Phase I Interim Report

A Study Evaluating the Ability for Point-of-Use (POU) Water Treatment Devices to Remove Perfluorochemicals

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Prepared for
State Of Minnesota
Minnesota Department of Health

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Forward

The following is the Phase I Interim Report Study Evaluating the ability for point-of-use (POU) water treatment devices to remove perfluorochemicals from groundwater, by Water Science and Marketing, LLC in cooperation with the Water Quality Association, under contract with the Minnesota Department of Health. Phase I challenge testing and sample collection was conducted during October and November of 2007 at the Water Quality Association laboratory in Lisle, Illinois, USA and PFC analysis was conducted at the Minnesota Department of Health, Public Health Laboratory in St. Paul, Minnesota.

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Abbreviations and Acronyms

AC	Activated Carbon
CSA	Canadian Standards Association
IAPMO	International Association of Plumbing Mechanical Officials
MDH	Minnesota Department of Health
MSRP	Manufacturer Suggested Retail Price
NSF	NSF International
PHL	Public Health Lab (Minnesota state laboratory)
PFBA	Perfluorobutanoic acid
PFC	Perfluorochemical
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
POU	Point-of-use
POU-PFC Workgroup	A group within MDH
RO	Reverse Osmosis
UL	Underwriters Laboratories
WQA	Water Quality Association
WSM	Water Science and Marketing, LLC

Acknowledgments

Water Science and Marketing, (WSM), was responsible for management of elements in the testing sequence, including data collection and analysis, data management, data interpretation and the preparation of this report.

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Chapter 1
Introduction

1.1 Purpose and Program Operations

It is the Minnesota Department of Health's (MDH) goal for the full project that Minnesotans who learn that they have PFCs in their residential drinking water are provided with independent, research-based advice on which point-of-use water treatment devices will likely be effective in reducing perfluorochemical (PFCs) to acceptable concentrations.

To accomplish this goal, Water Science and Marketing (WSM) was contracted to identify and verify the performance of a number of products from the pool of commercially available, certified point-of-use (POU) water treatment devices, and assess the maximum number of such devices that the project budget and timetable will allow.

The objectives were to identify all commercially available POU devices comprising the technologies of high performance GAC, carbon block, reverse osmosis, ion exchange resins, mixed bed media and other devices including multi-stage design, which have probable capability for PFC reduction to the following criteria:

- Will likely reduce the concentration of PFCs from the range of 3 to 10 *u*g/L to less than 0.2 *u*g/L each for PFBA, PFOA, PFOS, and less than 0.5 *u*g/L in total.
- Are specified by the manufacturer/supplier to have a minimum capacity of 500 gallons treated water.
- Are certified to an NSF/ANSI standard, or equivalent, for drinking water.
- The manufacturer/supplier is willing to provide commercial support for PFC reduction claims.
- Adsorbent devices must have a 500 gallons minimum output rating.

To accomplish this objective, WSM made a test plan which MDH approved to maximize the number of PFC reduction technologies and POU devices given the constraints of the budget, time, and allowable number of the MDH PFC analyses. In Phase I of this plan, the laboratory-screening test that this Interim Report covers, the process, procedures and protocols that follow were defined and approved, and testing was performed as defined.

1.2 Participants and Responsibilities

Water Science and Marketing (WSM), a Minnesota Corporation, collaborated with the Water Quality Association (WQA), an Illinois not-for-profit international trade association, to execute, the laboratory device screening part this project – "Phase I". WSM served as the prime contractor, with the WQA under contract to perform defined work assignments. Both organizations participated in all major tasks to gain the input of the teams combined experience.

1.2.1 Minnesota Department of Health

Mr. Tom Alvarez served as the MDH project manager and liaison with WSM. A multi-disciplinary, POUPFC Workgroup within the MDH (including members of the Well Management, Drinking Water Management groups and the Public Health Lab) approved the project test plan**,** and made final decisions on the device selection after receiving recommendations from WSM and WQA.

1.2.2 Water Science and Marketing

Philip Olsen and David Paulson are Principals of WSM. Mr. Olsen served as Project Manager, with Mr. Paulson coordinating activities with the WQA for Phase I testing.

1.2.3 Water Quality Association

Tom Palkon, Director of Product Certification, with advice from Joseph Harrison Technical Director, represented the WQA in the execution of Phase I testing.

1.3 Test Site Description

The testing was conducted at the WQA Certification Laboratory in Lisle, IL, and ANSI certified lab, which supports the WQA product certification program. The Director of Product Certification, Tom Palkon, supervised challenge testing and sample collection. The laboratory designated a POU test bench, which was configures and used for the study. The test bench was set up in a manner to allow the number of devices selected (8 reverse osmosis systems, 6 adsorptive filter devices) to be tested simultaneously and in parallel. Feed tanks, controls and sampling valves were configured to allow the test protocol to be executed. (See photographs in Appendix G).

