

**PERFLUOROCARBON (PFC)-CONTAINING FIREFIGHTING FOAMS
AND THEIR USE IN MINNESOTA:
GROUNDWATER SAMPLING at KANDIYOHI COUNTY LANDFILL**

ANTEA GROUP PROJECT NO. SFDE1208
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PERFLUOROCARBON (PFC)-CONTAINING FIREFIGHTING FOAMS AND THEIR USE IN MINNESOTA: GROUNDWATER SAMPLING at KANDIYOHİ COUNTY LANDFILL

1.0 INTRODUCTION

1.1 Purpose

Antea™ Group (formerly Delta Consultants) has worked under contract with the Minnesota Pollution Control Agency (MPCA) investigating perfluorochemicals in Class B firefighting foams and the use of Class B firefighting foams in Minnesota. Previous information regarding this investigation was presented in the following reports:

- *Perfluorocarbon (PFC)-Containing Firefighting Foams and Their Use In Firefighting Training in Minnesota*, dated June 30, 2008 (the June 2008 Report);
- *Addendum to PFC-Containing Firefighting Foams and Their Use In Firefighting Training in Minnesota*, dated October 22, 2008 (the October 2008 Addendum Report);
- *Firefighting Training Area Site Reconnaissance, Pine Bend Flint Hills Refinery, Marathon Refinery, Burnsville Fire Training Center, and Site Access for 21 Fire Departments*, dated April 3, 2009 (the April 2009 Report);
- *Report of Site Reconnaissance and Sampling at Select Firefighting Foam Training Areas in Minnesota*, dated June 30, 2009 (the June 2009 Report);
- *Report of Investigation Activities at Select Firefighting Foam Training Areas and Foam Discharge Sites in Minnesota*, dated February 10, 2010 (the February 2010 Report);
- *Perfluorocarbon (PFC)-Containing Firefighting Foams and Their Use in Firefighting Training in Minnesota*, dated June 30, 2010 (the June 2010 Report);
- *Perfluorocarbon (PFC)-Containing Firefighting Foams and Their Use in Minnesota: Well Receptor Surveys and Follow-Up Sampling at Select Sites*, dated November 15, 2010 (the November 2010 Report);
- *Perfluorocarbon (PFC)-Containing Firefighting Foams and Their Use in Minnesota: Sampling at the Lake Superior College Emergency Response Training Center, Duluth*, dated February 25, 2011 (the February 2011 Report); and,
- *Perfluorocarbon (PFC)-Containing Firefighting Foams and Their Use in Minnesota: Sampling at the Hidden Harbor Marina, Burnsville Wetland, and Bemidji Private Wells*, dated May 13, 2011 (the May 2011 Report).
- *Perfluorocarbon (PFC)-Containing Firefighting Foams and Their Use in Minnesota: Survey and Sampling Activities, State Fiscal Year 2011*, dated June 30, 2011 (the June 2011 Report).

This report summarizes data and information for groundwater sampling activities conducted at the Kandiyohi County Landfill in “PFC/Firefighting Foam” project during the Minnesota State Fiscal Year of 2012.

1.2 Background

As a part of an overall investigation of PFCs in Minnesota, the MPCA and Minnesota Department of Health (MDH) have been investigating firefighting foams as a possible source of PFCs in the environment. Aqueous film-forming foam, or

Class B AFFF, has a fluorochemical-based surfactant that rapidly forms a film across the fire surface, which prevents the release of flammable fuel vapors and excludes oxygen from the fuel surface. PFCs have been identified in soil, sediment, surface water and groundwater samples collected from locations in Minnesota where various brands of Class B AFFF have been used repeatedly in training exercises or in large quantity to extinguish fires.

A fire occurred at the construction and demolition (C&D) portion of the Kandiyohi County Landfill over a period of four days, starting on October 22, 2009. According to news reports, fire departments from New London, Spicer, Willmar, Sunburg, Pennock, and Belgrade responded to the fire. In November 2009 the Willmar Fire Department Fire Chief was contacted regarding the fire response at the landfill. The Willmar Fire Chief indicated that, while mostly Class A foam was used to fight the fire, 3M- and Ansul-brands of Class B foam were also used. The Kandiyohi County Director of Environmental Services confirmed that 545 gallons of Class B foam concentrate were used on the landfill fire, although a break down of the brands of Class B foams used was not available.

