/Total organisms	= 0.02

Biotic Condition Index

Community Tolerance Quotient (a)	= 72.19
Community Tolerance Quotient (d)	= 69.05

DIVERSITY MEASURES

Shannon H (loge)	= 2.20
Shannon H (log2)	= 3.17
Evenness	= 0.67
Simpson D	= 0.18

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	158.4	37.33
Univoltine	266.0	62.67
Semivoltine	0.0	0.00

Station 7, October 18, 1995, AB007

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS007

IDENTIFICATION CODE	B071	B072	B073
SUBSAMPLING CORRECTION	6	7.5	6
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Naididae	0	15	12	9.0	7.9	0.29
Acari	0	7.5	6	4.5	4.0	0.14
TOTAL: NON INSECTS	0	22.5	18	13.5	11.9	0.43
Baetis tricaudatus	42	67.5	108	72.5	33.3	2.32
Ephemerella inermis/infrequens	216	233	318	255.5	54.8	8.18
Heptageniidae-early instar	6	22.5	18	15.5	8.5	0.50
Heptagenia	36	67.5	114	72.5	39.2	2.32
Rhithrogena	18	22.5	18	19.5	2.6	0.62
Isonychia	0	0	6	2.0	3.5	0.06
Tricorythodes minutus	0	0	6	2.0	3.5	0.06
TOTAL: EPHEMEROPTERA	318	413	588	439.5	137.0	14.06
Capniidae-early instar	126	143	198	155.5	37.7	4.98
Chloroperlidae	0	7.5	0	2.5	4.3	0.08
Isogenoides	48	52.5	24	41.5	15.3	1.33
Isoperla	1218	1298	888	1134.5	217.1	36.30
Pteronarcys dorsata	12	0	0	4.0	6.9	0.13
Taenionema	36	82.5	108	75.5	36.5	2.42
TOTAL: PLECOPTERA	1440	1583	1218	1413.5	183.7	45.23
Brachycentrus occidentalis	24	45	24	31.0	12.1	0.99
Cheumatopsyche	18	15	6	13.0	6.2	0.42
Hydropsyche	30	75	36	47.0	24.4	1.50
Neureclipsis	6	0	6	4.0	3.5	0.13
TOTAL: TRICHOPTERA	78	135	72	95.0	34.8	3.04
Hemerodromia	0	15	0	5.0	8.7	0.16
Simulium	78	97.5	168	114.5	47.3	3.66
TOTAL: DIPTERA	78	113	168	119.5	45.4	3.82
Brillia	6	15	0	7.0	7.5	0.22
Chironomini-early instar	0	0	24	8.0	13.9	0.26
Diamesa	0	0	12	4.0	6.9	0.13
Micropsectra	570	638	384	530.5	131.3	16.98
Nanocladius	0	15	0	5.0	8.7	0.16
Orthocladiinae-early instar	30	15	66	37.0	26.2	1.18
Orthocladius Complex	6	15	24	15.0	9.0	0.48
Paracladopelma	18	0	12	10.0	9.2	0.32
Parametriocnemus	0	0	12	4.0	6.9	0.13
Pentaneurini-early instar	0	0	12	4.0	6.9	0.13
Polypedilum	6	0	0	2.0	3.5	0.06
Rheotanytarsus	6	15	24	15.0	9.0	0.48
Stempellinella	0	15	0	5.0	8.7	0.16
Tanytarsini-early instar	0	0	24	8.0	13.9	0.26
Thienemanniella	0	22.5	0	7.5	13.0	0.24
Thienemannimyia	18	60	36	38.0	21.1	1.22
Tvetenia	180	270	582	344.0	211.0	11.01
TOTAL: CHIRONOMIDAE	840	1080	1212	1044.0	188.6	33.41
GRAND TOTAL	2754	3345	3276	3125.0	323.1	100.00

Non-benthic invertebrates			
Corixidae (Sigara)	162	97.5	168
Cladocera (Daphnia)	6		12
Copepoda		22.5	

Station 7, October 18, 1995, AB007

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 3125.0	EPT abundance	= 1948.0
Total number of taxa	= 38	Number EPT taxa	= 17
Hilsenhoff Biotic Index	= 3.59	Brillouin H	= 2.23

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	2	13.5	0.43
Odonata	0	0.0	0.00
Ephemeroptera	7	439.5	14.06
Plecoptera	6	1413.5	45.24
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	4	95.0	3.04
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	2	119.5	3.82
Chironomidae	17	1044.0	33.42

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	6	1225.5	39.22
Parasite	1	4.5	0.14
Collector-gatherer	13	1294.0	41.42
Collector-filterer	5	191.5	6.12
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	3	107.5	3.44
Shredder	2	162.5	5.20
Xylophage	0	0.0	0.00
Omnivore	4	112.5	3.60
Unknown	4	27.0	0.87

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	1134.5	36.30
Micropsectra	530.5	16.98
Tvetenia	344.0	11.01
Ephemerella inermis/infreq	255.5	8.18
Capniidae-early instar	155.5	4.98
SUBTOTAL 5 DOMINANTS	2420.0	77.45
Simulium	114.5	3.66
Taenionema	75.5	2.42
Baetis tricaudatus	72.5	2.32
Heptagenia	72.5	2.32
Hydropsyche	47.0	1.50
TOTAL 10 DOMINANTS	2802.0	89.67

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	2.0	0.06
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	13.0	0.42
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	10.0	0.32
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 7, October 18, 1995, AB007
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 1.87
Hydropsychidae/Total Trichoptera	= 0.63
Baetidae/Total Ephemeroptera	= 0.16

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.56
Scraper/(Scraper + C.-filterer)	= 0.36
Shredder/Total organisms	= 0.05

Biotic Condition Index

Community Tolerance Quotient (a)	= 82.53
Community Tolerance Quotient (d)	= 77.43

DIVERSITY MEASURES

Shannon H (loge)	= 2.25
Shannon H (log2)	= 3.25
Evenness	= 0.62
Simpson D	= 0.19

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	858.9	27.48
Univoltine	2231.1	71.40
Semivoltine	35.0	1.12

Station 8, October 18, 1995, AB008

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS008

IDENTIFICATION CODE	B082	B083	B084
SUBSAMPLING CORRECTION	3	9	3
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Naididae	6	45	15	22.0	20.4	0.93
TOTAL: NON INSECTS	6	45	15	22.0	20.4	0.93
Baetidae?	0	9	0	3.0	5.2	0.13
Baetis tricaudatus	48	126	39	71.0	47.8	3.01
Centroptilum	6	0	3	3.0	3.0	0.13
Diphetor hageni	0	9	0	3.0	5.2	0.13
Ephemerella inermis/infrequens	141	396	138	225.0	148.1	9.53
Heptageniidae-early instar	0	36	0	12.0	20.8	0.51
Heptagenia	63	81	27	57.0	27.5	2.41
Rhithrogena	3	0	3	2.0	1.7	0.08
Stenonema	0	0	3	1.0	1.7	0.04
Ameletus	6	0	0	2.0	3.5	0.08
TOTAL: EPHEMEROPTERA	267	657	213	379.0	242.3	16.05
Capniidae-early instar	21	108	6	45.0	55.1	1.91
Chloroperlidae	0	0	6	2.0	3.5	0.08
Isogenoides	6	0	3	3.0	3.0	0.13
Isoperla	672	1611	723	1002.0	528.0	42.44
Taenionema	45	45	27	39.0	10.4	1.65
Taeniopteryx	3	9	27	13.0	12.5	0.55
TOTAL: PLECOPTERA	747	1773	792	1104.0	579.8	46.76
Cheumatopsyche	0	0	3	1.0	1.7	0.04
Hydropsyche	36	72	24	44.0	25.0	1.86
Hydroptila	0	0	3	1.0	1.7	0.04
Neureclipsis	3	18	0	7.0	9.6	0.30
TOTAL: TRICHOPTERA	39	90	30	53.0	32.4	2.24
Clinocera	0	9	0	3.0	5.2	0.13
Hemerodromia	0	0	3	1.0	1.7	0.04
Simulium	33	72	51	52.0	19.5	2.20
TOTAL: DIPTERA	33	81	54	56.0	24.1	2.37
Brillia	0	18	0	6.0	10.4	0.25
Micropsectra	246	648	45	313.0	307.0	13.26
Nanocladius	0	0	3	1.0	1.7	0.04
Orthocladiinae-early instar	3	81	0	28.0	45.9	1.19
Orthocladius Complex	0	36	9	15.0	18.7	0.64
Paracladopelma	3	0	0	1.0	1.7	0.04
Pentaneurini-early instar	0	99	0	33.0	57.2	1.40
Rheotanytarsus	30	144	15	63.0	70.5	2.67
Thienemanniella	0	18	0	6.0	10.4	0.25
Thienemannimyia	18	36	12	22.0	12.5	0.93
Tvetenia	87	666	24	259.0	353.9	10.97
TOTAL: CHIRONOMIDAE	387	1746	108	747.0	876.3	31.64
GRAND TOTAL	1479	4392	1212	2361.0	1764.0	100.00

Non-benthic invertebrates

Corixidae (Sigara)	69	117	45			

Station 8, October 18, 1995, AB008

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 2361.0	EPT abundance	= 1536.0
Total number of taxa	= 35	Number EPT taxa	= 20
Hilsenhoff Biotic Index	= 3.55	Brillouin H	= 2.08

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	22.0	0.93
Odonata	0	0.0	0.00
Ephemeroptera	10	379.0	16.05
Plecoptera	6	1104.0	46.76
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	4	53.0	2.24
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	3	56.0	2.37
Chironomidae	11	747.0	31.64

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	7	1040.0	44.05
Parasite	0	0.0	0.00
Collector-gatherer	13	951.0	40.29
Collector-filterer	4	160.0	6.77
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	1	1.0	0.04
Scraper	4	72.0	3.04
Shredder	2	51.0	2.16
Xylophage	0	0.0	0.00
Omnivore	2	52.0	2.20
Unknown	2	34.0	1.44

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	1002.0	42.44
Micropsectra	313.0	13.26
Tvetenia	259.0	10.97
Ephemerella inermis/infreq	225.0	9.53
Baetis tricaudatus	71.0	3.01
SUBTOTAL 5 DOMINANTS	1870.0	79.21
Rheotanytarsus	63.0	2.67
Heptagenia	57.0	2.41
Simulium	52.0	2.20
Capniidae-early instar	45.0	1.91
Hydropsyche	44.0	1.86
TOTAL 10 DOMINANTS	2131.0	90.26

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	2	4.0	0.17
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	2	2.0	0.08
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	1.0	0.04
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 8, October 18, 1995, AB008
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 2.06
Hydropsychidae/Total Trichoptera	= 0.85
Baetidae/Total Ephemeroptera	= 0.21

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.45
Scraper/(Scraper + C.-filterer)	= 0.31
Shredder/Total organisms	= 0.02

Biotic Condition Index

Community Tolerance Quotient (a)	= 77.23
Community Tolerance Quotient (d)	= 77.37

DIVERSITY MEASURES

Shannon H (loge)	= 2.11
Shannon H (log2)	= 3.04
Evenness	= 0.59
Simpson D	= 0.22

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	635.8	26.93
Univoltine	1725.2	73.07
Semivoltine	0.0	0.00

Station 9, October 21, 1995, AB009

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS009

IDENTIFICATION CODE	B091	B092	B094
SUBSAMPLING CORRECTION	2	1.2	1.2
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Hydra	0	0	1.2	0.4	0.7	0.06
Nematoda	0	0	1.2	0.4	0.7	0.06
Naididae	0	3.6	0	1.2	2.1	0.19
Hyalella azteca	4	0	0	1.3	2.3	0.22
TOTAL: NON INSECTS	4	3.6	2.4	3.3	0.8	0.54
Baetis tricaudatus	0	1.2	2.4	1.2	1.2	0.19
Ephemerella inermis/infrequens	2	3.6	3.6	3.1	0.9	0.50
Heptageniidae-early instar	0	0	9.6	3.2	5.5	0.52
Heptagenia	8	7.2	10.8	8.7	1.9	1.40
Leptophlebia	2	3.6	1.2	2.3	1.2	0.37
Ameletus	4	0	1.2	1.7	2.1	0.28
TOTAL: EPHEMEROPTERA	16	15.6	28.8	20.1	7.5	3.25
Capniidae-early instar	34	46.8	36	38.9	6.9	6.29
Isogenoides	2	1.2	2.4	1.9	0.6	0.30
Isoperla	362	355.2	253.2	323.5	60.9	52.23
Pteronarcys dorsata	2	0	1.2	1.1	1.0	0.17
Taenionema	2	4.8	2.4	3.1	1.5	0.50
Taeniopteryx	0	1.2	1.2	0.8	0.7	0.13
TOTAL: PLECOPTERA	402	409.2	296.4	369.2	63.1	59.61
Brachycentrus occidentalis	0	0	1.2	0.4	0.7	0.06
Cheumatopsyche	0	0	1.2	0.4	0.7	0.06
Hydropsyche	0	0	1.2	0.4	0.7	0.06
Neureclipsis	0	1.2	0	0.4	0.7	0.06
TOTAL: TRICHOPTERA	0	1.2	3.6	1.6	1.8	0.26
Ceratopogoninae	0	1.2	0	0.4	0.7	0.06
Simulium	2	7.2	0	3.1	3.7	0.50
TOTAL: DIPTERA	2	8.4	0	3.5	4.4	0.56
Chironomini-early instar	0	3.6	2.4	2.0	1.8	0.32
Corynoneura	4	1.2	0	1.7	2.1	0.28
Diamesa	0	1.2	0	0.4	0.7	0.06
Heterotrissocladius	6	1.2	1.2	2.8	2.8	0.45
Micropsectra	180	118.8	81.6	126.8	49.7	20.47
Microtendipes	4	0	0	1.3	2.3	0.22
Nanocladius	6	2.4	3.6	4.0	1.8	0.65
Orthocladiinae-early instar	26	1.2	1.2	9.5	14.3	1.53
Orthocladius Complex	4	6	1.2	3.7	2.4	0.60
Paraboreochlus	0	1.2	0	0.4	0.7	0.06
Paracladopelma	106	32.4	20.4	52.9	46.3	8.55
Parametriocnemus	0	1.2	0	0.4	0.7	0.06
Paratrissocladius	4	1.2	1.2	2.1	1.6	0.34
Pentaneurini-early instar	14	8.4	7.2	9.9	3.6	1.59
Polypedilum	0	0	1.2	0.4	0.7	0.06
Thienemannimyia	6	0	3.6	3.2	3.0	0.52
TOTAL: CHIRONOMIDAE	360	180	124.8	221.6	123.0	35.78
GRAND TOTAL	784	618	456	619.3	164.0	100.00
Non-benthic invertebrates						
Corixidae (Sigara)	92	80.4	51.6			
Copepoda	2					

Station 9, October 21, 1995, AB009

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 619.4	EPT abundance	= 391.1
Total number of taxa	= 38	Number EPT taxa	= 16
Hilsenhoff Biotic Index	= 3.69	Brillouin H	= 1.61

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	4	3.3	0.53
Odonata	0	0.0	0.00
Ephemeroptera	6	20.2	3.26
Plecoptera	6	369.3	59.62
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	4	1.6	0.24
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	2	3.5	0.56
Chironomidae	16	221.5	35.76

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	6	329.8	53.23
Parasite	1	0.4	0.06
Collector-gatherer	18	165.9	26.79
Collector-filterer	3	3.9	0.62
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	2	11.9	1.92
Shredder	1	38.9	6.29
Xylophage	0	0.0	0.00
Omnivore	5	5.8	0.92
Unknown	2	62.8	10.14

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	323.5	52.23
Micropsectra	126.8	20.47
Paracladopelma	52.9	8.55
Capniidae-early instar	38.9	6.29
Pentaneurini-early instar	9.9	1.59
SUBTOTAL 5 DOMINANTS	552.0	89.13
Orthocladiinae-early insta	9.5	1.53
Heptagenia	8.7	1.40
Nanocladius	4.0	0.65
Orthocladius Complex	3.7	0.60
Heptageniidae-early instar	3.2	0.52
TOTAL 10 DOMINANTS	581.1	93.83

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	2.3	0.37
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	0.4	0.06
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	2	3.2	0.51
K Tolerant midges	1	52.9	8.55
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 9, October 21, 1995, AB009
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 1.77
Hydropsychidae/Total Trichoptera	= 0.50
Baetidae/Total Ephemeroptera	= 0.06

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 3.05
Scraper/(Scraper + C.-filterer)	= 0.75
Shredder/Total organisms	= 0.06

Biotic Condition Index

Community Tolerance Quotient (a)	= 83.58
Community Tolerance Quotient (d)	= 68.56

DIVERSITY MEASURES

Shannon H (loge)	= 1.69
Shannon H (log2)	= 2.43
Evenness	= 0.46
Simpson D	= 0.33

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	168.0	27.13
Univoltine	449.9	72.63
Semivoltine	1.5	0.24

Station 10, October 20, 1995, AB010

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS010

IDENTIFICATION CODE	B101	B102	B104
SUBSAMPLING CORRECTION	1	2.3	1
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Baetis tricaudatus	6	43.7	26	25.2	18.9	3.85
Centroptilum	0	6.9	0	2.3	4.0	0.35
Ephemerella inermis/infrequens	15	151.8	84	83.6	68.4	12.74
Heptageniidae-early instar	0	18.4	0	6.1	10.6	0.94
Heptagenia	7	41.4	31	26.5	17.6	4.03
Ameletus	3	9.2	1	4.4	4.3	0.67
TOTAL: EPHEMEROPTERA	31	271.4	142	148.1	120.3	22.58
Capniidae-early instar	0	39.1	8	15.7	20.7	2.39
Chloroperlidae	0	2.3	0	0.8	1.3	0.12
Zapada cinctipes	0	0	1	0.3	0.6	0.05
Isogenoides	4	2.3	3	3.1	0.9	0.47
Isoperla	52	372.6	184	202.9	161.1	30.93
Pteronarcys dorsata	3	9.2	3	5.1	3.6	0.77
Taenionema	15	36.8	27	26.3	10.9	4.00
Taeniopteryx	8	41.4	14	21.1	17.8	3.22
TOTAL: PLECOPTERA	82	503.7	240	275.2	213.0	41.96
Brachycentrus americanus	0	0	1	0.3	0.6	0.05
Cheumatopsyche	0	9.2	0	3.1	5.3	0.47
Hydropsyche	7	96.6	11	38.2	50.6	5.82
Lepidostoma-sand case larvae	0	0	1	0.3	0.6	0.05
Neureclipsis	0	6.9	0	2.3	4.0	0.35
TOTAL: TRICHOPTERA	7	112.7	13	44.2	59.4	6.74
Simulium	66	158.7	30	84.9	66.4	12.94
TOTAL: DIPTERA	66	158.7	30	84.9	66.4	12.94
Brillia	0	2.3	0	0.8	1.3	0.12
Micropsectra	0	16.1	16	10.7	9.3	1.63
Orthocladiinae-early instar	6	2.3	10	6.1	3.9	0.93
Orthocladius Complex	0	4.6	0	1.5	2.7	0.23
Parametriocnemus	0	0	2	0.7	1.2	0.10
Paratrissocladius	0	2.3	0	0.8	1.3	0.12
Rheotanytarsus	0	13.8	10	7.9	7.1	1.21
Thienemanniella	0	2.3	2	1.4	1.3	0.22
Thienemannimyia	1	2.3	0	1.1	1.2	0.17
Tvetenia	12	133.4	72	72.5	60.7	11.05
TOTAL: CHIRONOMIDAE	19	179.4	112	103.5	80.5	15.77
GRAND TOTAL	205	1226	537	656.0	520.7	100.00

Non-benthic invertebrates

Corixidae (Sigara)	2.3	7

Station 10, October 20, 1995, AB010

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 656.0	EPT abundance	= 467.6
Total number of taxa	= 30	Number EPT taxa	= 19
Hilsenhoff Biotic Index	= 3.26	Brillouin H	= 2.26

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	0	0.0	0.00
Odonata	0	0.0	0.00
Ephemeroptera	6	148.1	22.58
Plecoptera	8	275.3	41.95
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	5	44.2	6.74
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	84.9	12.94
Chironomidae	10	103.5	15.78

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	5	210.2	32.04
Parasite	0	0.0	0.00
Collector-gatherer	11	209.2	31.89
Collector-filterer	4	134.1	20.44
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	2	32.6	4.97
Shredder	4	17.1	2.61
Xylophage	0	0.0	0.00
Omnivore	4	52.8	8.04
Unknown	0	0.0	0.00

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	202.9	30.93
Simulium	84.9	12.94
Ephemerella inermis/infreq	83.6	12.74
Tvetenia	72.5	11.05
Hydropsyche	38.2	5.82
SUBTOTAL 5 DOMINANTS	482.1	73.48
Heptagenia	26.5	4.03
Taenionema	26.3	4.00
Baetis tricaudatus	25.2	3.85
Taeniopteryx	21.1	3.22
Capniidae-early instar	15.7	2.39
TOTAL 10 DOMINANTS	596.9	90.97

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	2.3	0.35
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	3.1	0.47
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	0	0.0	0.00
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 10, October 20, 1995, AB010
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 4.52
Hydropsychidae/Total Trichoptera	= 0.93
Baetidae/Total Ephemeroptera	= 0.19

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.24
Scraper/(Scraper + C.-filterer)	= 0.20
Shredder/Total organisms	= 0.03

Biotic Condition Index

Community Tolerance Quotient (a)	= 68.60
Community Tolerance Quotient (d)	= 71.38

DIVERSITY MEASURES

Shannon H (loge)	= 2.33
Shannon H (log2)	= 3.36
Evenness	= 0.69
Simpson D	= 0.15

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	109.7	16.73
Univoltine	540.9	82.45
Semivoltine	5.4	0.82

Station 11, October 20, 1995, AB011

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS011

IDENTIFICATION CODE	B111	B112	B113
SUBSAMPLING CORRECTION	2.3	2.5	1
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Porifera	0	2.5	0	0.8	1.4	0.09
Naididae	9.2	12.5	4	8.6	4.3	0.96
Hyalella azteca	2.3	0	0	0.8	1.3	0.09
Acari	0	0	1	0.3	0.6	0.04
TOTAL: NON INSECTS	11.5	15	5	10.5	5.1	1.18
Ophiogomphus	0	0	1	0.3	0.6	0.04
TOTAL: ODONATA	0	0	1	0.3	0.6	0.04
Baetis tricaudatus	9.2	12.5	41	20.9	17.5	2.34
Ephemerella inermis/infrequens	55.2	50	16	40.4	21.3	4.53
Heptageniidae-early instar	6.9	7.5	1	5.1	3.6	0.58
Heptagenia	11.5	12.5	9	11.0	1.8	1.23
Leptophlebia	2.3	5	1	2.8	2.0	0.31
Ameletus	4.6	2.5	0	2.4	2.3	0.27
TOTAL: EPHEMEROPTERA	89.7	90	68	82.6	12.6	9.25
Capniidae-early instar	64.4	27.5	27	39.6	21.5	4.44
Isogenoides	0	0	3	1.0	1.7	0.11
Isoperla	565.8	927.5	206	566.4	360.8	63.48
Pteronarcys dorsata	0	0	1	0.3	0.6	0.04
Taenionema	27.6	35	29	30.5	3.9	3.42
Taeniopteryx	2.3	5	3	3.4	1.4	0.38
TOTAL: PLECOPTERA	660.1	995	269	641.4	363.4	71.88
Brachycentrus occidentalis	4.6	2.5	2	3.0	1.4	0.34
Cheumatopsyche	0	2.5	0	0.8	1.4	0.09
Hydropsyche	4.6	12.5	6	7.7	4.2	0.86
Oecetis	0	0	1	0.3	0.6	0.04
Neureclipsis	4.6	5	1	3.5	2.2	0.40
TOTAL: TRICHOPTERA	13.8	22.5	10	15.4	6.4	1.73
Hemerodromia	0	5	0	1.7	2.9	0.19
Simulium	32.2	40	22	31.4	9.0	3.52
TOTAL: DIPTERA	32.2	45	22	33.1	11.5	3.71
Brillia	2.3	2.5	0	1.6	1.4	0.18
Micropsectra	57.5	30	20	35.8	19.4	4.02
Nanocladius	2.3	0	0	0.8	1.3	0.09
Orthocladiinae-early instar	11.5	5	6	7.5	3.5	0.84
Orthocladius Complex	13.8	10	3	8.9	5.5	1.00
Paracladopelma	9.2	5	0	4.7	4.6	0.53
Parametriocnemus	0	0	2	0.7	1.2	0.07
Paratrissocladius	4.6	0	0	1.5	2.7	0.17
Pentaneurini-early instar	0	0	3	1.0	1.7	0.11
Rheotanytarsus	4.6	2.5	2	3.0	1.4	0.34
Stempellinella	2.3	0	0	0.8	1.3	0.09
Thienemannimyia	39.1	52.5	3	31.5	25.6	3.53
Tvetenia	18.4	5	10	11.1	6.8	1.25
TOTAL: CHIRONOMIDAE	165.6	112.5	49	109.0	58.4	12.22
GRAND TOTAL	972.9	1280	424	892.3	433.7	100.00

Non-benthic invertebrates			
Corixidae (Sigara)	50.6	145	24
Copepoda	2.3		
Cladocera (Daphnia)	2.3	2.5	1
Gyrinus		2.5	

Station 11, October 20, 1995, AB011

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 891.9	EPT abundance	= 739.1
Total number of taxa	= 37	Number EPT taxa	= 17
Hilsenhoff Biotic Index	= 2.79	Brillouin H	= 1.62

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	4	10.5	1.18
Odonata	1	0.3	0.04
Ephemeroptera	6	82.6	9.26
Plecoptera	6	641.2	71.87
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	5	15.3	1.73
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	2	33.1	3.71
Chironomidae	13	108.9	12.22

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	6	604.4	67.75
Parasite	1	0.3	0.04
Collector-gatherer	13	142.2	15.94
Collector-filterer	5	43.7	4.90
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	2	16.1	1.81
Shredder	2	41.2	4.62
Xylophage	0	0.0	0.00
Omnivore	5	37.5	4.22
Unknown	3	6.5	0.73

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	566.4	63.48
Ephemerella inermis/infreq	40.4	4.53
Capniidae-early instar	39.6	4.44
Micropsectra	35.8	4.02
Thienemannimyia	31.5	3.53
SUBTOTAL 5 DOMINANTS	713.7	80.00
Simulium	31.4	3.52
Taenionema	30.5	3.42
Baetis tricaudatus	20.9	2.34
Tvetenia	11.1	1.25
Heptagenia	11.0	1.23
TOTAL 10 DOMINANTS	818.6	91.76

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	2.8	0.31
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	2	1.1	0.13
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	4.7	0.53
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 11, October 20, 1995, AB011
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 6.79
Hydropsychidae/Total Trichoptera	= 0.56
Baetidae/Total Ephemeroptera	= 0.25

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.37
Scraper/(Scraper + C.-filterer)	= 0.27
Shredder/Total organisms	= 0.05

Biotic Condition Index

Community Tolerance Quotient (a)	= 80.36
Community Tolerance Quotient (d)	= 71.62

DIVERSITY MEASURES

Shannon H (loge)	= 1.69
Shannon H (log2)	= 2.43
Evenness	= 0.47
Simpson D	= 0.41

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	101.5	11.38
Univoltine	786.4	88.17
Semivoltine	4.0	0.45

Station 12, October 20, 1995, AB012

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc.
Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.
Relative abundance per basket. FILE: 95AS012

IDENTIFICATION CODE	B121	B123	B124
SUBSAMPLING CORRECTION	2.7	1	1
CONVERSION (M2)	1		

Taxon	R1	R2	R3	MEAN	STDEV	%
Nematoda	0	0	6	2.0	3.5	0.42
Tubificidae	0	4	20	8.0	10.6	1.68
Sphaeriidae*	0	3	21	8.0	11.4	1.68
Ostracoda	0	0	4	1.3	2.3	0.28
Acari	0	0	2	0.7	1.2	0.14
TOTAL: NON INSECTS	0	7	53	20.0	28.8	4.20
Ophiogomphus	0	0	1	0.3	0.6	0.07
TOTAL: ODONATA	0	0	1	0.3	0.6	0.07
Baetis tricaudatus	8.1	0	0	2.7	4.7	0.57
Heptagenia	45.9	27	8	27.0	19.0	5.66
Leptophlebia	89.1	64	24	59.0	32.8	12.39
TOTAL: EPHEMEROPTERA	143.1	91	32	88.7	55.6	18.62
Capniidae-early instar	0	1	2	1.0	1.0	0.21
Chloroperlidae	5.4	1	0	2.1	2.9	0.45
Isoperla	32.4	17	6	18.5	13.3	3.88
TOTAL: PLECOPTERA	37.8	19	8	21.6	15.1	4.53
Ceratopogoninae	0	0	11	3.7	6.4	0.77
Hemerodromia	0	0	1	0.3	0.6	0.07
Simulium	0	1	0	0.3	0.6	0.07
Tabanidae	0	0	1	0.3	0.6	0.07
TOTAL: DIPTERA	0	1	13	4.7	7.2	0.98
Chironomidae-pupae	0	1	1	0.7	0.6	0.14
Chironomini-early instar	13.5	2	0	5.2	7.3	1.08
Heterotrissocladius	10.8	10	37	19.3	15.4	4.04
Micropsectra	305.1	200	326	277.0	67.5	58.16
Microtendipes	2.7	0	0	0.9	1.6	0.19
Nilotanypus	0	0	4	1.3	2.3	0.28
Orthocladiinae-early instar	0	2	0	0.7	1.2	0.14
Orthocladius Complex	0	0	4	1.3	2.3	0.28
Paracladopelma	8.1	7	0	5.0	4.4	1.06
Pentaneurini-early instar	5.4	7	0	4.1	3.7	0.87
Phaenopsectra	0	0	4	1.3	2.3	0.28
Polypedilum	2.7	2	0	1.6	1.4	0.33
Procladius	0	0	12	4.0	6.9	0.84
Rheotanytarsus	2.7	0	0	0.9	1.6	0.19
Stempellinella	2.7	0	0	0.9	1.6	0.19
Thienemannimyia	40.5	10	0	16.8	21.1	3.53
TOTAL: CHIRONOMIDAE	394.2	241	388	341.1	86.7	71.60
GRAND TOTAL	575.1	359	495	476.4	109.2	100.00

Non-benthic invertebrates			
Corixidae (Sigara)	602.1	133	32
Copepoda	64.8	4	
Deronectes	5.4		

* 1 Sphaerium striatinum specimen present

Station 12, October 20, 1995, AB012

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

Total invertebrate abundance	= 476.2	EPT abundance	= 110.3
Total number of taxa	= 32	Number EPT taxa	= 6
Hilsenhoff Biotic Index	= 5.91	Brillouin H	= 1.63

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	5	20.0	4.20
Odonata	1	0.3	0.07
Ephemeroptera	3	88.7	18.62
Plecoptera	3	21.6	4.54
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	4	4.6	0.98
Chironomidae	16	341.0	71.60

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	8	43.3	9.12
Parasite	2	2.7	0.56
Collector-gatherer	12	387.4	81.33
Collector-filterer	2	1.2	0.26
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	2	28.3	5.94
Shredder	1	1.0	0.21
Xylophage	0	0.0	0.00
Omnivore	1	1.6	0.33
Unknown	4	10.7	2.26

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	277.0	58.16
Leptophlebia	59.0	12.39
Heptagenia	27.0	5.66
Heterotrissocladius	19.3	4.04
Isoperla	18.5	3.88
SUBTOTAL 5 DOMINANTS	400.8	84.13
Thienemannimyia	16.8	3.53
Tubificidae	8.0	1.68
Sphaeriidae	8.0	1.68
Chironomini-early instar	5.2	1.08
Paracladopelma	5.0	1.06
TOTAL 10 DOMINANTS	443.8	93.16

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	59.0	12.39
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	1	0.3	0.07
J Intolerant midges	1	19.3	4.04
K Tolerant midges	2	9.0	1.90
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 12, October 20, 1995, AB012
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined ABA, Inc. Benthic invertebrate biomonitoring. Artificial substrate samples, baskets, 250 micron.

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.32
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.03

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter = 23.58
Scraper/(Scraper + C.-filterer) = 0.96
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 94.34
Community Tolerance Quotient (d) = 79.98

DIVERSITY MEASURES
Shannon H (loge) = 1.72
Shannon H (log2) = 2.48
Evenness = 0.50
Simpson D = 0.36

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	261.8	54.97
Univoltine	210.1	44.13
Semivoltine	4.3	0.90

Station 1, October 20, 1995, AB001-B015

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK001

IDENTIFICATION CODE	95EK001
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Nematoda	14.4	0.83
Tubificidae	144	8.26
TOTAL: NON INSECTS	158.4	9.09
Ophiogomphus	14.4	0.83
TOTAL: ODONATA	14.4	0.83
Ephemerella inermis/infrequens	14.4	0.83
Heptagenia	14.4	0.83
TOTAL: EPHEMEROPTERA	28.8	1.65
Capniidae-early instar	57.6	3.31
Isoperla	316.8	18.18
Taenionema	43.2	2.48
TOTAL: PLECOPTERA	417.6	23.97
Brachycentrus occidentalis	14.4	0.83
TOTAL: TRICHOPTERA	14.4	0.83
Simulium	100.8	5.79
TOTAL: DIPTERA	100.8	5.79
Brillia	14.4	0.83
Micropsectra	849.6	48.76
Paracladopelma	43.2	2.48
Polypedilum	72	4.13
Procladius	14.4	0.83
Thienemannimyia	14.4	0.83
TOTAL: CHIRONOMIDAE	1008	57.85
GRAND TOTAL	1742.4	100.00

Non-benthic invertebrates

Corixidae (Sigara)	86.4

Station 1, October 20, 1995, AB001-B015
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK001

Total invertebrate abundance	= 1742.4	EPT abundance	= 460.8
Total number of taxa	= 16	Number EPT taxa	= 6
Hilsenhoff Biotic Index	= 5.66	Brillouin H	= 1.75

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	2	158.4	9.09
Odonata	1	14.4	0.83
Ephemeroptera	2	28.8	1.66
Plecoptera	3	417.6	23.97
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	1	14.4	0.83
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	100.8	5.79
Chironomidae	6	1008.0	57.86

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	3	345.6	19.84
Parasite	0	0.0	0.00
Collector-gatherer	4	1022.4	58.68
Collector-filterer	1	100.8	5.79
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	1	14.4	0.83
Shredder	2	72.0	4.14
Xylophage	0	0.0	0.00
Omnivore	4	144.0	8.27
Unknown	1	43.2	2.48

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	849.6	48.76
Isoperla	316.8	18.18
Tubificidae	144.0	8.26
Simulium	100.8	5.79
Polypedilum	72.0	4.13
SUBTOTAL 5 DOMINANTS	1483.2	85.12
Capniidae-early instar	57.6	3.31
Taenionema	43.2	2.48
Paracladopelma	43.2	2.48
Nematoda	14.4	0.83
Ophiogomphus	14.4	0.83
TOTAL 10 DOMINANTS	1656.0	95.05

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	14.4	0.83
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 1, October 20, 1995, AB001-B015
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK001

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 0.46
Hydropsychidae/Total Trichoptera	= 0.00
Baetidae/Total Ephemeroptera	= 0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.14
Scraper/(Scraper + C.-filterer)	= 0.12
Shredder/Total organisms	= 0.04

Biotic Condition Index

Community Tolerance Quotient (a)	= 81.50
Community Tolerance Quotient (d)	= 81.66

DIVERSITY MEASURES

Shannon H (loge)	= 1.78
Shannon H (log2)	= 2.56
Evenness	= 0.64
Simpson D	= 0.29

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	770.4	44.21
Univoltine	943.2	54.13
Semivoltine	28.8	1.65

Station 2, October 22 1995, AB002-B025

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK002

IDENTIFICATION CODE	95EK002
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Tubificidae	14.4	14.29
TOTAL: NON INSECTS	14.4	14.29
Ametropus	28.8	28.57
TOTAL: EPHEMEROPTERA	28.8	28.57
Micropsectra	28.8	28.57
Paracladopelma	28.8	28.57
TOTAL: CHIRONOMIDAE	57.6	57.14
GRAND TOTAL	100.8	100.00

Station 2, October 22 1995, AB002-B025

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK002

Total invertebrate abundance	= 100.8	EPT abundance	= 28.8
Total number of taxa	= 4	Number EPT taxa	= 1
Hilsenhoff Biotic Index	= 7.40	Brillouin H	= 1.28

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	14.4	14.29
Odonata	0	0.0	0.00
Ephemeroptera	1	28.8	28.57
Plecoptera	0	0.0	0.00
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	0	0.0	0.00
Chironomidae	2	57.6	57.14

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	0	0.0	0.00
Parasite	0	0.0	0.00
Collector-gatherer	3	72.0	71.43
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	0	0.0	0.00
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	0	0.0	0.00
Unknown	1	28.8	28.57

DOMINANT TAXON	ABUNDANCE	PERCENT
Ametropus	28.8	28.57
Micropsectra	28.8	28.57
Paracladopelma	28.8	28.57
Tubificidae	14.4	14.29
	0.0	0.00
SUBTOTAL 5 DOMINANTS	100.8	100.00
	0.0	0.00
	0.0	0.00
	0.0	0.00
	0.0	0.00
	0.0	0.00
TOTAL 10 DOMINANTS	100.8	100.00

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	0	0.0	0.00
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 2, October 22 1995, AB002-B025
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK002

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.50
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.00

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) undefined
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 99.00
Community Tolerance Quotient (d) = 98.51

DIVERSITY MEASURES
Shannon H (loge) = 1.35
Shannon H (log2) = 1.95
Evenness = 0.98
Simpson D = 0.26

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	43.2	42.86
Univoltine	57.6	57.14
Semivoltine	0.0	0.00

Station 3, October 15, 1995, AB003-B035

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK003

IDENTIFICATION CODE	95EK003
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Nematoda	100.8	5.34
Tubificidae	158.4	8.40
Hyalella azteca	14.4	0.76
Acari	100.8	5.34
TOTAL: NON INSECTS	374.4	19.85
Aeshna	28.8	1.53
Somatochlora	14.4	0.76
Ophiogomphus	100.8	5.34
TOTAL: ODONATA	144	7.63
Caenis	57.6	3.05
TOTAL: EPHEMEROPTERA	57.6	3.05
Brachycentrus occidentalis	28.8	1.53
TOTAL: TRICHOPTERA	28.8	1.53
Dubiraphia	72	3.82
Haliplus	28.8	1.53
TOTAL: COLEOPTERA	100.8	5.34
Ceratopogoninae	345.6	18.32
Hemerodromia	72	3.82
Dicranota	57.6	3.05
TOTAL: DIPTERA	475.2	25.19
Brillia	14.4	0.76
Chironomini-early instar	14.4	0.76
Cryptochironomus	43.2	2.29
Dicrotendipes	86.4	4.58
Micropsectra	14.4	0.76
Orthocladiinae-early instar	28.8	1.53
Parametriocnemus	28.8	1.53
Phaenopsectra	14.4	0.76
Polypedilum	158.4	8.40
Potthastia Longimana Gr.	28.8	1.53
Stempellina	144	7.63
Stempellinella	43.2	2.29
Tanytarsini-early instar	28.8	1.53
Thienemannimyia	57.6	3.05
TOTAL: CHIRONOMIDAE	705.6	37.40
GRAND TOTAL	1886.4	100.00

Station 3, October 15, 1995, AB003-B035
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK003

Total invertebrate abundance	= 1886.4	EPT abundance	= 86.4
Total number of taxa	= 28	Number EPT taxa	= 2
Hilsenhoff Biotic Index	= 5.56	Brillouin H	= 2.91