Chapter 2
Test Device Selection Process

2.1 General Description

A selection protocol and survey were designed to identify, review and assess all candidate products on the market. Key MDH criteria for the products were:

- Product technology based on high performance GAC, carbon block, reverse osmosis, exchange resins, mixed bed media or other devices (including multistage).
- Technical feasibility for PFC removal from potable water.
- Device configured in a point-of-use (POU) device for water treatment.
- Commercially available and considered "shelf ready" units.
- Product certification to an ANSI/NSF point-of-use device standard.

At Project start, the WQA sent the attached survey (Appendix A) to each of its over 400 member companies. WSM reviewed all certified body product listings to find all companies not on the WQA mailing list who had devices certified to any of the NSF/ANSI point-of-use drinking water treatment standards (NSF/ANSI Standards 42, 53, 58, and 62). These comprised all ANSI accredited certification agencies for these standards aside from WQA. These agencies are:

- Canadian Standards Association (CSA)
- International Association of Plumbing Mechanical Officials (IAPMO)
- NSF International (NSF)
- Underwriters Laboratories (UL)

Initial contact was by email or the "contact" mechanisms of the identified company's Internet web sites.

Thus all commercial products which met these projects criteria were identified and the companies marketing these products contacted.

It was anticipated that more products would be submitted for consideration than the budget would allow to be tested. A selection process was required, and was designed to allow a uniform and fair process for determining the best candidate devices which met the project criteria, and represented product choices that Minnesota citizens could purchase and use successfully in a residential, POU manner to reduce exposure to PFC s in drinking water.

2.2 Survey

The survey was designed to allow a uniform decision process for the first step of determining the viability of a company's commercial product(s) in the study. WSM and WQA determined if the products met the test criteria and were viable by evaluating the first response, and if the products were not eliminated as non-viable, from the additional information collected in direct follow up contact with the company identified. A brief interview was used to fully qualify the products as

meeting the required criteria. See Appendix A for Letter of Introduction and Point-of-Use, Water Treatment Device Survey Form.

2.3 Device Selection Process

2.3.1 Factors

The desire to test all viable technologies within the MDH criteria, and representative devices employing different categories of adsorbent media (e.g. different membrane and activated carbon types, other adsorbent technologies etc) and different types of Reverse Osmosis (RO) membrane and devices, guided the selection choices and the number of devices tested. Where the timeframe and budget allowed, multiple representative devices were chosen. If all target technologies are adequately represented by the preceding requirements, select additional devices the budget will allow based on the criteria

WSM and MDH considered the following factors proposing devices to MDH

- Theoretical Viability and Limitations - A review of theoretical PFC removal chemistry/mechanics was made based upon the technology(s) employed by the device.
- Commercial Accessibility – WSM determined and factored the ease in which a homeowner can purchase the device, install, and at a later date have the device maintained/serviced.
- Maximizing the number of different media tested.
- Manufacturer's Commitment – WSM evaluated the manufacturer's stated commitment to commercially support the device for PFC reduction, such as promoting or not allowing a PFC reduction claim associated with the use of their device.
- Ease of Use in a Residential Setting.
- Historical Performance Data - WSM reviewed any historical performance data and associated test protocol(s), for PFCs and chemically similar molecules, in the literature or available from the manufacturer/supplier.
- Environmental Friendly Features - Including waste, disposal factors.

2.3.2 Process

Products were dropped from consideration if they did not meet the selection criteria defined above, or products from companies who stated they were not interested in this test, or from those companies who failed to respond or follow through in providing the required information by the deadline. Repeat efforts to contact suppliers were made for all products that appeared viable per the project criteria.

WSM reviewed the products of each potential manufacturer/supplier that had responded in full. Using the criteria listed above, WSM prepared a list of recommended products to be tested for review and approval by MDH. In discussions during two meetings, WSM answered MDH questions and explained detail regarding its proposed list of device candidates, and any factors it was aware of to consider for performing the testing. MDH provided further opinion on preferred device attributes. The final selection of devices for test was made by the MDH POU-PFC Workgroup

It happened that six AC filter devices that met the criteria for adsorbent media, and all were selected and tested. Also, it happened that more RO systems were submitted for consideration which met the criteria than could be accommodated by the test capacity and budget. In response, although arrangements were made with the test protocol, and the WQA Certification Lab, to increase the total number of RO systems above the initial plan. Eight RO systems were selected.

The selected devices, with attributes known at the time of device selection, are shown in Tables 2-1 and 2-2. Of the submitted RO devices, the specific model selected is highlighted in yellow.