The Kandiyohi County Landfill is located approximately three miles west-southwest of the City of New London, southwest of the corner of the intersection of 165th Avenue NW and Highway 71. The landfill location is shown on **Figure 1, Site Location Map, Kandiyohi County Landfill**. The layout of the landfill and the area of firefighting foam discharge are shown on the **Figure 2, Sample Locations, Kandiyohi Landfill**.

In order to assess if PFCs were released to the environment by the large quantity of foam used on the fire, groundwater samples were collected from existing landfill monitoring wells DMW-1A and DMW-3. Well DMW-1A is located upgradient of the fire area, and DMW-3 is located approximately 300 to 350 feet from the area of the fire, in an approximate downgradient groundwater flow direction. The referenced monitoring wells are shown on **Figure 2**. Efforts to install additional monitoring wells were unsuccessful due to the uneven terrain and sandy soil conditions. Groundwater samples were collected from DMW-1A and DMW-3 in January, May and August 2010. No PFCs were identified in the samples collected from upgradient well DMW-1A. The only PFC compound detected in the groundwater samples collected from DMW-3 was perflourobutanoic acid (PFBA), which was detected at concentrations ranging from 6.1 nanograms per liter (ng/l) to 11 ng/l. Analytical results are summarized in **Table 1, Groundwater PFC Analytical Results, Kandiyohi County Landfill**.

1.3 Scope of Work

Antea Group performed the following scope of work under MPCA Purchase Order No. 3000001645, Shell No. 33249, dated September 15, 2011:

1. Permission was obtained from Kandiyohi County Environmental Services to conduct additional groundwater sampling from DMW-3 and DMW-1A.

2. One round of groundwater samples was collected from existing monitoring wells DMW-3 and DMW-1A to evaluate if PFCs have migrated from the C&D portion of the Kandiyohi County Landfill to downgradient well DMW-3. Depths to groundwater were measured prior to sampling. Groundwater samples were submitted to a State-contracted laboratory for analysis of PFCs.
3. This report was prepared summarizing the work performed

2.0 SAMPLING ACTIVITIES AND RESULTS

2.1 Sample Collection

Permission was obtained from Kandiyohi County Environmental Services to conduct additional groundwater sampling from DMW-3 and DMW-1A for PFC analysis. The sampling was conducted under an existing site access agreement between Kandiyohi County and the MPCA.

Antea Group conducted sampling activities on October 13, 2011. Sampling was conducted first at upgradient well DMW-1A and then at DMW-3. The depth to groundwater measured at DMW-1A was 24.15 feet, and the depth to groundwater at DMW-3 was 52.90 feet. One well volume of water was purged from the wells prior to sampling. The wells were purged and sampled with disposable polyethylene bailers. Groundwater samples were placed directly into unpreserved, laboratory-supplied jars. Sampling methods are described in detail in **Appendix A**.

Samples were stored in a cooler on ice and then in an Antea Group sample refrigerator until shipment to the laboratory. The groundwater samples were submitted to Axys Analytical Services Ltd. (Axys) of British Columbia, Canada. The groundwater samples were shipped via overnight FedEx with appropriate chain-of-custody record and international shipping documents.

2.2 Analytical Results

Laboratory analyses were performed by Axys. Copies of the laboratory data provided by Axys and chain-of-custody are included in **Appendix B**. Laboratory results are summarized in **Table 1**.

Laboratory analysis detected PFBA in the upgradient groundwater sample collected from DMW-1A for the first time since PFC sampling began at the Kandiyohi County Landfill; the detected PFBA concentration is 3.81 ng/l. The PFBA concentration of 12.3 ng/l detected in the DMW-3 groundwater sample is only slightly higher than the PFBA concentrations previously detected. In addition, other PFC compounds were detected in the DMW-3 groundwater sample for the first time since PFC sampling began at the Kandiyohi County Landfill, including 14.7 ng/l perfluorooctane sulfonate, or PFOS. Perfluorooctanoic acid (PFOA) was not detected in the sample.