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	4	374.4	19.84
Odonata	3	144.0	7.63
Ephemeroptera	1	57.6	3.05
Plecoptera	0	0.0	0.00
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	1	28.8	1.53
Lepidoptera	0	0.0	0.00
Coleoptera	2	100.8	5.35
Misc. Diptera	3	475.2	25.19
Chironomidae	14	705.6	37.40

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	8	720.0	38.16
Parasite	1	100.8	5.34
Collector-gatherer	11	648.0	34.35
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	1	28.8	1.53
Piercer-herbivore	0	0.0	0.00
Scraper	1	14.4	0.76
Shredder	1	14.4	0.76
Xylophage	0	0.0	0.00
Omnivore	3	288.0	15.27
Unknown	2	72.0	3.82

DOMINANT TAXON	ABUNDANCE	PERCENT
Ceratopogoninae	345.6	18.32
Tubificidae	158.4	8.40
Polypedilum	158.4	8.40
Stempellina	144.0	7.63
Nematoda	100.8	5.34
SUBTOTAL 5 DOMINANTS	907.2	48.09
Acari	100.8	5.34
Ophiogomphus	100.8	5.34
Dicrotendipes	86.4	4.58
Dubiraphia	72.0	3.82
Hemerodromia	72.0	3.82
TOTAL 10 DOMINANTS	1339.2	70.99

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	57.6	3.05
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	2	100.8	5.35
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	144.0	7.63
K Tolerant midges	2	129.6	6.87
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 3, October 15, 1995, AB003-B035
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK003

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.12
Hydropsychidae/Total Trichoptera = 0.00
Baetidae/Total Ephemeroptera = 0.00

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) = 1.00
Shredder/Total organisms = 0.01

Biotic Condition Index
Community Tolerance Quotient (a) = 95.61
Community Tolerance Quotient (d) = 96.41

DIVERSITY MEASURES
Shannon H (loge) = 2.95
Shannon H (log2) = 4.25
Evenness = 0.88
Simpson D = 0.07

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	730.8	38.74
Univoltine	882.0	46.76
Semivoltine	273.6	14.50

Station 4, October 17, 1995, AB004-B045

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK004

IDENTIFICATION CODE	95EK004
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Nematoda	43.2	1.06
Tubificidae	115.2	2.82
TOTAL: NON INSECTS	158.4	3.87
Stylurus	14.4	0.35
Ophiogomphus	144	3.52
TOTAL: ODONATA	158.4	3.87
Ametropus	28.8	0.70
Ephemerella inermis/infrequens	144	3.52
Heptagenia	28.8	0.70
Leptophlebia	14.4	0.35
Tricorythodes minutus	14.4	0.35
TOTAL: EPHEMEROPTERA	230.4	5.63
Capniidae-early instar	43.2	1.06
Isoperla	720	17.61
Taenionema	14.4	0.35
Taeniopteryx	72	1.76
TOTAL: PLECOPTERA	849.6	20.77
Hydropsyche	14.4	0.35
Ceraclea	14.4	0.35
TOTAL: TRICHOPTERA	28.8	0.70
Ceratopogoninae	129.6	3.17
Hemerodromia	72	1.76
TOTAL: DIPTERA	201.6	4.93
Brillia	28.8	0.70
Chironomini-early instar	43.2	1.06
Cryptochironomus	28.8	0.70
Heterotrissocladius	28.8	0.70
Micropsectra	1238.4	30.28
Paracladopelma	187.2	4.58
Phaenopsectra	43.2	1.06
Polypedilum	748.8	18.31
Stempellinella	28.8	0.70
Thienemannimyia	86.4	2.11
TOTAL: CHIRONOMIDAE	2462.4	60.21
GRAND TOTAL	4089.6	100.00

Non-benthic invertebrates

Corixidae (Sigara)	28.8

Station 4, October 17, 1995, AB004-B045

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK004

Total invertebrate abundance	= 4089.2	EPT abundance	= 1108.8
Total number of taxa	= 27	Number EPT taxa	= 11
Hilsenhoff Biotic Index	= 5.24	Brillouin H	= 2.29

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	2	158.4	3.88
Odonata	2	158.4	3.87
Ephemeroptera	5	230.4	5.62
Plecoptera	4	849.6	20.78
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	2	28.8	0.70
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	2	201.6	4.93
Chironomidae	10	2462.0	60.20

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	7	1195.2	29.22
Parasite	0	0.0	0.00
Collector-gatherer	8	1626.8	39.78
Collector-filterer	1	14.4	0.35
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	2	72.0	1.76
Shredder	2	72.0	1.76
Xylophage	0	0.0	0.00
Omnivore	5	892.8	21.83
Unknown	2	216.0	5.28

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	1238.0	30.28
Polypedilum	748.8	18.31
Isoperla	720.0	17.61
Paracladopelma	187.2	4.58
Ophiogomphus	144.0	3.52
SUBTOTAL 5 DOMINANTS	3038.0	74.30
Ephemerella inermis/infreq	144.0	3.52
Ceratopogoninae	129.6	3.17
Tubificidae	115.2	2.82
Thienemannimyia	86.4	2.11
Taeniopteryx	72.0	1.76
TOTAL 10 DOMINANTS	3585.2	87.68

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	2	28.8	0.70
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	28.8	0.70
K Tolerant midges	1	28.8	0.70
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 4, October 17, 1995, AB004-B045
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK004

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 0.45
Hydropsychidae/Total Trichoptera	= 0.50
Baetidae/Total Ephemeroptera	= 0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 5.00
Scraper/(Scraper + C.-filterer)	= 0.83
Shredder/Total organisms	= 0.02

Biotic Condition Index

Community Tolerance Quotient (a)	= 86.26
Community Tolerance Quotient (d)	= 86.97

DIVERSITY MEASURES

Shannon H (loge)	= 2.31
Shannon H (log2)	= 3.33
Evenness	= 0.70
Simpson D	= 0.16

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	1893.3	46.30
Univoltine	2037.5	49.83
Semivoltine	158.4	3.87

Station 5, October 17, 1995, AB005-B055

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK005

IDENTIFICATION CODE	95EK005
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Nematoda	14.4	1.89
TOTAL: NON INSECTS	14.4	1.89
Baetis tricaudatus	14.4	1.89
Heptagenia	28.8	3.77
TOTAL: EPHEMEROPTERA	43.2	5.66
Isoperla	144	18.87
Taenionema	14.4	1.89
TOTAL: PLECOPTERA	158.4	20.75
Chernovskiia	72	9.43
Chironomus	14.4	1.89
Micropsectra	129.6	16.98
Paracladopelma	302.4	39.62
Polypedilum	14.4	1.89
Stempellina	14.4	1.89
TOTAL: CHIRONOMIDAE	547.2	71.70
GRAND TOTAL	763.2	100.00

Non-benthic invertebrates

Corixidae (Sigara)	28.8

Station 5, October 17, 1995, AB005-B055

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK005

Total invertebrate abundance	= 763.2	EPT abundance	= 201.6
Total number of taxa	= 11	Number EPT taxa	= 4
Hilsenhoff Biotic Index	= 5.64	Brillouin H	= 1.75

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	14.4	1.89
Odonata	0	0.0	0.00
Ephemeroptera	2	43.2	5.66
Plecoptera	2	158.4	20.76
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	0	0.0	0.00
Chironomidae	6	547.2	71.70

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	1	144.0	18.87
Parasite	0	0.0	0.00
Collector-gatherer	4	172.8	22.65
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	1	28.8	3.77
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	3	43.2	5.67
Unknown	2	374.4	49.05

DOMINANT TAXON	ABUNDANCE	PERCENT
Paracladopelma	302.4	39.62
Isoperla	144.0	18.87
Micropsectra	129.6	16.98
Chernovskiia	72.0	9.43
Heptagenia	28.8	3.77
SUBTOTAL 5 DOMINANTS	676.8	88.67
Nematoda	14.4	1.89
Baetis tricaudatus	14.4	1.89
Taenionema	14.4	1.89
Chironomus	14.4	1.89
Polypedilum	14.4	1.89
TOTAL 10 DOMINANTS	748.8	98.12

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	14.4	1.89
K Tolerant midges	1	14.4	1.89
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 5, October 17, 1995, AB005-B055
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK005

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.37
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.33

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) = 1.00
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 86.18
Community Tolerance Quotient (d) = 85.67

DIVERSITY MEASURES
Shannon H (loge) = 1.78
Shannon H (log2) = 2.57
Evenness = 0.74
Simpson D = 0.23

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	435.6	57.08
Univoltine	327.6	42.92
Semivoltine	0.0	0.00

Station 6, October 18, 1995, AB006-B065

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK006

IDENTIFICATION CODE	95EK006
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Nematoda	14.4	0.21
Enchytraeidae	14.4	0.21
Tubificidae	14.4	0.21
Ostracoda	129.6	1.90
TOTAL: NON INSECTS	172.8	2.54
Ametropus	28.8	0.42
Ephemerella inermis/infrequens	14.4	0.21
Heptagenia	14.4	0.21
TOTAL: EPHEMEROPTERA	57.6	0.85
Isoperla	14.4	0.21
Taenionema	14.4	0.21
TOTAL: PLECOPTERA	28.8	0.42
Ceratopogoninae	633.6	9.30
TOTAL: DIPTERA	633.6	9.30
Chironomidae-pupae	100.8	1.48
Chernovskiia	28.8	0.42
Chironomini-early instar	28.8	0.42
Chironomus	446.4	6.55
Cryptochironomus	115.2	1.69
Heterotrissocladius	28.8	0.42
Micropsectra	4464	65.54
Orthocladius Complex	28.8	0.42
Paracladopelma	86.4	1.27
Polypedilum	57.6	0.85
Procladius	504	7.40
Stempellinella	28.8	0.42
TOTAL: CHIRONOMIDAE	5918.4	86.89
GRAND TOTAL	6811.2	100.00

Station 6, October 18 1995, AB006-B065

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK006

Total invertebrate abundance	= 6811.2	EPT abundance	= 86.4
Total number of taxa	= 22	Number EPT taxa	= 5
Hilsenhoff Biotic Index	= 7.18	Brillouin H	= 1.39

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	4	172.8	2.53
Odonata	0	0.0	0.00
Ephemeroptera	3	57.6	0.84
Plecoptera	2	28.8	0.42
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	633.6	9.30
Chironomidae	12	5918.4	86.88

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	3	763.2	11.20
Parasite	0	0.0	0.00
Collector-gatherer	11	5702.4	83.70
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	1	14.4	0.21
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	3	86.4	1.27
Unknown	4	244.8	3.59

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	4464.0	65.54
Ceratopogoninae	633.6	9.30
Procladius	504.0	7.40
Chironomus	446.4	6.55
Ostracoda	129.6	1.90
SUBTOTAL 5 DOMINANTS	6177.6	90.69
Cryptochironomus	115.2	1.69
Chironomidae-pupae	100.8	1.48
Paracladopelma	86.4	1.27
Polypedilum	57.6	0.85
Ametropus	28.8	0.42
TOTAL 10 DOMINANTS	6566.4	96.40

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	28.8	0.42
K Tolerant midges	3	1065.6	15.64
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 6, October 18 1995, AB006-B065
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK006

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.01
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.00

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) = 1.00
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 94.36
Community Tolerance Quotient (d) = 98.70

DIVERSITY MEASURES
Shannon H (loge) = 1.40
Shannon H (log2) = 2.02
Evenness = 0.45
Simpson D = 0.45

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	4582.8	67.28
Univoltine	2228.4	32.72
Semivoltine	0.0	0.00

Station 7, October 18,1995, AB007-B075

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK007

IDENTIFICATION CODE	95EK007
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Tubificidae	14.4	2.13
TOTAL: NON INSECTS	14.4	2.13
Baetis tricaudatus	57.6	8.51
Ephemerella inermis/infrequens	57.6	8.51
Heptagenia	14.4	2.13
TOTAL: EPHEMEROPTERA	129.6	19.15
Isogenoides	14.4	2.13
Isoperla	417.6	61.70
TOTAL: PLECOPTERA	432	63.83
Brachycentrus occidentalis	28.8	4.26
Hydropsyche	28.8	4.26
TOTAL: TRICHOPTERA	57.6	8.51
Simulium	14.4	2.13
TOTAL: DIPTERA	14.4	2.13
Cryptochironomus	28.8	4.26
TOTAL: CHIRONOMIDAE	28.8	4.26
GRAND TOTAL	676.8	100.00

Non-benthic invertebrates

Cladocera (Daphnia)	14

Station 7, October 18,1995, AB007-B075
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK007

Total invertebrate abundance	= 676.8	EPT abundance	= 619.2
Total number of taxa	= 10	Number EPT taxa	= 7
Hilsenhoff Biotic Index	= 2.83	Brillouin H	= 1.41

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	14.4	2.13
Odonata	0	0.0	0.00
Ephemeroptera	3	129.6	19.15
Plecoptera	2	432.0	63.83
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	2	57.6	8.52
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	14.4	2.13
Chironomidae	1	28.8	4.26

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	3	460.8	68.09
Parasite	0	0.0	0.00
Collector-gatherer	3	129.6	19.15
Collector-filterer	2	43.2	6.39
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	1	14.4	2.13
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	1	28.8	4.26
Unknown	0	0.0	0.00

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	417.6	61.70
Baetis tricaudatus	57.6	8.51
Ephemerella inermis/infreq	57.6	8.51
Brachycentrus occidentalis	28.8	4.26
Hydropsyche	28.8	4.26
SUBTOTAL 5 DOMINANTS	590.4	87.24
Cryptochironomus	28.8	4.26
Tubificidae	14.4	2.13
Heptagenia	14.4	2.13
Isogenoides	14.4	2.13
Simulium	14.4	2.13
TOTAL 10 DOMINANTS	676.8	100.02

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	28.8	4.26
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 7, October 18,1995, AB007-B075
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK007

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 21.50
Hydropsychidae/Total Trichoptera = 0.50
Baetidae/Total Ephemeroptera = 0.44

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter = 0.33
Scraper/(Scraper + C.-filterer) = 0.25
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 67.20
Community Tolerance Quotient (d) = 63.22

DIVERSITY MEASURES
Shannon H (loge) = 1.45
Shannon H (log2) = 2.09
Evenness = 0.63
Simpson D = 0.40

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	72.0	10.64
Univoltine	576.0	85.11
Semivoltine	28.8	4.26

Station 8, October 18,1995, AB008-B085

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK008

IDENTIFICATION CODE	95EK008
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Sphaeriidae*	14.4	1.92
TOTAL: NON INSECTS	14.4	1.92
Ametropus	14.4	1.92
Ephemerella inermis/infrequens	43.2	5.77
Heptagenia	28.8	3.85
TOTAL: EPHEMEROPTERA	86.4	11.54
Isoperla	187.2	25.00
TOTAL: PLECOPTERA	187.2	25.00
Ceratopogoninae	115.2	15.38
TOTAL: DIPTERA	115.2	15.38
Chironomini-early instar	14.4	1.92
Chironomus	86.4	11.54
Lopescladius	14.4	1.92
Micropsectra	187.2	25.00
Paracladopelma	28.8	3.85
Polypedilum	14.4	1.92
TOTAL: CHIRONOMIDAE	345.6	46.15
GRAND TOTAL	748.8	100.00

**Sphaerium striatinum*

Station 8, October 18,1995, AB008-B085

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK008

Total invertebrate abundance	= 748.8	EPT abundance	= 273.6
Total number of taxa	= 12	Number EPT taxa	= 4
Hilsenhoff Biotic Index	= 5.41	Brillouin H	= 1.99

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	14.4	1.92
Odonata	0	0.0	0.00
Ephemeroptera	3	86.4	11.54
Plecoptera	1	187.2	25.00
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	115.2	15.38
Chironomidae	6	345.6	46.15

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	2	302.4	40.38
Parasite	0	0.0	0.00
Collector-gatherer	7	374.4	49.99
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	1	28.8	3.85
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	1	14.4	1.92
Unknown	1	28.8	3.85

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	187.2	25.00
Micropsectra	187.2	25.00
Ceratopogoninae	115.2	15.38
Chironomus	86.4	11.54
Ephemerella inermis/infreq	43.2	5.77
SUBTOTAL 5 DOMINANTS	619.2	82.69
Heptagenia	28.8	3.85
Paracladopelma	28.8	3.85
Sphaeriidae	14.4	1.92
Ametropus	14.4	1.92
Chironomini-early instar	14.4	1.92
TOTAL 10 DOMINANTS	720.0	96.15

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	1	86.4	11.54
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 8, October 18,1995, AB008-B085
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK008

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.79
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.00

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) = 1.00
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 88.00
Community Tolerance Quotient (d) = 85.86

DIVERSITY MEASURES
Shannon H (loge) = 2.03
Shannon H (log2) = 2.92
Evenness = 0.81
Simpson D = 0.17

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	259.2	34.62
Univoltine	482.4	64.42
Semivoltine	7.2	0.96

Station 9, October 21, 1995, AB009-B095

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK009

IDENTIFICATION CODE	95EK009
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Tubificidae	532.8	18.32
TOTAL: NON INSECTS	532.8	18.32
Isoperla	115.2	3.96
TOTAL: PLECOPTERA	115.2	3.96
Brachycera	14.4	0.50
Ceratopogoninae	187.2	6.44
TOTAL: DIPTERA	201.6	6.93
Brillia	14.4	0.50
Chironomus	43.2	1.49
Cryptochironomus	57.6	1.98
Cryptotendipes	57.6	1.98
Heterotrissocladius	14.4	0.50
Micropsectra	576	19.80
Monodiamesa	129.6	4.46
Paracladopelma	374.4	12.87
Polypedilum	432	14.85
Procladius	360	12.38
TOTAL: CHIRONOMIDAE	2059.2	70.79
GRAND TOTAL	2908.8	100.00

Station 9, October 21, 1995, AB009-B095

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK009

Total invertebrate abundance	= 2908.8	EPT abundance	= 115.2
Total number of taxa	= 14	Number EPT taxa	= 1
Hilsenhoff Biotic Index	= 7.20	Brillouin H	= 2.16

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	532.8	18.32
Odonata	0	0.0	0.00
Ephemeroptera	0	0.0	0.00
Plecoptera	1	115.2	3.96
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	2	201.6	6.94
Chironomidae	10	2059.2	70.81

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	3	360.0	12.38
Parasite	0	0.0	0.00
Collector-gatherer	6	1656.0	56.95
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	0	0.0	0.00
Shredder	1	14.4	0.50
Xylophage	0	0.0	0.00
Omnivore	1	432.0	14.85
Unknown	3	446.4	15.35

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	576.0	19.80
Tubificidae	532.8	18.32
Polypedilum	432.0	14.85
Paracladopelma	374.4	12.87
Procladius	360.0	12.38
SUBTOTAL 5 DOMINANTS	2275.2	78.22
Ceratopogoninae	187.2	6.44
Monodiamesa	129.6	4.46
Isoperla	115.2	3.96
Cryptochironomus	57.6	1.98
Cryptotendipes	57.6	1.98
TOTAL 10 DOMINANTS	2822.4	97.04

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	1	14.4	0.50
K Tolerant midges	4	518.4	17.83
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 9, October 21, 1995, AB009-B095
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK009

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.06
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephem. undefined. Total Ephem.=0

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) undefined
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 101.54
Community Tolerance Quotient (d) = 101.63

DIVERSITY MEASURES
Shannon H (loge) = 2.18
Shannon H (log2) = 3.14
Evenness = 0.83
Simpson D = 0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	1544.4	53.09
Univoltine	1364.4	46.91
Semivoltine	0.0	0.00

Station 10, October 20, 1995, AB010-B105

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK010

IDENTIFICATION CODE	95EK010
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Ametropus	28.8	6.67
Ephemerella inermis/infrequens	86.4	20.00
TOTAL: EPHEMEROPTERA	115.2	26.67
Isogenoides	14.4	3.33
Isoperla	100.8	23.33
Taenionema	14.4	3.33
TOTAL: PLECOPTERA	129.6	30.00
Cheumatopsyche	14.4	3.33
Hydropsyche	57.6	13.33
TOTAL: TRICHOPTERA	72	16.67
Ceratopogoninae	14.4	3.33
Hemerodromia	14.4	3.33
Simulium	14.4	3.33
TOTAL: DIPTERA	43.2	10.00
Micropsectra	28.8	6.67
Polypedilum	14.4	3.33
Rheotanytarsus	28.8	6.67
TOTAL: CHIRONOMIDAE	72	16.67
GRAND TOTAL	432	100.00

Station 10, October 20, 1995, AB010-B105

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK010

Total invertebrate abundance	= 432.0	EPT abundance	= 316.8
Total number of taxa	= 13	Number EPT taxa	= 7
Hilsenhoff Biotic Index	= 3.39	Brillouin H	= 2.20

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	0	0.0	0.00
Odonata	0	0.0	0.00
Ephemeroptera	2	115.2	26.67
Plecoptera	3	129.6	29.99
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	2	72.0	16.66
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	3	43.2	9.99
Chironomidae	3	72.0	16.67

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	4	144.0	33.32
Parasite	0	0.0	0.00
Collector-gatherer	3	144.0	33.34
Collector-filterer	4	115.2	26.66
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	0	0.0	0.00
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	2	28.8	6.66
Unknown	0	0.0	0.00

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	100.8	23.33
Ephemerella inermis/infreq	86.4	20.00
Hydropsyche	57.6	13.33
Ametropus	28.8	6.67
Micropsectra	28.8	6.67
SUBTOTAL 5 DOMINANTS	302.4	70.00
Rheotanytarsus	28.8	6.67
Isogenoides	14.4	3.33
Taenionema	14.4	3.33
Cheumatopsyche	14.4	3.33
Ceratopogoninae	14.4	3.33
TOTAL 10 DOMINANTS	388.8	89.99

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	14.4	3.33
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	0	0.0	0.00
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 10, October 20, 1995, AB010-B105
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK010

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 4.40
Hydropsychidae/Total Trichoptera	= 1.00
Baetidae/Total Ephemeroptera	= 0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.00
Scraper/(Scraper + C.-filterer)	= 0.00
Shredder/Total organisms	= 0.00

Biotic Condition Index

Community Tolerance Quotient (a)	= 82.08
Community Tolerance Quotient (d)	= 79.47

DIVERSITY MEASURES

Shannon H (loge)	= 2.26
Shannon H (log2)	= 3.27
Evenness	= 0.88
Simpson D	= 0.13

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	72.0	16.67
Univoltine	360.0	83.33
Semivoltine	0.0	0.00

Station 11, October 20, 1995, AB011-B115

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK011

IDENTIFICATION CODE	95EK011
CORRECTION FACTOR	14.4

Taxon	Abundance	%
Tubificidae	14.4	2.50
TOTAL: NON INSECTS	14.4	2.50
Ophiogomphus	14.4	2.50
TOTAL: ODONATA	14.4	2.50
Ametropus	28.8	5.00
TOTAL: EPHEMEROPTERA	28.8	5.00
Isoperla	216	37.50
TOTAL: PLECOPTERA	216	37.50
Lopescladius	43.2	7.50
Micropsectra	144	25.00
Orthocladiinae-early instar	28.8	5.00
Paracladopelma	86.4	15.00
TOTAL: CHIRONOMIDAE	302.4	52.50
GRAND TOTAL	576	100.00

Station 11, October 20, 1995, AB011-B115

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK011

Total invertebrate abundance	= 576.0	EPT abundance	= 244.8
Total number of taxa	= 8	Number EPT taxa	= 2
Hilsenhoff Biotic Index	= 4.82	Brillouin H	= 1.64

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	1	14.4	2.50
Odonata	1	14.4	2.50
Ephemeroptera	1	28.8	5.00
Plecoptera	1	216.0	37.50
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	0	0.0	0.00
Chironomidae	4	302.4	52.50

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	2	230.4	40.00
Parasite	0	0.0	0.00
Collector-gatherer	5	259.2	45.00
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	0	0.0	0.00
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	0	0.0	0.00
Unknown	1	86.4	15.00

DOMINANT TAXON	ABUNDANCE	PERCENT
Isoperla	216.0	37.50
Micropsectra	144.0	25.00
Paracladopelma	86.4	15.00
Lopescladius	43.2	7.50
Ametropus	28.8	5.00
SUBTOTAL 5 DOMINANTS	518.4	90.00
Orthocladiinae-early insta	28.8	5.00
Tubificidae	14.4	2.50
Ophiogomphus	14.4	2.50
	0.0	0.00
	0.0	0.00
TOTAL 10 DOMINANTS	576.0	100.00

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	0	0.0	0.00
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 11, October 20, 1995, AB011-B115
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK011

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.81
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.00

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) undefined
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 93.00
Community Tolerance Quotient (d) = 89.31

DIVERSITY MEASURES
Shannon H (loge) = 1.68
Shannon H (log2) = 2.42
Evenness = 0.81
Simpson D = 0.24

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	226.8	39.38
Univoltine	334.8	58.12
Semivoltine	14.4	2.50

Station 12, October 30, 1995, AB012-B125

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc. Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron). Abundances adjusted to a square meter basis. FILE: 95EK012

IDENTIFICATION CODE	95EK012
CORRECTION FACTOR	30.9

Taxon	Abundance	%
Nematoda	61.8	0.32
Tubificidae	5160.3	26.98
Sphaeriidae*	1823.1	9.53
TOTAL: NON INSECTS	7045.2	36.83
Stylurus	123.6	0.65
TOTAL: ODONATA	123.6	0.65
Leptophlebia	61.8	0.32
TOTAL: EPHEMEROPTERA	61.8	0.32
Ceratopogoninae	401.7	2.10
TOTAL: DIPTERA	401.7	2.10
Cryptochironomus	309	1.62
Micropsectra	10382.4	54.28
Polypedilum	92.7	0.48
Procladius	710.7	3.72
TOTAL: CHIRONOMIDAE	11494.8	60.10
GRAND TOTAL	19127.1	100.00

* 2 specimens were Sphaerium striatinum

Station 12, October 30, 1995, AB012-B125
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK012

Total invertebrate abundance	= 19126.3	EPT abundance	= 61.8
Total number of taxa	= 10	Number EPT taxa	= 1
Hilsenhoff Biotic Index	= 7.66	Brillouin H	= 1.27

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	3	7044.8	36.83
Odonata	1	123.6	0.65
Ephemeroptera	1	61.8	0.32
Plecoptera	0	0.0	0.00
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	0	0.0	0.00
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	1	401.7	2.10
Chironomidae	4	11494.4	60.10

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	3	834.3	4.37
Parasite	0	0.0	0.00
Collector-gatherer	5	18137.5	94.83
Collector-filterer	0	0.0	0.00
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	0	0.0	0.00
Scraper	0	0.0	0.00
Shredder	0	0.0	0.00
Xylophage	0	0.0	0.00
Omnivore	2	154.5	0.80
Unknown	0	0.0	0.00

DOMINANT TAXON	ABUNDANCE	PERCENT
Micropsectra	10382.0	54.28
Tubificidae	5160.0	26.98
Sphaeriidae	1823.0	9.53
Procladius	710.7	3.72
Ceratopogoninae	401.7	2.10
SUBTOTAL 5 DOMINANTS	18477.4	96.61
Cryptochironomus	309.0	1.62
Stylurus	123.6	0.65
Polypedilum	92.7	0.48
Nematoda	61.8	0.32
Leptophlebia	61.8	0.32
TOTAL 10 DOMINANTS	19126.3	100.00

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	0	0.0	0.00
B Tolerant mayflies	1	61.8	0.32
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	0	0.0	0.00
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	0	0.0	0.00
J Intolerant midges	0	0.0	0.00
K Tolerant midges	2	1019.7	5.34
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 12, October 30, 1995, AB012-B125
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Deter. by ABA, Inc.
Benthic invertebrate biomonitoring. Composite 3 Ekman dredges (250 micron).
Abundances adjusted to a square meter basis. FILE: 95EK012

RATIOS OF TAX. GROUP ABUNDANCES
EPT/Chironomidae = 0.01
Hyd./Total Tri. undefined. Total Tri.= 0
Baetidae/Total Ephemeroptera = 0.00

RATIOS OF FFG ABUNDANCES
Scraper/Collector-filter undefined - Coll.-Filt.=0
Scraper/(Scraper + C.-filterer) undefined
Shredder/Total organisms = 0.00

Biotic Condition Index
Community Tolerance Quotient (a) = 99.60
Community Tolerance Quotient (d) = 102.34

DIVERSITY MEASURES
Shannon H (loge) = 1.27
Shannon H (log2) = 1.84
Evenness = 0.55
Simpson D = 0.38

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	8682.6	45.40
Univoltine	9408.6	49.19
Semivoltine	1035.1	5.41

Station 1, October 19, 1995, SB001

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc.
Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.
Mean abundances adjusted to a square meter basis. FILE: 95HS001

IDENTIFICATION CODE	B011	B021	B031	B041	B051
SUBSAMPLING CORRECTION	1	1	1	1	1
CONVERSION (M2)	10				

	REPLICATES							
Taxon	R1	R2	R3	R4	R5	MEAN	STDEV	%
Nematoda	2	9	6	3	1	42.0	32.7	0.61
Enchytraeidae	0	0	0	0	1	2.0	4.5	0.03
Naididae	5	6	23	8	14	112.0	74.6	1.64
Tubificidae	0	0	4	2	0	12.0	17.9	0.18
Sphaeriidae	0	0	1	0	2	6.0	8.9	0.09
Ferrissia	0	4	2	3	3	24.0	15.2	0.35
Gyraulus	0	6	1	0	0	14.0	26.1	0.20
Ostracoda	5	14	3	4	1	54.0	50.3	0.79
Acari	31	19	15	126	74	530.0	470.5	7.74
TOTAL: NON INSECTS	43	58	55	146	96	796.0	421.0	11.63
Ophiogomphus	4	0	1	1	3	18.0	16.4	0.26
TOTAL: ODONATA	4	0	1	1	3	18.0	16.4	0.26
Baetis tricaudatus	35	3	10	153	51	504.0	605.0	7.36
Diphetor hageni	1	4	1	1	9	32.0	34.9	0.47
Drunella grandis	0	0	0	8	1	18.0	34.9	0.26
Ephemerella inermis/infrquens	44	20	18	28	42	304.0	121.2	4.44
Heptageniidae-early instar	0	0	0	0	2	4.0	8.9	0.06
Heptagenia	0	2	0	0	1	6.0	8.9	0.09
Rhithrogena	0	0	0	2	8	20.0	34.6	0.29
TOTAL: EPHEMEROPTERA	80	29	29	192	114	888.0	680.3	12.97
Capniidae-early instar	8	2	0	4	5	38.0	30.3	0.56
Chloroperlidae	12	10	4	18	16	120.0	54.8	1.75
Claassenia sabulosa	0	0	0	0	1	2.0	4.5	0.03
Skwala	0	0	0	0	3	6.0	13.4	0.09
Pteronarcys dorsata	0	0	0	0	1	2.0	4.5	0.03
Taeniopteryx	1	0	0	0	0	2.0	4.5	0.03
TOTAL: PLECOPTERA	21	12	4	22	26	170.0	88.9	2.48
Arctopsyche grandis	0	0	0	0	1	2.0	4.5	0.03
Brachycentrus americanus	3	0	3	9	2	34.0	33.6	0.50
Brachycentrus occidentalis	25	7	19	38	91	360.0	327.1	5.26
Micrasema	0	0	1	12	1	28.0	51.7	0.41
Glossosoma	0	0	0	3	1	8.0	13.0	0.12
Protoptila	4	0	1	0	0	10.0	17.3	0.15
Hydropsyche	7	0	0	17	21	90.0	96.7	1.31
Hydroptilidae-early instar	4	7	5	4	2	44.0	18.2	0.64
Hydroptila	32	9	18	31	6	192.0	120.7	2.80
Lepidostoma-sand case larvae	34	28	16	9	24	222.0	98.6	3.24
Ceraclea	2	1	0	0	0	6.0	8.9	0.09
Psychomyia	6	4	0	1	0	22.0	26.8	0.32
TOTAL: TRICHOPTERA	117	56	63	124	149	1018.0	404.8	14.87
Atherix	7	3	8	19	7	88.0	60.2	1.29
Brachycera	0	0	1	0	0	2.0	4.5	0.03
Chelifera	6	4	5	4	5	48.0	8.4	0.70
Hemerodromia	36	12	46	16	17	254.0	147.9	3.71
Wiedemannia	2	1	3	1	6	26.0	20.7	0.38
Simulium	0	0	0	1	0	2.0	4.5	0.03
Tipulidae	0	0	1	0	0	2.0	4.5	0.03
Antocha	3	2	0	17	2	48.0	69.1	0.70
Dicranota	1	1	0	0	0	4.0	5.5	0.06
Hexatoma	2	1	0	1	4	16.0	15.2	0.23
TOTAL: DIPTERA	57	24	64	59	41	490.0	164.2	7.16

Station 1, October 19, 1995, SB001

Taxon	R1	R2	R3	R4	R5	MEAN	STDEV	%
Brillia	4	0	0	0	0	8.0	17.9	0.12
Chironomini-early instar	12	37	58	2	13	244.0	227.7	3.56
Cladotanytarsus	12	21	6	0	0	78.0	89.0	1.14
Cricotopus Nostococladius	0	0	0	4	3	14.0	19.5	0.20
Cryptochironomus	4	12	0	5	0	42.0	49.2	0.61
Eukiefferiella	16	21	9	20	10	152.0	55.4	2.22
Krenosmittia	0	0	12	0	0	24.0	53.7	0.35
Lopescladius	55	4	28	5	23	230.0	208.2	3.36
Micropsectra	59	21	31	14	65	380.0	228.3	5.55
Microtendipes	8	0	0	2	4	28.0	33.5	0.41
Orthocladiinae-early instar	12	25	24	18	6	170.0	80.6	2.48
Orthocladius Complex	87	148	46	94	17	784.0	499.5	11.45
Parametriocnemus	8	45	15	9	23	200.0	152.0	2.92
Pentaneurini-early instar	4	0	0	0	4	16.0	21.9	0.23
Polypedilum	0	0	3	2	0	10.0	14.1	0.15
Potthastia Longimana Gr.	0	12	9	2	4	54.0	49.8	0.79
Rheotanytarsus	95	49	37	34	42	514.0	250.3	7.51
Stempellinella	0	0	0	0	2	4.0	8.9	0.06
Synorthocladius	12	49	24	2	13	200.0	179.9	2.92
Tanytarsini-early instar	20	12	24	0	6	124.0	98.4	1.81
Thienemannimyia	8	0	6	2	0	32.0	36.3	0.47
Tvetenia	24	0	0	38	17	158.0	162.8	2.31
TOTAL: CHIRONOMIDAE	440	456	332	253	252	3466.0	982.5	50.63
GRAND TOTAL	762	635	548	797	681	6846.0	997.0	100.00

Station 1, October 19, 1995, SB001

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc. Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.

Total invertebrate abundance	= 6846.0	EPT abundance	= 2076.0
Total number of taxa	= 67	Number EPT taxa	= 25
Hilsenhoff Biotic Index	= 4.86	Brillouin H	= 3.35

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	9	796.0	11.63
Odonata	1	18.0	0.26
Ephemeroptera	7	888.0	12.97
Plecoptera	6	170.0	2.49
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	12	1018.0	14.87
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	10	490.0	7.16
Chironomidae	22	3466.0	50.62

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	13	658.0	9.61
Parasite	1	530.0	7.74
Collector-gatherer	22	3642.0	53.20
Collector-filterer	3	606.0	8.85
Macrophyte-herbivore	1	28.0	0.41
Piercer-herbivore	3	250.0	3.64
Scraper	8	108.0	1.58
Shredder	3	268.0	3.92
Xylophage	0	0.0	0.00
Omnivore	8	608.0	8.89
Unknown	5	148.0	2.16

DOMINANT TAXON	ABUNDANCE	PERCENT
Orthocladius Complex	784.0	11.45
Acari	530.0	7.74
Rheotanytarsus	514.0	7.51
Baetis tricaudatus	504.0	7.36
Micropsectra	380.0	5.55
SUBTOTAL 5 DOMINANTS	2712.0	39.61
Brachycentrus occidentalis	360.0	5.26
Ephemerella inermis/infrqu	304.0	4.44
Hemerodromia	254.0	3.71
Chironomini-early instar	244.0	3.56
Lopescladius	230.0	3.36
TOTAL 10 DOMINANTS	4104.0	59.94

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	2	38.0	0.55
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	192.0	2.80
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	1	88.0	1.29
J Intolerant midges	4	292.0	4.26
K Tolerant midges	1	42.0	0.61
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 1, October 19, 1995, SB001
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc. Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 0.60
Hydropsychidae/Total Trichoptera	= 0.09
Baetidae/Total Ephemeroptera	= 0.60

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.18
Scraper/(Scraper + C.-filterer)	= 0.15
Shredder/Total organisms	= 0.04

Biotic Condition Index

Community Tolerance Quotient (a)	= 78.24
Community Tolerance Quotient (d)	= 83.46

DIVERSITY MEASURES

Shannon H (loge)	= 3.37
Shannon H (log2)	= 4.87
Evenness	= 0.80
Simpson D	= 0.05

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	3827.0	55.90
Univoltine	2598.0	37.95
Semivoltine	421.0	6.15

Station 2, October 19, 1995, SB002

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc.
Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.
Mean abundances adjusted to a square meter basis. FILE: 95HS002

IDENTIFICATION CODE	B011	B021	B031	B041	B051
SUBSAMPLING CORRECTION	1	1	1	1	1
CONVERSION (M2)	10				

	REPLICATES							
Taxon	R1	R2	R3	R4	R5	MEAN	STDEV	%
Nematoda	1	3	2	1	0	14.0	11.4	0.40
Enchytraeidae	7	38	11	19	11	172.0	124.2	4.91
Naididae	6	4	10	10	7	74.0	26.1	2.11
Tubificidae	0	27	6	30	8	142.0	134.2	4.05
Ferrissia	0	0	0	2	1	6.0	8.9	0.17
Ostracoda	0	0	0	0	1	2.0	4.5	0.06
Acari	18	0	4	18	25	130.0	105.4	3.71
TOTAL: NON INSECTS	32	72	33	80	53	540.0	219.4	15.41
Ophiogomphus	0	0	0	3	0	6.0	13.4	0.17
TOTAL: ODONATA	0	0	0	3	0	6.0	13.4	0.17
Baetis tricaudatus	43	62	218	8	57	776.0	812.7	22.15
Drunella grandis	0	0	0	0	1	2.0	4.5	0.06
Ephemerella inermis/infrequens	19	12	9	26	39	210.0	120.2	5.99
Heptageniidae-early instar	2	0	4	0	0	12.0	17.9	0.34
Heptagenia	4	0	0	12	6	44.0	49.8	1.26
Rhithrogena	5	4	15	2	2	56.0	54.1	1.60
Paraleptophlebia	0	0	0	1	0	2.0	4.5	0.06
Ameletus	0	1	0	0	0	2.0	4.5	0.06
TOTAL: EPHEMEROPTERA	73	79	246	49	105	1104.0	783.8	31.51
Capniidae-early instar	0	3	2	0	4	18.0	17.9	0.51
Chloroperlidae	0	1	2	0	5	16.0	20.7	0.46
Zapada cinctipes	1	0	2	0	0	6.0	8.9	0.17
Claassenia sabulosa	1	0	0	2	0	6.0	8.9	0.17
Isoperla	3	2	3	0	0	16.0	15.2	0.46
Skwala	0	0	0	1	0	2.0	4.5	0.06
Pteronarcys dorsata	1	0	0	0	0	2.0	4.5	0.06
Taeniopteryx	0	0	0	1	0	2.0	4.5	0.06
TOTAL: PLECOPTERA	6	6	9	4	9	68.0	21.7	1.94
Micrasema	0	0	0	1	0	2.0	4.5	0.06
Hydropsyche	0	1	1	2	7	22.0	27.7	0.63
Hydroptilidae-early instar	3	1	0	3	3	20.0	14.1	0.57
Hydroptila	16	9	4	47	38	228.0	187.5	6.51
Neotrichia	1	0	0	0	0	2.0	4.5	0.06
Ochrotrichia	0	0	1	0	0	2.0	4.5	0.06
Lepidostoma-sand case larvae	6	8	0	6	5	50.0	30.0	1.43
Ceraclea	1	0	0	0	1	4.0	5.5	0.11
TOTAL: TRICHOPTERA	27	19	6	59	54	330.0	227.9	9.42
Atherix	2	1	5	2	1	22.0	16.4	0.63
Chelifera	2	4	2	1	6	30.0	20.0	0.86
Hemerodromia	23	25	13	21	31	226.0	65.4	6.45
Wiedemannia	0	0	0	2	4	12.0	17.9	0.34
Simulium	0	1	39	2	0	84.0	171.3	2.40
Dicranota	0	3	1	0	0	8.0	13.0	0.23
TOTAL: DIPTERA	27	34	60	28	42	382.0	135.7	10.90
Chironomini-early instar	13	12	3	5	5	76.0	45.6	2.17
Cladotanytarsus	0	5	0	0	1	12.0	21.7	0.34
Corynoneura	0	0	0	0	1	2.0	4.5	0.06
Cryptochironomus	0	1	0	0	0	2.0	4.5	0.06
Eukiefferiella	10	32	28	2	2	148.0	143.2	4.22
Lopescladius	8	0	0	0	0	16.0	35.8	0.46
Micropsectra	16	1	14	11	26	136.0	90.2	3.88

Station 2, October 19, 1995, SB002

Taxon	R1	R2	R3	R4	R5	MEAN	STDEV	%
Microtendipes	0	3	0	0	0	6.0	13.4	0.17
Orthocladiinae-early instar	4	4	11	2	10	62.0	40.2	1.77
Orthocladius Complex	12	18	4	8	6	96.0	55.5	2.74
Paramerina	0	1	0	0	0	2.0	4.5	0.06
Parametriocnemus	3	1	3	0	11	36.0	43.4	1.03
Pentaneura	1	0	0	0	1	4.0	5.5	0.11
Polypedilum	0	9	0	6	1	32.0	40.9	0.91
Potthastia Longimana Gr.	3	4	0	2	3	24.0	15.2	0.68
Rheocricotopus	2	0	0	0	0	4.0	8.9	0.11
Rheotanytarsus	35	12	4	22	32	210.0	131.1	5.99
Stempellinella	0	0	0	1	1	4.0	5.5	0.11
Synorthocladius	1	3	2	1	4	22.0	13.0	0.63
Tanytarsini-early instar	7	18	4	5	4	76.0	59.4	2.17
Thienemannimyia	2	1	4	3	6	32.0	19.2	0.91
Tvetenia	15	7	7	0	7	72.0	53.1	2.05
TOTAL: CHIRONOMIDAE	132	132	84	68	121	1074.0	295.6	30.65
GRAND TOTAL	297	342	438	291	384	3504.0	617.5	100.00

Station 2, October 19, 1995, SB002

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc. Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.