Table 2-1
Activated Carbon Filter Ranking as of 3 OCT MDH Meeting

Rank	Company	Product Name	Type AC	Additional media/treatment	Flow Rate (gpm)	Capacity (Gal)	NSF 42 / WQA 200	NSF 53	Fail-Safe Feature	Lit. Received	Date Expect units @ WQA	Retail Access thru
1	GE	GE Smart Water GXSL 55F	Block – "blended"	Probable* add'l media	0.78	1,200	X	X	Flashing LED after 6 Months of Filter Replacement	X	28th or earlier	Internet + Home Depot
2	Kinetico	MACguard 7500	Block-coconut	Additive or treatment for lead & MTBE sorption	0.75	500	X	X Lead, VOC, MTBE, Cysts	Filter life indicator, Automatic shut-off at 500 gallons	X	24th or 26th	Kinetico Stores + Dealer Network
5	Access	eSpring water Purifier 100188	Carbon Block (Coconut)	Patented grind coupled with binder material, lead adsorption	0.9	1,320	X	X Lead, VOC	LED indicator based upon water usage	X	Week of 24th	Direct Internet Sales & Independent Dealer
4	RainSoft **division of Aquion**	Hydrefiner P-12 9878	Carbon Block	Additional media treatment	0.75	500	X	X Lead, VOC, MTBE, Cysts		X	Sept 28th	Through Rainsoft Distributors
	ProSystems **division of Aquion**	ProSystems Premium Model 38247	Carbon Block (Coconut)	Supplied by Multipure	0.75	500	Pending	Pending Lead, VOC, MTBE, Cysts			Available for Delivery to WQA	Ace Hardware Menards
3	Culligan	Aqua Cleer Total Defense Cartridge (RC-EZ-4)	Carbon Block	With Proprietary lead scavenger	0.5	500	X	X		Yes - Sent with units	Week of 24th	Culligan Dealers
	Culligan	AquaCleer Total Defense Cartridge	Carbon Block	With Proprietary lead scavenger	0.5	1,000	Pending	Pending Lead, VOC, MTBE, Cysts		Yes - Sent with units	Week of 24th	Culligan Dealers
	EcoWater	Sears Kenmore Model # 625.384610	Carbon Block	5-micron prefilter	0.6	4,500	X		Flashing LED after 6 Months of Filter Replacement	X	10/2/2007	Sears
6	EcoWater	Sears Kenmore Model # 625.385010	Carbon block	Lead sorbent media	0.5	270	X	Lead, Cysts, MTBE, VOC	Flashing LED after 6 Months of Filter Replacement	X	10/2/2007	Sears

Table 2-2
RO System Ranking as of 3 OCT MDH Meeting

FINAL RANK	Device Manufacturer	Device Supplier	Retail Outlets			Model	Devices Received at WQA	Membrane type	Membrane MFGR	Post RO AC Type	Post RO AC Config	Post RO Media MFGR	Literature Received	
			Inter-net	Stores	Dist.								Performance Spec Sheet	Owner's Manual
8	CUNO/3M	Water Factory	X	Un-know n	X	SQC-3(04-045	X			coconut		P	X	pending
	CUNO/3M	Water Factory	X	Un-know n	X	SQC-4(04-063	X			coconut		P	X	pending
3	GE Water	Diamond W.S.	?	No	X	Merlin I	X	PA/TFC - 2	P	coconut	block	P	X	X
1	Ecowater	Ecowater	No	X	X	ERO-375E-CP	X	PA/TFC - 1	P	Coal	block	KX	X	X
	Ecowater	Sears	?	X	X	Kemore **625.385560**	X	PA/TFC - 1	P	Coal	block	KX	X	X
	Ecowater	Whirlpool		X		Wher25	X	PA/TFC - 1	P	Coal	block	KX	X	X
2	GE Appliance	GE Appliance	X	X	No	GXRM 10GBL	X	PA/TFC - 2	P	UN	block	UN	X	X
	GE Appliance	GE Appliance	X	X	No	PXRQR 15F	X	PA/TFC - 2	P	UN	block	UN	X	X
5	Kinetico	Kinetico	No	X	X	Plus Deluxe VX	X	PA/TFC-1	P	coconut	block	P	X	X
	Pentair	Pentair	X	No	X	RO-3500EX	X	PA/TFC - 1	P	P	block	P	X	X
	Pentair	Pentair	X	No	X		X	PA/TFC - 1	P	coconut	block	P	X	X
4	Watts Premier	Watts Premier	X	X	X	WP-4V	X	PA/TFC - 1	FT				X	X
			Devices Claimed to be Pending Certification											
6	Pentair	Pentair	N/A	N/A	N/A	RO-3500EX w/GS	X	PA/TFC-1	P	XI resin + AC proprietary	n/a	Propri etary	X	X