2.3 Health Risk Limits/Health-Based Values for PFCs

The laboratory data is compared to State drinking water health risk limits or health-based values set by the MDH in

Table 1. None of the detected PFC concentrations in the DMW-3 groundwater sample exceeded a drinking water limit or health-based value.

3.0 CONCLUSIONS AND RECOMMENDATIONS

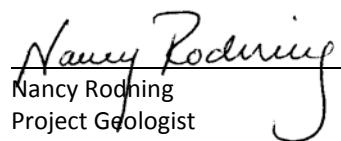
PFCs were detected in a groundwater sample collected in October 2011 in a downgradient groundwater flow direction from the site of the October 2009 fire at the Kandiyohi County Landfill. The release of 545 gallons of Class B foam on the fire is likely to have released PFCs to the environment and is the likely source of the PFCs detected in the groundwater in the DMW-3 well sample. 3M was the principal global manufacturer of PFOS, and PFOS was used in the manufacture of their firefighting foam.

PFCs were (largely) not detected in groundwater samples collected previously from DMW-3, in January 2010, May 2010, and August 2010. Therefore, some time between August 2010 and October 2011 the PFCs in groundwater traveled as far as DMW-3. Hence, from the time the foam was discharged in October 2009, it took somewhere between ten months and two years for the PFCs in the firefighting foam to migrate through the soils underlying the C&D portion of the landfill and to travel approximately 300 feet to the location of DMW-3.

In order to monitor PFC levels in the area of the firefighting foam discharge over time, additional groundwater sampling of DMW-3 is recommended.

4.0 REMARKS

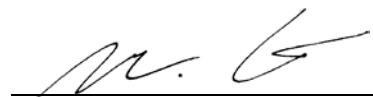
The conclusions and recommendations contained in this report represent Antea Group's professional opinions based upon the currently available information and are arrived at in accordance with currently accepted professional standards. This report is based upon a specific scope of work requested by the client. The contract between Antea Group and its client outlines the scope of work, and only those tasks specifically authorized by that contract or outlined in this report were performed. This report is intended only for the use of Antea Group's client. Antea Group will not and cannot be liable for unauthorized reliance by any other third party. Other than as contained in this paragraph, Antea Group makes no express or implied warranty as to the contents of this report.



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Project Geologist

Date: December 20, 2011

Reviewed by:



John Estes
Project Manager

Date: December 20, 2011

TABLES

Table 1 Groundwater PFC Analytical Results, Kandiyohi County Landfill

TABLE 1
Groundwater PFC Analytical Results
Kandiyohi County Landfill

		Perfluorobutanoic acid (PFBA)	Perfluoro-n-pentanoic acid (PFPeA)	Perfluorohexanoic acid (PFHxA)	Perfluoroheptanoic acid (PFHpA)	Perfluoroctanoic acid (PFOA)	Perfluorononanoic acid (PFNA)	Perfluorodecanoic acid (PFDA)	Perfluoroundecanoic acid (PFUnA)	Perfluorododecanoic acid (PFDoA)	Perfluorobutanoic acid (PFBS)	Perfluorohexane sulfonate (PFHxS)	Perfluoroctane sulfonate (PFOS)	Perfluoroctane sulfonamide (PFOSA)
#Perfluorinated Carbon Chains:		4	5	6	7	8	9	10	11	12	4	6	8	8
Health-Based Limits:		7000 ⁽¹⁾	ND	ND	ND	300 ⁽²⁾	ND	ND	ND	ND	7000 ⁽¹⁾	RAA ⁽³⁾	300 ⁽²⁾	ND
Sample ID	Date													
Kandiyohi DMW-1A	1/12/2010	< 2.43	< 2.43	< 2.43	< 2.43	< 2.43	< 2.43	< 2.43	< 2.43	< 2.43	< 4.87	< 4.87	< 4.87	< 2.43
Kandiyohi DMW-3	1/12/2010	6.1	< 2.51	< 2.51	< 2.51	< 2.51	< 2.51	< 2.51	< 2.51	< 2.51	< 5.01	< 5.01	< 5.01	< 2.51
Kandiyohi DMW-1A	5/4/2010	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 4.99	< 4.99	< 4.99	< 2.49
Kandiyohi DMW-3	5/4/2010	11	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 2.49	< 4.98	< 4.98	< 4.98	< 2.49
Kandiyohi DMW-1A	8/12/2010	< 2.54	< 2.54	< 2.54	< 2.54	< 2.54	< 2.54	< 2.54	< 2.54	< 2.54	< 5.09	< 5.09	< 5.09	< 2.54
Kandiyohi DMW-3	8/12/2010	7.61	< 2.48	< 2.48	< 2.48	< 2.48	< 2.48	< 2.48	< 2.48	< 2.48	< 4.95	< 4.95	< 4.95	< 2.48
Kandiyohi DMW-1A	10/13/2011	3.81	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 5.06	< 5.06	< 5.06	< 2.53
Kandiyohi DMW-3	10/13/2011	12.3	9.65	20.1	< 2.57	< 2.57	< 2.57	< 2.57	< 2.57	< 2.57	17.5	22.8	14.7	< 2.57