Total invertebrate abundance	= 3504.0	EPT abundance	= 1502.0
Total number of taxa	= 60	Number EPT taxa	= 24
Hilsenhoff Biotic Index	= 5.70	Brillouin H	= 3.08

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	7	540.0	15.41
Odonata	1	6.0	0.17
Ephemeroptera	8	1104.0	31.52
Plecoptera	8	68.0	1.95
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	8	330.0	9.43
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	6	382.0	10.91
Chironomidae	22	1074.0	30.63

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	13	380.0	10.86
Parasite	1	130.0	3.71
Collector-gatherer	22	1946.0	55.54
Collector-filterer	3	316.0	9.02
Macrophyte-herbivore	1	2.0	0.06
Piercer-herbivore	3	250.0	7.14
Scraper	5	120.0	3.43
Shredder	3	74.0	2.11
Xylophage	0	0.0	0.00
Omnivore	7	206.0	5.87
Unknown	2	80.0	2.28

DOMINANT TAXON	ABUNDANCE	PERCENT
Baetis tricaudatus	776.0	22.15
Hydroptila	228.0	6.51
Hemerodromia	226.0	6.45
Ephemerella inermis/infreq	210.0	5.99
Rheotanytarsus	210.0	5.99
SUBTOTAL 5 DOMINANTS	1650.0	47.09
Enchytraeidae	172.0	4.91
Eukiefferiella	148.0	4.22
Tubificidae	142.0	4.05
Micropsectra	136.0	3.88
Acari	130.0	3.71
TOTAL 10 DOMINANTS	2378.0	67.86

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	1	6.0	0.17
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	3	232.0	6.63
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	1	22.0	0.63
J Intolerant midges	2	46.0	1.31
K Tolerant midges	1	2.0	0.06
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 2, October 19, 1995, SB002
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc. Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 1.40
Hydropsychidae/Total Trichoptera	= 0.07
Baetidae/Total Ephemeroptera	= 0.70

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.38
Scraper/(Scraper + C.-filterer)	= 0.28
Shredder/Total organisms	= 0.02

Biotic Condition Index

Community Tolerance Quotient (a)	= 80.70
Community Tolerance Quotient (d)	= 86.38

DIVERSITY MEASURES

Shannon H (loge)	= 3.12
Shannon H (log2)	= 4.51
Evenness	= 0.76
Simpson D	= 0.08

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	1728.0	49.32
Univoltine	1762.0	50.29
Semivoltine	14.0	0.40

Station 3, October 19, 1995, SB003

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc.
Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.
Mean abundances adjusted to a square meter basis. FILE: 95HS003

IDENTIFICATION CODE	B011	B021	B031	B041	B051
SUBSAMPLING CORRECTION	1	1	1	1	1
CONVERSION (M2)	10				

	REPLICATES							
Taxon	R1	R2	R3	R4	R5	MEAN	STDEV	%
Nematoda	0	0	0	0	3	6.0	13.4	0.38
Enchytraeidae	1	0	0	0	0	2.0	4.5	0.13
Naididae	2	1	1	0	0	8.0	8.4	0.51
Tubificidae	10	0	0	0	0	20.0	44.7	1.28
Ferrissia	0	0	0	2	0	4.0	8.9	0.26
Acari	1	0	1	0	1	6.0	5.5	0.38
TOTAL: NON INSECTS	14	1	2	2	4	46.0	53.7	2.94
Baetis tricaudatus	25	103	58	54	71	622.0	283.3	39.82
Ephemerella inermis/infrequens	3	4	4	1	8	40.0	25.5	2.56
Heptageniidae-early instar	0	2	4	2	3	22.0	14.8	1.41
Rhithrogena	4	0	0	1	1	12.0	16.4	0.77
TOTAL: EPHEMEROPTERA	32	109	66	58	83	696.0	286.9	44.56
Capniidae-early instar	1	5	2	8	1	34.0	30.5	2.18
Zapada cinctipes	0	0	0	1	1	4.0	5.5	0.26
Isoperla	1	4	1	6	4	32.0	21.7	2.05
Pteronarcys dorsata	0	0	0	0	1	2.0	4.5	0.13
Taenionema	0	0	0	0	1	2.0	4.5	0.13
Taeniopteryx	1	0	0	0	2	6.0	8.9	0.38
TOTAL: PLECOPTERA	3	9	3	15	10	80.0	51.0	5.12
Glossosoma	0	0	1	0	0	2.0	4.5	0.13
Hydroptila	0	1	0	0	0	2.0	4.5	0.13
TOTAL: TRICHOPTERA	0	1	1	0	0	4.0	5.5	0.26
Atherix	0	0	0	0	1	2.0	4.5	0.13
Ceratopogoninae	0	0	1	0	0	2.0	4.5	0.13
Chelifera	0	1	0	0	0	2.0	4.5	0.13
Hemerodromia	1	2	0	0	1	8.0	8.4	0.51
Simulium	24	36	20	72	97	498.0	334.1	31.88
Dicranota	1	1	0	0	0	4.0	5.5	0.26
TOTAL: DIPTERA	26	40	21	72	99	516.0	331.3	33.03
Brillia	0	0	0	0	1	2.0	4.5	0.13
Chironomini-early instar	7	2	1	1	0	22.0	27.7	1.41
Corynoneura	0	0	0	1	0	2.0	4.5	0.13
Eukiefferiella	2	0	0	1	0	6.0	8.9	0.38
Micropsectra	4	6	2	2	1	30.0	20.0	1.92
Orthocladiinae-early instar	0	0	2	0	1	6.0	8.9	0.38
Orthocladius Complex	0	0	0	0	2	4.0	8.9	0.26
Paramerina	0	1	0	0	0	2.0	4.5	0.13
Parametriocnemus	3	3	0	0	1	14.0	15.2	0.90
Polypedilum	0	0	0	4	0	8.0	17.9	0.51
Rheotanytarsus	0	1	0	2	2	10.0	10.0	0.64
Synorthocladius	0	0	0	0	1	2.0	4.5	0.13
Tanytarsini-early instar	0	1	0	0	3	8.0	13.0	0.51
Thienemanniella	0	0	0	0	1	2.0	4.5	0.13
Thienemannimyia	0	2	1	4	1	16.0	15.2	1.02
Tvetenia	4	12	5	9	13	86.0	40.4	5.51
TOTAL: CHIRONOMIDAE	20	28	11	24	27	220.0	68.9	14.08
GRAND TOTAL	95	188	104	171	223	1562.0	551.4	100.00

Station 3, October 19, 1995, SB003

ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc. Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.

Total invertebrate abundance	= 1562.0	EPT abundance	= 780.0
Total number of taxa	= 40	Number EPT taxa	= 12
Hilsenhoff Biotic Index	= 5.55	Brillouin H	= 1.90

TAXONOMIC GROUP	#TAXA	ABUNDANCE	PERCENT
Non-insects	6	46.0	2.94
Odonata	0	0.0	0.00
Ephemeroptera	4	696.0	44.56
Plecoptera	6	80.0	5.13
Hemiptera	0	0.0	0.00
Megaloptera	0	0.0	0.00
Trichoptera	2	4.0	0.26
Lepidoptera	0	0.0	0.00
Coleoptera	0	0.0	0.00
Misc. Diptera	6	516.0	33.04
Chironomidae	16	220.0	14.09

FEEDING GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	8	68.0	4.36
Parasite	1	6.0	0.38
Collector-gatherer	14	860.0	55.07
Collector-filterer	2	508.0	32.52
Macrophyte-herbivore	0	0.0	0.00
Piercer-herbivore	1	2.0	0.13
Scraper	4	40.0	2.57
Shredder	3	40.0	2.57
Xylophage	0	0.0	0.00
Omnivore	6	30.0	1.91
Unknown	1	8.0	0.51

DOMINANT TAXON	ABUNDANCE	PERCENT
Baetis tricaudatus	622.0	39.82
Simulium	498.0	31.88
Tvetenia	86.0	5.51
Ephemerella inermis/infreq	40.0	2.56
Capniidae-early instar	34.0	2.18
SUBTOTAL 5 DOMINANTS	1280.0	81.95
Isoperla	32.0	2.05
Micropsectra	30.0	1.92
Heptageniidae-early instar	22.0	1.41
Chironomini-early instar	22.0	1.41
Tubificidae	20.0	1.28
TOTAL 10 DOMINANTS	1406.0	90.02

INDICATOR ASSEMBLAGE	#TAXA	ABUNDANCE	PERCENT
A Tolerant snails	1	4.0	0.26
B Tolerant mayflies	0	0.0	0.00
C Intolerant mayflies	0	0.0	0.00
D Intolerant stoneflies	0	0.0	0.00
E Tolerant caddisflies	1	2.0	0.13
F Intolerant caddisflies	0	0.0	0.00
G Tolerant beetles	0	0.0	0.00
H Intolerant flies	0	0.0	0.00
I Tolerant flies	1	2.0	0.13
J Intolerant midges	1	2.0	0.13
K Tolerant midges	0	0.0	0.00
L	0	0.0	0.00
M	0	0.0	0.00
N	0	0.0	0.00

Station 3, October 19, 1995, SB003
ALTA: Athabasca R. nr. Ft. McMurray. For EVS Consultants. Determined by ABA, Inc. Benthic invertebrate biomonitoring. Hess samples, 5 replicates, 0.1 m2, 250 micron mesh.

RATIOS OF TAX. GROUP ABUNDANCES

EPT/Chironomidae	= 3.55
Hydropsychidae/Total Trichoptera	= 0.00
Baetidae/Total Ephemeroptera	= 0.89

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filter	= 0.08
Scraper/(Scraper + C.-filterer)	= 0.07
Shredder/Total organisms	= 0.03

Biotic Condition Index

Community Tolerance Quotient (a)	= 83.58
Community Tolerance Quotient (d)	= 83.51

DIVERSITY MEASURES

Shannon H (loge)	= 1.95
Shannon H (log2)	= 2.81
Evenness	= 0.53
Simpson D	= 0.27

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	645.0	41.29
Univoltine	915.0	58.58
Semivoltine	2.0	0.13

Muskeg River Basin

TAXONOMIC COMPOSITION (number/m^2) OF BENTHIC INVERTEBRATE SAMPLES COLLECTED IN THE MUSKEG RIVER BASIN IN FALL, 1995

(a = adult; l = larva; p = pupa)

Taxon	Site-Replicate								
	S4-1	S4-2	S4-3	8-4	8-5	8-6	9-1	9-2	9-3
Hydra	0	0	11	0	0	0	0	0	0
Nematoda	0	183	355	0	0	22	3789	3531	1507
Turbellaria	0	0	0	0	0	0	0	0	0
Enchytraeidae	0	22	65	0	0	0	0	0	0
Lumbricidae	0	0	0	0	0	0	0	0	0
Naididae	0	108	204	11	0	32	0	0	43
Tubificidae	0	129	140	22	11	0	1981	431	1636
Glossiphonia complanata	0	0	0	0	0	0	0	0	0
Helobdella fusca	0	0	0	0	0	0	0	0	0
Helobdella stagnalis	0	0	0	0	0	0	0	0	0
Placobdella ornata	0	0	0	0	0	0	0	0	0
Mooreobdella fervida	0	0	0	0	0	0	0	0	0
Ferrissia rivularis	0	0	11	0	0	0	0	0	0
Physa	0	0	0	0	0	0	0	0	0
Helisoma	0	0	0	0	0	0	0	0	0
Pisidium	0	0	0	0	0	0	1077	43	129
Sphaerium	0	0	0	0	0	0	0	0	129
Lasmigona complanata	0	0	0	0	0	0	43	0	689
Hydrachnidia	22	387	420	0	65	65	344	0	732
Cladocera	0	0	0	0	0	0	1033	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Chydoridae	0	11	0	0	0	22	172	0	0
Daphnia	0	0	0	0	0	0	0	0	0
Diaphanosoma	0	0	0	0	0	0	0	0	0
Cyclopoida	0	0	0	0	22	43	1033	0	0
Harpaticoida	0	0	0	0	0	0	1206	0	344
Ostracoda	22	22	0	0	0	0	2067	689	689
Hyalella azteca	0	0	0	0	0	0	0	43	0
Isotomus	0	0	22	0	0	0	0	0	0
Baetis	118	215	484	0	0	0	0	0	0
Baetis pygmaeus	0	0	0	0	0	22	0	0	0
Caenis	0	0	0	0	0	0	0	0	0
Drunella	0	0	22	0	0	0	0	0	0
Ephemerella	0	0	0	0	0	0	0	0	0
Heptageniidae	0	22	11	0	0	0	0	0	0
Heptagenia	0	0	0	0	0	0	0	0	0
Stenonema	0	0	0	0	0	0	0	0	0
Stenacron	0	0	0	0	0	0	0	0	0
Leptophlebia	0	0	0	0	0	0	0	0	0
Parameletus	0	0	0	11	11	0	0	0	0
Ophiogomphus	0	0	0	0	0	0	0	0	0

BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN (Page 2 of 6)

Taxon	Site-Replicate								
	S4-1	S4-2	S4-3	8-4	8-5	8-6	9-1	9-2	9-3
Plecoptera	22	32	129	0	0	0	0	0	0
Capniidae	0	0	0	54	140	108	0	0	0
Capnia	0	0	0	0	0	0	0	0	0
Chloroperlidae	0	0	11	0	0	11	0	0	0
Nemouridae	0	0	0	0	11	22	0	0	0
Nemoura	0	0	0	0	22	0	0	0	0
Zapada	0	0	22	0	0	0	0	0	0
Perlidae	0	0	11	0	0	0	0	0	0
Claassenia	0	22	0	0	0	0	0	0	0
Perlodidae	11	0	0	0	0	0	0	0	0
Isoperla	0	0	11	0	0	0	0	0	0
Skwala	0	0	0	0	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0
Callicorixa	0	0	0	0	0	0	0	0	0
Sigara	0	0	0	0	0	0	0	0	0
Noctuidae	0	0	0	11	0	0	0	0	0
Brachycentrus	0	0	11	0	0	0	0	0	0
Glossosomatidae	0	0	0	0	0	0	0	0	0
Anagapetus	22	86	108	0	0	0	0	0	0
Hydropsyche	0	11	32	0	0	0	0	0	0
Hydroptilidae	0	0	0	0	0	0	0	0	0
Hydroptila	0	11	0	0	0	0	0	0	0
Oxyethira	0	0	0	0	0	0	0	0	0
Lepidostoma	0	22	0	0	0	0	0	0	0
Oecetis	0	0	0	0	0	0	0	0	0
Limnephilus	0	0	0	0	0	0	0	0	0
Ptilostomis	0	0	0	0	0	0	0	0	0
Neureclipsis	0	0	0	0	0	0	0	0	0
Optioservus a	0	0	0	0	0	0	0	0	0
Optioservus l	0	108	118	0	0	0	0	0	0
Dubiraphia	0	0	0	0	0	0	0	0	0
Diptera l	0	0	0	0	0	0	0	0	0
Diptera p	0	0	0	0	0	0	0	0	0
Bezzia	0	0	11	0	0	0	775	43	43
Chironomidae p	0	11	0	0	0	0	43	0	0
Chironomidae l	22	0	0	0	0	0	0	0	0
Diamesinae	0	0	0	0	0	0	1809	431	258
Orthocladiinae	43	441	215	226	237	420	10636	1679	6071
Corynoneura	86	43	108	0	0	0	14813	129	1550
Thienemanniella	0	0	22	0	0	0	0	43	344
Tanypodinae	43	0	54	11	11	0	301	43	0
Chironomini	43	247	269	43	32	86	10507	2325	1550
Tanytarsini	22	0	22	0	43	86	215	86	646
Dolichopodidae	0	0	0	0	0	0	0	0	0
Chelifera	0	32	22	11	54	11	0	0	0
Hemerodromia	11	97	97	11	0	0	0	0	0
Pericoma	0	0	0	0	0	0	0	0	0
Simuliidae p	0	0	0	0	0	0	0	0	0
Simuliidae	0	0	11	11	0	0	0	0	0
Chrysops	0	0	0	0	0	0	0	0	0
Tabanus	0	0	0	0	0	0	0	0	0
Tipulidae	0	0	0	0	0	0	0	0	0
Hexatoma	0	11	11	0	11	0	0	0	0
Terrestrial	11	86	43	11	0	11	0	0	0
Total	498	2359	3083	433	670	961	51844	9516	16360

BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN (Page 3 of 6)

Taxon	Site-Replicate								
	14-1	14-2	14-3	17-1	17-2	17-3	18-1	18-2	18-3
Hydra	0	0	0	0	0	22	0	258	0
Nematoda	646	560	344	75	86	54	129	431	2497
Turbellaria	0	0	0	0	0	0	0	43	0
Enchytraeidae	0	0	0	0	0	0	0	0	0
Lumbricidae	0	0	0	0	0	0	0	0	0
Naididae	0	344	172	237	11	65	0	344	0
Tubificidae	1421	344	0	22	22	22	947	4737	1206
Glossiphonia complanata	0	0	0	0	0	0	0	43	0
Helobdella fusca	0	0	43	0	0	0	0	0	0
Helobdella stagnalis	0	0	43	0	0	11	0	258	0
Placobdella ornata	0	0	0	0	0	0	0	43	0
Mooreobdella fervida	0	0	0	0	0	0	0	43	0
Ferrissia rivularis	0	0	0	0	11	0	0	0	0
Physa	0	0	0	0	0	0	0	86	0
Helisoma	0	0	0	0	0	0	0	0	0
Pisidium	0	0	0	11	0	75	0	904	344
Sphaerium	0	0	0	11	0	32	0	474	0
Lasmigona complanata	0	0	0	0	0	0	0	0	0
Hydrachnidia	0	0	0	323	560	301	0	990	344
Cladocera	0	0	86	0	0	0	86	0	0
Bosmina	0	0	0	0	0	11	0	0	0
Chydoridae	0	0	0	0	0	0	0	0	0
Daphnia	0	0	0	0	0	0	0	0	0
Diaphanosoma	0	0	0	0	0	0	0	0	0
Cyclopoida	0	0	431	22	22	54	86	258	0
Harpaticoida	344	172	431	0	32	0	0	86	0
Ostracoda	474	0	86	0	0	0	258	388	0
Hyalella azteca	0	0	0	0	0	0	0	172	0
Isotomus	0	0	0	0	0	0	0	0	0
Baetis	0	0	0	54	54	11	0	0	0
Baetis pygmaeus	0	0	0	86	194	151	0	0	0
Caenis	0	172	0	0	0	0	0	0	0
Drunella	0	0	0	0	0	0	0	0	0
Ephemerella	0	0	0	0	11	0	0	0	0
Heptageniidae	0	0	0	43	54	0	0	0	0
Heptagenia	0	0	0	129	11	0	0	0	0
Stenonema	0	0	0	22	0	22	0	0	0
Stenacron	0	0	0	22	0	11	0	0	0
Leptophlebia	0	0	43	11	22	0	0	43	0
Parameletus	0	0	0	0	0	0	43	0	0
Ophiogomphus	0	0	0	0	0	0	0	43	0

BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN (Page 4 of 6)

Taxon	Site-Replicate								
	14-1	14-2	14-3	17-1	17-2	17-3	18-1	18-2	18-3
Plecoptera	0	0	0	11	11	22	0	0	0
Capniidae	0	0	0	0	0	11	0	0	0
Capnia	0	0	0	0	0	0	0	0	0
Chloroperlidae	0	0	0	11	0	0	0	0	0
Nemouridae	0	0	0	0	0	0	0	0	0
Nemoura	0	0	0	0	0	0	0	0	0
Zapada	0	0	0	11	0	0	0	0	0
Perlidae	0	0	0	0	0	0	0	0	0
Claassenia	0	0	0	0	0	0	0	0	0
Perlodidae	0	0	0	0	0	0	0	0	0
Isoperla	0	0	0	0	0	0	0	0	0
Skwala	0	0	0	0	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0	0	43
Callicorixa	0	0	0	0	0	0	0	0	0
Sigara	0	0	0	0	0	0	0	0	0
Noctuidae	0	0	0	0	0	0	0	0	0
Brachycentrus	0	0	0	0	0	0	0	0	0
Glossosomatidae	0	0	0	0	11	0	0	0	0
Anagapetus	0	0	0	0	0	0	0	0	0
Hydropsyche	0	0	0	0	0	11	0	0	0
Hydroptilidae	0	0	0	0	11	0	86	0	0
Hydroptila	0	0	0	0	22	11	0	0	0
Oxyethira	0	0	0	0	0	0	0	0	344
Lepidostoma	344	0	0	0	0	11	0	0	0
Oecetis	0	0	0	11	11	0	0	0	0
Limnephilus	0	0	0	0	0	0	0	43	0
Ptilostomis	0	0	43	11	0	0	43	0	0
Neureclipsis	0	0	0	0	0	32	0	86	0
Optioservus a	0	0	0	0	0	0	0	0	0
Optioservus l	0	0	0	0	0	11	0	0	0
Dubiraphia	0	0	0	0	0	0	0	129	0
Diptera l	0	0	0	0	0	0	0	0	0
Diptera p	0	0	0	11	0	0	0	0	0
Bezzia	0	172	43	11	0	0	431	2368	689
Chironomidae p	0	0	0	11	0	0	0	0	0
Chironomidae l	0	0	0	0	0	0	0	0	0
Diamesinae	0	172	0	0	0	11	43	474	689
Orthocladiinae	1464	517	258	65	247	43	215	818	344
Corynoneura	4091	689	301	0	194	22	86	3402	689
Thienemanniella	43	0	215	0	0	0	0	129	0
Tanypodinae	431	43	1421	226	226	204	215	2799	0
Chironomini	7622	732	3230	194	538	646	2325	15588	4220
Tanytarsini	0	689	344	764	570	118	43	775	0
Dolichopodidae	0	0	0	0	0	0	0	0	0
Chelifera	0	0	0	43	0	0	0	0	0
Hemerodromia	0	0	0	312	183	226	0	0	0
Pericoma	0	0	0	11	0	0	0	0	0
Simuliidae p	0	0	0	0	0	11	0	0	0
Simuliidae	0	0	0	0	0	0	0	0	0
Chrysops	0	0	0	0	0	0	0	0	0
Tabanus	0	0	43	0	0	0	43	43	43
Tipulidae	0	0	0	0	0	0	0	0	0
Hexatoma	0	0	0	22	22	32	0	0	0
Terrestrial	0	0	0	0	43	11	0	0	0
Total	16880	4606	7577	2793	3179	2275	5079	36298	11452

BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN (Page 5 of 6)

Taxon	Site-Replicate									
	30-1	30-2	30-3	35-1	55-4	55-5	55-6	80-1	80-2	80-3
Hydra	0	0	0	0	0	0	0	0	0	0
Nematoda	258	54	129	86	194	344	97	0	86	43
Turbellaria	0	0	0	0	0	0	0	0	0	0
Enchytraeidae	118	32	43	0	0	0	0	0	0	0
Lumbricidae	11	0	0	0	0	0	0	0	0	0
Naididae	151	129	108	474	0	0	43	43	258	0
Tubificidae	194	280	549	474	646	323	65	43	86	43
Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0
Helobdella fusca	0	0	0	0	0	0	0	0	0	0
Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0
Placobdella ornata	0	0	0	0	0	0	0	0	0	0
Mooreobdella fervida	0	0	0	0	0	0	0	0	0	0
Ferrissia rivularis	0	0	0	0	0	0	0	0	0	0
Physa	0	0	0	0	0	0	0	0	0	0
Helisoma	0	0	0	86	0	0	0	0	0	0
Pisidium	0	0	11	0	11	0	0	0	0	0
Sphaerium	0	0	0	0	43	0	11	0	0	0
Lasmigona complanata	0	0	0	86	0	0	0	0	0	0
Hydrachnidia	129	129	75	0	172	312	291	0	0	0
Cladocera	0	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	129	0	0	0	0	0	0
Chydoridae	0	0	0	43	0	0	0	0	0	0
Daphnia	0	0	0	689	0	0	0	0	0	0
Diaphanosoma	0	0	0	172	0	0	0	0	0	0
Cyclopoida	11	0	11	172	129	0	11	43	0	0
Harpaticoida	0	0	0	43	0	0	0	0	0	0
Ostracoda	11	0	22	43	344	0	32	0	43	0
Hyalella azteca	0	0	0	0	0	0	0	0	0	0
Isotomus	0	0	0	86	0	0	0	0	0	0
Baetis	86	151	108	0	151	86	43	0	0	0
Baetis pygmaeus	0	0	0	0	0	11	0	0	0	0
Caenis	0	0	0	0	0	0	0	0	0	0
Drunella	0	0	0	0	0	0	0	0	0	0
Ephemerella	0	11	11	0	0	0	0	0	0	0
Heptageniidae	0	0	0	0	0	0	0	0	0	0
Heptagenia	11	11	32	0	0	0	0	0	0	0
Stenonema	0	0	0	0	0	0	0	0	0	0
Stenacron	0	0	0	0	0	0	0	0	0	0
Leptophlebia	0	0	0	0	0	0	11	0	0	0
Parameletus	0	0	0	0	86	108	11	0	0	0
Ophiogomphus	0	11	0	0	0	0	0	0	0	0

BENTHIC INVERTEBRATE DATA - MUSKEG RIVER BASIN (Page 6 of 6)

Taxon	Site-Replicate									
	30-1	30-2	30-3	35-1	55-4	55-5	55-6	80-1	80-2	80-3
Plecoptera	0	11	43	0	0	0	0	0	0	0
Capniidae	0	0	0	0	0	0	0	0	0	0
Capnia	0	0	0	0	0	0	11	0	0	0
Chloroperlidae	65	43	43	0	0	0	0	0	0	0
Nemouridae	0	0	0	0	0	0	0	0	0	0
Nemoura	0	0	0	0	11	11	0	0	0	0
Zapada	0	0	0	0	0	0	0	0	0	0
Perlidae	0	0	0	0	0	0	0	0	0	0
Claassenia	0	0	0	0	0	0	0	0	0	0
Perlodidae	0	0	0	0	0	0	0	0	0	0
Isoperla	11	0	0	0	0	0	0	0	0	0
Skwala	0	11	0	0	0	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0	0
Callicorixa	11	43	11	0	0	0	0	0	0	0
Sigara	0	0	11	0	0	0	0	0	0	0
Noctuidae	0	0	0	0	0	0	0	0	0	0
Brachycentrus	0	0	11	0	151	86	129	0	0	0
Glossosomatidae	0	11	0	0	0	0	0	0	0	0
Anagapetus	0	0	0	0	86	22	43	0	0	0
Hydropsyche	0	32	0	0	0	0	0	0	0	0
Hydroptilidae	0	0	0	0	0	0	0	0	0	0
Hydroptila	11	0	0	0	0	0	0	0	0	0
Oxyethira	0	0	0	0	0	0	0	0	0	0
Lepidostoma	0	0	0	0	0	0	0	0	0	0
Oecetis	0	0	0	0	0	0	0	0	0	0
Limnephilus	0	0	0	0	0	0	0	0	0	0
Ptilostomis	0	0	0	0	0	0	0	0	0	0
Neureclipsis	0	0	0	0	0	0	0	0	0	0
Optioservus a	0	0	0	0	0	11	0	0	0	0
Optioservus l	11	11	22	0	420	366	398	0	0	0
Dubiraphia	0	0	0	0	0	0	0	0	0	0
Diptera l	0	0	0	0	0	11	0	0	0	0
Diptera p	0	0	0	0	0	0	0	0	0	0
Bezzia	0	0	0	43	0	0	0	0	0	0
Chironomidae p	0	0	0	0	43	0	22	0	0	0
Chironomidae l	0	0	0	0	0	0	0	0	0	0
Diamesinae	0	11	11	0	172	43	43	0	43	43
Orthocladiinae	22	22	11	344	4175	2959	1216	0	344	0
Corynoneura	32	54	22	775	86	22	11	0	0	0
Thienemanniella	0	0	0	0	0	22	0	0	0	0
Tanypodinae	0	22	11	388	129	0	22	0	43	0
Chironomini	32	11	86	1550	2410	452	86	215	2411	129
Tanytarsini	0	0	11	646	43	151	108	0	0	0
Dolichopodidae	0	0	0	0	32	0	0	0	0	0
Chelifera	0	11	11	0	172	118	86	0	0	0
Hemerodromia	32	22	97	0	0	0	0	0	0	0
Pericoma	0	0	0	0	0	0	0	0	0	0
Simuliidae p	0	0	0	0	11	11	43	0	0	0
Simuliidae	11	0	0	0	0	0	43	0	0	0
Chrysops	11	0	0	0	0	0	0	0	0	0
Tabanus	0	0	0	0	0	11	0	0	0	0
Tipulidae	0	0	0	0	0	0	22	0	0	0
Hexatoma	11	0	11	0	0	0	0	0	0	0
Terrestrial	11	54	22	86	118	65	172	0	0	0
Total	1251	1177	1533	6415	9835	5545	3070	344	3314	258

ETL Enviro-Test

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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6 AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: December 13, 1995

ATTN: RANDY SHAW

Lab Work Order #:	E510131	**Sampled By:**	TD/JD
Project Reference:	952-2308/7130 SEAL 10	**Date Received:**	10/05/95
Project P.O.#:	NOT SUBMITTED		

Comments:

APPROVED BY:

Doug Johnson
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510131-01	SRD95F30							
Sample Type:INSECTS								
Collected:09/27/95								
		PAH & Alkylated PAH						
		Naphthalene	0.06	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Phenanthrene	0.02	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Anthracene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl naphthalene	0.07	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd naphthalene	0.07	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C3 sub'd naphthalene	0.11	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd phenanthrene/anth.	0.04	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C3 sub'd phenanthrene/anth.	0.05	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C3 sub'd dibenzothiophene	0.05	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C4 sub'd dibenzothiophene	0.06	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Acridine	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Carbazole	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
E510131-02	SRD95FS4							
Sample Type:INSECTS								
Collected:09/28/95								
		PAH & Alkylated PAH						
		Naphthalene	0.08	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Phenanthrene	0.02	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Anthracene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl naphthalene	0.05	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd naphthalene	0.11	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C3 sub'd naphthalene	0.17	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510131-02	SRD95FS4							
Sample Type:INSECTS								
Collected:09/28/95								
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	M
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	M "
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C2 sub'd phenanthrene/anth.	0.04	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C3 sub'd phenanthrene/anth.	0.05	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	M
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C3 sub'd dibenzothiophene	0.06	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C4 sub'd dibenzothiophene	0.05	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	M
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/18/95	11/30/95	
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	M "
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	M
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	
		Acridine	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	MJL
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	M
		Carbazole	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/18/95	11/30/95	

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

ENVIRO-TEST QA/QC REPORT

PAH & Alkylated PAH

Average Surrogate Recovery for E510131	%
Nitrobenzene d5	98
2-Fluorobiphenyl	90
p-Terphenyl d14	76

PANH & Alkylated PANH's

Average Surrogate Recovery for E510131	%
Quinoline d7	95

Relative percent difference is expressed as RPD.
Percent Recovery is expressed as %.
THIS IS THE LAST PAGE OF THE QAQC REPORT

Appendix A Test Methodologies

PAH & Alkylated PAH

Preparation Method:	Soxhlet extraction with DCM.
Instrument Method:	GC/MSD analysis
Method Reference:	Extraction Method: EPA 3540 (modified) Analytical Method: EPA 8270 (modified)

PANH & Alkylated PANH's

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

SPECIFIC WORK INSTRUCTIONS

SPECIFIC WORK INSTRUCTIONS **SWI No.:** SWI1.0

Project: Suncor Tributary Samping - Spring 1996

Date: April 30, 1996

Author: Marie Lagimodiere

To: Tony Calverley

cc: Dave Fernet **File No.**:

Subject: Spring 1996 Aquatic Field Program **Job/Task No.**: 962-2320

Scope of Work/Specific Instructions:

Survey the lower reaches of Leggett Creek, Wood Creek, and the Unnamed Creek that drains Shipyard Lake and examine for fish presence, habitat conditions, fish passage and potential use as spawning stream (for fish from the mainstem Athabasca River), using a backpack shocker, seine nets and minnow traps. Gill nets, seine nets or minnow traps are to be used to sample habitats in which electrofishing effectiveness is reduced and to sample for fish species which are not as susceptible to capture by electrofishing.

Video tape the habitat of Unnamed Creek, Shipyard Lake, Leggett Creek, Wood Creek and Horseshoe Lake. While video taping note major changes in habitat type (e.g., from wetland to defined channel). Spend one day in total at the upper and middle reaches, and one day at the mouth going upstream as far as time allows. Habitat map 100 m representative reaches as per Golder TP8.5-0. In addition, install gill nets and minnow traps in Shipyard Lake and Horseshoe Lake. Retrieve gill nets and minnow traps the following day.

All captured individuals of all fish species are to be identified to species and enumerated. Large fish species are to be measured for fork length and weight and the appropriate non-lethal ageing structure is to be collected. The life history stage, sex and state of maturity is to be recorded for each fish, when discernible from external examination. External pathology is to be recorded and all abnormalities are to be recorded as per the external examination form classification. Incidental mortalities are to be examined internally and results are to be recorded on internal examination forms and lethal ageing structures collected. For forage fish species, a sub-sample is to be measured for fork length and weight and sacrificed to obtain ageing materials. GPS techniques are to be used to record the location of all significant habitat areas, locations of significant concentrations of fish and all sampling locations. Golder TP 8.1-0 Fish Inventory and Biomarker Method and Golder TP 5.1-0 Habitat Classification system must be followed.

Project Manager: Marie Lagimodiere

Work Product(s) Due By: May 31, 1996

Allocated Manhours: see budget

Subcontractor (as applicable): n/a

Special Handling Requirements: Any unidentifiable whole fish will be stored in 10% buffered formalin, clearly labelled and returned to the lab for positive identification.

Applicable Specs. and Procedures: Golder TP 8.1-0, Golder TP5.1-0

Project Manager Approval/Date: **QA Manager/Date:**

SPECIFIC WORK INSTRUCTIONS

SPECIFIC WORK INSTRUCTIONS **SWI No.:** SWI1.0

Project: Suncor Tributary Samping - Spring 1996

Date: April 30, 1996

Author: Marie Lagimodiere

To: Tony Calverley

cc: Dave Fernet **File No.**:

Subject: Spring 1996 Aquatic Field Program **Job/Task No.**: 962-2320

Scope of Work/Specific Instructions:

Survey the lower reaches of Leggett Creek, Wood Creek, and the Unnamed Creek that drains Shipyard Lake and examine for fish presence, habitat conditions, fish passage and potential use as spawning stream (for fish from the mainstem Athabasca River), using a backpack shocker, seine nets and minnow traps. Gill nets, seine nets or minnow traps are to be used to sample habitats in which electrofishing effectiveness is reduced and to sample for fish species which are not as susceptible to capture by electrofishing.

Video tape the habitat of Unnamed Creek, Shipyard Lake, Leggett Creek, Wood Creek and Horseshoe Lake. While video taping note major changes in habitat type (e.g., from wetland to defined channel). Spend one day in total at the upper and middle reaches, and one day at the mouth going upstream as far as time allows. Habitat map 100 m representative reaches as per Golder TP8.5-0. In addition, install gill nets and minnow traps in Shipyard Lake and Horseshoe Lake. Retrieve gill nets and minnow traps the following day.

All captured individuals of all fish species are to be identified to species and enumerated. Large fish species are to be measured for fork length and weight and the appropriate non-lethal ageing structure is to be collected. The life history stage, sex and state of maturity is to be recorded for each fish, when discernible from external examination. External pathology is to be recorded and all abnormalities are to be recorded as per the external examination form classification. Incidental mortalities are to be examined internally and results are to be recorded on internal examination forms and lethal ageing structures collected. For forage fish species, a sub-sample is to be measured for fork length and weight and sacrificed to obtain ageing materials. GPS techniques are to be used to record the location of all significant habitat areas, locations of significant concentrations of fish and all sampling locations. Golder TP 8.1-0 Fish Inventory and Biomarker Method and Golder TP 5.1-0 Habitat Classification system must be followed.

Project Manager: Marie Lagimodiere

Work Product(s) Due By: May 31, 1996

Allocated Manhours: see budget

Subcontractor (as applicable): n/a

Special Handling Requirements: Any unidentifiable whole fish will be stored in 10% buffered formalin, clearly labelled and returned to the lab for positive identification.