	Water Group	Water Group	No	No	X	4VTFC09G	No	PA/TFC	UN	UN	block	UN	pending	pending
	Water Group	Water Group	No	No	X	4VTFC25G	No	PA/TFC	UN	UN	block	UN	pending	pending
	Water Group	Water Group	No	No	X	4VTFC50G	No	PA/TFC	UN	UN	block	UN	pending	pending
	Water Group	Water Group	No	No	X	4VTFC75G	No	PA/TFC	UN	UN	block	UN	pending	pending
7	Culligan	Culligan	No	No	X	AquaCleer	?	PA/TFC	P	coconut s.	block	UN	X	X
	Aquion	Aquion	No	No	X	Aqua4 RO w Integrated Tank	?	PA/TFC - 1&2	P	P	block	Py	X	X
	Aquion	Aquion	No	No	X	Aqua4 RO w Satellite Tank	?	PA/TFC - 1&2	P	P	block	P	X	X

Notes:
Yellow shading = Device selected
P = proprietary
UN - Unknown

Chapter 3
Methods and Procedures

3.1 Test Site

The challenge testing and sampling was conducted at the WQA Certification Laboratory in Lisle, IL. The Director of Product Certification, Tom Palkon, supervised testing with input from Joe Harrison, Technical Director. The laboratory designated a test bench that shall be used for the study. The test bench was set up in a manner that allowed the maximum number of devices to be tested in parallel. The limiting factors for the number of units to be tested were:

3.2 Test Solution

Initial QA/QC testing of both the WQA Laboratory's incoming makeup water, and test devices was performed before any testing was started by recirculating water through the test bench and sampling it for background PFC readings. These samples were sent to the MDH PHL for analyses. PFC concentrations above detection limits were not present in either sample.

Challenge tanks were prepared using the Water Quality Association's city water supply (Lisle, IL) municipal water. Lisle's municipal water supply contains the following average water characteristics:

- Alkalinity – 100 mg/l as CaCO3
- Hardness – 140 mg/l as CaCO3
- TDS – 210 - 230 mg/L
- TOC – 1.7 mg/L
- pH – 7.5
- Chloride – 14 mg/L
- Sulfate – 28 mg/L

The challenge water requirements allowed the water to be used as make-up without modification. Three standard challenge feed stocks were prepared, and repeated as needed to produce enough water for the test, by adding PFCs, to the following separate characteristics:

- PFBA concentration of 10 *u*g/l
- PFOA and PFOS concentration of 3 *u*g/l each
- PFOA and PFOS concentrations of 3 *u*g/l each, and PFBA of 10 *u*g/l

To assure that the PFC concentrations could be made consistently during the test to within desired range, prior to the start of the tests the WQA lab ran verification tests by preparing trial batch tanks with the feed stock supplied by the MDH PHL. Theoretically, calculated amounts of feed stock were added to these challenge tanks, mixed, sampled both at one quarter hour and again after 24 hours. These samples were sent to the MDH public health lab (PHL) for priority analysis to ensure that the theoretical added PFC volumes would yield the correct concentrations of the PFCs, and that the tank concentrations were stable for 24 hours. Volumes and chemical

additive mass were documented for all feed stock batches, and duplicate samples were collected and saved at WQA under refrigeration for reference.

During the test, samples were collected within 10 to15 minutes of initial mixing and sent with other samples for QA/QC verification of feed PFC concentrations values. Those values are documented in the MDH/PHL lab results (Appendix D) and in the QA/QC section and in Table 4.6.

3.3 Device Challenge and Sample Generation

3.3.1 Adsorbent Devices

These devices are simple filter devices, operated in "normal flow" dead-end mode – with one effluent stream comprising the output of the filter. They operate in the same manner as a simple sediment filter cartridge, and come with their own housing and connections for use in the field. They were connected and operated per manufacturer's published specifications and instructions, and preconditioned for this test according to manufacturers' instructions.

One influent sample was collected per tank for QA/QC analysis

Water passing through the units was totalized and the units were challenged, and samples taken at the pre-determined points of percent-of-capacity, until 150% of the capacity was reached. (Table 4-2)

Shutoff mechanism on one device (the Kinetico MACguard 7500) was disabled to allow for a constant flow rate. That unit still cycled 50% on 50% off for 20-minute cycles.

3.3.2 Reverse Osmosis Devices

These devices are systems with several interacting but separate unit operations. A typical residential point-of-use RO system is designed and operated as follows:

A prefilter protects the membrane from fouling by sediment. If the membrane is made of the most common polymer, polyamide (PA), that prefilter is an AC media filter, which also removes free chlorine – which oxidizes PA membrane over time and shortens membrane life. The pre-filtered water feeds the RO module and is split into two steams; the permeate and concentrate (or reject). The permeate is purified as it is forced through the membrane, while the concentrate only passes over or across the membrane, and carries the rejected contaminants to drain. The permeate is routed to a "post-RO" polishing filter, typically made with AC media to remove taste and odor components not removed by the membrane or added by the system materials. Connected off a tee between the RO membrane and post filter is a storage tank, which contains a pressure bladder. When this tank is pressurized to a pre-set point, the pressure cut-off switch stops flow and the system is in shut down mode. This prevents the system from running when no more water can be stored, and prevents excess water (concentrate stream) from going to drain. Following the post-RO filter and the storage tank is the dispensing valve, which the homeowner operates to draw water. In this configuration all water treated for consumption moves serially through three purification devices: the pre-filter, RO membrane, and post filter.