Notes:

All results and standards are in nanograms per liter (ng/L), which is equivalent to parts per trillion.

All samples were analyzed by Arys Analytical Services LTD.

MPI: MPI Research

Bolded type indicates detection above the laboratory method detection limit.

(1) Health-Based Value (HBV) for chronic exposure defined by the Minnesota Department of Health.

(2) Health Risk Limit (HRL) for drinking water defined by the Minnesota Department of Health.

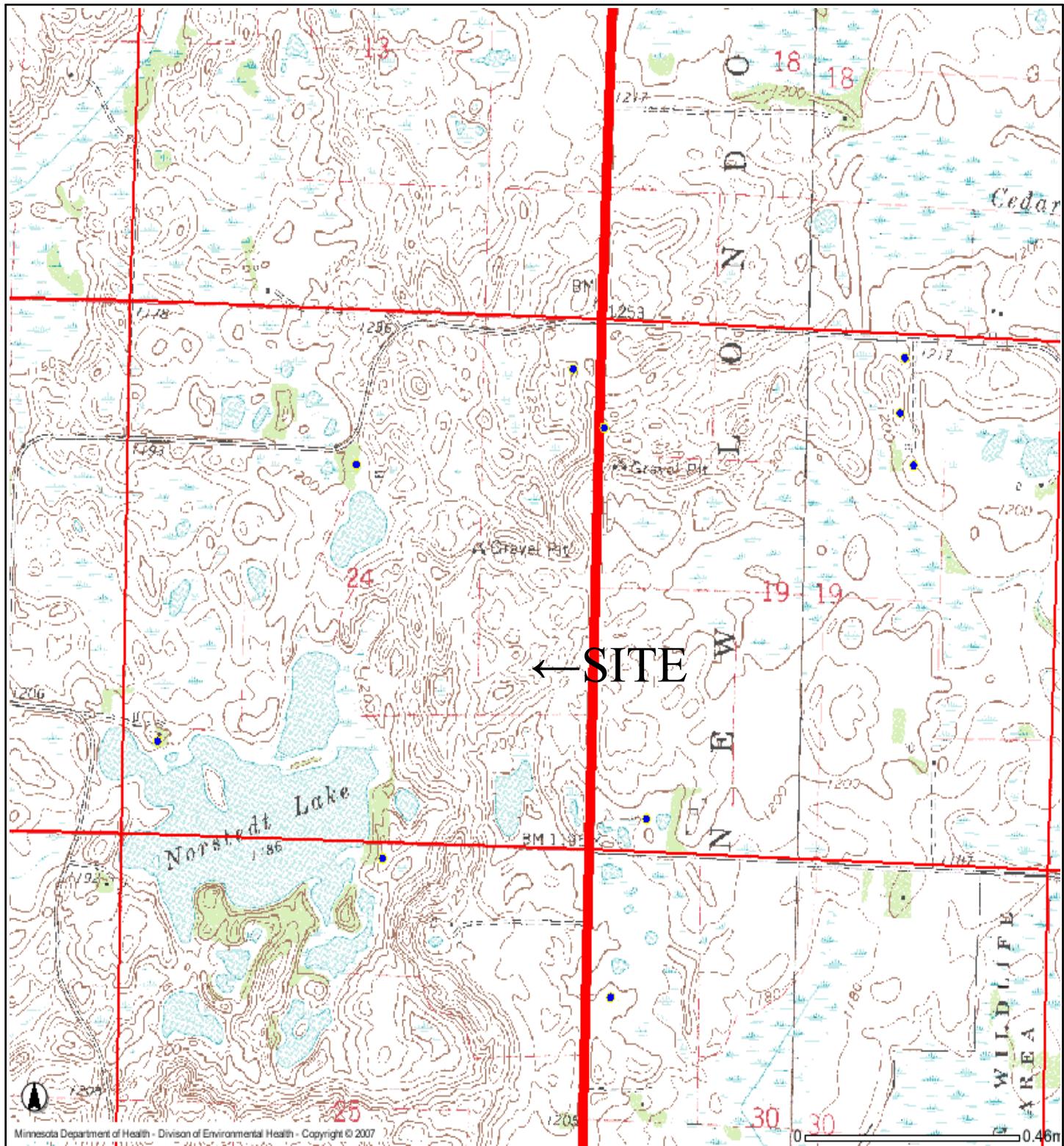
(3) Risk Assessment Advice (RAA) set by the Minnesota Department of Health for PFHxS does not specify numeric values.