Applicable Specs. and Procedures: Golder TP 8.1-0, Golder TP5.1-0

Project Manager Approval/Date: **QA Manager/Date:**

APPENDIX X

WATER SURVEY OF CANADA STREAM DISCHARGES FOR THE ATHABASCA AND STEEPBANK RIVERS

E.C.-AEB-MOD*CALGARY ID:403-292-5314 JAN'09'96 13:41 No.008 P.02

WATER SURVEY OF CANADA
NOV 29 1995 PAGE 7
CALGARY, ALTA 07:36

ATHABASCA RIVER BELOW FORT McMURRAY

STATION NO. 07DA001

STREAM VAX JUN/93

(PRELIMINARY) DAILY DISCHARGE IN CUBIC METRES PER SECOND FOR 1995

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	199 B	154 B	131 B	183 B	518	624	1440	939	1040	442			1
2	196 B	154 B	133 B	196 B	522	620	1330	995	981	438			2
3	194 B	152 B	132 B	207 B	509	635	1210	978	933	435			3
4	191 B	152 B	133 B	207 B	496	752	1100	930	889	432			4
5	188 B	151 B	133 B	204 B	487	908	1050	906	858	426			5
6	182 B	149 B	132 B	200 B	476	954	1050	871	819	425			6
7	177 B	149 B	131 B	192 B	463	941	1140	841	785	420			7
8	171 B	150 B	130 B	199 B	445	936	1650	833	751	414			8
9	171 B	152 B	131 B	208 B	433	958	1860	903	724	410			9
10	164 B	150 B	131 B	217 B	427	1030	1770	1120	703	403			10
11	159 B	151 B	131 B	218 B	418	1170	1730	1460	680	395			11
12	155 B	151 B	128 B	226 B	421	1240	1660	2440	659	390			12
13	152 B	150 B	127 B	232 B	425	1140	1540	3050	662	385			13
14	150 B	148 B	125 B	242 B	428	1080	1430	2810	659	381			14
15	149 B	147 B	124 B	247 B	436	1040	1370	2610	649	375			15
16	143 B	147 B	125 B	252 B	442	997	1330	2430	629	383			16
17	150 B	142 B	125 B	254 B	453	975	1260	2290	612	386			17
18	150 B	139 B	125 B	273 B	472	974	1150	2150	595	397			18
19	151 B	140 B	129 B	288 B	552	982	1060	2020	586	400			19
20	150 B	140 B	130 B	298 B	639	969	1000	1890	576	404			20
21	149 B	141 B	130 B	314 B	682	965	957	1770	555	403			21
22	150 B	139 B	134 B	324 B	681	1000	920	1660	543	398			22
23	152 B	137 B	138 B	336 B	695	1050	891	1560	531	396			23
24	153 B	135 B	143 B	350 B	699	1140	878	1490	516	404			24
25	153 B	134 B	147 B	360 B	671	1560	876	1420	503	417			25
26	153 B	132 B	157 B	375 B	641	1860	873	1330	497	422			26
27	154 B	131 B	164 B	390 B	622	1740	914	1270	486	419			27
28	154 B	131 B	169 B	410 B	605	1680	945	1220	470	413			28
29	154 B		172 B	440 B	602	1630	936	1200	457				29
30	155 B		176 B	470 B	605	1550	946	1160	449				30
31	154 B		179 B		616		935	1110					31
TOTAL	5023	4048	4295	8312	16581	33100	37201	47656	19797				TOTAL
MEAN	162	145	139	277	535	1100	1200	1540	660				MEAN
DAM3	434000	350000	371000	718000	1430000	2860000	3210000	4120000	1710000				DAM3
MAX	199	154	179	470	699	1860	1860	3050	1040				MAX
MIN	143	131	124	183	418	620	873	833	449				MIN

SUMMARY FOR THE YEAR 1995 (INCOMPLETE YEAR, SUMMARY DATA MAY NOT BE VALID)

MEAN DISCHARGE, M3/S
TOTAL DISCHARGE, DAM3

MAXIMUM DAILY DISCHARGE, M3/S ON
MINIMUM DAILY DISCHARGE, M3/S ON

MAXIMUM INSTANTANEOUS DISCHARGE, ? 3090 M3/S AT 08:34 MST ON AUG 13

B-ICE CONDITIONS

301 DAY(S) WITH DATA
120 DAY(S) WITH ICE
0 DAY(S) MANUAL DATA
0 DAY(S) ESTIMATED
64 DAY(S) WITH NO DATA

E.C.-AEB-MOD*CALGARY ID:403-292-5314 JAN 09'96 13:42 No.008 P.03

WATER SURVEY OF CANADA
NOV 29 1995 PAGE 6
CALGARY, ALTA 07:36

ATHABASCA RIVER BELOW FORT McMURRAY

STATION NO. 07DA001

STREAM VAX JUN/93

(PRELIMINARY) DAILY WATER LEVEL IN METRES FOR 1995

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	2.101	1.974	1.904	2.226	1.925	2.055	3.098	2.478	2.750	1.765			1
2	2.104	1.975	1.912	2.273	1.927	2.042	2.974	2.558	2.671	1.757			2
3	2.095	1.966	1.912	2.310	1.902	2.069	2.826	2.535	2.603	1.753			3
4	2.082	1.968	1.917	2.311	1.873	2.266	2.695	2.465	2.535	1.747			4
5	2.062	1.964	1.920	2.302	1.852	2.511	2.637	2.426	2.488	1.736			5
6	2.042	1.960	1.915	2.286	1.827	2.577	2.639	2.372	2.428	1.736			6
7	2.027	1.960	1.914	2.257	1.799	2.554	2.765	2.325	2.376	1.726			7
8	2.019	1.968	1.909	2.286	1.758	2.543	3.410	2.311	2.323	1.714			8
9	2.005	1.976	1.917	2.314	1.732	2.570	3.643	2.422	2.281	1.707			9
10	1.983	1.972	1.923	2.341	1.717	2.668	3.542	2.717	2.247	1.692			10
11	1.966	1.976	1.922	2.345	1.698	2.835	3.468	3.126	2.211	1.677			11
12	1.946	1.977	1.913	2.368	1.704	2.925	3.351	4.172	2.178	1.668			12
13	1.931	1.974	1.907	2.385	1.714	2.792	3.206	4.697	2.184	1.657			13
14	1.920	1.968	1.904	2.417	1.717	2.721	3.092	4.495	2.180	1.651			14
15	1.921	1.965	1.900	2.434	1.732	2.663	3.023	4.326	2.164	1.640			15
16	1.928	1.967	1.907	2.447	1.741	2.597	2.979	4.163	2.125	1.660			16
17	1.926	1.942	1.911	2.452	1.760	2.562	2.888	4.044	2.093	1.668			17
18	1.928	1.923	1.914	2.499	1.799	2.556	2.764	3.918	2.062	1.693			18
19	1.935	1.931	1.936	2.539	1.964	2.564	2.648	3.795	2.044	1.703			19
20	1.934	1.936	1.947	2.711	2.132	2.542	2.571	3.677	2.027	1.713			20
21	1.930	1.940	1.949	2.843	2.206	2.531	2.505	3.553	1.987	1.713			21
22	1.937	1.933	1.972	2.913	2.208	2.580	2.450	3.439	1.965	1.704			22
23	1.948	1.922	2.001	2.909	2.221	2.648	2.403	3.340	1.943	1.701			23
24	1.956	1.915	2.031	2.680	2.223	2.751	2.382	3.270	1.915	1.721			24
25	1.960	1.909	2.055	2.545	2.171	3.262	2.379	3.187	1.891	1.751			25
26	1.962	1.900	2.107	2.317	2.113	3.641	2.375	3.094	1.879	1.763			26
27	1.966	1.898	2.141	2.250	2.072	3.512	2.440	3.020	1.856	1.759			27
28	1.967	1.900	2.164	2.133	2.032	3.411	2.488	2.966	1.822	1.747			28
29	1.970		2.179	2.016	2.022	3.327	2.475	2.941	1.793				29
30	1.975		2.197	2.022	2.025	3.220	2.489	2.899	1.779				30
31	1.975		2.211		2.043		2.473	2.841					31
TOTAL	61.401	54.559	61.311	72.131	59.601	81.495	87.078	99.572	64.800				TOTAL
MEAN	1.981	1.949	1.978	2.404	1.923	2.717	2.809	3.212	2.160				MEAN
MAX	2.104	1.977	2.211	2.913	2.223	3.641	3.643	4.697	2.750				MAX
MIN	1.920	1.898	1.900	2.016	1.698	2.042	2.375	2.311	1.779				MIN

SUMMARY FOR THE YEAR 1995 (INCOMPLETE YEAR, SUMMARY DATA MAY NOT BE VALID)

MAXIMUM DAILY WATER LEVEL, 4.697 METRES ON AUG 13
MINIMUM DAILY WATER LEVEL, 1.640 METRES ON OCT 15

MAXIMUM INSTANTANEOUS WATER LEVEL, ? 4.734 METRES AT 08:34 MST ON AUG 13

WATER LEVELS ARE REFERRED TO AN ASSUMED DATUM
ADD 235.821 METRES TO CONVERT TO APPROX. GEODETIC SURVEY OF CANADA

301 DAY(S) WITH DATA
0 DAY(S) WITH ICE
0 DAY(S) MANUAL DATA
0 DAY(S) ESTIMATED
64 DAY(S) WITH NO DATA

E.C.-AEB-MOD*CALGARY ID:403-292-5314 JAN 09'96 13:42 No.008 P.04

WATER SURVEY OF CANADA
NOV 29 1995 PAGE 7
CALGARY, ALTA 07:34

STEEPBANK RIVER NEAR FORT McMURRAY

STATION NO. 07DA006

STREAM VAX JUN/93

(PRELIMINARY) DAILY DISCHARGE IN CUBIC METRES PER SECOND FOR 1995

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1			0.285 B	0.479 B	1.75 B	1.93	15.2	9.41	16.1	4.00			1
2			0.280 B	0.478 B	1.85 B	1.77	13.7	9.23	14.3	4.05			2
3			0.279 B	0.470 B	2.00 B	1.65	12.2	8.89	13.0	4.09			3
4			0.278 B	0.468 B	2.20 B	1.54	11.1	8.48	11.8	4.16			4
5			0.277 B	0.465 B	2.50 B	1.44	10.2	7.89	10.8	3.87			5
6			0.276 B	0.464 B	3.10 B	1.33	9.41	7.38	9.98	3.69			6
7			0.277 B	0.465 B	3.50 B	1.19	8.77	7.34	9.12	3.66			7
8			0.279 B	0.470 B	4.40 E	1.04	8.14	7.44	8.44	3.71			8
9			0.282 B	0.477 B	5.50 A	0.965	7.70	10.2	8.17	3.80			9
10			0.287 B	0.482 B	8.17	0.854	7.37	15.4	7.54	3.80			10
11			0.294 B	0.490 B	11.1	0.697	7.06	20.4	7.20	3.89			11
12			0.297 B	0.500 B	14.8	0.550	6.93	24.6	6.64	3.96			12
13			0.296 B	0.510 B	11.9	0.566	6.73	28.8	6.20	3.89			13
14			0.297 B	0.535 B	7.63	0.642	6.40	29.6	5.73	3.73			14
15			0.298 B	0.560 B	4.48	0.529	6.17	28.0	5.52	3.71			15
16			0.297 B	0.590 B	3.92	0.822	5.89	25.5	5.71	3.61			16
17			0.296 B	0.620 B	3.71	1.28	5.67	23.1	5.73	3.98			17
18			0.297 B	0.650 B	3.63	2.48	5.38	21.4	5.59	4.03			18
19			0.300 B	0.685 B	3.60	7.43	5.43	22.2	5.42	4.26			19
20			0.320 B	0.725 B	3.51	12.2	5.66	23.0	5.17	4.32			20
21			0.340 B	0.770 B	3.54	16.4	5.87	23.6	4.94	4.32			21
22			0.345 B	0.830 B	3.37	20.6	6.03	23.7	4.86	4.26			22
23			0.342 B	0.900 B	3.29	22.5	6.19	24.2	4.72	4.13			23
24			0.347 B	0.980 B	3.14	23.1	6.05	24.0	4.56	4.00			24
25			0.355 B	1.07 B	3.06	22.9	5.85	24.2	4.43	3.87 E			25
26			0.370 B	1.18 B	2.91	22.6	6.48	24.6	4.30	3.75 E			26
27			0.400 B	1.25 B	2.81	22.0	6.67	24.3	4.18	3.64 E			27
28			0.425 B	1.35 B	2.74	21.0	7.52	23.2	4.07	3.54 E			28
29			0.443 B	1.45 B	2.57	19.0	9.06	21.7	3.92	3.45 E			29
30			0.462 B	1.60 B	2.37	17.1	9.69	19.9	3.74	3.37 E			30
31			0.475 B		2.14		9.68	17.9		3.30 E			31
TOTAL			10.096	21.963	135.19	248.105	244.20	589.56	211.88	119.84			TOTAL
MEAN			0.326	0.732	4.36	8.27	7.88	19.0	7.06	3.87			MEAN
DAM3			872	1900	11700	21400	21100	50900	18300	10400			DAM3
MAX			0.475	1.60	14.8	23.1	15.2	29.6	16.1	4.32			MAX
MIN			0.276	0.464	1.75	0.529	5.38	7.34	3.74	3.30			MIN

SUMMARY FOR THE STANDARD PERIOD MAR TO OCT

MEAN DISCHARGE, 6.45 M3/S
TOTAL DISCHARGE, 137000 DAM3

MAXIMUM DAILY DISCHARGE, 29.6 M3/S ON AUG 14
MINIMUM DAILY DISCHARGE, 0.276 M3/S ON MAR 6

MAXIMUM INSTANTANEOUS DISCHARGE, 29.8 M3/S AT 06:38 MST ON AUG 14

A-MANUAL GAUGE
B-ICE CONDITIONS
E-ESTIMATED

245 DAY(S) WITH DATA
68 DAY(S) WITH ICE
1 DAY(S) MANUAL DATA
8 DAY(S) ESTIMATED
0 DAY(S) WITH NO DATA

E.C.-AEB-MOD*CALGARY ID:403-292-5314 JAN 09'96 13:42 No.008 P.03

ATHABASCA RIVER BELOW FORT McMURRAY

STATION NO. 07DA001

STREAM VAX JUN/93

(PRELIMINARY) DAILY WATER LEVEL IN METRES FOR 1995

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	2.101	1.974	1.904	2.226	1.925	2.055	3.098	2.478	2.750	1.765			1
2	2.104	1.975	1.912	2.273	1.927	2.042	2.974	2.558	2.671	1.757			2
3	2.095	1.966	1.912	2.310	1.902	2.069	2.826	2.535	2.603	1.753			3
4	2.082	1.968	1.917	2.311	1.873	2.266	2.695	2.465	2.535	1.747			4
5	2.062	1.964	1.920	2.302	1.852	2.511	2.637	2.426	2.488	1.736			5
6	2.042	1.960	1.915	2.286	1.827	2.577	2.639	2.372	2.428	1.736			6
7	2.027	1.960	1.914	2.257	1.799	2.554	2.765	2.325	2.376	1.726			7
8	2.019	1.968	1.909	2.286	1.758	2.543	3.410	2.311	2.323	1.714			8
9	2.005	1.976	1.917	2.314	1.732	2.570	3.643	2.422	2.281	1.707			9
10	1.983	1.972	1.923	2.341	1.717	2.668	3.542	2.717	2.247	1.692			10
11	1.966	1.976	1.922	2.345	1.698	2.835	3.468	3.126	2.211	1.677			11
12	1.946	1.977	1.913	2.368	1.704	2.925	3.351	4.172	2.178	1.668			12
13	1.931	1.974	1.907	2.385	1.714	2.792	3.206	4.697	2.184	1.657			13
14	1.920	1.968	1.904	2.417	1.717	2.721	3.092	4.495	2.180	1.651			14
15	1.921	1.965	1.900	2.434	1.732	2.663	3.023	4.326	2.164	1.640			15
16	1.928	1.967	1.907	2.447	1.741	2.597	2.979	4.163	2.125	1.660			16
17	1.926	1.942	1.911	2.452	1.760	2.562	2.888	4.044	2.093	1.668			17
18	1.928	1.923	1.914	2.499	1.799	2.556	2.764	3.918	2.062	1.693			18
19	1.935	1.931	1.936	2.539	1.964	2.564	2.648	3.795	2.044	1.703			19
20	1.934	1.936	1.947	2.711	2.132	2.542	2.571	3.677	2.027	1.713			20
21	1.930	1.940	1.949	2.843	2.206	2.531	2.505	3.553	1.987	1.713			21
22	1.937	1.933	1.972	2.913	2.200	2.580	2.450	3.439	1.965	1.704			22
23	1.948	1.922	2.001	2.909	2.221	2.648	2.403	3.340	1.943	1.701			23
24	1.956	1.915	2.031	2.680	2.223	2.751	2.382	3.270	1.915	1.721			24
25	1.960	1.909	2.055	2.545	2.171	3.262	2.379	3.187	1.891	1.751			25
26	1.962	1.900	2.107	2.317	2.113	3.641	2.375	3.094	1.879	1.763			26
27	1.966	1.898	2.141	2.250	2.072	3.512	2.440	3.020	1.856	1.759			27
28	1.967	1.900	2.164	2.133	2.032	3.411	2.488	2.966	1.822	1.747			28
29	1.970		2.179	2.016	2.022	3.327	2.475	2.941	1.793				29
30	1.975		2.197	2.022	2.025	3.220	2.489	2.899	1.779				30
31	1.975		2.211		2.043		2.473	2.841					31
TOTAL	61.401	54.559	61.311	72.131	59.601	81.495	87.078	99.572	64.800				TOTAL
MEAN	1.981	1.949	1.978	2.404	1.923	2.717	2.809	3.212	2.160				MEAN
MAX	2.104	1.977	2.211	2.913	2.223	3.641	3.643	4.697	2.730				MAX
MIN	1.920	1.898	1.900	2.016	1.698	2.042	2.375	2.311	1.779				MIN

SUMMARY FOR THE YEAR 1995 (INCOMPLETE YEAR, SUMMARY DATA MAY NOT BE VALID)

MAXIMUM DAILY WATER LEVEL, 4.697 METRES ON AUG 13
MINIMUM DAILY WATER LEVEL, 1.640 METRES ON OCT 15

MAXIMUM INSTANTANEOUS WATER LEVEL, ? 4.734 METRES AT 08:34 MST ON AUG 13

WATER LEVELS ARE REFERRED TO AN ASSUMED DATUM
ADD 235.821 METRES TO CONVERT TO APPROX. GEODETIC SURVEY OF CANADA

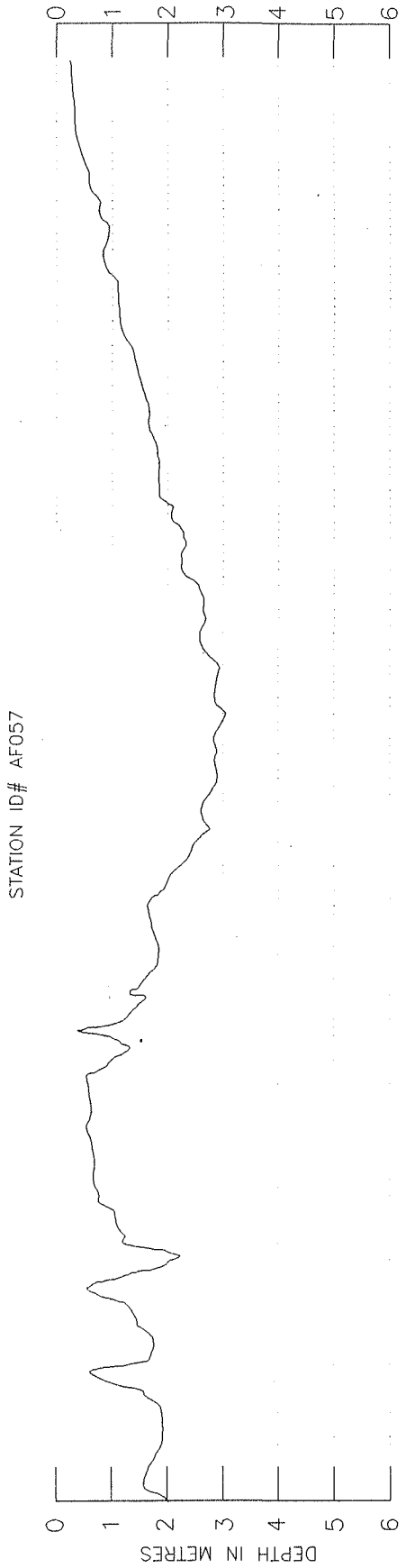
301 DAY(S) WITH DATA
0 DAY(S) WITH ICE
0 DAY(S) MANUAL DATA
0 DAY(S) ESTIMATED
64 DAY(S) WITH NO DATA

APPENDIX XI

HABITAT TRANSECT OF PROPOSED BRIDGE CORSSING, SPRING, 1995

Habitat Transect of
Proposed Bridge Crossing
Spring 1995

Figure XI-1



PROJECT 952-2308 DRAWN MOH/CG REVIEWED _____ DATE 01 APR 96 \2308\AF057

Golder Associates

APPENDIX XII

STREAM CATALOGUE FOR THE MUSKEG RIVER AND ITS TRIBUTARIES, SPRING AND SUMMER, 1995

1.0 INTRODUCTION

This stream catalogue provides a summary of habitat and fisheries information for watercourses in the Muskeg River watershed and Kearl Lake. The data was collected by Golder Associates as part of the Syncrude Aquatic Baseline Environmental Study. Eight stream sites were sampled in May, 1995, six of which had been previously sampled by Beak (1986) and R.L.&L. (1989) as part of the OSLO study. An additional two stream sites (a previous site on Iyinimin Creek and a new site on Blackfly Creek) and Kearl Lake were examined in August. To allow comparisons of the data, the format of this stream catalogue is based on the format used by R.L.&L. (1989) and Beak (1986). Two additional pieces of information have been added: UTM coordinates that were recorded by a Geo Explored GPS unit and site access (i.e. road, helicopter etc.).

Fish species are recorded using abbreviations as recommended by Alberta Fish and Wildlife division. The four letter fish code, and the scientific and common names of fish found in this study are presented in Table 1.

Common Name	Species Code	Scientific Name
Arctic grayling	ARGR	*Thymallus articus*
northern pike	NRPK	*Esox lucius*
walleye	WALL	*Stizostedion vitreum*
burbot	BURB	*Lota lota*
trout-perch	TRPR	*Percopsis omiscmaycus*
slimy sculpin	SLSC	*Cottus cognatus*
fathead minnow	FTMN	*Pimphales promelas*
white sucker	WHSC	*Catastomus commersoni*
longnose sucker	LNSC	*Catastomus catastomus*
pearl dace	PRDC	*Semotilus margarita*
brook stickleback	BRST	*Culea inconstans*

Table 1: List of fish species codes, common and scientific names

2.0 GLOSSARY

The following is a glossary of terms and parameters that are used in the stream catalogue:

average depth — average depth of pools, riffles, and runs based on measurements taken in 1-3 transects within the 50 meter stream section

average wet width — average width of the water surface based on 3 to 6 transects

bank — The rising ground bordering a stream channel below the level of rooted terrestrial vegetation and above the normal stream bed. The left and right banks are defined looking upstream.

bank coverage — Vegetation along the edge of the stream within the influence of the groundwater table associated with the stream (i.e. riparian vegetation). Riparian vegetation is arbitrarily divided into tree canopy (coniferous

	and deciduous trees), understory (shrubs) and ground (mosses, grasses etc.)	
bank form	The range of bank forms is separated into four classes:	
	flat	The stream bed slopes gently to the beginning of rooted vegetation, frequently with overlapping bar deposits.
	repose	The bank is eroded at high water levels, but is at the angle of repose of the unconsolidated material (usually 34-37°).
	steep	The bank is nearly vertical, due to consolidation by cementation, compaction, root structure or some other agent.
	undercut	The bank has an undercut structure caused by erosion
bank stability	failing	Active erosion and slumping is taking place
	stable	The bank is of rock, has very high root density or is otherwise protected from or not subject to active erosion
	aggrading	Continuous sediment deposition is taking place, causing the river channel to migrate away from the river bank
channel cover	The vegetation which projects over the channel width of a stream and material which is in the stream. It is recorded as the percent of the channel width covered within a 50 m section of the stream at each site. Channel cover is arbitrarily divided into three levels:	
	crown	vegetation greater than 1 m above the water surface
	overhanging	vegetation less than 1 m above the water surface
	instream	material (debris, stumps, fallen trees etc.) in the stream that can provide cover for fish.
conductivity	Recorded in the field using a YSI TLC conductivity meter	
dissolved oxygen	Recorded in the field using a YSI 57 dissolved oxygen meter	
elevation	Determined to the nearest 10 m using 1:50,000 scale NTS maps	
fish species	Fish were captured using a backpack electroshocker, a portable boat shocker or minnow traps (Kearl Lake only). Fish species caught by each method are listed using letter codes. "No captures" for a	

particular method denotes than an attempt was made to catch fish by that method but none were captured.

flow character

The surface expression of the water, described as follows:

placid	tranquil, sluggish
swirling	eddies, boils, swirls
rolling	unbroken wave forms are numerous
broken	standing waves are broken, rapids
tumbling	cascades, usually over large boulders or rock outcrops

maximum depth

The maximum depth of the 50 meter section of stream recorded for each pool, riffle and run.

pH

Recorded in the field using an Omega 25 model pH meter.

pool:run:riffle ratio

The ratio of pool:run:riffle based on the percentage of each stream type in the 50 m section of stream . These habitat types are described as follows:

pool	a deep area of low current velocity relative to the main current
run	a moderately deep area within the main current
riffle	a shallow area where the water surface is broken into waves by bed material

site

Sites are numbered as per R.L.&L. (1989) except site 30, 55 and 60 which are new sites. See Figure 1.2-3 for locations of sites.

substrate

Material in the stream bed. The assemblage of sizes of material are described as follows:

organic/silt	organic material and/or fine sediment < 0.06 mm
sand	0.06 to 2.0 mm
small gravel	2 to 8 mm
large gravel	8 to 32 mm
pebble	32 to 64 mm
cobble	64 to 256 mm
boulder	> 256 mm

temperature

Recorded using a mercury pocket thermometer to the nearest degree Celsius.

WATERBODY

Muskeg River Site 30

Grid Reference NTS 74 E/4 Elevation (m) 250

Date Habitat - May 8/1995 U.T.M 12VVU (466550 6338750)*
Fish Inventory - May 8/1995

Access accessible by road; Highway 63 at bridge over Athabasca River

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	12.5		
maximum depth (cm)	pool: -	run: 65	riffle: 88
average depth (cm)	pool: -	run: 29	riffle: 33
flow characteristics	rolling		
pool:run:riffle ratio	0:2:4		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
5	10	5	30	40	10	

Bank

form repose, some undercutting

stability agrading,

Stream Discharge

1.59 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	white spruce
understory	willows
ground	grasses

Channel Cover (%)

crown	5
overhanging	5
instream	5

WATER QUALITY

temperature	11° C
dissolved oxygen	11.2 mg/L
conductivity	231 µs @25 °C
pH	8.24

BIOTA

Aquatic Macrophytes none

Fish Species

electroshock BURB, LNSC, FTMN, SLSC

observed

COMMENTS

* map UTM

WATERBODY

Jackpine Creek Site S-4

Grid Reference NTS 74 E/3 Elevation (m) 310

Date Habitat - May 18/1995 U.T.M 12VVU (475300 6343850)*
Fish inventory - May 20/1995

Access accessible by Canterra Rd.

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	9.7		
maximum depth (cm)	pool: -	run: 91	riffle: 28
average depth (cm)	pool: -	run: 32	riffle: 18
flow characteristics	swirling, rolling at riffles		
pool:run:riffle ratio	1:2:2		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
25				5	40	30

Bank

form	flat, some undercutting
stability	stable, failing in undercut areas

Stream Discharge
0.39 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	white spruce
understory	willows
ground	grasses

Channel Cover (%)

crown	20
overhanging	60
instream	50

WATER QUALITY

temperature	10° C
dissolved oxygen	9.9 mg/L
conductivity	188 µs @25 °C
pH	7.83

BIOTA

Aquatic Macrophytes none

Fish Species

electroshock SLSC, LNSC, FTMN

observed

COMMENTS

This site has good arctic grayling habitat although none were found.
About 50 m upstream of the site there is a large beaver dam that appears to be impassable to large fish.
* map UTM

WATERBODY

North Muskeg Creek Site 9

Grid Reference NTS 74 E/6 Elevation (m) 330

Date May 19, 1995 U.T.M 12VVU (484077 6346815)
Fish: May 20, 1995

Access accessible by Canterra Road, then south on road west of Kearl Lake

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	5.4		
maximum depth (cm)	pool: 34	run: 34	riffle:
average depth (cm)	pool: 18	run: 17	riffle:
flow characteristics	placid		
pool:run:riffle ratio	1:4:0		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
90				5	5	

Bank

form	steep, some undercutting
stability	stable

Stream Discharge
0 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	
understory	willows
ground	grasses, *Typha latifolia*

Channel Cover (%)

crown	15
overhanging	25
instream	20

WATER QUALITY

temperature	9° C
dissolved oxygen	10.0 mg/L
conductivity	120 µs @25 °C
pH	7.64

BIOTA

Aquatic Macrophytes *Typha latifolia, Myriophyllum exalbescens*

Fish Species

electroshock observed BRST, FTMN, PRDC, SLSC, LNSC

COMMENTS

There are two large beaver dams downstream of the site that are visible on 1:40,000 air photo (air photo 74E, 57:15).

WATERBODY

Muskeg River Site 18

Grid Reference NTS 74 E/6 Elevation (m) 279

Date May 21, 1995 U.T.M 12VVU (469971 6345620)*

Access accessible by Canterra Rd. (north at fork just west of Muskeg River crossing)

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	14.6		
maximum depth (cm)	pool: -	run: 240	riffle: 88
average depth (cm)	pool: -	run: 160	riffle: 29
flow characteristics	placid, rolling at riffle		
pool:run:riffle ratio	0:1:5		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
85					10	5

Bank

form	repose, some undercutting
stability	failing

Stream Discharge

3.25 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	white spruce
understory	willows
ground	grasses

Channel Cover (%)

crown	50
overhanging	10
instream	15

WATER QUALITY

temperature	10° C
dissolved oxygen	10.2 mg/L
conductivity	277 µs @25 °C
pH	7.29

BIOTA

Aquatic Macrophytes none

Fish Species
electroshock WHSC, LNSC, ARGR,
observed

COMMENTS

The habitat was mainly placid, deep runs but there were some riffles
* map UTM

WATERBODY

Jackpine Creek Site 17

Grid Reference NTS 74 E/6 Elevation (m) 279

Date May 22, 1995 U.T.M 12VVU (476440 6350971)

Access By road to Alsands test pit (with permission from Shell Canada) and zodiac or by helicopter

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	6.6		
maximum depth (cm)	pool: -	run: 92	riffle: -
average depth (cm)	pool: -	run: 66	riffle: -
flow characteristics	placid		
pool:run:riffle ratio	1:0:1		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
85	2				8	5

Bank

form	steep, some undercutting
stability	stable, eroding in undercut areas

Stream Discharge

0.67 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	white spruce
understory	willow, red osier dogwood
ground	

Channel Cover (%)

crown	70
overhanging	65
instream	65

WATER QUALITY

temperature	11° C
dissolved oxygen	9.9 mg/L
conductivity	226 µs @25 °C
pH	7.96

BIOTA

Aquatic Macrophytes none

Fish Species

electroshock	SLSC, LNSC, FTMN
observed	WHSC

COMMENTS

Many beaver dams in the area both upstream and downstream of the site.

WATERBODY

Khahago Creek Site 14

Grid Reference NTS 74 E/3 Elevation (m) 330

Date May 27, 1995 U.T.M 12VVU (480435 6342156)

Access Helicopter

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	~ 10		
maximum depth (cm)	pool: -	run:>165	riffle: -
average depth (cm)	pool: -	run: ~ 150	riffle: -
flow characteristics	placid		
pool:run:riffle ratio	0:1:0		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
100						

Bank

form	steep, some undercutting
stability	stable, eroding in undercut areas

RIPARIAN VEGETATION

Bank Coverage

tree canopy	
understory	
ground	

Channel Cover (%)

crown	10
overhanging	10
instream	80

WATER QUALITY

temperature	12° C
dissolved oxygen	9.4 mg/L
conductivity	156 µs @25 °C
pH	6.3

BIOTA

Aquatic Macrophytes *Sagittaria cuneata*

Fish Species
electroshock
observed

COMMENTS

Water was too deep for backpack electroshocking and habitat transects. Flow was almost non-existent, probably due to beaver activity. An old beaver lodge was present on the bank.

WATERBODY

Muskeg River Site 4

Grid Reference NTS 74 E/6 Elevation (m) 290

Date May 28, 1995 U.T.M 12VVU (476194 6351411)*

Access Helicopter

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	~ 15		
maximum depth (cm)	pool: -	run:>100	riffle: -
average depth (cm)	pool: -	run: -	riffle: -
flow characteristics	placid		
pool:run:riffle ratio	0:1:0		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
100						

Bank

form	moderately steep, some undercutting
stability	slumping, failing in undercut areas

RIPARIAN VEGETATION

Bank Coverage

tree canopy	
understory	willows
ground	grasses

Channel Cover (%)

crown	5
overhanging	15
instream	10

WATER QUALITY

temperature	15° C
dissolved oxygen	6.9 mg/L
conductivity	295 µs @25 °C
pH	7.68

BIOTA

Aquatic Macrophytes none

Fish Species
electroshock
observed NRPK

COMMENTS

Water was too deep for backpack electroshocking and habitat transects. Flow was almost non-existent due to beaver dam downstream of site. Lots of beaver activity in area.
*map UTM

WATERBODY

Stanley Creek Site 60

Grid Reference NTS 74 E/6 Elevation (m) 290

Date May 28, 1995 U.T.M 12VVU (478876 6355856)

Access Helicopter

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	14		
maximum depth (cm)	pool: 64	run:	riffle: -
average depth (cm)	pool: 62	run:	riffle: -
flow characteristics	placid		
pool:run:riffle ratio	0:1:0		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
100						

Bank

form steep, some undercutting

stability stable

Stream Discharge

0.10 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	
understory	willows
ground	grasses

Channel Cover (%)

crown	0
overhanging	5
instream	10

WATER QUALITY

temperature	8° C
dissolved oxygen	7.8 mg/L
conductivity	229 µs @25 °C
pH	7.28

BIOTA

Aquatic Macrophytes *Myriophyllum exalbescens*

Fish Species
electroshock
observed BRST

COMMENTS

Channel is braided with numerous grassy islands. Water is essentially stagnant.

WATERBODY

Blackfly Creek Site 55

Grid Reference NTS 74 E/6 Elevation (m)

Date August 11/1995 U.T.M 12VVU (484413 6340135)

Access Helicopter

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	5.7		
maximum depth (cm)	pool: -	run: 98	riffle: -
average depth (cm)	pool: -	run: 70	riffle: -
flow characteristics	placid, broken in riffles		
pool:run:riffle ratio	0:5:1		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
	90	5			5	

Bank

form steep, moderate undercutting

stability stable, failing where undercut

Stream Discharge

1.65 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	white spruce
understory	alder
ground	grasses

Channel Cover (%)

crown	35
overhanging	30
instream	15

WATER QUALITY

temperature	11° C
dissolved oxygen	10.9 mg/L
conductivity	193 µm/cm
pH	6.79

BIOTA

Aquatic Macrophytes none

Fish Species

electroshock	BRST
observed	BRST

COMMENTS

WATERBODY

Iyinimin Creek Site 8

Grid Reference NTS 74 E/6 Elevation (m) 460

Date August 16/1995 U.T.M 12VVU (489380 6345017)

Access Helicopter

PHYSICAL CHARACTERISTICS

Hydraulics

average wet width (m)	5.4		
maximum depth (cm)	pool: -	run: 83	riffle: -
average depth (cm)	pool: -	run: 51	riffle: -
flow characteristics	placid		
pool:run:riffle ratio	1:5:1		

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
	100					

Bank

form	steep, some undercutting
stability	stable, slumping where undercut

Stream Discharge

3.80 m^3/s

RIPARIAN VEGETATION

Bank Coverage

tree canopy	white spruce, balsam fir
understory	alder
ground	grasses, ferns

Channel Cover (%)

crown	70
overhanging	50
instream	15

WATER QUALITY

temperature	9 ° C
dissolved oxygen	13.2 mg/L
conductivity	119 µm/cm
pH	7.29

BIOTA

Aquatic Macrophytes none

Fish Species

electroshock none captured
observed

COMMENTS

Lots of sand deposits and high stream discharges. In fall, where flows were lower, gravel deposits were evident.

WATERBODY

Kearl Lake Site 80

Grid Reference NTS 74 E/6 Elevation (m) 300

Date August 13, 1995 UTM (N/A)

Access By Cantera Road

PHYSICAL CHARACTERISTICS

Hydraulics

perimeter (km)	23.7
surface area (km^2)	5.3
maximum depth (m)	2.5
average depth (m)	1.4

Substrate Composition (%)

organics/silt	sand	sm. gravel	lg. gravel	pebble	cobble	boulder
100						

RIPARIAN VEGETATION

Bank Coverage

tree canopy	spruce, birch, poplar
understory	willows
ground	sedge

WATER QUALITY

temperature	16.5° C
dissolved oxygen	9.0 mg/L
conductivity	167 @ 25° C
pH	7.0

BIOTA

Aquatic Macrophytes — *Typha latifolia, Scirpus* spp., *Potamogeton rishardsoni, Potamogetan natans, Nuphar variegatum, Myriophyllum exalbescens, Ceratopylum demersum, Lemna* sp.

Fish Species

electroshock	WHSC
minnow trap	FTMN, PRDC, BRST
observed	

COMMENTS

Hydraulics data from December 1989 R.L & L. Environmental Services Ltd OSLO Project Report

APPENDIX XIII

FISH HEALTH DATA

Suncor Fish Data

HydroQual Laboratories Ltd.

#3, 6125 - 12 Street S.E. Calgary, Alberta Canada T2H 2K1
TEL: (403) 253-7121 FAX: (403) 252-9363 1-800-808-6942

TRANSMITTAL

DATE: Tuesday, October 17, 1995

FROM: J. Stephen Goudey, Ph.D., P.Biol.
GENERAL MANAGER

TO: Kym Holley
Golder Associates Ltd.

TEL: (403) 299-5600
FAX: (403) 299-5606

TEL: (403) 253-7121
FAX: (403) 252-9363

I have attached the lactate analyses on the serum samples submitted to HydroQual. I've also included data on glucose and protein at no additional charge. We are analyzing all three serum parameters in the Suncor Fish Health Study. The coefficent of variations for each of the parameters analyzed is less than 5%.