As in the ANSI/NSF standard test, in this test the pre-filters were removed from the systems. Since they were AC media, they would have removed an unknown amount of the PFC molecules, obscuring the RO membrane performance results. Although such removal would be a beneficial action in a household installation, the AC prefilter will become saturated with PFCs at an unknown time - but long before it is typically changed out. At this point of prefilter "failure", the RO membrane's performance is essential: it is the main removal media in the RO system. Therefore the AC filters were removed to allow the performance of the RO membranes to be measured under known conditions.

Since the RO membranes might pass an unknown (but presumably low) amount of PFC, and the post-RO filter may remove that, the post-RO filters were left in place and their performance measured was measured as part of the device performance.

The WQA prepared 500-gallon challenge tanks as needed each day, using the WQA city water supply spiked with the influent PFCs. One influent sample was collected per tank for QA/QC.

RO test units were set up and conditioned in accordance with the manufacturers instructions. In this case, all of the systems were filled and flushed twice. All pre-filters were removed from the system. WQA installed a sample port after the RO membrane and a sample port after the post filter. One RO system had two post-membrane adsorbent filters, and samples were taken after each of these post-filters.

Repeating this cycle three times for each of the three feed solutions, each RO test unit was tested 24 hours per day for seven days, based on the ANSI/NSF Standard 58 protocol as follows:

- Day 1 – samples were drawn from the systems after 4, 12 and 16 hours of operation. The storage tank was emptied after each sample, and only the 16-hour sample was analyzed for PFCs.
- During days 2, 3 and 4 of testing, about 5 % of the system's certified daily product rate was withdrawn from the storage tank every 6 hours. The 6-hour sample was analyzed for PFCs.
- During days 5 and 6, the RO systems remained shut down with water in the system and storage tank under pressure. (the "stagnation period").
- During day 7 – a sample was collected at the start up (144 hours) into the test, the storage tank was emptied and a final sample was collected after a four hour period (148 hours). Both samples were analyzed for PFCs.
- At each sample point WQA took two effluent samples. One directly after the RO membrane and one after the systems post filter. The volume of water passing through the post filter was recorded.

For the system with two post-RO adsorbent filters (Pentair RO3500 EX (activated carbon and ion exchange) effluent samples were taken at three locations; after the membrane, after the ion exchange filter and after the post filter.

The GE Merlin system is of different design and does not contain an RO storage tank. For this system, on days 1 and 7, three gallons of water were emptied from the system after 4, 12, and 16

hours of operation. For days 2, 3, and 4 one gallon of water was emptied from the system every 6 hours. On days 5 and 6 the system remained stagnant under pressure.

3.4 Sample Collection

MDH Public Health Laboratory (PHL) provided WQA with commercial standards of PFOA, PFOS, and PFBA, which had been pre-tested for purity. PHL provided concentrated solutions of these standards (individually and as mixtures) and 250-milliliter, high-density polyethylene sample bottles. Representative bottles from each lot were pre-tested to ensure that effect on analytical results of PFC levels were negligible.

Sampling frequency was based on both MDH objectives as noted in 1.1 above, and based on the industry standard ANSI/NSF Standards for the adsorbent filters and RO systems, Standards 53 and 58, respectively.

3.4.1 Adsorbent Technologies Sample Collection and Submission and Analysis

Industry standard sample handling procedures were followed. Common feed solution and device-produced water (filtrate) was collected in the MDH-supplied sample bottles, labeled, documented on the master test log, and immediately refrigerated until shipment. The first 5 days of samples (PFBA cycle 1) were accumulated for 5 days and then shipped. Other samples were refrigerated and saved for periods of from 1 to 3 days before shipment. To ship, the samples were placed in coolers with appropriate refrigerant packs and. shipped to the MDH laboratory on a one-day basis to assure proper sample storage at the 2-10 degree Celsius requirement. The PFC molecules are not known to be particularly sensitive to time or temperature degradation effects and it is believed no significant effect on PFC concentrations occurred from this sampling and analyzing protocol.

The challenge and sample protocol was based on the test methods for organics removal verification in ANSI/NSF Standard 53 *Drinking water treatment units -Health effects*. Devices were run for 16 hours a day, in 20 minute each on/off cycle, at the manufacturer-rated maximum flow rate for that device. Samples were collected in the middle of the 20 minute on cycle. Devices were shut down for the intervening 8-hour periods. Filtrate water (post-filter) was discarded to drain. New tanks were mixed as they were depleted.