ND: No health-based limit defined.

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FIGURES

Figure 1	Site Location Map
Figure 2	Sample Locations



LEGEND:

- Well Locations



FIGURE 1
SITE LOCATION MAP
KANDIYOHI COUNTY LANDFILL
NEW LONDON, MINNESOTA

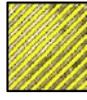
PROJECT NO. 19382DEL	PREPARED BY NR	DRAWN BY DD
DATE 12/12/11	REVIEWED BY	FILE NAME New London-1





LEGEND:

▲ Sample Location



Foam Use Area



0 350
SCALE IN FEET

FIGURE 2
SAMPLE LOCATIONS
KANDIYOHI LANDFILL
NEW LONDON, MINNESOTA

PROJECT NO. 45618DEL04	PREPARED BY NR	DRAWN BY DD
DATE 12/12/11	REVIEWED BY	FILE NAME Kandiyohi-1

Appendix A

Sampling Methods

SAMPLING METHODOLOGIES AT FIREFIGHTING FOAM TRAINING AND DISCHARGE AREAS

Special PFC Sampling Consideration

Since PFCs are also found in numerous everyday items, the following special precautions were taken during all sampling activities: no use of Teflon®-containing materials (i.e. Teflon® tubing, bailers, tape, plumbing paste); no Tyvek® clothing was worn; clothes treated with stain- or rain-resistant coatings were avoided or had gone through several washings; no Post-It® Notes were handled or brought on site; no fast food wrappers, disposable cups or microwave popcorn were brought on site during sampling, and hands were washed after handling such items and prior to any sampling activities; and no use of chemical (blue) ice packs was allowed.

Nitrile gloves were worn during all sample collection activities.

Groundwater Level Measurement

Groundwater level measurements were obtained using an electronic Water Level Indicator (WLI), which emits a beep when the WLI probe is in contact with the ground water in the well. The WLI probe is lowered into the well until it beeps. The depth to water was measured from the notched or north side of top of casing. All measurements were recorded to the nearest 0.01 foot; however, the manufacturer's reported accuracy for the instrument is 0.04 foot. The water level indicator probe and attached measuring tape that have been introduced into the well were decontaminated between each well with a mixture of Alconox and distilled water.

Well Purging

One well volume was purged from each well using a dedicated, disposal bailer prior to sampling. One well volume for a 2-inch well, for example, is calculated using to the following equation:

$$\begin{aligned}\text{Well Volume, gallon} &= \pi \times \text{well radius (ft)}^2 \times \text{height of water column (ft)} \times 7.48 \text{ gal./cu. ft.} \\ &= 3.14159 \times 0.007 \text{ sq. ft.} \times \text{height of water column (ft)} \times 7.48 \text{ gal/cu. ft.} \\ &= 0.2 \times \text{height of water column in feet}\end{aligned}$$

The depth of the well was measured at the time of groundwater level measurement using the WLI. The height of the water column was calculated by subtracting the water level from the total well depth. The capacity of each bailer is approximately 1 liter, which is equivalent to approximately 1/4-gallon.