ENTERED ... COMPUTER
16 NOV 95

↑
now called
HLTH-WORK.WQ5
20 NOV 95

Blood Serum Analysis

	Fish	Date Collected	Time Collected	Glucose (mg/dL)	Protien (g/dL)	Lactate (mg/dL)
A	SUN95UWALLAF004T027a2	95/08/10	1501	164	2.7	84
B	SUN95UGOLDAF002T028a2	95/07/30	1809	100	3.2	139
C	SUN95UGOLDAF005T017a2	95/07/30	1549	89	3.8	122
D	SUN95UGOLDAF041T001a2	95/07/31	1529	93	3.4	109
E	SUN95UGOLDAF041T003a2	95/07/31	1555	139	3.3	156
F	SUN95UWALLAF004T010a2	95/07/31	1110	214	3.9	74
G	SUN95UWALLAF005T014a2	95/07/30	1507	104	4.1	73
H	SUN95UGOLDAF005T016a2	95/07/30	1537	94	3.0	95
I	SUN95UGOLDAF019T002a2	95/08/01	1108	132	3.4	120
J	SUN95UWALLAF003T005a2	95/08/01	1707	353	4.0	70
K	SUN95UWALLAF004T026a2	95/08/10	1032	141	4.4	49
L	SUN95UWALLAF003T004a2	95/08/01	1658	338	2.5	73
M	SUN95UWALLAF004T012a2	95/07/31	1142	277	3.9	62
N	SUN95UWALLAF004T011a2	95/07/31	1124	145	3.7	67

FAXED

Tracy Marchant
University of Saskatchewan

	Code	Testosterone	Estradiol
1	AF002T029	*<200	*<80
2	AF002T030	250	*<80
3	AF002T031	*<200	178
4	AF002T032	*<200	*<80
5	AF002T033	342	*<80
6	AF003T001	*<200	579
7	AF003T002	230	175
8	AF003T003	*<200	128
9	AF003T004	*<200	*<80
10	AF003T006	800	*<80
11	AF003T007	*<200	*<80
12	AF003T008	*<200	*<80
13	AF003T009	792	*<80
14	AF004T013	*<200	98
15	AF004T014	226	758
16	AF004T015	664	*<80
17	AF004T016	628	*<80
18	AF004T017	1132	136
19	AF004T018	832	*<80
20	AF004T019	*<200	*<80
21	AF004T020	*<200	1437
22	AF004T021	296	146
23	AF004T022	247	221
24	AF004T023	1300	*<80
25	AF004T024	648	*<80
26	AF004T025	1048	*<80
27	AF004T026	416	5824
28	AF004T027	*<200	116
29	AF004T028	*<200	173
30	AF004T029	*<200	259
31	AF004T030	*<200	1558
32	AF004T031	396	159
33	AF004T032	308	2791
34	AF005T015	*<200	152
35	AF005T018	238	1643
36	AF006T004	604	102
37	AF006T005	512	143
38	AF006T006	n.a.	96.8
39	AF005T007	*<200	192
40	AF006T008	*<200	100

AF006T006 768 pg/mL

	Code	Testosterone	Estradiol
41	AF018T001	*<200	*<80
42	AF019T001	*<200	180
43	AF019T003	270	94
44	AF019T004	*<200	*<80
45	AF019T005	*<200	158
46	AF020T001	*<200	83
47	AF020T002	*<200	*<80
48	AF033T001	*<200	191
49	AF033T002	281	178
50	AF033T003	*<200	208
51	AF033T004	*<200	205
52	AF033T005	209	876
53	AF033T006	504	156
54	AF033T007	1196	*<80
55	AF033T008	*<200	126
56	AF036T001	920	168
57	AF036T002	640	146
58	AF036T003	492	164
59	AF036T004	*<200	*<80
60	AF036T005	*<200	87
61	AF036T006	840	133
62	AF036T007	*<200	131
63	AF036T008	*<200	186
64	AF041T002	283	205
65	AF042T001	*<200	186
66	AF042T002	*<200	372

Fisheries and Oceans / Pêches et Océans

Sender's Address
Department of Fisheries & Oceans
501 University Crescent
Winnipeg, Manitoba R3T 2N6
FAX: 204-984-6587

Page 1 of/de 4

Date: Jan 10/95

TO/A:

Name / Nom	Stella Swanson
Organization/Company / Organisation/Compagnie	Golder Assoc.
Telephone Number / Numéro de téléphone	~~403 299-2301~~ (403) 299-4607
Facsimile Number / Numéro de téléphone	(403) -299-5606

MESSAGE

Analyses as requested

FROM/DE:

Name / Nom	Jean Brown
Telephone Number / Numéro de téléphone	(204) 983-5009

GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Page 1 of 1

Field Sampler: (Signature)
Kym Holley / Lynda Gummer
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier:
Weigh Bill No.:

Ship To: FRESHWATER INSTITUTE
501 University Crescent
Winnipeg, Manitoba
R3T 2N6
ATTN: SCOTT BROWN

Send Results To: STELLA SWANSON
GOLDER ASSOC. LTD
1011 - 6TH AVE SW
CALGARY, AB
T2P 0W1

Project Name: SUNCOR - NEW MINE EIA

Project No. 952-2307
Phone No.: 1-403-299-5606

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested
SUN95U GOLD AF003T007 b2	FISH LIVER	07 AUG95 1528	RETINOL
SUN95U WALL AF003T001 b2	FISH LIVER	30 JUL95 1218	
SUN95U WALL AF003T004 b2	FISH LIVER	01 AUG95 1658	
SUN95U WALL AF004T012 b2	FISH LIVER	31 JUL95 1142	
SUN95U GOLD AF004T013 b2	FISH LIVER	31 JUL95 1152	
SUN95U WALL AF004T014 b2	FISH LIVER	06 AUG95 1401	
SUN95U GOLD AF004T015 b2	FISH LIVER	06 AUG95 1410	
SUN95U GOLD AF004T016 b2	FISH LIVER	06 AUG95 1420	
SUN95U GOLD AF004T023 b2	FISH LIVER	10 AUG95 1000	
SUN95U WALL AF033T004 b2	FISH LIVER	04 AUG95 1122	
SUN95U WALL AF033T008 b2	FISH LIVER	11 AUG95 1052	
SUN95U GOLD AF036T004 b2	FISH LIVER	03 AUG95 1138	
SUN95U WALL AF004T027 b2	Fish Liver	10 AUG95 1501	
SUN95U WALL AF004T029 b2	Fish liver	10 AUG95 1519	
SUN95U WALL AF005T015 b2	Fish liver	30 JUL95 1523	
SUN95U GOLD AF006T006 b2	Fish liver	02 AUG95 1336	

Special Instructions/Comments:

Rush (surcharge):

Standard Turnaround Time: X

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January 10, 1996

To: Stella Swanson
Golder Assoc. Ltd

From: Scott Brown
Department of Fisheries & Oceans
Freshwater Institute
Winnipeg, MB

Dear Stella,

First, I apologize for the delay in getting this to you. My lab has been very busy and we have not been routinely running vitamin A compounds for the last several months.

To follow is data about retinoids in livers of goldeye and walleye. Both species have didehydroretinoids as their major source of vitamin A compounds. Unfortunately we have no standard for the major didehydroretinyl peak. We know that it is a didehyroretinyl ester based on its characteristic UV absorbance spectra and different absorption/fluoresence characteristics. Just to give you some sort of number on which to base comparisons I have quantified it using the retinyl palmitate standard curve. Retinyl palmitate is low in these fish and consistent with values found in other species from polluted areas or experimentally exposed to organochlorine contaminants. However, this may not be the correct interpretation for this data because the didehydroretinoids can also support the various vitamin A roles in vision/growth etc.. Didehydroretinoids are quite high in these fish. Astaxanthin is very high in Goldeye and we need to rerun the samples at lower dilution to get the peaks to integrate. Carotinoids (Astaxanthin ,Canthaxanthin and ß-Carotine) are pro-vitamin A compounds that are detectable in Goldeye but not Walleye. There is a range values and correlates with measures of MFO and contaminants need to be done. There can also be sex differences and differences with respect to state of maturity. With some the ancillary information I can provide a better overview. If required, I can provide you with example chromatograms, etc. Please contact me if you wish further information.

Sincerely,

Scott Brown, PhD

cc: Lyle Lockhart

Golder Assoc
Ltd.
Goldeye and
Walleye
Retinoids

SAMPLE #	SPECIES	Didehydroretinol (ug/gram)	Major Didehydroretinyl Ester (calc as ret.palm) (ug/gram)	Retinol (ug/gram)	Retinyl Palmitate (ug/gram)	Astaxanthin (ug/gram)	Canthaxanthin (ug/gram)	ß-Carotine (ug/gram)
AF003T007	GOLDEYE	12.74	131.92	0.74	15.88OVER*		0.54	4.66
AF004T013	GOLDEYE	47.35	210.64	1.46	21.07OVER*		1.41	2.79
AF004T015	GOLDEYE	20.19	159.35	0.79	19.81OVER*		0.59	0.52
AF004T016	GOLDEYE	23.17	146.65	0.51	16.45OVER*		4.41	4.05
AF004T023	GOLDEYE	9.22	275.06	0.94	27.49OVER*		0.85	0.58
AF036T004	GOLDEYE	96.82	175.47	0.28	8.37OVER*		0.08	1.48
AF006T006	GOLDEYE	70.72	236.06	1.36	21.68OVER*		4.45	7.33
	OVER*	Integrators off-scale samples need to be rerun at higher dilution						
AF003T001	WALLEYE	3.10	232.52	0.04	6.64	0.06	0.05	0.05
AF003T004	WALLEYE	13.93	657.42	0.09	12.86	0.06	0.05	0.05
AF004T012	WALLEYE	5.19	378.56	0.08	15.20	0.06	0.05	0.05
AF004T014	WALLEYE	7.87	427.62	0.23	33.59	0.06	0.05	0.05
AF004T027	WALLEYE	2.81	392.76	0.10	33.39	0.06	0.05	0.05
AF004T029	WALLEYE	62.23	836.63	0.49	22.13	0.06	0.05	0.05
AF033T004	WALLEYE	4.32	303.52	0.05	9.33	0.06	0.05	0.05
AF033T008	WALLEYE	14.87	157.33	0.17	3.78	0.06	0.05	0.05
AF005T015	WALLEYE	2.36	177.45	0.05	5.55	0.06	0.05	0.05
Detecton Limit		0.01	0.08	0.01	0.03	0.06	0.05	0.05

ETL Enviro-Test

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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: November 30, 1995

ATTN: STELLA SWANSON

Lab Work Order #: E510325 **Sampled By:** CLIENT

Project Reference: 952-2307 **Date Received:** 10/13/95

Project P.O.#: NOT SUBMITTED

Comments:

Note that the 2-fluorobiphenyl recovery is low due to fractionation - this does not effect the PAH results.

APPROVED BY:

Doug Johnson
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510325-02	SUN95UWALLAF868T001							
Sample Type:WHOLE_FISH								
		Arsenic (As)	<0.5	0.5	mg/kg		11/17/95	TW
		PAH & Alkylated PAH (Fish)						
		Naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Carbazole	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Selenium (Se)	<0.5	0.5	mg/kg		11/20/95	TW
		ICP Metals in Tissue						
		Silver (Ag)	<0.2	0.2	mg/kg		11/09/95	TW
		Aluminum (Al)	<2	2	mg/kg		11/09/95	TW
		Barium (Ba)	<0.5	0.5	mg/kg		11/09/95	TW
		Beryllium (Be)	<0.5	0.5	mg/kg		11/09/95	TW
		Boron (B)	<5	5	mg/kg		11/09/95	TW
		Calcium (Ca)	277	10	mg/kg		11/09/95	TW
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/09/95	TW
		Cobalt (Co)	<0.5	0.5	mg/kg		11/09/95	TW
		Chromium (Cr)	<0.5	0.5	mg/kg		11/09/95	TW
		Copper (Cu)	<1	1	mg/kg		11/09/95	TW
		Iron (Fe)	12	1	mg/kg		11/09/95	TW
		Potassium (K)	4640	10	mg/kg		11/09/95	TW
		Magnesium (Mg)	321	10	mg/kg		11/09/95	TW
		Manganese (Mn)	1.2	0.5	mg/kg		11/09/95	TW
		Molybdenum (Mo)	<1	1	mg/kg		11/09/95	TW
		Sodium (Na)	440	50	mg/kg		11/09/95	TW
		Nickel (Ni)	<1	1	mg/kg		11/09/95	TW
		Lead (Pb)	<2	2	mg/kg		11/09/95	TW
		Phosphorus (P)	2800	10	mg/kg		11/09/95	TW
		Silicon (Si)	4	2	mg/kg		11/09/95	TW
		Tin (Sn)	<2	2	mg/kg		11/09/95	TW
		Strontium (Sr)	<0.5	0.5	mg/kg		11/09/95	TW

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510325-02	SUN95UWALLAF868T001							
Sample Type:WHOLE_FISH								
		ICP Metals in Tissue						
		Thallium (Tl)	<1	1	mg/kg		11/09/95	TW
		Vanadium (V)	<1	1	mg/kg		11/09/95	TW
		Zinc (Zn)	9	1	mg/kg		11/09/95	

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

ENVIRO-TEST QA/QC REPORT

PAH & Alkylated PAH (Fish)

Surrogate Recovery for E51032502C	%
Nitrobenzene d5	64
2-Fluorobiphenyl	26
p-Terphenyl d14	97

PANH & Alkylated PANH's

Surrogate Recovery for E51032502C	%
Quinoline d7	80

Relative percent difference is expressed as RPD.
Percent Recovery is expressed as %.
THIS IS THE LAST PAGE OF THE QAQC REPORT

Appendix A Test Methodologies

Acid Digestion

Method: Open vessel digest with nitric acid and peroxide
Reference: EPA/600 4-91 Method 200.3

Arsenic (As)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

PAH & Alkylated PAH (Fish)

Preparation Method:	Soxhlet extraction with DCM.
Instrument Method:	GC/MSD analysis
Method Reference:	Extraction Method: EPA 3540 (modified) Analytical Method: EPA 8270 (modified)

PANH & Alkylated PANH's

Selenium (Se)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

Hydride Metals Preparation

Preparation: Digestion with permanganate/persulphate, nitric, and sulphuric acid
Addition of hydrochloric acid and cysteine prior to analysis.
Reference: US EPA SW 846, APHA 3114

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

Proj · 952-2307/[illegible]

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) LYNDA GUMMER / KYM HOLLEY
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier: Canadian Air Cargo
Weigh Bill No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SUN95UWALL AF004T027e2	FISH FILLET	10AUG95 1501	ICP METALS, AS, SE	Seal intact
SUN95UWALL AF004T031e2	FISH FILLET	11AUG95 1505	↓	↓
SUN95UWALL AF006T007e2	FISH FILLET	02AUG95 1346	↓	↓
SUN95UWALL AF019T005e2	FISH FILLET	08AUG95 1105	↓	↓
SUN95UWALL AF033T002e2	FISH FILLET	04AUG95 1108	↓	↓
SUN95UWALL AF036T007e2	FISH FILLET	03AUG95 1549	↓	↓
SUN95UWALL AF036T008e2	FISH FILLET	07AUG95 1230	↓	↓
SUN95UWALL AF041T002e2	FISH FILLET	31JUL95 1546	↓	↓
SUN95UWALL AF003T001e2	FISH FILLET	30JUL95 1218	↓	↓
SUN95UWALL AF004T014e2	FISH FILLET	06AUG95 1401	↓	↓
SUN95UWALL AF004T020e2	FISH FILLET	08AUG95 1509	↓	↓
SUN95UWALL AF004T026e2	FISH FILLET	10AUG95 1032	↓	↓
SUN95UWALL AF004T030e2	FISH FILLET	11AUG95 1455	↓	↓
SUN95UWALL AF005T018e2	FISH FILLET	07AUG95 1241	↓	↓
SUN95UWALL AF033T003e2	FISH FILLET	04AUG95 1114	↓	↓
SUN95UWALL AF033T005e2	FISH FILLET	05AUG95 1345	↓	↓
SUN95UWALL AF033T008e2	FISH FILLET	11AUG95 1052	↓	↓
SUN95UWALL AF042T002e2	FISH FILLET	11AUG95 1109	↓	↓
SUN95UWALL AF868T001	WHOLE FISH		ONE FILLET: PAH, PANH, ALKYLPAH; ONE FILLET: ICP METALS, AS, SE	↓ [illegible]

Margin notes: SUN95U WALL COMP 4 (continued); SUN95UWALL COMP 5 512325-01A, 01B; not part of composite →; ICP ITI, AST 251, SET 25, VAP 251

Special Instructions/Comments:

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Unit F - 1420 Clarence Avenue, Winnipeg, Manitoba R3T 1T6 Telephone: (204) 452-8104 Fax: (204) 477-8719

CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: November 30, 1995

ATTN: STELLA SWANSON

Lab Work Order #:	E510326	**Sampled By:**	CLIENT
Project Reference:	952-2307	**Date Received:**	10/13/95
Project P.O.#:	NOT SUBMITTED		

Comments:

Note that the 2-fluorobiphenyl recovery is low due to fractionation - this does not effect the PAH results

APPROVED BY:

Doug Johnson
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association

5760

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510326-11	SUN95UWALL COMP 5							
Sample Type:FISH_FILLET								
Collected:08/11/95 14:55								
		PAH & Alkylated PAH (Fish)						
		Naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Carbazole	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
E510326-44	SUN95UWALL COMP 4							
Sample Type:FISH_FILLET								
Collected:08/11/95 15:05								
		Arsenic (As)	<0.5	0.5	mg/kg		11/17/95	TW
		Selenium (Se)	<0.5	0.5	mg/kg		11/20/95	TW
		ICP Metals in Tissue						
		Silver (Ag)	<0.2	0.2	mg/kg		11/09/95	TW
		Aluminum (Al)	3	2	mg/kg		11/09/95	TW
		Barium (Ba)	<0.5	0.5	mg/kg		11/09/95	TW
		Beryllium (Be)	<0.5	0.5	mg/kg		11/09/95	TW
		Boron (B)	<5	5	mg/kg		11/09/95	TW
		Calcium (Ca)	662	10	mg/kg		11/09/95	TW
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/09/95	TW
		Cobalt (Co)	<0.5	0.5	mg/kg		11/09/95	TW
		Chromium (Cr)	<0.5	0.5	mg/kg		11/09/95	TW
		Copper (Cu)	1	1	mg/kg		11/09/95	TW
		Iron (Fe)	7	1	mg/kg		11/09/95	TW
		Potassium (K)	4880	10	mg/kg		11/09/95	TW
		Magnesium (Mg)	307	10	mg/kg		11/09/95	TW
		Manganese (Mn)	<0.5	0.5	mg/kg		11/09/95	TW
		Molybdenum (Mo)	<1	1	mg/kg		11/09/95	TW
		Sodium (Na)	338	50	mg/kg		11/09/95	TW

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510326-44	SUN95UWALL COMP 4							
Sample Type:FISH_FILLET								
Collected:08/11/95 15:05								
		ICP Metals in Tissue						
		Nickel (Ni)	<1	1	mg/kg		11/09/95	TW
		Lead (Pb)	<2	2	mg/kg		11/09/95	
		Phosphorus (P)	2880	10	mg/kg		11/09/95	
		Silicon (Si)	4	2	mg/kg		11/09/95	
		Tin (Sn)	<2	2	mg/kg		11/09/95	TW
		Strontium (Sr)	0.6	0.5	mg/kg		11/09/95	TW
		Thallium (Tl)	<1	1	mg/kg		11/09/95	
		Vanadium (V)	<1	1	mg/kg		11/09/95	
		Zinc (Zn)	6	1	mg/kg		11/09/95	

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

ENVIRO-TEST QA/QC REPORT

PAH & Alkylated PAH (Fish)

Surrogate Recovery for E51032611A	%
Nitrobenzene d5	65
2-Fluorobiphenyl	29
p-Terphenyl d14	89

PANH & Alkylated PANH's

Surrogate Recovery for E51032611A	%
Quinoline d7	71

Relative percent difference is expressed as RPD.
Percent Recovery is expressed as %.
THIS IS THE LAST PAGE OF THE QAQC REPORT

Appendix A Test Methodologies

Acid Digestion

Method: Open vessel digest with nitric acid and peroxide
Reference: EPA/600 4-91 Method 200.3

Arsenic (As)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

PAH & Alkylated PAH (Fish)

Preparation Method:	Soxhlet extraction with DCM.
Instrument Method:	GC/MSD analysis
Method Reference:	Extraction Method: EPA 3540 (modified) Analytical Method: EPA 8270 (modified)

PANH & Alkylated PANH's

Selenium (Se)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

Hydride Metals Preparation

Preparation: Digestion with permanganate/persulphate, nitric, and sulphuric acid
Addition of hydrochloric acid and cysteine prior to analysis.
Reference: US EPA SW 846, APHA 3114

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Lynda Gummel / Kim Holley
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier: Canadian Air Cargo
Weigh Bill No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	ES10326-
SUN9SUGOLD AFOC4TO17 e2	FISH FILLET	06AUG95 1428	ICP METALS, AS, SE	25A
SUN9SUGOLD AFOC4TO21 e2	FISH FILLET	08AUG95 1520		-26A
SUN9SUGOLD AFOC6TOO5 e2	FISH FILLET	02AUG95 1328		-27A
SUN9SUGOLD AFO19TOO3 e2	FISH FILLET	08AUG95 1047		-28A
SUN9SUGOLD AFO20TOO1 e2	FISH FILLET	06AUG95 1059		-29A
SUN9SUGOLD AFO33TOO6 e2	FISH FILLET	05AUG95 1354		-30A
SUN9SUGOLD AFO36TOO1 e2	FISH FILLET	03AUG95 1116		-31A
SUN9SUGOLD AFO36TOO6 e2	FISH FILLET	03AUG95 1537		-32A
SUN9SUGOLD AFOO3TOO4 e2	FISH FILLET	01AUG95 1658		-34A
SUN9SUWALL AFOC4TO22 e2	FISH FILLET	08AUG95 1527		-35A
SUN9SUWALL AFOC4TO27 e2	FISH FILLET	10AUG95 1501		-36A
SUN9SUWALL AFOC4TO31 e2	FISH FILLET	11AUG95 1505		37A
SUN9SUWALL AFOC6TOO7 e2	FISH FILLET	02AUG95 1346		-38A
SUN9SUWALL AFO19TOO5 e2	FISH FILLET	08AUG95 1105		-39A
SUN9SUWALL AFO33TOO2 e2	FISH FILLET	04AUG95 1108		-40A
SUN9SUWALL AFO36TOO7 e2	FISH FILLET	03AUG95 1549		-41A
SUN9SUWALL AFO36TOO8 e2	FISH FILLET	07AUG95 1230		-42A
SUN9SUWALL AFO41TOO2 e2	FISH FILLET	31JUL95 1546		-43A
SUN9SUWALL AFOO3TOO1 e2	FISH FILLET	30JUL95 1218		-45A
SUN9SUWALL AFOC4TO14 e2	FISH FILLET	06AUG95 1401		-46A
SUN9SUWALL AFOC4TO20 e2	FISH FILLET	08AUG95 1509		-47A
SUN9SUWALL AFOC4TO24 e2	FISH FILLET	10AUG95 1032		-48A
SUN9SUWALL AFOO4TO30 e2	FISH FILLET	11AUG95 1455		-49A
SUN9SUWALL AFOOSTO18 e2	FISH FILLET	07AUG95 1241		-50A
SUN9SUWALL AFO33TOO3 e2	FISH FILLET	04AUG95 1114		51A

ES10326-33A,B SUN9SU GOLD COMP 4

ES10326-44A,B SUN9SUWALL COMP 6

ES10327-51A,B SUN9SUWALL COMP 7

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: X

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A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED

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Bay 2, 1313 - 44 Avenue N.E., Calgary, Alberta T2E 6L5 Telephone: (403) 291-9897 Fax: (403) 291-0298
107 - 111 Research Drive, Saskatoon, Saskatchewan S7N 3R2 Telephone: (306) 668-8370 Fax: (306) 668-8383
Bay 3, 10919 - 96 Avenue, Grande Prairie T8V 3J4 Telephone: (403) 539-5196 Fax: (403) 539-6295
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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: November 30, 1995

ATTN: STELLA SWANSON

Lab Work Order #:	E510323	**Sampled By:**	client
Project Reference:	952-2307	**Date Received:**	10/13/95
Project P.O.#:	Seal # 042		

Comments:

Note that the 2-fluorobiphenyl recovery is low due to fractionation - this does not effect the PAH results.

APPROVED BY:

Doug Johnson
Project Manager

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ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID / SAMPLE ID / TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510323-01 SUN95UGOLD-AF002T031C Sample Type:FISH_BILE Collected:08/01/95 13:43 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-02 SUN95UGOLD-AF003T007C Sample Type:FISH_BILE Collected:08/07/95 15:28 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-03 SUN95UGOLD-AF003T009C Sample Type:FISH_BILE Collected:08/07/95 15:46 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-04 SUN95UGOLD-AF004T015C Sample Type:FISH_BILE Collected:08/06/95 14:10 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-05 SUN95UGOLD-AF004T016C Sample Type:FISH_BILE Collected:08/06/95 14:20 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-06 SUN95UGOLD-AF004T019C Sample Type:FISH_BILE Collected:08/08/95 14:55 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-07 SUN95UGOLD-AF004T021C Sample Type:FISH_BILE Collected:08/08/95 15:20 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-08 SUN95UGOLD-AF036T004C Sample Type:FISH_BILE Collected:08/03/95 11:38 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-09 SUN95UWALLAF004T011C Sample Type:FISH_BILE Collected:07/31/95 11:24 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-12 SUN95UWALL COMP 1 Sample Type:FISH_BILE Collected:08/01/95 16:58 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-15 SUN95UWALL COMP 2 Sample Type:FISH_BILE Collected:08/11/95 10:52 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG
E510323-19 SUN95UWALL COMP 3 Sample Type:FISH_BILE Collected:08/11/95 11:00 PAH Metab. in Bile Samples	WP		ppb		11/15/95	RG

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510323-30	SUN95UGOLD COMP 1							
Sample Type:FISH_FILLET								
Collected:08/10/95	10:08							
		PAH & Alkylated PAH (Fish)						
		Naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Fluorene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Carbazole	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
E510323-41	SUN95UGOLD COMP 2							
Sample Type:FISH_FILLET								
Collected:08/08/95	10:47							
		PAH & Alkylated PAH (Fish)						
		Naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJ
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		Methyl naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	M
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510323-41	SUN95UGOLD COMP 2							
Sample Type:FISH_FILLET								
Collected:08/08/95 10:47								
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Carbazole	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
E510323-52	SUN95UWALL COMP 4							
Sample Type:FISH_FILLET								
Collected:08/11/95 15:05								
		PAH & Alkylated PAH (Fish)						
		Naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl naphthalene	N.D.	0.02	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510323-52	SUN95UWALL COMP 4							
Sample Type:FISH_FILLET								
Collected:08/11/95	15:05							
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/02/95	11/21/95	M
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M
		Carbazole	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/02/95	11/24/95	M

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

ENVIRO-TEST QA/QC REPORT

PAH & Alkylated PAH (Fish)

Average Surrogate Recovery for E510323	%
Nitrobenzene d5	76
2-Fluorobiphenyl	37
p-Terphenyl d14	109

PANH & Alkylated PANH's

Average Surrogate Recovery for E510323	%
Quinoline d7	97

Relative percent difference is expressed as RPD.
Percent Recovery is expressed as %.
THIS IS THE LAST PAGE OF THE QAQC REPORT

Appendix A Test Methodologies

PAH & Alkylated PAH (Fish)

Preparation Method: Soxhlet extraction with DCM.

Instrument Method: GC/MSD analysis

Method Reference: Extraction Method: EPA 3540 (modified)
Analytical Method: EPA 8270 (modified)

PAH Metab. in Bile Samples

POLYAROMATIC HYDROCARBON (PAH) METABOLITES IN BILE METHOD REFERENCE:
ETL MSOP# 66.00

PANH & Alkylated PANH's

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

ENVIRO-TEST LABORATORIES
RESULTS REPORT
HIGH PRESSURE LIQUID CHROMATOGRAPHY / HPLC FLOURESCENCE

PROJECT: GOLDER ASSOCIATES
ANALYSIS DATE: November 15, 1995
INSTRUMENT: VARIAN 5000 LC
COLUMN: Perkin Elmer HCODSW/PAH Column
MATRIX: Fish Bile

LAB SAMPLE#	SAMPLE I.D.	RESULT(ug/g,ppm) B(a)P equivalents	RESULT(ug/g,ppm) Naphthalene equivalents
E5-10-323-1A	SUN95UGOLD-AF002 T031C	1.9	390
E5-10-323-2A	SUN95UGOLD-AF003 T007C	3.8	810
E5-10-323-3A	SUN95UGOLD-AF003 T009C	9.3	1100
E5-10-323-4A	SUN95UGOLD-AF004 T015C	5.4	1000
E5-10-323-5A	SUN95UGOLD-AF004 T016C	6.1	120
E5-10-323-6A	SUN95UGOLD-AF004 T019C	4.3	640
E5-10-323-7A	SUN95UGOLD-AF004 T021C	3.0	560
E5-10-323-8A	SUN95UGOLD-AF036 T004C	1.8	350
E5-10-323-9A	SUN95UWALL-AF004 T011C	26	660
E5-10-323-12A	SUN95UWALL-COMP1	3.1	490
E5-10-323-15A	SUN95UWALL-COMP2	6.7	890
E5-10-323-19A	SUN95UWALL-COMP3	10	620
Minimum Detectable Level		0.02	0.2

ND - Not Detected, less than the Minimum Detectable Level (MDL).

N/A - Not Applicable.

QA/QC:

The Laboratory Method Blank showed no B(a)P or Naphthalene contamination > MDL

Samples were quantitated by external standard calibration and are reported as B(a)P or Naphthalene equivalents.

GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Lynda Gummer / Kym Tolky
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier: ~~GREYHOUND~~ Canadian Airlines
Weigh Bill No.:

Ship To: ENVIRO-TEST LABORATORIES
9936 - 67 AVE
EDMONTON, AB
T6E 0P5

Send Results To: STELLA SWANSON
GOLDER ASSOC. LTD
1011 - 6TH AVE SW
CALGARY, AB
T2P 0W1

Project Name: SUNCOR - NEWMINE EIA

Project No. 952-2307 / ~~952-2329~~
SEAL ~~NO~~. No.: 042

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested
SUN95LGOLD AF002T031C	FISH BILE	01 AUG 95/ 1343	BENZO-A-PYRINE / NAPHTHALENE E510323-01
SUN95LGOLD AF003T007C	FISH BILE	07 AUG 95/ 1528	07A
SUN95LGOLD AF003T009C	FISH BILE	07 AUG 95/ 1546	09A
SUN95LGOLD AF004T015C	FISH BILE	06 AUG 95/ 1410	04A
SUN95LGOLD AF004T016C	FISH BILE	06 AUG 95/ 1420	05A
SUN95LGOLD AF004T021C	FISH BILE	08 AUG 95/ 1520	08A
SUN95LGOLD AF004T019C	FISH BILE	08 AUG 95/ 1455	09A
SUN95LLGOLD AF036T004C	FISH BILE	03 AUG 95/ 1138	08A
SUN95LWALL AF004T011C	FISH BILE	31 JUL 95/ 1124	09A
SUN95LWALL AF003T002C	FISH BILE	30 JUL 95/ 1250	10A
SUN95LWALL AF003T004C	FISH BILE	01 AUG 95/ 1658	18A
SUN95LWALL AF033T008C	FISH BILE	11 AUG 95/ 1052	12A
SUN95LWALL AF004T014C	FISH BILE	06 AUG 95/ 1401	14A ~~12A~~
SUN95LWALL AF033T001C	FISH BILE	30 JUL 95/ 1218	16A ~~18A~~
SUN95LWALL AF033T005C	FISH BILE	05 AUG 95/ 1345	17A ~~19A~~
SUN95LLWALL AF042T001C	FISH BILE	11 AUG 95/ 1100	18A ~~20A~~ ~~16A~~
SUN95LGGLD AF007TC3,20	FISH FILLET	05 AUG 95/ 1802	PAH, ALKYL PAH, PANH 22A 21 ~~PAH, ALKYL PAH, PANH~~ 08 TOCT95
SUN95LGOLD AF003T006E1	FISH FILLET	07 AUG 95/ 1521	PAH, ALKYL PAH, PANH ~~22A~~ ~~21~~

COMPOSITE #1 SUN95LWALL COMP1 E-10323 12A
COMPOSITE #2 SUN95LWALL COMP2 E-10323 14A
COMPOSITE #3 SUN95LWALL COMP3 E-10323 18A
SUN95LGOLD COMP1

Special Instructions/Comments: PLEASE RECORD CONDITION OF SEAL UPON ARRIVAL AT LAB

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GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Kym Holley / Lynda Gummier
Phone No. (403) 299-4407

Shipment Date: 13 OCT 95
Carrier: Canadian Airfreight
Weigh Bill No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested ES10323-
SLLN95LI GOLD AF003 T009e1	FISH FILLET	07AUG95/ 1546	PAH, ALKYL PAH, PANH 22A
SLLN95LI GOLD AF004 T018e1	FISH FILLET	08AUG95/ 1447	23A
SLLN95LI GOLD AF004 T019e1	FISH FILLET	08AUG95/ 1455	24A
SLLN95LI GOLD AF004 T015e1	FISH FILLET	06AUG95/ 1410	25A
SLLN95LI GOLD AF004 T024e1	FISH FILLET	10AUG95/ 1008	26A
SLLN95LI GOLD AF006 T006e1	FISH FILLET	02AUG95/ 1336	27A
SLLN95LI GOLD AF033 T007e1	FISH FILLET	05AUG95/ 1408	28A
SLLN95LI GOLD AF020 T002e1	FISH FILLET	06AUG95/ 1113	29A
SLLN95LI GOLD AF002 T033e1	FISH FILLET	05AUG95/ 1806	30A
SLLN95LI GOLD AF003 T008e1	FISH FILLET	07AUG95/ 1539	31A
SLLN95LI GOLD AF004 T017e1	FISH FILLET	06AUG95/ 1428	32A
SLLN95LI GOLD AF004 T021e1	FISH FILLET	08AUG95/ 1520	34A
SLLN95LI GOLD AF006 T005e1	FISH FILLET	02AUG95/ 1328	35A
SLLN95LI GOLD AF019 T003e1	FISH FILLET	08AUG95/ 1047	36A
SLLN95LI GOLD AF020 T001e1	FISH FILLET	06AUG95/ 1059	37A
SLLN95LI GOLD AF033 T006e1	FISH FILLET	05AUG95/ 1354	98A
SLLN95LI GOLD AF036 T001e1	FISH FILLET	03AUG95/ 1116	39A
SLLN95LI GOLD AF036 T006e1	FISH FILLET	03AUG95/ 1537	40A
SLLN95LI WALL AF003 T004e1	FISH FILLET	01AUG95/ 1658	42A
SLLN95LI WALL AF004 T022e1	FISH FILLET	08AUG95/ 1507	43A
SLLN95LI WALL AF004 T027e1	FISH FILLET	10AUG95/ 1501	44A
SLLN95LI WALL AF004 T031e1	FISH FILLET	11AUG95/ 1505	45A
SLLN95LI WALL AF006 T007e1	FISH FILLET	02AUG95/ 1346	46A
SLLN95LI WALL AF019 T005e1	FISH FILLET	08AUG95/ 1105	47A
SLLN95LI WALL AF033 T002e1	FISH FILLET	04AUG95/ 1105	48A

LN95LI GOLD COMP1 ES10323-30A

LN95LI GOLD COMP2 ES10323-34A

LN95LI WALL COMP4 ES10323-47A

Special Instructions/Comments:

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Proj 952-2304/[illegible]

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Kym Holley / Lynda Grummer
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier: Canadian Air Cargo
Weigh Bill No.:

E510323-

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt	
SUN95LIGOLD AF02CT001.e1	FISH FILLET	06AUG95 1059	PAH, ALKYL PAH, PANH	Seal intact	-39A
SUN95LIGOLD AF033T006e1	FISH FILLET	05AUG95 1354			-38
SUN95LIGOLD AF036T001e1	FISH FILLET	03AUG95 1116			39A
SUN95LIGOLD AF036T006e1	FISH FILLET	03AUG95 1537			-40
SUN95LIWALL AFCC3T004e1	FISH FILLET	01AUG95 1658			-42A
SUN95LIWALL AFCC4T022e1	FISH FILLET	08AUG95 1527			-43
SUN95LIWALL AFCC4T027e1	FISH FILLET	10AUG95 1501			-44A
SUN95LIWALL AFCC4T031e1	FISH FILLET	11AUG95 1505			-45
SUN95LIWALL AFCC6T007e1	FISH FILLET	02AUG95 1346			-46A
SUN95LIWALL AF019T005e1	FISH FILLET	08AUG95 1105			-47
SUN95LIWALL AF033T002e1	FISH FILLET	04AUG95 1108			-50A
SUN95LIWALL AF036T007e1	FISH FILLET	03AUG95 1549			-49A
SUN95LIWALL AF036T008e1	FISH FILLET	07AUG95 1230			-52A
SUN95LIWALL AFC41T002e1	FISH FILLET	31JUL95 1546			-53A
SUN95LIWALL AF003T001e1	FISH FILLET	30JUL95 1218		E510326-^1	
SUN95LIWALL AFCC4T014e1	FISH FILLET	06AUG95 1401			-02A
SUN95LIWALL AFCC4T008e1	FISH FILLET	08AUG95 1509			-03A
SUN95LIWALL AFCC4T026e1	FISH FILLET	10AUG95 1032			-04
SUN95LIWALL AFCC4T030e1	FISH FILLET	11AUG95 1455			-05A
SUN95LIWALL AF005T018e1	FISH FILLET	07AUG95 1241			-06
SUN95LIWALL AF033T003e1	FISH FILLET	04AUG95 1114			-07A
SUN95LIWALL AF033T005e1	FISH FILLET	05AUG95 1345			-08
SUN95LIWALL AF033T008e1	FISH FILLET	11AUG95 1052			-09A

E510323-41A-

SUN95LIGOLD COMP2 (continued)

SUN95LIWALL COMP4 E510323-39A -52A

SUN95LIWALL COMP5 (plus fish on next pg.)

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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: September 26, 1995

ATTN: STELLA SWANSON

Lab Work Order #:	E508378 & E508379	**Sampled By:**	CLIENT
Project Reference:	952-2307/5245 SEAL # 041	**Date Received:**	08/16/95
Project P.O.#:	NOT SUBMITTED		

Comments:

Please see attached for Methods and Results.