Samples of filtrate were collected at points defined in the protocol; correlating with approximate waypoints in the rated filter life capacity (e.g. 30, 60, 100, 150% of rated volume capacity). Samples were collected at the midpoint in the “on” or flow-through part of the continuous 20-minute on/20 minute off run cycle

3.4.2 Reverse Osmosis Technologies

The general sampling procedures defined in 3.3.2 above were followed. In the case of the RO systems samples were collected in two places; after the RO membrane and ahead of the post filter – to determine the performance of the RO membrane alone, and after the post- RO filter to - determine the performance of this filter at “polishing” the water by removing any PFC that

might pass through the RO membrane. Both samples are reported in the RO system data spreadsheets.

The challenge and sampling protocol was based on the test methods for organics removal verification in ANSI/NSF Standard 58 ***"****Reverse osmosis drinking water treatment systems"*. New tanks were mixed as they were depleted. Tanks were prepared by using WQA city water and adding 1 liter of PFC stock solution to a 500-gallon tank while overhead mixers continually stirred the PFC spiked water for one hour. During testing the tanks were constantly re-circulated to ensure PFC stayed in solution at an equal concentration.

3.5 Instrumentation

WQA used their standard certification bench equipment for testing similar POU devices. These include instruments with the following ranges and nominal accuracies.

3.5.1 Pressure

Aschroft gauges with 0 to 100 psig range and plus-minus 1% nominal accuracy.

3.5.2 Flow

GPI digital flowmeters with 0 to 3 gpm range and are within 5% of the actual flow rate.

3.5.3 Thermometer

Oakton thermometer with -328.0 to 1562 degree Fahrenheit range, and plus-minus 0.4 degrees Fahrenheit nominal accuracy.

3.6 Analytical for Perfluorocarbons

All samples generated for PFC analysis were sent to the Minnesota Public Health Lab (PHL) for quantitation of the three PFC molecules, which was done by PHL internal standard technique. The lower quantification limit for all three PFC molecules was at 0.2 microgram per liter (*u*g/L) for each analysis [ug/L is essentially equivalent to parts per billion (ppb)]. The detection limit (positive identification) for all three PFC molecules was at 0.05 *u*g/L and shown on the PHL Report of Analytical Results forms as "J 0.05", for example, with a footnote, "The analyte was positively identified. The result is below the report level and is estimated." Detection at levels between and including 0.05 to 0.2 *u*g/L could be made, however, in this range analyses are not quantified with the required degree of confidence to accept the values.

In this report the actual values are only reported if greater than or equal to 0.2 *u*g/L. Values detected but below this quantification limit are reported as detected, not quantified (DNQ).

3.7 QA/QC

3.7.1 Recording Data and Procedures

WQA was responsible for the maintenance of the logbooks and field notebooks. Data was collected and recorded for each day. Data was documented in raw datasheets and on charts from the individual testing instruments. Documentation of field application testing events was facilitated through the use of photographs, data sheets and chain of custody forms.

WSM retains records and documentation associated with the preparation and collection of water samples under the contract for a minimum of five (5) years.

3.7.2 Chain of Custody

The WQA initiated their standard chain of custody forms for each sample taken, and forwarded these per standard procedure to the MDH Public health Laboratory, with the samples for analyses. See Appendix D for complete Chain of Custody forms.

3.7.3 Datasheets

WQA maintains their raw datasheets on file for future reference.

Chapter 4
Results and Discussion

4.1 Introduction

The test was run as planned and as described in Chapter 3 with no significant deviations. This evaluation was a laboratory screening test. The set test conditions are conservative, and designed to produce comparisons between devices and may not duplicate those encountered in some actual use conditions of POU devices in the home.

The target requirements for the device performance were to reduce to less 0.2 ppb each challenge feed concentrations of 10 parts per billion (ppb, or microgram per liter *u*/L) of PFBA, and 3 ppb each of PFOA and PFOS molecules.. When challenged with a mixture of all three PFCs, performance requirements were less than 0.2 ppb each and less than 0.5 ppb in total.

Generally, the RO systems performed well against the target requirements, and the AC filters did not. There was one strong exception in each category of devices.

4.2 Limitations

One limitation of Phase I is that as an initial performance screening laboratory test, operating conditions, and sample collection protocols were conservative and set toward extreme ends of anticipated product use ranges to provide meaningful comparisons in performance between devices/technologies. This approach is taken in the ANSI/NSF Standards used as templates for these tests. The resultant data provides insight for which devices/technologies have greater potential for PFC removal. However, since test samples were collected after many volumes of water were drawn (passed through the device) the results may not reflect the PFC removal in typical use patterns. Typically, in a kitchen installation a small volume of water is drawn for drinking and consumed immediately. The water consumed may have been subjected to longer residence periods within the device than in this test. Water inside an AC filter receives additional filtration influences when the residence time of the water in the device is increased. To a varying degree, the real world draw of water for consumption from a POU adsorbent-media device would yield water with more residence time in the media, and therefore potentially lower values of contaminants. This difference will vary considerably by media type, filter construction and actual usage patterns, resulting in differing measured removal rates.