Monitoring Well Sample Collection

After well purging, groundwater samples were retrieved using dedicated, disposable polyethylene well bailers. Water samples are transferred from the bailer directly into prescribed containers provided by the testing laboratory with the appropriate preservative. For PFC analysis no chemical preservatives are included in the laboratory containers. Samples were kept in a cooler on ice or in the Antea Group sample refrigerator prior to shipment to the laboratory. A chain of custody record was kept with the samples at all times.

Chain of Custody

A chain-of-custody record was prepared for the samples, including client (MPCA) name and address, project name, sample identification, sample matrix, sample date and time, type of analysis, and sampler name and signature. The chain-of-custody was kept with the samples until shipment of the samples to the laboratory.

Sample Shipment

Samples for PFC analysis were securely packed in an insulated cooler provided by the laboratory with ice and chain-of-custody record. The cooler was shipped Priority Overnight via FedEx to the following laboratory:

Axys Analytical Services, LTD
2045 Mills Road West
Sidney, British Columbia V8L5X2
Canada

Samples were shipped with required international shipping documents.

Appendix B

Axys Laboratory Data



Axys Analytical
Services Ltd

2045 Mills Road West TEL: (250) 655-5800
Sidney, British Columbia, Canada V8L 5X2 FAX: (250) 655-5811

CHAIN OF CUSTODY

AXYS CLIENT #: 4095

REPORT TO:			INVOICE TO:			ANALYSIS REQUESTED		
Company	MN POLLUTION CONTROL AGENCY		Company	MPCA		PFC's		
Address	520 LAFAYETTE RD N.		Address	DINER				
	ST. PAUL, MN 55155							
Contact	WILEY FELLOWS		Contact					
Phone	(651-297-2352)		Phone					
FAX	(651-296-9707)		FAX					
E-mail	wiley.fellows@state.mn.us		E-mail					
Project Name/Number:			Sampler's Name: Signature:					
Client Sample Identification	Matrix	Sampling Date	Sampling Time	Container Type/No.	AXYS Lab Sample ID (Lab use only)			
DMW-1A	GW	10/3/11	11:35	1-1L HDP				X
DMW-3	GW	10/3/11	12:45	1-1L HDP				X
Relinquished by (Signature)	Date	Time	Received by (Signature)			Courier	Waybill No.	
<i>John Hall</i>	10/3/11	11:35						
Relinquished by (Signature)	Date	Time	Received by (Signature)			Sample Receipt		
Remarks							Cooler	
							Temp °C	
							Custody Seal #	
							Seal Intact	Y / N
							Sample Tags	Y / N

CLIENT ID	DMW-1A	DMW-3	Lab Blank	Spiked Matrix	Spiked Matrix (Duplicate)
AXYS ID	L17036-1	L17036-2	WG38007-101	WG38007-102 (A)	WG38007-103 (DUP WG38007-102)
WORKGROUP	WG38007	WG38007	WG38007	WG38007	WG38007
Sample Size	0.494 L	0.486 L	0.500 L		
UNITS	ng/L	ng/L	ng/L	% Recov	% Recov
PFBA	3.81	12.3	< 2.50	88	86.1
PFPeA	< 2.53	9.65	< 2.50	80.4	77.3
PFHxA	< 2.53	20.1	< 2.50	95.9	91.4
PFHpA	< 2.53	< 2.57	< 2.50	88.2	83.4
PFOA	< 2.53	< 2.57	< 2.50	92.4	93.5
PFNA	< 2.53	< 2.57	< 2.50	90.8	93.3
PFDA	< 2.53	< 2.57	< 2.50	88.2	91.8
PFUnA	< 2.53	< 2.57	< 2.50	89	85.1
PFDoA	< 2.53	< 2.57	< 2.50	101	104
PFBS	< 5.06	17.5	< 5.00	96.1	96.2
PFHxS	< 5.06	22.8	< 5.00	88.3	89.3
PFOS	< 5.06	14.7	< 5.00	92.9	95.5
PFOSA	< 2.53	< 2.57	< 2.50	101	95

See below for definitions of possible flags and labels in the database.

< = less than the detection limit

number following this symbol represents the detection limit

For homologue totals sums, please see the individual congener data for the detection limit.

There may be additional flags associated with these data; please see individual hard copy reports for a complete list of flags and definitions.