APPROVED BY:

per: Deib Birkholz
Project Manager

ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registere with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registere with the Association

LAB SAMPLE #	CLIENT ID	% P450	EROD	AHH
E5-08-378-01	SUN95UGOLDAF002T028B1	100	491	89
E5-08-378-02	SUN95UGOLDAF002T029B1	100	158	21
E5-08-378-03	SUN95UWALLAF002T030B1	70		
E5-08-378-04	SUN95UGOLDAF002T031B1	100	8.0	3.3
E5-08-378-05	SUN95UGOLDAF002T032B1	100	180	36
E5-08-378-06	SUN95UGOLDAF002T033B1	100	60	18
E5-08-378-07	SUN95UWALLAF003T001B1	89	184	40
E5-08-378-08	SUN95UWALLAF003T002B	87	101	28
E5-08-378-09	SUN95UWALLAF003T003B1	77		
E5-08-378-10	SUN95UWALLAF003T004B1	83	135	36
E5-08-378-11	SUN95UWALLAF003T005B1	50		
E5-08-378-12	SUN95UGOLDAF002T006B1	100	478	96
E5-08-378-13	SUN95UGOLDAF002T007B1	100	460	109
E5-08-378-14	SUN95UGOLDAF002T008B1	100	302	87
E5-08-378-15	SUN95UWALLAF003T009B1	100	262	75
E5-08-378-16	SUN95UGOLDAF004T010B1	100	107	26
E5-08-378-17	SUN95UWALLAF004T011B1	89	57	17
E5-08-378-18	SUN95UWALLAF004T012B1	100	190	50
E5-08-378-19	SUN96UGOLDAF004T013B1	100	381	156
E5-08-378-20	SUN95UWALLAF004T014B1	100	165	76
E5-08-378-21	SUN95UGOLDAF004T015B1	100	450	133
E5-08-378-22	SUN95UGOLDAF004T016B1	100	352	154
E5-08-378-23	SUN95UGOLDAF004T017B1	100	102	81
E5-08-378-24	SUN95UGOLDAF004T018B1	78		
E5-08-378-25	SUN95UGOLDAF004T019B1	100	259	87
E5-08-378-26	SUN95UWALLAF004T020B1	50		
E5-08-378-27	SUN95UGOLDAF004T021B1	100	54	15
E508-378-228	SUN95UWALLAF004T022B1	100	195	39
E5-08-378-29	SUN95UGOLDAF004T023B1	100	239	100
E5-08-378-30	SUN95UGOLDAF004T024B1	100	477	90

Units pmol/min/mg protein

LAB SAMPLE #	CLIENT ID	% P450	EROD	AHH
E5-08-378-31	SUN95UGOLDAF004T025B1	100	593	215
E5-08-378-32	SUN95UWALLAF004T026B1	76		
E5-08-378-33	SUN95UWALLAF004T027B1	100	323	111
E5-08-378-34	SUN95UWALLAF004T028B1	73		
E5-08-378-35	SUN95UWALLAF004T029B1	100	273	85
E5-08-378-36	SUN95UWALLAF004T030B1	65		
E5-08-378-37	SUN95UWALLAF004T031B1	100	114	38
E5-08-378-38	SUN95UWALLAF004T032B1	84	38	8.9
E5-08-378-39	SUN95UWALLAF005T014B1	100	206	53
E5-08-378-40	SUN95UWALLAF005T015B1	88	631	183
E5-08-378-41	SUN95UGOLDAF005T016B1	100	312	35
E5-08-378-42	SUN95UGOLDAF005T017B1	100	234	59
E5-08-378-43	SUN95UWALLAF005T018B1	88	247	79
E5-08-378-44	SUN95UGOLDAF006T004B1	100	206	58
E5-08-378-45	SUN95UGOLDAF006T005B1	63		
E5-08-378-46	SUN95UGOLDAF005T006B1	100	457	85
E5-08-378-47	SUN95UWALLAF005T007B1	83	116	43
E5-08-378-48	SUN95UWALLAF005T008B1	100	211	67
E5-08-378-49	SUN95UGOLDAF018T001B1	100	387	85
E5-08-378-50	SUN95UWALLAF019T001B1	83	186	50
E5-08-378-51	SUN95UGOLDAF019T002B1	100	253	54
E5-08-378-52	SUN95UGOLDAF019T003B1	100	314	69
E5-08-378-53	SUN95UGOLDAF019T004B1	100	83	24
E5-08-378-54	SUN95UWALLAF019T005B1	82	170	49
E5-08-378-55	SUN95UGOLDAF020T001B1	100	368	141
E5-08-378-56	SUN95UGOLDAF205T002B1	100	409	102
E5-08-378-57	SUN95UWALLAF033T001B1	53		

Units pmol/min/mg protein

LAB SAMPLE #	CLIENT ID	%P450	EROD	AHH
E5-08-379-01	SUN95UWALLAF033T002B1	58		
E5-08-379-02	SUN95UWALLAF033T003B1	66		
E5-08-379-03	SUN95UWALLAF033T004B1	84	309	65
E5-08-379-04	SUN95UWALLAF033T005B1	90	170	25
E5-08-379-05	SUN95UGOLDAF033T006B1	100	117	34
E5-08-379-06	SUN95UGOLDAF033T007B1	100	320	78
E5-08-379-07	SUN95UWALLAF033T008B1	100	241	70
E5-08-379-08	SUN95UGOLDAF036T001	100	60	22
E5-08-379-09	SUN95UGOLDAF036T002	100	34	13
E5-08-379-10	SUN95UGOLDAF036T003	100	89	34
E5-08-379-11	SUN95UGOLDAF036T004	100	274	146
E5-08-379-12	SUN95UGOLDAF036T005B1	100	231	91
E5-08-379-13	SUN95UGOLDAF036T006B1	100	193	5.2
E5-08-379-14	SUN95UWALLAF036T007B1	57		
E5-08-379-15	SUN95UWALLAF036T008B1	57		
E5-08-379-16	SUN95UGOLDAF041T011B1	100	159	31
E5-08-379-17	SUN95UWALLAF041T002B1	50		
E5-08-379-18	SUN95UGOLDAF041T003B1	100	199	48
E5-08-379-19	SUN95UWALLAF042T001B1	100	75	24
E5-08-379-20	SUN95UWALLAF042T002B1	62		
QC-L AUG 95		100	17	1.8
QC-L AUG 95		100	27	3.2
QC-L AUG 95		100	12	8.4
QC-H MAY 92		100	2270	163
QC-H AUG 95		100	1590	148
QC-H AUG 95		100	2210	149
QC-H AUG 95		92	1490	258

EROD and AHH. Units pmol/min/mg protein

METHODS

EROD - Ethoxyresorufin o-deethylase-spectroflurometric analysis.

EROD activity was determined by the spectroflurometric method of Prough et. al. (1978) as described by Hodson et. al. (1991). Briefly, 50 to 150 μg of a liver microsomal preparation was added to 975 μl of EROD reaction buffer containing 2 mM ethoxyresorufin (Hodson et al. 1991). The reaction was initiated by the addition of 20 μl of a 27.5 mg/ml NADPH stock. Resorufin product was detected using a Perkin-Elmer LS50 spectroflurometer with on excitation wavelength of 530 nm and a emission wavelength of 585nm. Three reaction samples and a blank without NADPH were monitored at 30 second intervals using a kinetic program. Fluorescence units were calibrated using a resorfin stock (Hodson et al. 1991). Detection limits in this assay were below 1 pmole resorufin/min/mg protein. Protein concentration of microsomal preparations were determined using the Biorad Bradford assay. Protein concentrations were determined in triplicate and compared to a standard curve prepared with BSA.

AHH ASSAY

Sample aryl hydroxylase activity (AHH) was determined as described by Nebert and Gelbon 1968. Briefly, 800 μg of microsomal protein was incubated in a 1 ml reaction containing 80ml benzo[a]pyrene; 50 mM tris (pH 7.5); 3mM $MgCL_2$ and 360 uM NADPH. Samples were incubated at 27°C as recommended by Hodson et al. 1991. Enzyme activity was terminated after a 20 minute incubation with the addition of 1 ml of cold acetone. The hydroxylated benzopyrene product was recovered by hexane and alkali extraction as described by Nebert and Gelbon 1968. The concentration of hydroxylated benzopyrene was determined using a spectrofluorometer with an excitation of 396 nm and a fluorescence omission at 522 nm. Sample readings were compared to a curve prepared using a hydroxylated benzopyrene standard. Enzyme activity was expressed as the number of pmoles of hydroxylated benzopyrene produced per mg protein.

TOTAL P450

Integrity of microsomal samples was determined by examining total P450 content on all samples. A large P420 absorption peak indicates sample degradation at some point between field collection and microsomal preparation. Samples which displayed less than 80% total P450 content were considered to be too degraded for reliable analysis. For this reason only samples with a P450 greater than 80% were analyzed for AHH and EROD activity.

QUALITY CONTROL

Several important controls were used when assaying for EROD and AHH activity. First, control liver samples (prepared as described by Miller et al. (1989)) with known high enzyme levels were prepared in parallel with each batch of client samples. Preparing control livers at the same time as sample tissues provided a means of monitoring for the loss of enzyme activity during microsomal preparation.

To ensure that the enzyme assay was working, a sample with known activity was tested prior to testing any client samples. Client samples were tested only if assay conditions were found to be within acceptable limits.

REFERENCES

1. Hodson, P.V., P.J. Kloepper-Sams, K.R. Munkittrick, W.L. Lockhart, D.A. Metner, P.L.Luxon, I.R. Smith, M.M. Gagnon, M. Servos and J.F. Payne [1991]. Protocols for Measuring Mixed Function Oxygenases of Fish Liver. Canadian Technical Report of Fisheries and Aquatic Sciences 1829, 51 pp.

2. Miller M.R., D. E. Hinton and J.J. Stegeman [1989]. Cytochrome P-450E Induction and Localization in Gill Pillar (Endothelial) Cells of Scup and Rainbow Trout. Aquatic Toxicology, 14:307-22.

3. Prough R.A., M.D. Burke and R.T. Mayer [1978]. Direct fluorometric methods for measuring mixed function oxidase activity. Methods in enzymology (Fleischer, S., and Packer L., eds.), Vol 52, Part C, pp. 372, Academic Press, New York.

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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: December 1, 1995

ATTN: STELLA SWANSON

Lab Work Order #:	E510324	**Sampled By:**	CLIENT
Project Reference:	952-2307	**Date Received:**	10/13/95
Project P.O.#:	NOT SUBMITTED		

Comments:

APPROVED BY:

Erv Callin
Project Manager

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ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E510324-22	SUN95UGOLD COMP 1							
Sample Type:FISH_FILLET								
Collected:08/10/95	10:08							
		Arsenic (As)	<0.5	0.5	mg/kg		11/17/95	TW
		Selenium (Se)	<0.5	0.5	mg/kg		11/20/95	TW
		ICP Metals in Tissue						
		Silver (Ag)	<0.2	0.2	mg/kg		11/09/95	TW
		Aluminum (Al)	<2	2	mg/kg		11/09/95	TW
		Barium (Ba)	<0.5	0.5	mg/kg		11/09/95	TW
		Beryllium (Be)	<0.5	0.5	mg/kg		11/09/95	TW
		Boron (B)	<5	5	mg/kg		11/09/95	TW
		Calcium (Ca)	627	10	mg/kg		11/09/95	TW
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/09/95	TW
		Cobalt (Co)	<0.5	0.5	mg/kg		11/09/95	TW
		Chromium (Cr)	<0.5	0.5	mg/kg		11/09/95	TW
		Copper (Cu)	<1	1	mg/kg		11/09/95	TW
		Iron (Fe)	12	1	mg/kg		11/09/95	TW
		Potassium (K)	4380	10	mg/kg		11/09/95	TW
		Magnesium (Mg)	315	10	mg/kg		11/09/95	TW
		Manganese (Mn)	<0.5	0.5	mg/kg		11/09/95	TW
		Molybdenum (Mo)	<1	1	mg/kg		11/09/95	TW
		Sodium (Na)	360	50	mg/kg		11/09/95	TW
		Nickel (Ni)	<1	1	mg/kg		11/09/95	TW
		Lead (Pb)	<2	2	mg/kg		11/09/95	TW
		Phosphorus (P)	2590	10	mg/kg		11/09/95	TW
		Silicon (Si)	5	2	mg/kg		11/09/95	TW
		Tin (Sn)	<2	2	mg/kg		11/09/95	TW
		Strontium (Sr)	<0.5	0.5	mg/kg		11/09/95	TW
		Thallium (Tl)	<1	1	mg/kg		11/09/95	TW
		Vanadium (V)	<1	1	mg/kg		11/09/95	TW
		Zinc (Zn)	6	1	mg/kg		11/09/95	TW
E510324-33	SUN95UGOLD COMP 2							
Sample Type:FISH_FILLET								
Collected:08/08/95	15:20							
		Arsenic (As)	<0.5	0.5	mg/kg		11/17/95	TW
		Selenium (Se)	<0.5	0.5	mg/kg		11/20/95	TW
		ICP Metals in Tissue						
		Silver (Ag)	<0.2	0.2	mg/kg		11/09/95	TW
		Aluminum (Al)	2	2	mg/kg		11/09/95	TW
		Barium (Ba)	<0.5	0.5	mg/kg		11/09/95	TW
		Beryllium (Be)	<0.5	0.5	mg/kg		11/09/95	TW
		Boron (B)	<5	5	mg/kg		11/09/95	TW
		Calcium (Ca)	342	10	mg/kg		11/09/95	TW
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/09/95	TW
		Cobalt (Co)	<0.5	0.5	mg/kg		11/09/95	TW
		Chromium (Cr)	<0.5	0.5	mg/kg		11/09/95	TW
		Copper (Cu)	2	1	mg/kg		11/09/95	TW
		Iron (Fe)	8	1	mg/kg		11/09/95	TW
		Potassium (K)	3950	10	mg/kg		11/09/95	TW
		Magnesium (Mg)	277	10	mg/kg		11/09/95	TW
		Manganese (Mn)	<0.5	0.5	mg/kg		11/09/95	TW
		Molybdenum (Mo)	<1	1	mg/kg		11/09/95	TW
		Sodium (Na)	357	50	mg/kg		11/09/95	TW
		Nickel (Ni)	2	1	mg/kg		11/09/95	TW
		Lead (Pb)	<2	2	mg/kg		11/09/95	TW
		Phosphorus (P)	2140	10	mg/kg		11/09/95	TW
		Silicon (Si)	7	2	mg/kg		11/09/95	TW
		Tin (Sn)	<2	2	mg/kg		11/09/95	TW
		Strontium (Sr)	<0.5	0.5	mg/kg		11/09/95	TW
		Thallium (Tl)	<1	1	mg/kg		11/09/95	TW
		Vanadium (V)	<1	1	mg/kg		11/09/95	TW
		Zinc (Zn)	6	1	mg/kg		11/09/95	TW

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

Appendix A Test Methodologies

Acid Digestion

Method: Open vessel digest with nitric acid and peroxide
Reference: EPA/600 4-91 Method 200.3

Arsenic (As)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

Selenium (Se)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

Hydride Metals Preparation

Preparation: Digestion with permanganate/persulphate, nitric, and sulphuric acid
Addition of hydrochloric acid and cysteine prior to analysis.
Reference: US EPA SW 846, APHA 3114

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

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GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Kym Holley / Lynda Gummer
Phone No. (403) 299-4607

Shipment Date: 23 OCT 95
Carrier: Canadian Air Cargo
Weigh Bill No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SUN95UGOLD AF020T001e1	FISH FILLET	06AUG95 1059	PAH, ALKYL PAH, PAH	Seal intact
SUN95UGOLD AF033T006e1	FISH FILLET	05AUG95 1354		
SUN95UGOLD AF036T001e1	FISH FILLET	03AUG95 1116		
SUN95UGOLD AF036T006e1	FISH FILLET	03AUG95 1537		
SUN95UWALL AF003T004e1	FISH FILLET	01AUG95 1658		
SUN95UWALL AF004T022e1	FISH FILLET	08AUG95 1527		
SUN95UWALL AF004T027e1	FISH FILLET	10AUG95 1501		
SUN95UWALL AF004T031e1	FISH FILLET	11AUG95 1525		
SUN95UWALL AF006T007e1	FISH FILLET	02AUG95 1346		
SUN95UWALL AF019T005e1	FISH FILLET	08AUG95 1105		
SUN95UWALL AF033T002e1	FISH FILLET	04AUG95 1108		
SUN95UWALL AF036T007e1	FISH FILLET	03AUG95 1549		
SUN95UWALL AF036T008e1	FISH FILLET	07AUG95 1230		
SUN95UWALL AF041T002e1	FISH FILLET	31JUL95 1546		
SUN95UWALL AF003T001e1	FISH FILLET	30JUL95 1218		E510324-01A
SUN95UWALL AF004T014e1	FISH FILLET	06AUG95 1401		-02
SUN95UWALL AF004T008e1	FISH FILLET	08AUG95 1509		03A
SUN95UWALL AF004T026e1	FISH FILLET	10AUG95 1032		-04A
SUN95UWALL AF004T030e1	FISH FILLET	11AUG95 1455		05A
SUN95UWALL AF005T018e1	FISH FILLET	07AUG95 1241		06A
SUN95UWALL AF033T003e1	FISH FILLET	04AUG95 1114		07A
SUN95UWALL AF033T005e1	FISH FILLET	05AUG95 1345		08A
SUN95UWALL AF033T008e1	FISH FILLET	11AUG95 1052		09A

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: X

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Carrier: Canadian Air Cargo
Weigh Bill No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt	
SUN95SUWALL AFC42T002e1	FISH FILLET	11 AUG 95 1109	PAH, ALKYL PAH, PANH	seal intact	CS10324-10
SUN95SUGOLD AFC02T032e2	FISH FILLET	05 AUG 95 1802	ICP METALS, AS, SE		-12A
SUN95SUGOLD AFC03T006e2	FISH FILLET	07 AUG 95 1521			13A
SUN95SUGOLD AFC03T009e2	FISH FILLET	07 AUG 95 1546			14A
SUN95SUGOLD AFC04T015e2	FISH FILLET	06 AUG 95 1410			15A
SUN95SUGOLD AFC04T018e2	FISH FILLET	08 AUG 95 1447			16A
SUN95SUGOLD AFC04T019e2	FISH FILLET	08 AUG 95 1455			17A
SUN95SUGOLD AFC04T024e2	FISH FILLET	10 AUG 95 1008			18A
SUN95SUGOLD AFC06T006e2	FISH FILLET	02 AUG 95 1336			19A
SUN95SUGOLD AFC33T007e2	FISH FILLET	05 AUG 95 1406			20A
SUN95SUGOLD AFC20T002e2	FISH FILLET	06 AUG 95 1113			21A
SUN95SUGOLD AFC02T033e2	FISH FILLET	05 AUG 95 1806			-23A
SUN95SUGOLD AFC03T008e2	FISH FILLET	07 AUG 95 1539			-24A
SUN95SUGOLD AFC04T017e2	FISH FILLET	06 AUG 95 1428			25A
SUN95SUGOLD AFC04T021e2	FISH FILLET	08 AUG 95 1520			26A
SUN95SUGOLD AFC06T005e2	FISH FILLET	02 AUG 95 1328			27A
SUN95SUGOLD AFC19T003e2	FISH FILLET	08 AUG 95 1047			28A
SUN95SUGOLD AFC20T001e2	FISH FILLET	06 AUG 95 1059			29A
SUN95SUGOLD AFC33T006e2	FISH FILLET	05 AUG 95 1354			30A
SUN95SUGOLD AFC36T001e2	FISH FILLET	03 AUG 95 1116			31A
SUN95SUGOLD AFC36T006e2	FISH FILLET	03 AUG 95 1537			32A
SUN95SUWALL AFC03T004e2	FISH FILLET	01 AUG 95 1658			34A
SUN95SUWALL AFC42T022e2	FISH FILLET	08 AUG 95 1527			35A

SUN95SUWALL COMPS (continued) CS10324-11

SUN95SUGOLD COMPS CS10324-22

SUN95SUGOLD COMPS CS10324-33

SUN95SUWALL COMPS (plus fish on next page)

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: X

PLEASE RETURN WHITE COPY TO GOLDER ASSOCIATES LTD.

Proj. 952-2307/[illegible]

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature)
LYNDA GUMMER / KYM HALLEY
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier: Canadian Air Cargo
Weigh Bill No.: _____

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SUN95SUWALL AF004T027e2	FISH FILLET	10AUG95 1501	ICP METALS, ASSE	Seal intact - BY CAT!
SUN95SUWALL AF004T031e2	FISH FILLET	11AUG95 1505		37A AST 25
SUN95SUWALL AF006T007e2	FISH FILLET	02AUG95 1346		38A SET 25
SUN95SUWALL AF019T005e2	FISH FILLET	08AUG95 1105		39A VAP 25
SUN95SUWALL AF033T002e2	FISH FILLET	04AUG95 1108		40A
SUN95SUWALL AF036T007e2	FISH FILLET	03AUG95 1549		41A
SUN95SUWALL AF036T008 e2	FISH FILLET	07AUG95 1230		42A
SUN95SUWALL AF041T002e2	FISH FILLET	31JUL95 1546		43A
SUN95SUWALL AF003T001e2	FISH FILLET	30JUL95 1218		-45A
SUN95SUWALL AF004T014e2	FISH FILLET	06AUG95 1401		46A
SUN95SUWALL AF004T020 e2	FISH FILLET	08AUG95 1509		47A
SUN95SUWALL AF004T026e2	FISH FILLET	10AUG95 1032		48A
SUN95SUWALL AF004T030 e2	FISH FILLET	11AUG95 1455		49A
SUN95SUWALL AF005T018 e2	FISH FILLET	07AUG95 1241		50A
SUN95SUWALL AF033T003e2	FISH FILLET	04AUG95 1114		51A
SUN95SUWALL AF033T005e2	FISH FILLET	05AUG95 1345		52A
SUN95SUWALL AF033T008e2	FISH FILLET	11AUG95 1052		53A
SUN95SUWALL AF042T002e2	FISH FILLET	11AUG95 1109		54A
SUN95SUWALL AF808T001	WHOLE FISH		ONE FILLET: PAH, ANH, ALKYLPAH; ONE FILLET: ICP METALS, AS, SE	

SUN95SU (WALL COMP (continued) 54 - 54 (E5)0324

SUN95SUWALL COMP 5 (E5)0325-01A

+ part composite →

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: X

PLEASE RETURN WHITE COPY TO GOLDER ASSOCIATES LTD.

Proj 452-2304/1

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Kym Holley / Lynda Gummer
Phone No. (403) 299-4607

Shipment Date: 13 OCT 95
Carrier: Canadian Air Cargo
Weigh Bill No.:

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt	
SUN95LWALL AFC42TC02e1	FISH FILLET	11 AUG 95 1109	PAH, ALKYL PAH, PANH	seal intact	10A
SUN95LGOLD AFCC2TC32e2	FISH FILLET	05 AUG 95 1802	ICP METALS, AS, SE	ES10324	12A
SUN95LGOLD AFCC3TC06e2	FISH FILLET	07 AUG 95 1521			13A
SUN95LGOLD AFCC3TC09e2	FISH FILLET	07 AUG 95 1546			14A
SUN95LGOLD AFCC4TC15e2	FISH FILLET	06 AUG 95 1410			15A
SUN95LGOLD AFCC4TC13e2	FISH FILLET	08 AUG 95 1447			16A
SUN95LGOLD AFCC4TC19e2	FISH FILLET	08 AUG 95 1455			17A
SUN95LGOLD AFOC4TD24e2	FISH FILLET	10 AUG 95 1008			18A
SUN95LGOLD AFCC6TC06e2	FISH FILLET	02 AUG 95 1336			19A
SUN95LGOLD AFC33TC07e2	FISH FILLET	05 AUG 95 1406			20A
SUN95LGOLD AFC20TC02e2	FISH FILLET	06 AUG 95 1113			21A
SUN95LGOLD AFCC2TC33e2	FISH FILLET	05 AUG 95 1806		ES10324	23A
SUN95LGOLD AFC03TC08e2	FISH FILLET	07 AUG 95 1539			24A
SUN95LGOLD AFCC4TC17e2	FISH FILLET	06 AUG 95 1423			25A
SUN95LGOLD AFCC4TC21e2	FISH FILLET	08 AUG 95 1520			26A
SUN95LGOLD AFCC6TC05e2	FISH FILLET	02 AUG 95 1328			27A
SUN95LGOLD AFC19TC03e2	FISH FILLET	05 AUG 95 1047			28A
SUN95LGOLD AFC2CTC01e2	FISH FILLET	06 AUG 95 1059			29A
SUN95LGOLD AFC33TC06e2	FISH FILLET	05 AUG 95 1354			30A
SUN95LGOLD AFC36TC01e2	FISH FILLET	03 AUG 95 1116			31A
SUN95LGOLD AFC36TC06e2	FISH FILLET	03 AUG 95 1537			32A
SUN95LWALL AFCC3TC04e2	FISH FILLET	01 AUG 95 1058		ES10326	34A
SUN95LWALL AFCC4TD22e2	FISH FILLET	05 AUG 95 1527			35A

ES10326-11A SUN95LWALL COMP 5 (continued)
ES10324-12A, 13A, 14A, 15A, 16A, 17A, 18A, 19A, 20A, 21A SUN95LGOLD COMP 1
ES10324-23A, ES10326-33A, 34A SUN95LGOLD COMP 2
SUN95LWALL COMP 4 (plus fish on next page)

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: X

PLEASE RETURN WHITE COPY TO GOLDER ASSOCIATES LTD.

Project No.: 952-2307 Personnel: EB Page: 1

Sample Description: LNSC

New age in brackets

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F060	LNSC	M	400	849	Aug 06		16			AF014 (8)
F275	LNSC	U	392	910	Aug 11		6			AF033
F175	LNSC	U	402	829	Aug 4		8			AF017
F257	LNSC	U	381	677	Aug 10		7			AF004
F180	LNSC	U	386	757	Aug 4		7			AF017
178	LNSC	U	375	804	Aug 5		5			AF040
F274	LNSC	U	356	696	Aug 11		7			AF037
F214	LNSC	U	324	428	Aug 4		4			AF017
F218	LNSC	U	318	388	Aug 4		3			AF017 (5)
F162	LNSC	U	256	243	Aug 5		4			AF040 (4)
F303	LNSC	U	241	170	July 30		3			AF005 (4)
F176	LNSC	U	278	262	Aug 4		3			AF017 (4)
F177	LNSC	U	236	198	Aug 4					AF017 Could not get tag out
F255	LNSC	U	222	155	Aug 4		3			AF017
F216	LNSC	U	150	48	Aug 4					AF004 - Too Bitty
F270	LNSC	U	108	16	Aug 4		1?			AF017

...No.: 952-2307

...Description: SUNCOR FISH Inventory LNSC

Personnel: KA

Page:

New age in bracket

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Scale	Fin Ray	Oto.	Other	Comments	
073	LNSC	F	509	1490	MAY15		11			AF002	✓
070	LNSC	m	422	1076	MAY15		9			AF002	✓
077	LNSC	m	455	1010	MAY15		8			AF002	✓
045	LNSC	m	442	1035	MAY28		6			AF040	
069	LNSC	F	388	750	MAY15		5			AF002 Not good without	✓ (8)
023	LNSC	m	364	662	MAY26	—	—	—	—	AF017 Can't age	
009	LNSC	F	425	1050	MAY25		5			AF014 Could not co	✓
x 008	LNSC	F	419	1101	MAY25		8			AF014 ? difficult to determine	✓
005	LNSC	m	335	490	MAY22		5			AF003 - GNI	✓
033	LNSC	F	318	480	MAY28		4			AF040	✓
003	LNSC	u	284	305	MAY28		4			AF040	✓
048	LNSC	u	197	104	MAY23		2			AF040	✓
413	LNSC	u	482	1561	SEPT25		10			AF005 (11)	✓
405	LNSC	u	345	532	SEPT29		4			AF002	✓
086	LNSC	u	459	1230	SEPT29		14			AF018	✓
411	LNSC	u	368	592	SEPT28		6			AF005	✓
091	LNSC	M	390	810	SEPT27		8			AF042	✓ (7)
x 078	LNSC	M	449	1224	Aug 7		6			AF041 Couldn't tell	✓
124	LNSC	m	416	981	Sept 28		9			AF019	✓
137	LNSC	u	171	63	Oct 9		2			AF014	✓
290	LNSC	u	231	150	Oct 8		3			STEEPBANK RIVER	✓
130	LNSC	u	183	100	Sept 27		2			AF006	✓
398	LNSC	u	92	13	Aug 7		YOY			AF003	
147	LNSC	u	247	197	Oct 9		3			AF014	(4) ✓
366	LNSC	u	241	159	Oct 7		3			AF017	✓
115	LNSC	u	288	231	Sept 27					AF042 couldn't age fin ray too small	
Checked											
[illegible]	LNSC	m	[illegible]	1055			10				✓
F002	LNSC	M	249	750	May 14 1995		10				✓
~~077~~	~~LNSC~~	~~m~~	~~455~~	~~1010~~	~~[illegible]~~		[illegible]				✓

Project No. 452-2307, Summer 95 Personnel: EJS Page: 1

Sample Description: AF041

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
001	NRPK	U	782	3575	July		5			
002	NRPK	U	675	2250	[illegible] 7/95		6			
003	NRPK	U	549	1105	July		3			
004	LNOC	U	178	69	July 14/95		1			
005	LWHT	U	216	96	13/07/95		2			
006	GWD	F	125	29	31/7/95					Sample too small to age
007	COHO	F	293	261	31/07/95		4			
008	LNOC	U	211	107	31/07/95		3			
009	FLCH	U	145	32	31 July 95		±			Sample too small to age
010	FLCH	U	141	33	31 July 95		4			
014	GOLD	F	160	36	July 31/95					Unable to determine age
015	GOLD	F	319	275	July 31/95		3			
016	COHO	U	261	174	July 31/95					Could not remove scale. Fish would be male
017	FLCH	U	123	15	Aug 31/95		3			

Project No.: 952-2307 Summer 95 Personnel: KA/EB Page:

Sample Description: AF003

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials				Comments
						Scale	Fin Ray	Oto.	Other	
15	WALL	U	345	445	Jul. 30		4			

Project No.: 952-2307 Summer 95 Personnel: EB Page: 1

Sample Description: AF044

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F001	GOLD	M	329	400	13/10/95		1/2 S			
F002	GOLD	F	322	358	13/10/95	Not Sure	5 yrs			
F003	FLCH	F	205	96	13/10/95					Not sure
F004	TRPR	M	61	3	13/10/95			2 yrs		
F005	EMSH	M	76	4	13/10/95	10				possible mercury contamination

Project No.: 452-2307 Summer 95 Personnel: ED Page: 1

Sample Description: AF033

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
002	GOLD	U	157	16	04/08/95					not smart
F003	FLCH	U	178	55	04/08/95		4 yr			
F004	FLCH	U	175	50	04/08/95		4yr			
F005	FLCH	U	137	27	04/08/95		2yrs			
006	FLCH	U	164	55	04/08/95		2yrs			
F007	FLCH	U	126	18	04/08/95		1yr?			
004	FLCH	U	145	26	04/08/95					Sample to unusual because
F010	FLCH	U	181	59	04/08/95		2yrs			

Project No.: 952-2307 Personnel: M.A/E.B Page:

Sample Description: AF018

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials Scale	Fin Ray	Oto.	Other	Comments
17	FISH	4	220	123	July 30/95		3 ?			
F010	WALL	4			30/07/XX		2yrs			

Project No.: 952-2307 Summer 95 Personnel: EP Page: 1

Sample Description: AF036

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F001	GOLD	M	301	311	03/08/95		5yrs			
F002	WALL	UN	350	429	03/08/95		5yrs			
F003	GOLD	M	292	316	03/08/95		5yrs.			
F004	FLCH	UN	166	46	03/08/95					fin to small
F005	WALL	U	90	6	03/08/95					fin to small
F006	GOLD	U	295	305	03/08/95		4yrs?			
F010	FLCH	M	159	47	Aug 3/95		3			
F008	GOLD	F	292	291	Aug 3/95		4			
F010	WALL	U	298	265	Aug 3/95		3yrs			

Project No.: 952-2307, summer 95 Personnel: EB Page: 1

Sample Description: AF019

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F004	WALL	U	369	545	11/08/95		4yr			
F005	WALL	U	340	385	11/08/95		5yrs			
F006	WALL	U	296	277	11/08/95		2yrs			
F007	WALL	U	255	165	11/08/95		2yrs			
F008	GOLD	U	284	264	11/08/95		4yrs			
F009	WALL	U	321	305	11/08/95		3yrs			
F010	FLCH	U	164	47	1 Aug 95		2yrs			
F016	FLCH	U	145	28	Aug 11 95					unable to determine age
F020	WALL	U	357	457	Aug 1 95		4			

Project No.: 952-2307, summer 95 Personnel: EB Page: 1

Sample Description: AF042

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Ageing Materials: Fin Ray	Ageing Materials: Oto.	Ageing Materials: Other	Comments
F001	LKWH	U	450	1245	11/Aug/95	6yrs				
F002	GOLD	F	305	287	11/Aug/95		4yrs			
F003	(NOID)	F	297	214	11/Aug/95		4yrs			
F020	GOLD	F	283	250	Aug 12/95		4			
F021	GOLD	M	325	370	Aug 12/95		5			
F024	FLSH	U	260	210	Aug 12/95		5			
F023	WHSC	U	398	890	Aug 12/95		5			
F028	WHSC	M	402	850	Aug 12/95		5			
F022	GOLD	M	316	310	Aug 12/95		3			
F025	WHSC	U	342	630	Aug 12/95		4			
F026	FLSH	U	318	405	Aug 12/95		9			
F027	GOLD	F	321	375	Aug 12/95		4			

Project No.: 952-2307 Personnel: KAIER Page:

Sample Description: AF006

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
024	WALL	U	329	362	Aug 2/95		4			
023	BOCD	F	317	372	Aug 2/95		3			
025	WALL	U	156	37	Aug 2/95		1			
027	FLCH	U	147	36	Aug 2/95		2			

Project No.: 952-2307-Summer-95 Personnel: EB Page: 1

Sample Description: AF020

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F001	NRPK	U	788	3460	06/14/95		5yrs			
F002	MNWH	M	280	290	06/08/95			7yrs		
F003	FLCH	U	150	41	06/08/95		2yrs			
F005	TRPD	IM	63	3	06/08/95			2yrs		
F004	FLCH	U	154	42	06/08/95		2yrs			
F006	FLCH	U	178	66	06/08/95		4yrs			
F009	FLCH	U	160	57	06/08/95		4yrs			

Project No.: 452-2307, Summer 95 Personnel: ES Page: 1

Sample Description: AF034

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F005	WHSC	U	305	357	03/08/95		2 yr			
F006	WHCL	U	366	465	03/08/95		5 yr			
F004	FLCH	U	185	31	03/08/95		3 yr			
F007	ENID	M	299	278	03/08/95		4 yr			RCS - WC - (P)
F008	WHCL	U	154	16	03/08/95					Sample to small
F020	FLCH	U	155	46	Aug 3/95		3			
F009	FLCH	U	136	28	03 Aug 95		2 yr			
F010	FLCH	U	141	29	03 Aug 95		2 yr			
F011	WHSC	U	240	158	03 Aug 95		3 yr			
015	LNSC	U	364	612	Aug 3/95		5			
021	FLCH	U	169	57	Aug 3/95		3			
022										
023	FLCH	U	137	25	Aug 4/95					Fish too small & cut.
024	LNSC	U	179	67	Aug 3/95		2			

Project No.: 952-2307 Personnel: KA Page: 1 of 1

Sample Description: Lower Fish Inventory

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F045	WALL	M	511	1440	MAY 15		12			AF002
F046	WALL	M	464	1130	MAY15		10			AF002
F041	WALL	M	490	1320	MAY15		12			AF002
F 517	WALL	U	543	1901	Oct. 5		14			AF003 (difficult to determine)
F 239	WALL	U	239	150	MAY16		2			AF005 SL1
F002	WALL	U	335	562	MAY28		4			AF029 SL1
F 354	WALL	U	274	180	July 30		3			AF005
F 135	WALL	U	120	14	Aug 1		1			AF002
F 178	WALL	U	212	90	Aug 1		2			AF002
F 347	WALL	F	510	1243	Aug 13		10			AF004 - SL1
F 307	WALL	U	662	3370	Oct 2		13			AF002 - SL1
F 349	WALL	U	723	5100	Sept 29		16			AF002
F005	WALL	U	595	2305	Sept 28		11			~~AF003~~ AF029 - SL3
F 378	WALL	U	571	2255	Sept 29		11			AF002
F 203	WALL	U	403	775	Sept 28		5			AF006 - SL2
F 423	WALL	U	310	312	Sept 28		4			AF005
F 112	WALL	U	245	130	Sept 27		2			AF002

Project No.: 952-2307 Personnel: KA Page: 1 of 1

Sample Description: Sooner Fish Inventory Goldeye

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
256	GOLD	F	338	710	Aug 10		6			AF004
113	GOLD	m	317	379	Sept 28		5			AF019
101	GOLD	m	290	295	Sept 28		3			AF019
162	GOLD	u	68	3	July 31		903			AF002
297	GOLD	m	343	465	Aug 1		5			AF004
233	GOLD	F	374	574	Aug 10		7			AF004
127	GOLD	F	377	654	Sept 27		8			AF036
101	GOLD	m	263	215	Aug 5		3			AF033
255	GOLD	F	279	249	Aug 10		3			AF004
001	GOLD	m	329	404	Aug 13		5			AF044
171	GOLD	F	160	55	Aug 6		1			AF004
164	GOLD	u	140	28	July 31		1			AF002
006	GOLD	F	145	27	July 31					AF041 - cannot determine
113	GOLD	u	163	41	July 31		1			AF004
200	GOLD	u	165	55	Aug 5		1			AF002
003	GOLD	F	353	542	May 22				5-OP	AF003 - GN1
010	GOLD	m	303	322	MAY 22				4-OP	AF003 - GN1
007	GOLD	F	381	637	MAY 22				5-OP	AF003 - GN1

Project No.: 95-2307 Personnel: EB Page: 1

Sample Description: LNSC

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials Scale	Fin Ray	Oto.	Other	Comments
F066	LNSC	M	400	841	Aug 06		6			AFC14
F275	LNSC	U	392	910	Aug 11		6			AF033
F175	LNSC	U	402	829	Aug 4		8			AF017
F257	LNSC	U	381	677	Aug 10		7			AF004
F190	LNSC	U	396	757	Aug 4		7			AF017
178	LNSC	U	375	804	Aug 5		5			AFC40
F274	LNSC	U	356	696	Aug 11		7			AF037
F21A	LNSC	U	324	428	Aug 4		4			AF017
F218	LNSC	U	318	389	Aug 4		3			AF017
F162	LNSC	U	256	243	Aug 5		4			AF040
F363	LNSC	U	241	170	July 30		3			AF005
F176	LNSC	U	278	262	Aug 4		3			AF017
F177	LNSC	U	236	196	Aug 4					AF017 - Could not get an age
F255	LNSC	U	222	155	Aug 4		3			AF017
F216	LNSC	U	150	48	Aug 6					AF004 - Too Small
F270	LNSC	U	108	LC	Aug 4		1?			AF017

Project No.: 952-2307 Personnel: EB Page: 1

Sample Description: ~~952-2307~~ MNWH (Summer, Spring, Fall)

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F313	MNWH	U	100	11	Oct8	1				AF040 (YOY)
F185	MNWH	U	107	11	Oct9	1				AF014 YOY
FA70	MNWH	U	115	16	Oct7	1				AF017 (YOY)
FA29	MNWH	U	104	13	Oct7	1				AF017 (YOY)
FA31	MNWH	U	120	18	Oct 7	1				AF017
FA30	MNWH	U	122	23	Oct7	1				AF017
F362	MNWH	U	121	21	Oct7	1				AF017
F423	MNWH	U	169	47	Oct7	2				AF017
F279	MNWH	U	147	35	Oct8	1				AF040
F283	MNWH	U	81	5	Aug4	YOY 1				AF017
F081	MNWH	U	139	31	Aug6	1				AF014
F072	MNWH	U	211	118	Aug6	3				AF014
F134	MNWH	U	239	148	Aug5	4				AF014
F165	MNWH	U	245	227	Aug4	4				AF017
F192	MNWH	U	287	346	Aug4	4				AF017
F232	MNWH	U	269	310	Aug4	5				AF017
F061	MNWH	U	327	412	Aug6	7				AF014
F278	MNWH	U	162	52	[redacted]	2				Oct 8 AF040
F439	MNWH	M	181	69	Oct7	2				Not readable (tail th broke)
F395	MNWH	U	187	72	Oct7	2				AF017
F303	MNWH	U	145	108	Oct8	2				AF040
A624	MNWH	U	239	160	Oct6	4				AF003
F182	MNWH	U	257	187	Oct9	4				AF014
F266	MNWH	U	318	456	Oct8	[redacted]		5?		AF040
F227	MNWH	F	336	524	Oct9			7		AF014
FC16	MNWH	U	131	34	May 26	1				AF017
FC74	MNWH	U	152	44	May 28	1				No site I.S.D
FC74	MNWH	U	214	135	May 26	2				AF017
FCA3	MNWH	U	232	151	May 25	4				AF014
FC47	MNWH	U	226	166	May 28	4				AF040
F088	MNWH	U	456	1447	Aug 6	12				AF014
FC54	MNWH	U	230	175	May 26	3				AF017
F041	MNWH	U	244	196	May 25	4				AF014
FC6E	MNWH	U	254	196	May 25	5				AF040
FC71	MNWH	U	320	455	May 26	7				AFC17
FC39	MNWH	U	372	705	May 25	8				AF014
FC22	MNWH	U	410	953	May 25	9				AFC14