A second limitation of this lab test is that the water used is of a closely defined and consistent quality. While the chemical make-up of water used for Phase I was similar to the groundwater of interest in the East/Southeast-St. Paul metro area, slight variations may affect performance considerably. Further, the test life and therefore exposure to material in the feed water that will foul the separation media was low compared to typical residential use. In a residential application, RO membrane is expected to typically last for at least one year. For instance, organic material (TOC) in the source will affect overall performance both RO membrane and AC technologies as it accumulates on the media surface. Accordingly, the total mass of TOC over time presented to the media was relatively low in this test and the test did not simulate the same degree of TOC fouling that devices might see at other sites over their lifetime. Such exposure

may affect removal performance of both the RO and especially the AC media, where organic material preferential adsorption and fouling can inhibit the removal of target molecules like PFCs.

4.3 Performance Data

This test was designed to identify commercially available POU devices that potentially can remove PFCs to safe health limits. It was not designed as research on the mechanisms of removal of perfluorocarbons, or for basic knowledge generation for the difference in media used in water treatment devices.

4.3.1 Adsorbent Technologies

All adsorbent devices tested were filters with media based on activated carbon (AC). The range of activated carbon media varies significantly. These variations depend on several factors, including; differing sources of starting material (e.g. coal and coconut shell etc.), the processing techniques used to activate and regenerate the carbon, proprietary additional treatment techniques and additional chemicals added into the media. Often these additives are intended to remove additional materials that "raw" AC does not remove well (e.g. lead, MTBE fuel additive, etc.). While several different AC media were selected, there was insufficient information available to select a media based on expected performance in removing PFC molecules. All AC filters submitted which met the selection criteria were tested.

Table 4-1
Activated Carbon Devices

Company	Product Name	Carbon Type
Culligan	RC-EZ-4	Carbon Block w/Lead Sorbent
Aquion Rainsoft	Hydrefiner P-12 9878	Carbon Bock w/Lead, VOC, MTBE Sorbent
Sears Kenmore Elite	Kenmore 625.385560	Carbon Bock w/Lead Sorbent
Kinetico	MACguard 7500	Block coconut w/Lead, VOC, MTBE Sorbent
Access Business Group	eSpring	Carbon block w/ Binder Material, & Lead Sorbent
GE SmartWater	GXSL55F	Block "blended"

The results for removal of all three PFCs varied substantially by filter device tested. Only one AC filter met all target removal requirements over the test life; Culligan RC EZ 4. Two filters did not meet the total PFC criteria of the 3-PFC mixture feed even at the first test point; Access eSpring and GE SmartWater GXSL55F. As expected, there was a very strong tendency of filters to allow increased breakthrough (also called "leakage" and "passage") of PFC molecules with increasing operating time, as available sorption sites were taken. No strong correlation for removal and media type was noted.

Table 4-2
SUMMARY - AC FILTERS PERFORMANCE
Select Data Points at Rated Lifetime

1st Tests (PFBA-10 alone) and 2nd Tests (PFOA-3 and PFOS-3)

Device name	Day 1 Initial - Final			~ 30 % capacity			~60 % capacity			~100% capacity			~150% capacity		
	PFBA-10	PFOA-3	PFOS-3	PFBA- 10	PFOA- 3	PFOS- 3	PFBA- 10	PFOA- 3	PFOS- 3	PFBA- 10	PFOA- 3	PFOS- 3	PFBA- 10	PFOA- 3	PFOS- 3
Culligan RC-EZ-4	ND	ND-ND	ND-ND	ND	ND	ND	DNQ	ND	ND	DNQ	ND	ND	DNQ	ND	ND
A. Rainsoft Hydrefiner P-12	ND	ND-ND	ND-ND	ND	ND	ND	0.5	ND	ND	1.7	ND	ND	2.6	ND	ND
Sears Kenmore Elite				DNQ	ND	ND	1.9	ND	ND	4.7	ND	ND	3.9	DNQ	ND
Kinetico MACguard	DNQ	ND-ND	ND-ND	0.2	ND	ND	4.2	1.9	2.1	5	DNQ	DNQ	4.7	0.2	DNQ
Access eSpring	0.7	ND-ND	ND-ND	0.7	ND	ND	6.1	DNQ	ND	8.4	0.4	DNQ	8	0.9	0.3
GE SmartWater GXSL55F	7.3	ND-ND	ND-ND	8.7	0.4	ND	8.9	0.9	DNQ	9.1	2.1	1.7	8.8	2.2	0.6

* first and 2nd tests are 10ppb PFBA alone, and mixture 3 ppb each PFOA and PFOS

3rd Test (all three PFC's mixed: PFBA-10, PFOA-3 and PFOS-3)