Project No.: 952-2307 Personnel: KA Page: 1 of 1

Sample Description: SUNCOR FISH Inventory

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Ageing Materials Scale	Fin Ray	Oto.	Other	Comments
760	NRPK	F	900	>4kg	MAY 16		13			AF004
061	NRPK	F	835	>4000	MAY 16		12			AF004
079	NRPK	UN	769	3190	MAY 15		9			AF002
005	NRPK	M	575	1360	MAY 26		5			AF018
037	NRPK	M	645	1780	MAY 25		9			AF014
006	NRPK	M	487	880	MAY 26		6			AF014
003	NRPK	U	454	600	MAY 25		4			AF015
506	NRPK	U	1095	5800	Oct 13		12			AF018
111	NRPK	U	830	3640	Sept 27		8			AF006
622	NRPK	U	622	1495			6			AF004 - SL2
473	NRPK	U	484	755	Oct 6		4			AF003
357	NRPK	U	574	1045	Aug 2		5			AF003
355	NRPK	U	680	2070	Aug 2		6			AF003
356	NRPK	U	677	2055	Aug 2		7			AF003
174	NRPK	U	738	2700	Aug 6		7			AF003
002	NRPK	U	675	2280	Jun 31		6			AF041
384	NRPK	U	725	2745	Aug 7		7			AF003
124	NRPK	U	765	4251	Aug 13		9			AF014
001	NRPK	U	782	3575	Sept		6			AF041
001	NRPK	U	788	3460	Aug 1		8			AF026
371	NRPK	U	769	4420	Aug 7		5			AF005
003	NRPK	U	549	1105	July		4			AF041
354	NRPK	U	628	2020	Aug 2		5			AF004
316	NRPK	U	612	1661	Aug 11		?			AF004 Condition determin-
380	NRPK	U	514	1635	Aug 7		6			AF003
350	NRPK	U	529	1580	July 30		6			AF005
076	NRPK	U	438	606	Aug 6		4			AF014
351	NRPK	U	387	420	July 30		3			AF005
173	NRPK	U	409	495	Aug 6		3			AF004
078	NRPK	U	372	315	Aug 5		2			AF003
034	NRPK	U	443	595	Aug 8		3			AF019
126	NRPK	U	461	690	July 29		4			AF002
474	NRPK	U	327	244	Oct 6		2			AF003
095	NRPK	U	364	310	SEPT 27		3			AF036
271	NRPK	U	402	490	SEPT 29		4			AF002

Project No.: 952307 Personnel: EDKA Page: 1 of 1

Sample Description: WHSC (summer, spring, fall)

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F352	WHSC	U	105	14	Aug 02					AF003 - sample too small and broken
F011	WHSC	U	240	158	Aug 03		3			AF034
F005	WHSC	U	305	357	Aug 03		3			AF034
F271	WHSC	U	390	418	Aug 11		5			AF033
F172	WHSC	U	402	896	Aug 4		7			AF017
F029	WHSC	M	402	850	Aug 6		5			AF012
F367	WHSC	U	432	1176	Aug 7		7			AF003
F295	WHSC	U	478	1480	Aug 11		7			AF004
F014	WHSC	U	383	855	May 15		6			AF004
F007	WHSC	F	422	978	May 5		8			AF004
F075	WHSC	F	440	1390	May 15		5			AF007
F001	WHSC	M	470	1700	May 25		8			AF015
F074	WHSC	F	535	2320	May 15		9			AF007
F015	WHSC	J	299	390	May 15		3			AF004
F045	WHSC	U	319	449	May 26		4			AF017
F002	WHSC	F	375	704	May 26		5			AF040
F021	WHSC	M	343	602	May 25		6			AF014
F465	WHSC	U	356	632	Sept 24		4			AF003
F136	WHSC	U	410	1280	Sept 27		7			AF036
F202	WHSC	U	529	2609	Sept 26		8			AF020
F213	WHSC	U	213	135	Sept 26		2			AF020
F126	WHSC	U	449	1400	Sept 27		5			AF006
F203	WHSC	U	498	2324	Sept 26		10			AF020
F206	WHSC	U	518	2345	Sept 26		9			AF020
F110	WHSC	U	428	1341	Sept 28		8			AF019
F004	WHSC	U	135	28	Oct 5		1			AF052
F253	WHSC	U	243	171	Oct 8		3			AF040
F117	WHSC	U	293	352	Sept 28		4			AF019
F165	WHSC	U	304	360	Oct 9		4			AF014
F255	WHSC	U	267	249	Oct 8		3			AF040
F162	WHSC	U	274	273	Oct 9		3			AF014
F196	WHSC	U	278	254	Oct 9		2			AF014
F403	WHSC	U	323	474	Sept 29		4			AF002
F 212	WHSC	U	315	390	Sept 26		4			AF020
F370	WHSC	U	332	540	Sept 29		4			AF002
F097	WHSC	U	340	580	Sept 29		4			AF018
F214	WHSC	U	348	607	Aug 4		4			AF017
F194	WHSC	U	274	303	Aug 4		3			AF017
F041	WHSC	U	91	7.6	MAY 26		1			AF023
F017	WHSC	U	73	5.1	MAY 26		yolk			AF023
F076	WHSC	U	495	1815	Oct 6		10			AF041
F002	WHSC	F	351	670	MAY 25		4			AF015

Project No.: 95-2307 Personnel: KA Page: 1 of 1

Sample Description: SENECA FISH INVENTORIES

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
006	ARGR	U	328	460	MAY26	4				AF012
085	ARGR	U	213	130	MAY26	2				AF017
072	ARGR	U	242	205	MA26	3				AF012
064	LKWH	M	348	701	SEPT29	6				AF018
023	MNWH	U	254	207	MAY25	5				AF014
005	MNWH	U	264	233	MAY25	5				AF040
072	MNWH	M	228	166	MAY28	4				AF040
	BURB	F	457	810	AUG14	5				AF029 - pec - sample
206	BURB	M	723	2180	SEPT28	10				AF006
178	NRPK	U	492	750	AUG1	5				AF002
032	NRPK	U	455	613	AUG1	-	—	—	—	AF016 - cultured age
090	LNSC	U	155	53	MAY26	2				AF017
049	LNSC	M	394	882	MAY28	6				AF017
090	LNSC	U	560	1715	SEPT27	8				AF042
135	LNSC	U	418	1055	SEPT27	9				AF036
103	LNSC	U	402	315	SEPT27	6				AF042
113	GOLD	F	382	630	SEPT27	7				AF006

Project No.: 952-2307 Personnel: KA Page:

Sample Description: JUVENILE FISH Enumerators LNSC

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
073	LNSC	F	509	1480	MAY15		11			AF002
070	LNSC	m	422	1076	MAY15		9			AF002
077	LNSC	m	455	1010	MAY15		8			AF002
045	LNSC	m	442	1035	MAY28		6			AF040
069	LNSC	F	388	750	MAY15		5			AF002
023	LNSC	m	364	662	MAY26	--	—	-	-	AF017 Can't age
009	LNSC	F	425	1050	MAY25		5			AF014
008	LNSC	F	419	1101	MAY25		8			AF014 ? difficult to determine
005	LNSC	m	335	490	MAY22		5			AF003 - GN1
033	LNSC	F	318	480	MAY28		4			AF040
003	LNSC	u	284	305	MAY28		4			AF040
048	LNSC	u	197	104	MAY28		2			AF040
413	LNSC	u	482	1561	SEPT28		10			AF005
405	LNSC	u	345	532	SEPT29		4			AF002
086	LNSC	u	459	1230	SEPT29		14			AF018
411	LNSC	u	368	592	SEPT28		6			AF005
091	LNSC	m	390	810	SEPT27		6			AF042
078	LNSC	m	449	1224	AUG 7		6			AF041
124	LNSC	m	416	981	SEPT28		9			AF019
137	LNSC	u	171	63	Oct 9		2			AF014
290	LNSC	u	231	150	Oct 8		3			STEEPBANK RIVER
130	LNSC	u	183	100	SEPT27		2			AF006
398	LNSC	u	92	13	AUG 7		YOY			AF003
147	LNSC	u	247	197	Oct 9		3			AF014
366	LNSC	u	241	159	Oct 7		3			AF017
115	LNSC	u	288	231	SEPT27					AF042 could not age fin ray too small

Project No.: 952- 2307 Personnel: EB Page: 1 of 1

Sample Description: ARGR

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F204	ARGR	U	76	3	Aug 4	1				
F257	ARGR	U	165	52	Aug 4	2				
F253	ARGR	U	176	64	Aug 4	2				
F157	ARGR	U	191	94	Aug 5	2				
F231	ARGR	U	254	218	Aug 4	3				
F190	ARGR	U	295	331	Aug 4	3				
F166	ARGR	U	283	293	Aug 4	3				
F193	ARGR	U	310	340	Aug 4	3				
FC35	ARGR	U	122	16	May 26	1				
FC91	ARGR	U	126	25	May 26	1				
FC73	ARGR	U	134	25	May 28	1				
FC14	ARGR	U	150	36	May 26	1				
FC12	ARGR	U	171	57	May 26	1				
FC24	ARGR	U	201	93	May 26	2				
F046	ARGR	U	250	212	May 28	3				
AF005	ARGR	U	300	376	May 25	3				
F004	ARGR	U	301	372	May 28	3				
FC40	ARGR	U	308	395	May 26	4				
F056	ARGR	U	338	480	May 20	3				
FC11	ARGR	U	232	165	May 26	2				
F020	ARGR	U	141	32	May 28	1				
F180	ARGR	U	106	10	Oct 9	1				
F425	~~ARGR~~	U	168	54	Oct 7	1				
F392	ARGR	U	210	111	Oct 7	2				
F466	ARGR	U	187	76	Oct 7	1				
F140	ARGR	U	246	187	Oct 9	2				Difficult to age
F418	ARGR	U	227	188	Oct 7	1				
F135	ARGR	U	278	291	Oct 9	3				
F354	ARGR	U	262	239	Oct 7	2				
F193	ARGR	M	361	559	Oct 9	4				
F243	ARGR	U	291	235	Oct 8	3				
F196	ARGR	M	317	434	Oct 9	4				Sample mixed with 244 after ageing was completed
F244	ARGR	U	320	402	Oct 8	3				
F175	ARGR	M	360	555	Oct 9	4				
E217	ARGR	M	356	530	Oct 6	6				
F291	ARGR	U	327	459	Oct 8	4				
F194	ARGR	F	364	506	Oct 9	5				

Project No: ~~952-2307~~ Personnel: ED Page: 1

Sample Description: LKWH (summer, spring, fall).

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
F381	LKWH	U	376	915	Aug 7	8				
F330	LKWH	M	430	1420	Aug 1	7				
1=379	LKWH	M	439	1520	Aug 7	9				
F001	LKWH	U	450	1205	Aug 1	8				
F344	LKWH	U	468	1457	Aug 2	10				
F345	LKWH	U	487	1373	Aug 2	11				
F383	LKWH	U	394	1030	Aug 7	7		7		
F335	LKWH	U	411	780	Aug 1	~~8~~				otoliths crumbled couldn't age.
F246	LKWH	F	244	360	Sept 29	7				
F230	LKWH	U	321	450	Sept 29	5				
F463	LKWH	M	340	545	Oct 6	9				
F400	LKWH	M	350	621	28 Oct	6				
F234	LKWH	M	362	655	29 Sept	7				
F441	LKWH	F	356	745	28 Sept	7				
F238	LKWH	M	372	785	Sept 29	9				
F436	LKWH	M	372	740	Oct 6	8				
F232	LKWH	M	382	840	Sept 29	7?				difficult to age
F464	LKWH	M	407	1080	Sept 28	11		8		
F451	LKWH	M	422	1145	Oct 6	9				
F453	LKWH	M	442	1265	Oct 6	11				
F509	LKWH	U	460	1445	Oct 13	X		12		
F046	LKWH	F	398	1020	Sept 29	9				
F086	LKWH	U	370	720	Sept 27	7				
F088	LKWH	F	416	1155	Sept 29	8				
F091	LKWH	U	426	1255	Sept 26	9				
F066	LKWH	F	448	1320	Sept 29	9				
093	LKWH	U	468	1755	Sept 26	9				
F057	LKWH	M	471	1610	Sept 29	10				difficult image
F336	LKWH	F	491	1220	Aug 1			10		
F055	LKWH	F	477	1235	Sept 29	10				
F048	LKWH	M	380	880	Sept 29	7				
071	LKWH	U	478	1505	Sept 27	12				
062	LKWH	U	466	1615	Sept 27	13				
F431	LKWH	F	494	1587	Oct 6	10				AF003
061	LKWH	U	491	1945	Sept 27	13?				AF036 - difficult image
F067	LKWH	M	481	1742	Sept 29	11?				AF018
F892	LKWH	F	509	2355	Sept 28	11				AF005
F040	LKWH	F	505	2185	Sept 29	13				AF018

Project No.: 95-2307 Personnel: KA Page: 1 of 1

Sample Description: SENCOR FISH INVENTORIES

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
006	ARGR	U	328	461	MAY26	4				AF012
085	ARGR	U	213	130	MAY26	2				AF017
072	ARGR	U	242	205	MAY26	3				AF012
064	LKWH	M	348	701	SEPT29	6				AF018
023	MNWH	U	254	207	MAY25	5				AF014
005	MNWH	U	264	233	MAY25	5				AF040
072	MNWH	M	228	166	MAY28	4				AF040
	BURB	F	457	980	AUG14	5				AF029 - pim - sample
206	RORB	M	723	2180	SEPT28	10				AF006
178	NRPK	U	492	750	AUG1	5				AF002
032	NRPK	U	455	615	AUG1	-	-	-	-	AF016 regurgitated
090	LNSC	U	155	53	MAY26	2				AF017
049	LNSC	M	394	832	MAY28	6				AF017
090	LNSC	U	560	1715	SEPT27	8				AF042 (whole)
135	LNSC	U	418	1055	SEPT27	9				AF036
108	LNSC	U	402	315	SEPT27	6				AF042
113	GOLD	F	382	630	SEPT27	7				AF006

Post-it® Fax Note 7671	Date 29 Nov 95	# of pages ▶ 1
To Marie Lagimodiere	From Amy Lois	
Co./Dept. Golder	Co. Golder	
Phone #	Phone #	
Fax #	Fax #	

Larval Fish Identification: SUNCOR 1995, 952-2307

1) Sample AF011-DT1 24 May 1995

10 Larval Sculpins, yolk-sac larvae 7-8 mm (most likely slimy sculpins)

Key Diagnostic Characteristics - 7-8 mm Larval Sculpin
- well developed pectoral fins for stage
- flexed notochord and development of caudal fin rays (hypurals)
- large yolk sac with posterior oil globule
- incipient anal and dorsal fin rays evident in fin folds

2) Sample AF012-DT1 25 May 1995

5 Larval Sculpins, yolk-sac, 7-8 mm (most likely slimy sculpins)
1 Larval Burbot, 8 mm
36 Larval Suckers, 12-13 mm (key to be LNSC ~~but probably both LNSC and WHSC~~) → most likely all LNSC

Key Diagnostic Characteristics - 8 mm Burbot
- median chin barbel evident
- anal and dorsal fin rays developed in finfolds
- digestive tract with at least one intestinal loop evident (yolk sac completely absorbed)

Key Diagnostic Characteristics - 12-13 mm Suckers
- long pre-anal length relative to total length (~65%)
- 1 row pigmentation mid-dorsal stripe (anterior to median finfold) - LNSC
- 3 rows of pigmentation in mid-dorsal stripe (anterior to median finfold) -WHSC
- most of yolk sac absorbed
- swim bladder beginning to inflate, anterior chamber
- more than 1 melanophore per myomere (sometimes) (mid-lateral stripe) - LNSC
- only one melanophore per myomere (mid-lateral stripe) - WHSC

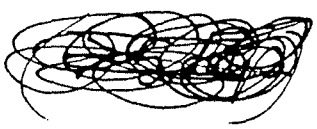
3) Sample AF012-DT1 24 May 1995

2 Larval Sculpins, yolk-sac, 7-8 mm (most likely slimy sculpins)
2 Larval Suckers, 12-13 mm (most likely LNSC)

4) Sample AF011-DT1 25 May 1995

43 Larval Sculpins, yolk-sac, 7-8 mm (most likely slimy sculpins)
9 Larval Suckers, 12-13 mm (most likely LNSC)
6 Larval Walleye

Key Diagnostic Characteristics - 9-10 mm Walleye
- yolk sac completely absorbed
- notochord straight
- 22 post anal myomeres, long intestine with anus located 3 or 4 myomeres posterior to gut
- teeth developing, long snout evident



6-10 day

Syncrude Fish Data

ETL Enviro-Test
A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED
9936 - 67th Avenue — Edmonton, Alberta T6E 0P5 Telephone: (403) 434-9509 FAX: (403) 437-2311

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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: January 8, 1996

ATTN: KYM HOLLEY

Lab Work Order #: E505437 **Sampled By:** LM

Project Reference: 952-2308 SYNCRUDE **Date Received:** 05/24/95

Project P.O.#: NOT SUBMITTED

Comments:

Three liver samples analyzed for total P-450. Analyses were performed using the method of Hodson et al. (1991).

APPROVED BY:

D.A.Birkholz
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E505437-40	**SRD95PLNSCCOMP01**							
Sample Type:LIVER								
		Arylhydrocarb. hydroxylase	70	1	pmol/mg/min	01/05/96	01/06/96	JAP
		EROD in Liver (MFO)	320	2	pmol/mg/min	01/05/96	01/06/96	JAP
		Cytochrome P450	100		%P450	01/05/96	01/05/96	JAP
E505437-41	**SRD95PLNSC COMP02**							
Sample Type:LIVER								
		Arylhydrocarb. hydroxylase	27	1	pmol/mg/min	01/05/96	01/06/96	JAP
		EROD in Liver (MFO)	70	2	pmol/mg/min	01/05/96	01/06/96	JAP
		Cytochrome P450	100		%P450	01/05/96	01/06/96	JAP

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

Appendix A Test Methodologies

Arylhydrocarb. hydroxylase

ARYLHYDROCARBON HYDROXYLASE METHOD REFERENCE: Please see attached write-up for method overview.

EROD in Liver (MFO)

Ethoxyresorufin-O-Deethylase Microsomal Fraction Preparation Method Reference:
ETL MSOP# 69.00

Cytochrome P450

Microsomal Fraction Prep for EROD/P-450 Analysis Method Reference:
ETL MSOP# 69.00

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

E5-05-437

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Marie Lapointe
Phone No. (403) 986-8444

Shipment Date: 23 May 95
Carrier: Loomis
Weigh Bill No.: L 909844884

Ship To: Attn: Shelly Pendagrast
Enviro-Test Laboratories
9936 -67 Avenue
Edmonton, AB T6E 0P5
~~(403) 434-9539~~ 1-800-668-9878 ux 265

Send Results To: Archive
Kim Holley
Golder Associates
1011 - 6th Ave S.W.
Calgary, AB

Project Name: Syncrude/Aquatics/Ft McMurray
Project No. 952-2308
P.O. No.:

Relinquished by: (Signature)	Received at ~~lab~~ by: (Signature)	Date	Time
Marie Lapointe	Cliff Kelly (shipper)	23 May 95	2:55
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	Susan Blouin ETL	05/24/95	AM
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

ANALYSIS REQUEST

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SRD95P31LNSC001	Liver	09/05/95 16:24	Archive - MFO	Frozen
SRD95P31LNSC002	Liver	10/05/95 10:00	Archive - MFO	
SRD95P31LNSC003	Liver	10/05/95 13:45	Archive - MFO	
SRD95P31LNSC004	Liver	10/05/95 12:22	Archive - MFO	
SRD95P31LNSC005	Liver	10/05/95 13:05	Archive - MFO	
SRD95P31LNSC006	Liver	10/05/95 13:54	Archive - MFO	
SRD95P31LNSC007	Liver	10/05/95 14:42	Archive - MFO	
SRD95P31LNSC008	Liver	10/05/95 15:26	Archive - MFO	
SRD95P31LNSC009	Liver	10/05/95 15:30	Archive - MFO	

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: _____

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£5 05 437

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Marie Lagniadecq
Phone No. (403) 861-8444

Shipment Date: 23 May 95
Carrier: Purolator
Weigh Bill No.: 809940864

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SRD95P31LNSC010	Liver	10/05/195 19:33	Archive-MFO	Frozen
SRD95P31LNSC011	Liver	11/05/195 10:33	Archive-MFO	
SRD95P31LNSC012	Liver	11/05/195 11:28	Archive-MFO	
SRD95P31LNSC013	Liver	11/05/195 12:15	Archive-MFO	
SRD95P31LNSC014	Liver	11/05/195 12:53	Archive-MFO	
SRD95P31LNSC015	Liver	11/05/195 14:27	Archive-MFO	
SRD95P31LNSC016	Liver	11/05/195 15:27	Archive-MFO	
SRD95P31LNSC017	Liver	11/05/195 16:45	Archive-MFO	
SRD95P31LNSC018	Liver	11/05/195 17:53	Archive-MFO	
SRD95P31LNSC019	Liver	12/05/195 9:48	Archive-MFO	
SRD95P31LNSC020	Liver	12/05/195 10:26	Archive-MFO	
~~SRD95P31LNSC021~~	Liver	12/05/195	~~Archive-MFO~~ NIL	
~~SRD95P31LNSC022~~	Liver	12/05/195	~~Archive-MFO~~ NIL	
SRD95P31LNSC023	Liver	12/05/195 13:19	Archive-MFO	
SRD95P31LNSC024	Liver	12/05/195 14:02	Archive-MFO	
SRD95P31LNSC025	Liver	12/05/195 14:59	Archive-MFO	
SRD95P31LNSC026	Liver	12/05/195 16:05	Archive-MFO	
SRD95P31LNSC027	Liver	12/05/195 16:59	Archive-MFO	
SRD95P31LNSC028	Liver	12/05/195 17:45	Archive-MFO	
SRD95P31LNSC029	Liver	13/05/195 9:50	Archive-MFO	
SRD95P31LNSC030	Liver	13/05/195 9:11	Archive-MFO	
SRD95P31LNSC031	Liver	13/05/195 10:39	Archive-MFO	
SRD95P31LNSC032	Liver	13/05/195 11:44	Archive-MFO	

Special Instructions/Comments: Samples SRD95P31LNSC020 & SRD95P31LNSC21 will be shipped at a later date.

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E5 05 437

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Meave Lagmodiere
Phone No. (403) 586 1-8444

Shipment Date: 23 May 95
Carrier: Loomis
Weigh Bill No.: 8D9848854

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SR095P31LNSC033	Liver	13/05/195 11:53	Archive - MFO	Frozer
SR095P31LNSC034	Liver	13105195 12:30	Archive-MFO	↓
SR095P31LNSC035	Liver	13105195 12:33	Archive-MFO	
SR095P31LNSC036	Liver	13105195 14:30	Archive-MFO	
SR095P31LNSC037	Liver	13105195 14:46	Archive-MFO	
SR095P31LNSC038	Liver	13105195 16:05	Archive-MFO	
SR095P31LNSC039	Liver	13105195 16:25	Archive-MFO	
SR095P31LNSC040	Liver	13105195 17:27	Archive-MFO	
SR095P31LNSC041	Liver	14105195 12:45	Archive-MFO	↓

Special Instructions/Comments:

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GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Marcel Lagrandeur
Phone No. (403)299-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 94851316

Ship To: Attn:
Enviroteast Laboratories
9936 - 67th Ave
Edmonton, AB T6E 0PE

Send Results To: Kym Holley
Golder Associates Ltd
1011 - 6th Ave S.W.
Calgary, AB ph(403)299

Project Name: Syncrude/Aquatic Baseline/Ft McMurray

Project No. 952-2308 task 7/4

P.O. No.: ~~Seal #~~

E50543

	Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	
SRD95PLNSC COMP01 40	SRD95P31LNSC004	fish liver	10 May 95 12:22	Composite these 9 samples and analyse for P450, AHH, and EROD. Archive 1/2 of each individual fish liver and send to Scott Brown. COMIX1 ARCIX1 P45IL1 EROIL1 AHHIL1	04
	SRD95P 31LNSC006	fish liver	10/05/95 13:54		06
	SRD95P 31LNSC013	fish liver	11/05/95 12:15		13
	SRD95P 31LNSC014	fish liver	11/05/95 12:53		14
	SRD95P 31LNSC015	fish liver	11/05/95 14:27		15
	SRD95P 31LNSC019	fish liver	12/05/95 9:48		19
	SRD95P 31LNSC023	fish liver	12/05/95 13:18		21
	SRD95P 31LNSC024	fish liver	12/05/95 14:02		22
	SRD95P 31LNSC032	fish liver	13/05/95 11:44		30
SRD95PLNSC COMP02 41	SRD95P 31LNSC003	fish liver	10/05/95 10:45	Composite these 10 samples and analyse for P450, AHH, and EROD. Archive 1/2 of each individual fish liver and send to Scott Brown.	03
	SRD95P 31LNSC005	fish liver	10/05/95 13:05		05
	SRD95P 31LNSC007	fish liver	10/05/95 14:42		07
	SRD95P 31LNSC011	fish liver	11/05/95 10:33		11
	SRD95P 31LNSC012	fish liver	11/05/95 11:28		12
	SRD95P 31LNSC018	fish liver	11/05/95 17:53		18
	SRD95P 31LNSC025	fish liver	12/05/95 14:58		23
	SRD95P 31LNSC027	fish liver	12/05/95 16:59		25
	SRD95P 31LNSC031	fish liver	13/05/95 12:39		29

continued on next page

Special Instructions/Comments: Note that livers are not in this shipment - were sent to ETL on 23 May 95 for storage.

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GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Renee Lapointe
Phone No. (403)299-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 94851316

ES11340-1a,B SRD95PLNSC COMP02 (cont)
ES11340-2a,B SRD95PLNSC COMP03
ES11340-2a,B SRD95PLNSC COMP04
ES11340-3a SRD95PLNSC COMP05

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested ES05437-33
SRD95P31 LNSC035	fish liver	13/05/95 12:33	↓ ↓
SRD95P31 LNSC004	fish fillet	10/05/95 12:12	Composite these 9 samples ES11934
SRD95P31 LNSC006	fish fillet	10/05/95 no time	and analyse for ICP metals, AS,
SRD95P31 LNSC013	fish fillet	13/05/95 12:22	SE
SRD95P31 LNSC014	fish fillet	11/05/95 13:04	↓ ↓
SRD95P31 LNSC015	fish fillet	10/05/95 14:45	
SRD95P31 LNSC019	fish fillet	12/05/95 9:35	
SRD95P31 LNSC023	fish fillet	12/05/95 13:28	
SRD95P31 LNSC024	fish fillet	12/05/95 14:13	
SRD95P31 LNSC032	fish fillet	13/05/95 12:00	
SRD95P31 LNSC003	fish fillet	10/05/95 10:46	Composite these 10 samples
SRD95P31 LNSC005	fish fillet	10/05/95 13:18	and analyse for ICP metals,
SRD95P31 LNSC007	fish fillet	10/05/95 14:55	AS, SE
SRD95P31 LNSC011	fish fillet	11/05/95 10:42	↓ ↓
SRD95P31 LNSC012	fish fillet	11/05/95 11:27	
SRD95P31 LNSC018	fish fillet	11/05/95 17:58	
SRD95P31 LNSC025	fish fillet	12/05/95 no time on sample	
SRD95P31 LNSC027	fish fillet	12/05/95 17:07	
SRD95P31 LNSC031	fish fillet	13/05/95 10:45	
SRD95P31 LNSC035	fish fillet	13/05/95 12:55	
SRD95P31 LNSC004	fish fillet	10/05/95 12:12	Composite these 9 samples
SRD95P31 LNSC006	fish fillet	10/05/95 no time	and analyse for PAH,
SRD95P31 LNSC013	fish fillet	11/05/95 12:22	Alkyl PAH, PANH
SRD95P31 LNSC014	fish fillet	11/05/95 13:04	↓ ↓
SRD95P31 LNSC015	fish fillet	11/05/95 14:45	

Continued on next page

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GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Marie Lagrandeur
Phone No. (403)299-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 94851316

Ship To: Attn:
Envirotest Laboratories
9936 - 67th Ave
Edmonton, AB T6E 0PE

Send Results To: Kym Holley
Golder Associates Ltd
1011 - 6th Ave S.W.
Calgary, AB ph(403)299-5

Project Name: Syncrude/Aquatic Baseline/Ft McMurray
Project No. 952-2308 task 715
P.O. No.:
W/seal #s

E505437

	Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	
SRD95PLNSC COMP01 40	SRD95P31LNSC004	fish liver	10 May 95 12:12	Composite these 9 samples and analyse for P450, AHH, and EROD. Archive 1/2 of each individual fish liver and send to Scott Brown.	04
	SRD95P 31LNSC006	fish liver	10/05/95 13:54		06
	SRD95P 31LNSC013	fish liver	11/05/95 12:15		13
	SRD95P 31LNSC014	fish liver	11/05/95 12:53		14
	SRD95P 31LNSC015	fish liver	11/05/95 14:27		15
	SRD95P 31LNSC019	fish liver	12/05/95 9:48	COMIX1 ARCIX1	19
	SRD95P 31LNSC023	fish liver	12/05/95 13:18	PHSIL1	21
	SRD95P 31LNSC024	fish liver	12/05/95 14:02	EROIL1	22
	SRD95P 31LNSC032	fish liver	13/05/95 11:44	AHHIL1	30
SRD95PLNSC COMP02 41	SRD95P 31LNSC003	fish liver	10/05/95 10:45	Composite these 10 samples and analyse for P450, AHH, and EROD. Archive 1/2 of each individual fish liver and send to Scott Brown.	03
	SRD95P 31LNSC005	fish liver	10/05/95 13:05		05
	SRD95P 31LNSC007	fish liver	10/05/95 14:42		07
	SRD95P 31LNSC011	fish liver	11/05/95 10:33		11
	SRD95P 31LNSC012	fish liver	11/05/95 11:28		12
	SRD95P 31LNSC018	fish liver	11/05/95 17:53		18
	SRD95P 31LNSC025	fish liver	12/05/95 14:58		23
	SRD95P 31LNSC027	fish liver	12/05/95 16:59		25
	SRD95P 31LNSC031	fish liver	13/05/95 10:39		29

continued on next page

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GOLDER ASSOCIATES LTD.
ANALYTICAL REQUEST FORM

Field Sampler: (Signature) Renee Lepine-Ouellet
Phone No. (403)299-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 94851316

ES11340-1a,B SRD95PLNSC COMP02 (cont)
ES11340-2a,B SRD95PLNSC COMP03
ES11340-2a,B SRD95PLNSC COMP04
ES11340-3a,B SRD95PLNSC COMP05

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested
SRD95P31 LNSC035	fish liver	13/05/95 12:33	ES05437-33
SRD95P31 LNSC004	fish fillet	10/05/95 12:12	Composite these 9 samples and analyse for ICP metals, AS, SE — ES11434
SRD95P31 LNSC006	fish fillet	10/05/95 no time	
SRD95P31 LNSC013	fish fillet	13/05/95 12:22	
SRD95P31 LNSC014	fish fillet	11/05/95 13:04	
SRD95P31 LNSC015	fish fillet	10/05/95 14:45	
SRD95P31 LNSC019	fish fillet	12/05/95 9:35	
SRD95P31 LNSC023	fish fillet	12/05/95 13:28	
SRD95P31 LNSC024	fish fillet	12/05/95 14:13	
SRD95P31 LNSC032	fish fillet	13/05/95 12:00	
SRD95P31 LNSC003	fish fillet	10/05/95 10:46	Composite these 10 samples and analyse for ICP metals, AS, SE
SRD95P31 LNSC005	fish fillet	10/05/95 13:18	
SRD95P31 LNSC007	fish fillet	10/05/95 14:55	
SRD95P31 LNSC011	fish fillet	11/05/95 10:42	
SRD95P31 LNSC012	fish fillet	11/05/95 11:27	
SRD95P31 LNSC018	fish fillet	11/05/95 17:58	
SRD95P31 LNSC025	fish fillet	12/05/95 no time on sample	
SRD95P31 LNSC027	fish fillet	12/05/95 17:07	
SRD95P31 LNSC031	fish fillet	13/05/95 10:45	
SRD95P31 LNSC035	fish fillet	13/05/95 12:55	
SRD95P31 LNSC04	fish fillet	10/05/95 12:12	Composite these 9 samples and analyse for PAH, Alkyl PAH, PANH
SRD95P31 LNSC06	fish fillet	10/05/95 no time	
SRD95P31 LNSC013	fish fillet	11/05/95 12:22	
SRD95P31 LNSC014	fish fillet	11/05/95 13:04	
SRD95P31 LNSC015	fish fillet	11/05/95 14:45	

Continued on next page

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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: December 13, 1995

ATTN: KYM HOLLEY

Lab Work Order #:	E511340	**Sampled By:**	M.L.
Project Reference:	952-2308 TASK7150 SEAL 23-24	**Date Received:**	11/17/95
Project P.O.#:	NOT SUBMITTED		

Comments:

APPROVED BY:

Doug Johnson
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E511340-10	SRD95PLNSC COMP03							
Sample Type:FILLET								
		Arsenic (As)	<0.5	0.5	mg/kg		12/05/95	TW
		Selenium (Se)	0.3	0.1	mg/kg	12/04/95	12/05/95	KH
		ICP Metals in Tissue						
		Silver (Ag)	<0.2	0.2	mg/kg		12/06/95	TW
		Aluminum (Al)	10	2	mg/kg		12/06/95	TW
		Barium (Ba)	<0.5	0.5	mg/kg		12/06/95	TW
		Beryllium (Be)	<0.5	0.5	mg/kg		12/06/95	TW
		Boron (B)	<5	5	mg/kg		12/06/95	TW
		Calcium (Ca)	246	10	mg/kg		12/06/95	TW
		Cadmium (Cd)	<0.5	0.5	mg/kg		12/06/95	TW
		Cobalt (Co)	<0.5	0.5	mg/kg		12/06/95	TW
		Chromium (Cr)	<0.5	0.5	mg/kg		12/06/95	TW
		Copper (Cu)	<1	1	mg/kg		12/06/95	TW
		Iron (Fe)	15	1	mg/kg		12/06/95	TW
		Potassium (K)	5190	10	mg/kg		12/06/95	TW
		Magnesium (Mg)	328	10	mg/kg		12/06/95	TW
		Manganese (Mn)	<0.5	0.5	mg/kg		12/06/95	TW
		Molybdenum (Mo)	<1	1	mg/kg		12/06/95	TW
		Sodium (Na)	352	50	mg/kg		12/06/95	TW
		Nickel (Ni)	<1	1	mg/kg		12/06/95	TW
		Lead (Pb)	<2	2	mg/kg		12/06/95	TW
		Phosphorus (P)	2760	10	mg/kg		12/06/95	TW
		Silicon (Si)	12	2	mg/kg		12/06/95	TW
		Tin (Sn)	<2	2	mg/kg		12/06/95	TW
		Strontium (Sr)	<0.5	0.5	mg/kg		12/06/95	TW
		Thallium (Tl)	<1	1	mg/kg		12/06/95	TW
		Vanadium (V)	<1	1	mg/kg		12/06/95	TW
		Zinc (Zn)	5	1	mg/kg		12/06/95	TW
E511340-21	SRD95PLNSC COMP04							
Sample Type:FILLET_COMP								
		Arsenic (As)	<0.5	0.5	mg/kg		12/05/95	TW
		Selenium (Se)	0.3	0.1	mg/kg	12/04/95	12/05/95	KH
		ICP Metals in Tissue						
		Silver (Ag)	<0.2	0.2	mg/kg		12/06/95	TW
		Aluminum (Al)	11	2	mg/kg		12/06/95	TW
		Barium (Ba)	<0.5	0.5	mg/kg		12/06/95	TW
		Beryllium (Be)	<0.5	0.5	mg/kg		12/06/95	TW
		Boron (B)	<5	5	mg/kg		12/06/95	TW
		Calcium (Ca)	680	10	mg/kg		12/06/95	TW
		Cadmium (Cd)	<0.5	0.5	mg/kg		12/06/95	TW
		Cobalt (Co)	<0.5	0.5	mg/kg		12/06/95	TW
		Chromium (Cr)	<0.5	0.5	mg/kg		12/06/95	TW
		Copper (Cu)	<1	1	mg/kg		12/06/95	TW
		Iron (Fe)	16	1	mg/kg		12/06/95	TW
		Potassium (K)	5120	10	mg/kg		12/06/95	TW
		Magnesium (Mg)	331	10	mg/kg		12/06/95	TW
		Manganese (Mn)	0.9	0.5	mg/kg		12/06/95	TW
		Molybdenum (Mo)	<1	1	mg/kg		12/06/95	TW
		Sodium (Na)	409	50	mg/kg		12/06/95	TW
		Nickel (Ni)	<1	1	mg/kg		12/06/95	TW
		Lead (Pb)	<2	2	mg/kg		12/06/95	TW
		Phosphorus (P)	2960	10	mg/kg		12/06/95	TW
		Silicon (Si)	9	2	mg/kg		12/06/95	TW
		Tin (Sn)	<2	2	mg/kg		12/06/95	TW
		Strontium (Sr)	0.9	0.5	mg/kg		12/06/95	TW
		Thallium (Tl)	<1	1	mg/kg		12/06/95	TW
		Vanadium (V)	<1	1	mg/kg		12/06/95	TW
		Zinc (Zn)	6	1	mg/kg		12/06/95	TW
E511340-31	SRD95PLNSC COMP05							
Sample Type:FILLET_COMP								
		PAH & Alkylated PAH (Fish)						
		Naphthalene	0.03	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Anthracene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Pyrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E511340-31	SRD95PLNSC COMPO5							
Sample Type:FILLET_COMP								
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	M
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Methyl naphthalene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	M
		Acridine	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Carbazole	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	M
E511340-42	SRD95PLNSC COMP06							
Sample Type:FILLET_COMP								
		PAH & Alkylated PAH (Fish)						
		Naphthalene	0.04	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Acenaphthylene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Acenaphthene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Fluorene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Dibenzothiophene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	M
		Phenanthrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Anthracene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Fluoranthene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Pyrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Benzo(a)anthracene/Chrysene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	M
		Benzo(b&k)fluoranthene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	M
		Benzo(a)pyrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Indeno(c,d-123)pyrene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	
		Dibenzo(a,h)anthracene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Benzo(ghi)perylene	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl naphthalene	0.03	0.02	ug/g (ppm)	11/24/95	11/30/95	M
		C2 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C3 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C4 sub'd naphthalene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Biphenyl	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl biphenyl	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		C2 sub'd biphenyl	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Methyl acenaphthene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		Methyl fluorene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C2 sub'd fluorene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl phenanthrene/anthracene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		C2 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	M
		C3 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		C4 sub'd phenanthrene/anth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	
		1-Methyl-7-isopropylphenanth.	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E511340-42	**SRD95PLNSC COMP06**							
Sample Type:FILLET_COMP								
		Methyl dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C3 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C4 sub'd dibenzothiophene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl fluoranthene/pyrene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 sub'd B(a)A/chrysene	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 sub'd B(b&k)F/B(a)P	N.D.	0.04	ug/g (ppm)	11/24/95	11/30/95	MJL
		PANH & Alkylated PANH's						
		Quinoline	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		7-Methyl quinoline	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		C3 Alkyl subst'd quinolines	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Acridine	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl acridine	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Phenanthridine	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Carbazole	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		Methyl carbazoles	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
		C2 Alkyl subst'd carbazoles	N.D.	0.02	ug/g (ppm)	11/24/95	11/30/95	MJL
E511340-52	**SRD95PLNSC COMP07**							
Sample Type:BILE_COMP								
		PAH Metab. in Bile Samples	WP attach		ppb		12/05/95	RBG

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT
NOT INCLUDING APPENDICES

ENVIRO-TEST LABORATORIES
RESULTS REPORT
POLYNUCLEAR AROMATIC HYDROCARBON (PAH) METABOLITES BY
HIGH PRESSURE LIQUID CHROMATOGRAPHY / HPLC FLOURESCENCE

PROJECT: GOLDER ASSOCIATES
ANALYSIS DATE: December 5, 1995
INSTRUMENT: VARIAN 5000 LC
COLUMN: Perkin Elmer HCODSW/PAH Column
MATRIX: Fish Bile

LAB SAMPLE#	SAMPLE I.D.	RESULT (ug/g,ppm) B(a)P equivalents	RESULT (ug/g,ppm) Naphthalene equivalents
E5-11-340-52A	SRD95P LNSC COMP 07	3.8	550
E5-11-342-11A	SRD95 LNSC COMP 08	2.3	420
Minimum Detectable Level (MDL)		0.02	0.2

B(a)P - Benzo(a)pyrene.

ND - Not Detected, less than the Minimum Detectable Level (MDL).

N/A - Not Applicable.

QA/QC:

The Laboratory Method Blank showed no B(a)P or Naphthalene contamination > MDL.

Samples were quantitated by external standard calibration and are reported as B(a)P or Naphthalene equivalents.

ENVIRO-TEST QA/QC REPORT

PAH & Alkylated PAH (Fish)

Average Surrogate Recovery for E511340	%
Nitrobenzene d5	100
2-Fluorobiphenyl	97
p-Terphenyl d14	93

PANH & Alkylated PANH's

Average Surrogate Recovery for E511340	%
Quinoline d7	62

Relative percent difference is expressed as RPD.
Percent Recovery is expressed as %.
THIS IS THE LAST PAGE OF THE QAQC REPORT

Appendix A Test Methodologies

Acid Digestion

Method: Open vessel digest with nitric acid and peroxide
Reference: EPA/600 4-91 Method 200.3

Arsenic (As)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

PAH & Alkylated PAH (Fish)

Preparation Method:	Soxhlet extraction with DCM.
Instrument Method:	GC/MSD analysis
Method Reference:	Extraction Method: EPA 3540 (modified) Analytical Method: EPA 8270 (modified)

PAH Metab. in Bile Samples

POLYAROMATIC HYDROCARBON (PAH) METABOLITES IN BILE METHOD REFERENCE:
ETL MSOP# 66.00

PANH & Alkylated PANH's

Selenium (Se)

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

Hydride Metals Preparation

Preparation: Digestion with permanganate/persulphate, nitric, and sulphuric acid
Addition of hydrochloric acid and cysteine prior to analysis.
Reference: US EPA SW 846, APHA 3114

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Marc Laguna-Diaz
Phone No. (403) 299-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 94851316

Ship To: Attn:
Envirotest Labs
9936-67th Ave
Edmonton AB T6E0P5
1-800-668-9679

Send Results To: Kym Holley
Golder Associates Ltd
1011 - 6th Ave S.W.
Calgary, AB
(403) 299-4607

Project Name: Syncrude/Aquatic Baseline/Ft McMurray Project No. 952-2308 task 7150
Sail # ~~P.O. No.~~: 23x24

Relinquished by: (Signature)	~~Received at lab by:~~ Loomis (Signature)	Date	Time
		11/16/95	10:45
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
		11/17/95	8:00a.m.
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

ANALYSIS REQUEST

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SRD95P31 LNSC004	Fish fillet	10/05/95 12:12	Composite tissue	seal intact
SRD95P31 LNSC006	Fish fillet	10/05/95 no time	Samples and analyse	
SRD95P31 LNSC013	Fish fillet	11/05/95 12:22	for ICP metals, AS, SE	
SRD95P31 LNSC014	Fish fillet	11/05/95 13:04		
SRD95P31 LNSC015	Fish fillet	10/05/95 14:45		
SRD95P31 LNSC019	Fish fillet	12/05/95 9:35		
SRD95P31 LNSC023	Fish fillet	12/05/95 13:25		
SRD95P31 LNSC024	Fish fillet	12/05/95 14:13		
SRD95P31 LNSC032	Fish fillet	13/05/95 12:00		

ES11340 SRD95PLNSCOMP03 - 109,3

ES11340 COMPIN ARCHI ICPITI AS12SI SE12SI VA12SI

Special Instructions/Comments: Please note condition of seal on arrival

Rush (surcharge): _____ Standard Turnaround Time: _____

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GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Marie Lagimodiere
Phone No. 403 1297-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 943 J3116

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SRO95P31 LNSC003	Fish fillet	10/05/95 10:46	Composite these	Seal intact
SRO95P31 LNSC005	Fish fillet	10/05/95 13:16	10 samples + analyse for	
SRO95P31 LNSC007	Fish fillet	10/05/95 14:55	ICP Metal, AS, SE	
SRO95P31 LNSC011	Fish fillet	11/05/95 10:42		
SRO95P31 LNSC012	Fish fillet	11/05/95 11:27		
SRO95P31 LNSC013	Fish fillet	11/05/95 17:56		
SRO95P31 LNSC035	Fish fillet	12/05/95 no time on sample		
SRO95P31 LNSC031	Fish fillet	13/05/95 10:45		
SRO95P31 LNSC027	Fish fillet	12/05/95 17:07		
SRO95P31 LNSC035	Fish fillet	13/05/95 12:55	↓ ↓	
SRO95P31 LNSC004	Fish fillet	10/05/95 12:12	Composite these	
SRO95P31 LNSC006	Fish fillet	10/05/95 no time	these 9 sample and	
SRO95P31 LNSC013	Fish fillet	11/05/95 12:33	analyse for PAH, Alkyl PAH,	
SRO95P31 LNSC014	Fish fillet	11/05/95 13:04	PANH	
SRO95P31 LNSC015	Fish fillet	11/05/95 14:45		
SRO95P31 LNSC019	Fish fillet	12/05/95 9:35		
SRO95P31 LNSC033	Fish fillet	12/05/95 13:28		
SRO95P31 LNSC024	Fish fillet	12/05/95 14:13		
SRO95P31 LNSC032	Fish fillet	13/05/95 12:07	↓ ↓	
SRO95P31 LNSC003	Fish fillet	10/05/95 10:45	Composite these 10	
SRO95P31 LNSC005	Fish fillet	10/05/95 13:16	Samples and analyze for	
SRO95P31 LNSC007	Fish fillet	10/05/95 14:55	PAH, Alkyl PAH	
SRO95P31 LNSC011	Fish fillet	11/05/95 10:42	PAH/VH ↓	↓

continued on next page

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SRO95PLNSC COMP04 -21g,B
SRO95PLNSC COMP05 -36g
SRO95PLNSC COMP06 -42g
ES11340
ES11340
Comp. n ARCHIVE PAH7 PNHIFI

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) [signature]
Phone No. (403) 299-4400

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 948 573 16

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt	
SR095P31 LNSC012 ✓	fish fillet	11/05/95 11:27		seal intact	ES11340
SR095P31 LNSC018 ✓	fish fillet	11/05/95 17:58	composite these		-
SR095P31 LNSC025 ✓	fish fillet	12/05/95 no time on sample	10 samples & analyse for PAH,		-
SR095P31 LNSC027 ✓	fish fillet	12/05/95 17:07	Alkyl PAH, PHN/A		-
SR095P31 LNSC031 ✓	fish fillet	13/05/95 10:45			-
SR095P31 LNSC035 ✓	fish fillet	13/05/95 12:55			-
SR095P31 LNSC004 ✓	fish bile	10/05/95 12:22	composite these		-
SR095P31 LNSC006 ✓	fish bile	10/05/95 no time on sample	9 samples x		-
SR095P31 LNSC013 ✓	fish bile	11/05/95 12:20	analyse for		COMPEV ARCHI PHAIB
SR095P31 LNSC014 ✓	fish bile	11/05/95 14:34	benzo-a-pyrene + naphalene		
SR095P31 LNSC015 ✓	fish bile	11/05/95 14:34			-
SR095P31 LNSC019 ✓	fish bile	12/05/95 9:52			-
SR095P31 LNSC023 ✓	fish bile	12/05/95 13:24			-
SR095P31 LNSC024 ✓	fish bile	12/05/95 14:06			-
SR095P31 LNSC032 ✓	fish bile	13/05/95 11:59			-
SR095P31 LNSC003 ✓	fish bile	10/05/95 10:45	composite these		ES113
SR095P31 LNSC005 ✓	fish bile	12/05/95 12:12	10 samples x		-
SR095P31 LNSC007 ✓	fish bile	10/05/95 14:49	analyse for benzo-a-pyrene		-
SR095P31 LNSC011 ✓	fish bile	11/05/95 10:37	+ naphtalene		-
SR095P31 LNSC012 ✓	fish bile	11/05/95 11:30			-
SR095P31 LNSC018 ✓	fish bile	11/05/95 16:58			-
SR095P31 LNSC025 ✓	fish bile	12/05/95 14:58			-
SR095P31 LNSC027 ✓	fish bile	12/05/95 17:04			-

ES11340 SR095PLNSCcomp07-529 SR095PLNSC comp06 -429 (cont'd)
ES11342 SR095PLNSCcomp08 -119

Continued on next page.

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-11a

SR095PLNSC comp08 (cont'd)

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Mary Lagrandeur
Phone No. (403) 299-4600

Shipment Date: 16NOV95
Carrier: LOOMIS
Weigh Bill No.: 94851316

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SR095PB1 LNSC031 ✓	Fish bile	13105195 12:41	Composite THESE ID samples + analyses	Seal intact
SR095P31 LNSC035 ✓	Fish bile	13105195 12:43	for benzo-a-pyrene and OCP analysis	"

-9c
-10

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: X

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ETL Enviro-Test

A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED

9936 - 67 Avenue, Edmonton, Alberta T6E 0P5 Telephone: (403) 434-9509 Fax: (403) 437-2311
Bay 2, 1313 - 44 Avenue N.E., Calgary, Alberta T2E 6L5 Telephone: (403) 291-9897 Fax: (403) 291-0298
107 - 111 Research Drive, Saskatoon, Saskatchewan S7N 3R2 Telephone: (306) 668-8370 Fax: (306) 668-8383
Bay 3, 10919 - 96 Avenue, Grande Prairie T8V 3J4 Telephone: (403) 539-5196 Fax: (403) 539-6295
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CHEMICAL ANALYSIS REPORT

GOLDER ASSOCIATES
1011 - 6TH AVENUE S.W.
CALGARY, ALBERTA
T2P 0W1

DATE: December 28, 1995

ATTN: KYM HOLLEY

Lab Work Order #:	E511342	**Sampled By:**	M.L.
Project Reference:	952-2308 TASK7150 SEAL 23-24	**Date Received:**	11/17/95
Project P.O.#:	NOT SUBMITTED		

Comments:

APPROVED BY:

FOR: Doug Johnson
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY: (Edmonton)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis registered by AIHA AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat
CERTIFIED BY: (Calgary)	CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) - For specific tests registered with the Association

ENVIRO-TEST LABORATORIES
RESULTS REPORT
POLYNUCLEAR AROMATIC HYDROCARBON (PAH) METABOLITES BY
HIGH PRESSURE LIQUID CHROMATOGRAPHY / HPLC FLOURESCENCE

PROJECT: GOLDER ASSOCIATES
ANALYSIS DATE: December 5, 1995
INSTRUMENT: VARIAN 5000 LC
COLUMN: Perkin Elmer HCODSW/PAH Column
MATRIX: Fish Bile

LAB SAMPLE#	SAMPLE I.D.	RESULT (ug/g,ppm) B(a)P equivalents	RESULT (ug/g,ppm) Naphthalene equivalents
E5-11-340-52A	SRD95P LNSC COMP 07	3.8	550
E5-11-342-11A	SRD95 LNSC COMP 08	2.3	420
Minimum Detectable Level (MDL)		0.02	0.2

B(a)P - Benzo(a)pyrene.

ND - Not Detected, less than the Minimum Detectable Level (MDL).

N/A - Not Applicable.

QA/QC:

The Laboratory Method Blank showed no B(a)P or Naphthalene contamination > MDL.

Samples were quantitated by external standard calibration and are reported as B(a)P or Naphthalene equivalents.

Appendix A Test Methodologies

PAH Metab. in Bile Samples

POLYAROMATIC HYDROCARBON (PAH) METABOLITES IN BILE METHOD REFERENCE:
ETL MSOP# 66.00

THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Page 1 of 4

Field Sampler: (Signature) Marie Leguerrier
Phone No. (403) 299-4600

Shipment Date: Nov 16/95
Carrier: Loomis
Weigh Bill No.: 94851316

Ship To: Attn:
Enviro-test Labs
9936-67th Ave
Edmonton AB T6E 0P5
1-800-668-9879

Send Results To: Kym Holley
Golder Associates Ltd
1011 - 6th Ave S.W.
Calgary, AB
(403) 299-4607

Project Name: Syncrude / Aquatic Baseline / Ft. McMurray Project No. 952-2308 task 7150
Sail # ~~P.O. No.~~: 23x24

Relinquished by: (Signature)	~~Received at lab by:~~ (Signature)	Date	Time
	Loomis	11/16/95	20:15
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
		11/17/95	8:00a.m.
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

ANALYSIS REQUEST

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SRD95P31 LNSC004	Fish fillet	10/05/95 12:12	Composite those 9	seal intact
SRD95P31 LNSC006	Fish fillet	10/05/95 no time	Samples and analyse	
SRD95P31 LNSC013	Fish fillet	11/05/95 12:22	for ICP metals, AS, SE	
SRD95P31 LNSC014	Fish fillet	11/05/95 13:09		
SRD95P31 LNSC015	Fish fillet	10/05/95 14:45		
SRD95P31 LNSC019	Fish fillet	12/05/95 9:35		
SRD95P31 LNSC023	Fish fillet	12/05/95 13:25		
SRD95P31 LNSC024	Fish fillet	12/05/95 14:13		
SRD95P31 LNSC032	Fish fillet	13/05/95 12:00		

SRD95PLNSCOMP03 - 109,9

ES11340.
COMPIN
ARCHIN
ICPITI -3
AST2SI -4
SET2SI -5
VAS2SI -6
-7
-8
-9

Special Instructions/Comments: Please note condition of seal / on arrival

Rush (surcharge): _____ Standard Turnaround Time: _____

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GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Marie Taylor-Moodie
Phone No. 403 299-4600

Shipment Date: Nov 16/95
Carrier: Ultramar
Weigh Bill No.: 9485J1316

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SRO95P31 LNSC003	fish fillet	10/05/95 10:46	Composite these	Seal intact
SRO95P31 LNSC005	fish fillet	13/05/95 13:16	10 samples + analyse for	
SRO95P31 LNSC007	fish fillet	10/05/95 14:55	ICP Metal, AS, SE	
SRO95P31 LNSC011	fish fillet	11/05/95 10:42		
SRO95P31 LNSC012	fish fillet	11/05/95 11:27		
SRO95P31 LNSC019	fish fillet	11/05/95 17:58		
SRO95P31 LNSC035	fish fillet	12/05/95 no time on sample		
SRO95P31 LNSC031	fish fillet	13/05/95 10:45		
SRO95P31 LNSC027	fish fillet	12/05/95 17:07		
SRO95P31 LNSC035	fish fillet	13/05/95 12:55	↓ ↓	
SRO95P31 LNSC04	fish fillet	10/05/95 12:12	Composite these	
SRO95P31 LNSC06	fish fillet	10/05/95 no time	these 9 sample and	
SRO95P31 LNSC013	fish fillet	11/05/95 12:33	analyse for PAH, Alkyl PAH,	
SRO95P31 LNSC014	fish fillet	11/05/95 13:04	PANH	
SRO95P31 LNSC015	fish fillet	11/05/95 14:45		
SRO95P31 LNSC019	fish fillet	12/05/95 9:35		
SRO95P31 LNSC033	fish fillet	12/05/95 13:28		
SRO95P31 LNSC024	fish fillet	12/05/95 14:13		
SRO95P31 LNSC033	fish fillet	13/05/95 12:07	↓ ↓	
SRO95P31 LNSC003	fish fillet	10/05/95 10:45	Composite these 10	
SRO95P31 LNSC005	fish fillet	10/05/95 13:18	Samples and analyze for	
SRO95P31 LNSC007	fish fillet	10/05/95 14:55	PAH, Alkyl PAH	
SRO95P31 LNSC011	fish fillet	11/05/95 10:42	PAH/VH	

continued on next page

Special Instructions/Comments:

Rush (surcharge): _____ Standard Turnaround Time: _____

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SRO95PLNSC COMPO4 -21a,B
SRO95PLNSC COMPO5 -34
SRO95PLNSC COMPO6 -42a
LES11340
Comp ARO PAHZFI PNH

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) [signature]
Phone No. (403) 299-4400

Shipment Date: Nov 16/95
Carrier: Commus
Weigh Bill No.: 948 513 16

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt	
SRD95P31 LNSC019	Fish fillet	11/05/95 11:27		Seal intact	E511340-
SRD95P31 LNSC018	Fish fillet	11/05/95 17:58	composite these		-2
SRD95P31 LNSC025	Fish fillet	12/05/95 no time on sample	to samples & analyse for PAA,		-38
SRD95P31 LNSC027	Fish fillet	12/05/95 17:07	Alkyl NPH, PANH		-39
SRD95P31 LNSC031	Fish fillet	13/05/95 10:45			-40
SRD95P31 LNSC035	Fish fillet	13/05/95 12:55			-41
SRD95P31 LNSC004 ✓	Fish bile	10/05/95 12:22	composite these		-43
SRD95P31 LNSC006 ✓	Fish bile	10/05/95 no time on sample	9 samples &		-44
SRD95P31 LNSC013 ✓	Fish bile	11/05/95 12:20	analyse for		COMPEV ✓
SRD95P31 LNSC014 ✓	Fish bile	11/05/95 14:34	benzo-a-pyrene & naphalene		ARCHIV. PHAIBI-
SRD95P31 LNSC015 ✓	Fish bile	11/05/95 14:34			-48
SRD95P31 LNSC019 ✓	Fish bile	12/05/95 9:52			-49
SRD95P31 LNSC023 ✓	Fish bile	12/05/95 13:24			-50
SRD95P31 LNSC024 ✓	Fish bile	12/05/95 14:06			-51
SRD95P31 LNSC032 ✓	Fish bile	13/05/95 11:59			
SRD95P31 LNSC003 ✓	Fish bile	10/05/95 10:45 ✓	composite these		E511342
SRD95P31 LNSC005 ✓	Fish bile	10/05/95 12:12 ✓	10 samples &		-2
SRD95P31 LNSC007 ✓	Fish bile	10/05/95 14:49 ✓	analyse for benzo-pyrene & naphthalene		-3
SRD95P31 LNSC011 ✓	Fish bile	11/05/95 10:37 ✓			-4
SRD95P31 LNSC012 ✓	Fish bile	11/05/95 11:30 ✓			-5
SRD95P31 LNSC016 ✓	Fish bile	11/05/95 16:53 ✓			-6
SRD95P31 LNSC026 ✓	Fish bile	12/05/95 14:58 ✓			-7
SRD95P31 LNSC027 ✓	Fish bile	12/05/95 17:04 ✓			-8

SRD95PLNSC comp06 -429 (cont'd)
SRD95PLNSC comp07 -529
SRD95PLNSC comp08 -119
E511342

Continued on next page.

Special Instructions/Comments:

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-11a

SR095PLRST composite (combined)

GOLDER ASSOCIATES LTD.
CHAIN-OF-CUSTODY RECORD

Field Sampler: (Signature) Rene Langmaerd
Phone No. (403) 299-4400

Shipment Date: 16 NOV 95
Carrier: LOOMIS
Weigh Bill No.: 7485316

Sample ID No.	Sample Description	Date/Time Sampled	Analysis Requested	Sample Condition Upon Receipt
SR095PB1 LNSC031 ✓	fish bile	13/05/95 10:41 ✓	composite the two samples + mixtures	seal intact
SR095PB1 LNSC035 ✓	fish bile	13/05/95 12:43 ✓	for benzo-pyrene and isoprocarbone	-1

-9
-10a

Special Instructions/Comments:

Rush (surcharge): _____

Standard Turnaround Time: X

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Project No.: 952-2308 Personnel: KA Page: 1 of 1

Sample Description: Separate Fish Inventory NRPK

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
473	NRPK	F	790	4250	MAY 5		10			TD-31-15
039	NRPK	m	443	605	MAY 8		5			TU-31-10
096	NRPK	m	540	1130	MAY 8		6			TU-31-10
447	NRPK	u	392	420	Oct 22		3			TD-31
448	NRPK	u	337	302	Oct 22					TD-31 could not age
180	NRPK	m	294	160	Oct 9		2			TU-31-11
240	NRPK	u	346	366	Oct 10		3			TD-31
367	NRPK	u	405	700	Oct 20		4			TD-31
034	NRPK	m	692	2390	MAY 8		7			TU-31-16
072	NRPK	F	540	1510	MAY 8		6			TU-31-20
120	NRPK	F	720	3000	MAY 8		7			TU-31-10
111	NRPK	F	620	1325	MAY 8		7			TU-31-10
410	NRPK	u	285	150	Oct 21	—	—	—	—	TD-31 could not age with
501	NRPK	u	333	400	Oct 23		4			TD-31
507	NRPK	u	310	220	Oct 23	—	—	—	—	TD-31 could not age
519	NRPK	u	240	90	Oct 23		1			TD-31
314	NRPK	u	320	35	Oct 11		1			TD-31 difficult to determine
024	NRPK	m	663	2300	MAY 7		5			TU-31-5
035	NRPK	m	598	1720	MAY 7		6			TU-31-7
013	NRPK	u	234	100	MAY 6		1			TU-31-3
031	NRPK	m	481	710	MAY 7		4			TU-31-7
030	NRPK	m	638	1600	MAY 7		5			TU-31-7
097	NRPK	F	370	310	MAY 5		3			TU-31-10
366	NRPK	u	470	340	Oct 20		5			TD-31
476	NRPK	m	332	270	MAY 11		2			TU-31-18
444	NRPK	F	640	6000	MAY 9		7			TU-31-13
574	NRPK	F	3270	3270	MAY 14		7			TU-31-2
315	NRPK	u	537	1150	Oct 12		5			TD-31 difficult to determine
124	NRPK	u	552	1750	Oct 12		6			TD
076	NRPK	F	715	2850	MAY 8		7			TU-31-20
446	NRPK	F	736	4250	MAY 9		9			TU-31-13
003	NRPK	u	145	25	Sept 25		1			TD-31
036	NRPK	F	340	545	MAY 8		7			TU-31-10
022	NRPK	u	160	22	SEP 25		1			TD-31
301	NRPK	F	760	4200	MAY 15		7			TU-31-28
305	NRPK	F	345	530	MAY 15		8			TU-31-

Project No.: 952-2308 Personnel: ED/KA Page: 1 of 1

Sample Description: WHSC (spring, fence fish fence)

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Cto.	Other	Comments
434	WHSC	M	295	340	May 9		3			TU-31
429	WHSC	M	365	640	May 9		5			TU-31
428	WHSC	F	344	500	May 9		5			TU-31
571	WHSC	F	395	940	May 14		5			TU-31
575	WHSC	M	425	1060	May 14		6			TU-31
650	WHSC	F	385	770	May 14		4			TU-31
607	WHSC	F	414	1100	May 14		7			TU-31
625	WHSC	F	428	1150	May 14		6			TU-31
410	WHSC	M	220	140	May 9		3			TU-31
411	WHSC	M	300	400	May 9		4			TU-31
408	WHSC	F	362	590	May 9		5			TU-31
360	WHSC	M	240	140	May 9					TU-31 Could not determine age
365	WHSC	UH	270	250	May 9		3			TU-31
343	WHSC	F	365	700	May 9		4			TU-31
369	WHSC	F	345	640	May 5		4			TU-31
372	WHSC	F	319	420	May 9		4			TU-31
347	WHSC	U	140	40	Oct 20		1			TD-31
367	WHSC	U	306	395	Oct 11		4			TD-31
128	WHSC	U	260	300	Oct 2		2			TD-31
423	WHSC	U	230	150	Oct 21		2			TD-31
523	WHSC	U	336	520	Oct 23		3			TD-31
338	WHSC	U	145	50	Oct 14					TD-31 Could not determine age
473	WHSC	U	162	100	Oct 22		2			TD-31
445	WHSC	U	180	90	Oct 21		1			TD-31
376	WHSC	U	254	230	Oct 26		3			TD-31
390	WHSC	U	185	80	Oct 20		1			TD-31
646	WHSC	M	322	500	May 15		3			TU-31-27
534	WHSC	F	412	1150	May 14		6			TU-31-27
528	WHSC	F	432	1300	May 14		10			TU-31-27
263	WHSC	F	344	570	May 9		3			TU-31-11
291	WHSC	F	345	550	May 9		4			TU-31-11
344	WHSC	M	322	450	May 9		3			TU-31-11

Project No.: 952-230S
Sample Description: ARGR

Personnel: KAIEB

Page: 1 of 1

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 1995	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
180	ARGR	U	125	15	Oct 14	1				TD-31 poor sample
330	ARGR	M	310	360	Oct 16	3				TD-31
540	ARGR	M	287	290	Oct 23	3				TD-31
539	ARGR	M	305	360	Oct 23	4				TD-31
346	ARGR	U	185	75	Oct 14	2				TD-31
334	ARGR	F	200	110	Oct 18	2				TD-31
360	ARGR	U	220	160	Oct 20	2				TD-31
361	ARGR	U	240	175	Oct 20	2				TD-31
347	ARGR	F	242	210	Oct 19	2				TD-31
342	ARGR	M	325	460	Oct 19	4				TD-31
489	ARGR	F	258	220	Oct 22	3				TD-31
486	ARGR	F	275	260	Oct 22	3				TD-31
459	ARGR	U	180	90	Oct 22	2				TD-31
434	ARGR	U	215	130	Oct 21	2				TD-31
420	ARGR	U	235	170	Oct 21	2				TD-31
415	ARGR	F	280	280	Oct 21	3				TD-31
427	ARGR	F	285	295	Oct 21	3				TD-31
867	ARGR	F	350	550	MAY 12	4				TD-31-31
1329	ARGR	U	247	200	MAY 23	2				TD-31-41
388	ARGR	U	243	150	MAY 18	2				TD-31-33
539	ARGR	F	285	280	MAY 13	3				TD-31-26
459	ARGR	U	180	90	Oct 22	2				TD-31
048	ARGR	F	363	645	MAY 8	4				TD-31-8
010	ARGR	M	260	310		2				TD-31-2
006	ARGR	M	267	310	MAY 6	3				TD-31-2
004	ARGR	U	286	325	MAY 6	3				TD-31-1
020	ARGR	M	340	450	MAY 7	—	—	—	—	TD-31-5 No scale or fin rays
413	ARGR	U	200	100	MAY 9	2				TU-31-2
414	ARGR	F	231	110	MAY 9	2				TU-31-12
1142	ARGR	U	223	160	MAY 21	3				TD 31-37
1139	ARGR	U	272	240	MAY 20	3				TU-31-36
075	ARGR	M	220	125	MAY 8	2				TU-31-10
126	ARGR	M	313	400	MAY 9	4				TU-31-11
160	ARGR	M	360	510	MAY 9	5				TU-31-11
125	ARGR	F	454	480	MAY 9	6				TU-31-11
50	ARGR	M	377	660	MAY 8	6				TU-31-9
002	ARGR	U	320	460	MAY 6	4				TD-31-1

Project No.: 452-2308 Personnel: ES Page: 1 of 1

Sample Description: LNSC (spring, trap Fish fence)

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
403	LNSC	U	155	60	Oct 20		1	1/2		TD-31 (2)
478	LNSC	U	148	45	Oct 22		1			TD-31 - barrel to det.
550	LNSC	U	205	110	Oct 24					TD-31 - could not age
109	LNSC	M	288	340	May 9		2 3			TU-31 (3)
188	LNSC	M	332	460	May 9		4			TU-31
173	LNSC	M	462	640	May 9		8			TU-31
174	LNSC	F	462	620	May 9		5			TU-31 (6)
235	LNSC	F	342	550	May 9		3			TU-31 (7)
215	LNSC	M	355	440	May 9		5			TU-31
241	LNSC	M	325	440	May 9		3			TU-31
250	LNSC	M	490	940	May 9		6			TU-31
311	LNSC	M	263	240	May 9		3			TU-31
551	LNSC	U	200	120	Oct 24		1			TD-31
222	LNSC	U	125	20	May 9		1			TU-31
270	LNSC	U	150	50	May 7		1			TD-31
349	LNSC	U	176	70	Oct 20		1			TD-21 (2)

Project No.: 952-2308 Personnel: KA Page: 1 of 1

Sample Description: KEAL LAKE

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date 95	Ageing Materials Scale	Fin Ray	Oto.	Other	Comments
1170	WHSC	U	245	200	May 23					unable to read cross section properly
1171	WHSC	F	328	490	May 23	L	4			
1172	WHSC	F	305	420	May 23		4			
1173	WHSC	M	254	250	May 23		3			
1176	WHSC	U	176	80	May 23		1			Difficult to determine
1177	WHSC	M	235	170	May 23		3			
1178	WHSC	F	280	260	May 23		3			
1179	WHSC	F	283	280	May 23		3			
1180	WHSC	M	330	460	May 23		5			
1181	WHSC	M	285	340	May 23					unable to interpret age
1182	WHSC	M	300	360	May 23		4			

Project No.: 952-2308 Personnel: KA/EB Page: 1 of 1

Sample Description: SRD95P BIOMARKERS

Fish No.	Species	Sex	Length (mm)	Weight (g)	Date (May 95)	Ageing Materials: Scale	Fin Ray	Oto.	Other	Comments
375	LNSC	M	367	590	May 9		5			SRD95P31LNSC001
447	LNSC	F	422	910	MAY 10		7			SRD95P31LNSC002
448	LNSC	F	395	900	MAY10		6			SRD95P31LNSC003
450	LNSC	M	377	620	MAY 10		6			SRD95P31LNSC004
451	LNSC	F	433	960	MAY10		7			SRD95P31LNSC005
452	LNSC	M	369	600	MAY10		6			SRD95P31LNSC006
453	LNSC	F	414	975	MAY10		7			SRD95P31LNSC007
454	LNSC	F	448	1300	MAY10		8			SRD95P31LNSC008
455	LNSC	M	380	710	MAY10		6			SRD95P31LNSC009
457	LNSC	F	390	770	MAY10		6			SRD95P31LNSC010
458	LNSC	F	382	825	MAY11	—	—	—	—	SRD95P31LNSC011 (COULDN'T CROSS SECT for ray photo. n/a
461	LNSC	F	412	945	MAY11		6			SRD95P31LNSC012
464	LNSC	M	380	650	MAY11		5			SRD95P31LNSC013
465	LNSC	M	382	775	MAY11		5			SRD95P31LNSC014
466	LNSC	M	373	620	MAY11		5			SRD95P31-LNSC015
467	LNSC	F	422	1110	MAY11		7			SRD95P31LNSC016
468	LNSC	F	390	825	MAY11		6			SRD95P31LNSC017
469	LNSC	F	453	1150	MAY11		8			SRD95P31LNSC018
494	LNSC	M	365	600	MAY12		5			SRD95P31LNSC019
500	LNSC	M	350	840	MAY12		5			SRD95P31LNSC020
501	LNSC	M	375	770	MAY12		6			SRD95P31LNSC021
502	LNSC	M	413		MAY12		6			SRD95P31LNSC022
503	LNSC	M	430	1055	MAY12		6			SRD95P31LNSC023
504	LNSC	M	390	775	MAY12		6			SRD95P31LNSC024
505	LNSC		409	900	MAY12		6			SRD95P31LNSC025
506	LNSC	M	392	690	MAY12		7			SRD95P31LNSC026
508	LNSC	F	454	1215	MAY12		7			SRD95P31LNSC027
526	LNSC	F	345	810	MAY12		7			SRD95P31LNSC028
527	LNSC	F	426	1050	MAY13		7			SRD95P31LNSC029
528	LNSC	F	412	925	MAY13		6			SRD95P31LNSC030
529	LNSC	F	475	1400	MAY13		7			SRD95P31LNSC031
530	LNSC	M	380	750	MAY13		6			SRD95P31LNSC032
531	LNSC	M	405	830	MAY13		5			SRD95P31LNSC033
532	LNSC	M	427	990	MAY13		7			SRD95P31LNSC034
533	LNSC	F	451	950	MAY13		5			SRD95P31LNSC035 ?
534	LNSC	F	388	770	MAY 13		5			SRD95P31LNSC036
535	LNSC	M	362	610	MAY13		5			SRD95P31LNSC037
536	LNSC	M	399	810	MAY13		5			SRD95P31LNSC038
537	LNSC	M	404	850	MAY13		7			SRD95P31LNSC039
538	LNSC	M	375	690	MAY13		5			SRD95P31LNSC040
546	LNSC	F	395	830	MAY 14		6			SRD95P31LNSC041

Tracy Marchant U of Saskatchewan

Syncrude Samples:

Sample code	Estradiol (pg/ml)	Testosterone (pg/ml)
LNSC 004	not assayed	4540
LNSC 006	"	1670
LNSC 013	"	4310
LNSC 015	"	7560
LNSC 019	"	3840
LNSC 023	"	5460
LNSC 024	"	9660
LNSC 032	"	6290
LNSC 014	"	3800
LNSC 001	"	2820
LNSC 009	"	8710
LNSC 020	"	4310
LNSC 021	"	1810
LNSC 022	"	5390
LNSC 026	"	4280
LNSC 033	"	4040
LNSC 034	"	7660
LNSC 037	"	3090
LNSC 038	"	6850
LNSC 040	"	7130
LNSC 003	3210	5460
LNSC 005	3560	12870
LNSC 007	2190	4040
LNSC 011	687	10370
LNSC 012	4530	1810
LNSC 018	842	9140
LNSC 025	517	7460
LNSC 027	3070	29900
LNSC 031	6220	10040
LNSC 035	1120	2780
LNSC 002	2820	11360
LNSC 008	2710	6460
LNSC 010	3560	1610
LNSC 016	3040	26210
LNSC 017	3010	4180
LNSC 028	1360	4080
LNSC 029	1590	2820
LNSC 030	767	2160
LNSC 036	1120	18730
LNSC 039	656	3500
LNSC 041	252	18730

952-2308 Fecundity (1.0g eggs) Nov. 20/95

SAMPLE NO.	EGG COUNT
SRD95 P31 LNSC 007	266
" 039	237
" 002	299 full size + approx 143 underdev.
" 011	394
" 016	264
" 017	298
" 005 (on container) 001 (on bags)	216
" 010	288
" 029	288
" 036	264
" 012	347
" 041	341
" 025	216
" 030	233
" 018	205
" 035	308
" 031	224
" 027	248
" 003	486
" 028	345
" 008	258

Post-it™ Fax Note 7671E	Date 20 Nov 95	# of pages ▸ 1
To Marie Lagimodiere	From Anne Young	
Co./Dept. GA Downtown	Co. GA Lab	
Phone # 299-4600	Phone # 259-0246	
Fax # 299-5606	Fax # 259-0241	

Tissue Level

SAMPLE Longnose	Tocopherol µg/gram	Retinol µg/gram	Retinyl Palmitate µg/gram
3	84.15	2.19	117.02
4	327.75	0.96	54.28
5	216.64	1.33	260.13
6	202.43	1.71	131.01
7	93.46	1.17	107.14
11	107.90	1.98	146.31
12	29.21	1.78	108.45
14	227.24	1.05	147.85
15	464.75	0.48	107.89
18	82.51	1.69	352.50
19	367.04	0.69	62.15
27	143.94	5.49	256.28
24	175.62	1.02	217.06
25	143.33	5.01	245.80
31	169.15	8.50	609.30
32	377.09	0.88	41.50
35	56.55	3.28	157.37

APPENDIX XIV

HISTOPATHOLOGY ANALYSIS REPORT
(GLOBALTOX INTERNATIONAL CONSULTANTS INC.)

ALBERTA AQUATIC

BASELINE STUDIES

Histopathology of Mountain Whitefish, Walleye, Goldeye and Burbot Sampled from the Athabasca River in the Spring of 1995.

November 10, 1995

for

Dr. Stella Swanson
Golder Associates Ltd.

GLOBALTOX
INTERNATIONAL CONSULTANTS INC.
30 METCALFE ST, OTTAWA, ON K2P 1R9
TEL: (613) 798-0808
FAX: (613) 798-1100

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Overview: This report contains the pathological evaluation of Mountain White, Walleye and Burbot fish submitted by Golder Associates Ltd to GLOBALTOX INTERNATIONAL CONSULTANTS INC. in October 1995.

Findings: The findings ranged from incidental changes that could be attributed to the method of capture and sampling to chronic parasitism. There were no changes consistent with toxicity, nor were there any neoplasia

Recommendations:

More tissues per submission may help GLOBALTOX to give a better picture as to the health of the individual under investigation.

I INTRODUCTION

This report contains the results of the pathological evaluation of Mountain Whitefish, Goldeye, Burbot and Walleye taken in the spring of 1995 from the Athabasca river, as requested by Dr. Stella Swanson of Golder Associates Ltd. These samples are part of an Environmental Effects Monitoring program for various regions of the Athabasca River. Each fish has been evaluated and gross observations supplied by Golder Associates Ltd., have been incorporated in each report. The pathological terminology used in this report is that used by the American College of Veterinary Pathology and the Armed Forces Institute of Pathology. Following a summary morphological diagnosis (a statement of standardised altered morphology with respect to process, duration, exudate and other findings), a comment section has been inserted to explain the observations. It should be noted that the order of the morphological diagnoses does not reflect the order of importance.

Photographs of lesions and parasites, taken with Ektachrome 100 diapositive film, can be found at the end of the report.

II METHODOLOGY

II.A SAMPLING

Samples were taken by Golder Associates Ltd. All tissues sampled were trimmed, routinely processed, sectioned at 5 µm, stained with hematoxylin and eosin, and mounted. Where necessary special stains were used to highlight specific lesions or causative agents. Parasites were identified wherever possible. All samples were well packaged and arrived with a chain of custody form, which has been attached to this report as Appendix A.

II.B Quality Assurance

Drs. R. Müller and C.G. Rousseaux were the pathologists who read all aspects of the work. Samples were trimmed by Dr. Müller, and then processed. Each sub-sample was labelled and records kept using the method outlined in Section II. E. Samples and pathological interpretations were double checked. All blocks were resealed and stored in water-resistant material for archiving.

II.C Comments on Samples Submitted

Samples were received in sealed containers (triple protected) that would not allow exposure of third parties to the formalin. The rigid outer containers prevented damage to the primary container.

II.D Suggestions for Improving Future Samples

Standardisation of sampling was maintained. Fixation and labelling was excellent. No further improvements on specimen submission needs to be made at this time, except to decrease the trauma to the intestine when sampling.

II.E Sampling Method

The standardised codes used for cassette identification can be found in Table 1. in the future, recall from the archives for comparison purposescan be made using this coding system.

Table 1. Identification Codes for Cassettes Containing Fish Tissues.

A	Hypophysis (pituitary)			B	Brain	C	Spinal Cord
D	Eyes	D1	Right	E	Nerves (marked on side of cassette)		
		D2	Left				
F	Oral cavity mucosa			G	Thyroid	H	Aorta
I	Tongue			J	Mesentery	K	Heart
L	Gills	L1	cranial right		L4 cranial left		
		L2	middle right		L5 middle left		
		L3	caudal right		L6 caudal left		
M	Stomach	M1	esophagus	M3	fundus		
		M2	cardia	M4	pylorus, pyloric caeca		
N	Upper intestine			O	Lower intestine		
P	Liver (lobes marked on cassettes)			Q	Open		
R	Urinary system	R4	Cloaca	(other parts marked on the cassette)			
S	Spleen	T	Ovaries and Testes			T1	Testis right
						T2	Testis left
U	Open	V	Bone marrow			W	Bone (specify on the cassette)
X	Muscle (specify on the cassette)						
Y	Skin, fin etc. (specify on the cassette)					Z	Miscellaneous

All special areas of sampling other than the coded ones are marked on the side of the cassettes

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