Device name	Day 15 Initial - Final			~30 % capacity			60 %capacity			~100% capacity			~150% capacity		
	Mixed	Mixed	Mixed	PFBA- 10	PFOA- 3	PFOS- 3	PFBA- 10	PFOA- 3	PFOS- 3	PFBA- 10	PFOA- 3	PFOS- 3	PFBA- 10	PFOA- 3	PFOS- 3
Culligan RC-EZ-4	ND-ND	ND-ND	ND-ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
A. Rainsoft Hydrefiner P-12	DNQ-DNQ	ND-ND	ND-ND	DNQ	ND	ND	0.3	ND	ND	1.4	ND	ND	1.5	DNQ	ND
Sears Kenmore Elite	ND-ND	ND-ND	ND-ND	1.3	ND	ND	1.6	ND	ND	2.9	DNQ	ND	4.5	DNQ	ND
Kinetico MACguard	ND- 0.2	ND-ND	ND-ND	0.9	ND	ND	1.8	DNQ	ND	2.5	DNQ	ND	3.3	DNQ	DNQ
Access eSpring	ND- 1.2	ND-ND	ND-ND	4.3	DNQ	ND	5.6	DNQ	ND	8	0.3	DNQ	8.2	0.8	0.6
GE SmartWater GXSL55F	ND- 7.8	ND-DNQ	ND-ND	9.3	0.8	0.4	9.5	0.8	0.4	9.6	1.4	1.7	11	1.3	0.2

** third test is mixture of 10ppb PFBA and 3 ppb each of PFOA and PFOS

ND = not detected (< 0.05) DNQ = detected, not quantified (0.05 to 0.2)

In this test and under this sampling protocol, of the five (5) filters that failed to remove the PFCs to the target level, none met the combined total PFC target limit of 0.5 ppb for all three PFCs in the final challenge solution (10 ppb PFBA + 3 ppb each of PFOA and PFOS). For the feed challenge solution of only the PFOA plus PFOS, three (3) filters met the removal criteria over their rated lifetime: Aquion Rainsoft Hydrefiner P-12, Sears Kenmore Elite, and Kinetico MACguard.

The PFBA molecule proved the most difficult to remove. Most filters which passed either the PFOA or the PFOS molecule also passed the PFBA at a higher rate, both as a percentage of feed concentration and as an absolute number (the PFBA was challenged at 10 ppb compared to 3 ppb for both the PFOA and PFOS molecules).

In general, for all filter devices, among the PFC molecules the relationship of passage or leakage was PFBA > PFOA > PFOS.

It is known that AC media is capable of removing all three molecules used in this test, and this has been accomplished in Minnesota groundwater on a municipal basis. The residence time, and other variables, in these municipal treatment installations are undoubtedly engineered to accomplish near complete removal of these molecules.

4.3.2 Reverse Osmosis Technologies

In total, the RO systems performed very well on all three PFC molecules. Five of the eight systems tested had no samples in any test over the target limits of 0.2 ppb limits for each PFC molecule individually, and 0.5 ppb in total; Pentair, CUNO Water Factory, Ecowater, Kinetico and Watts. Two more of the systems had no PFC detected in the finished water - after the post-RO polishing AC filters; GE Smartwater GXRM10G and Culligan Aqua-Cleer. Only one RO membrane had detectable PFC's that it's post-RO filter did not remove; the GE Merlin, a high flow, storage tank-less model.

Table 4-3 lists the RO manufactures and products that were selected for Phase I testing.

Table 4-3
Reverse Osmosis Devices

Company	Product Name
Culligan	Aqua-Cleer
Ecowater	ERO-375E-CP
GE	Merlin
GE	Smartwater GXRM10GBL
Kinetico	Plus Deluxe VX
Pentair	RO-3500EX w/ GS
3M/CUNO/Water Factory	SQC-3 (04-045)
Watts Premier	WP-4V

The PFBA molecule was shown to be the most difficult to remove for RO membranes, with the PFOA contaminant the second most difficult. This pattern was also followed with AC filter removal.

As expected, the higher concentrations of PFCs occurred in the first sample taken after the stagnation periods. See section 4.4.2 below for more discussion on this finding.

Most RO membranes removed or significantly reduced PFC concentrations in the RO permeate. In all but one case, detectable PFC concentrations in the membrane permeate were removed by the post-RO membrane filters to below non-detect limits. Given the low concentrations in the RO permeate, this is expected.

It cannot be concluded on the basis of available information, but it can be speculated that the reason the GE Merlin removed fewer PFCs than the other RO systems is that the GE Merlin is designed to operate at a higher flow rate than others RO. Manufacture literature shows that the GE Merlin's manufacturer, daily processing capacity rating is 748 gallons while the other RO systems' rates vary from 8 to 35 gallons per day. It is well known in the membrane industry that, it is very difficult to keep both the flow high and the purification levels high at the same time.

See section 4.4.2 for more performance discussion.

Table 4-4
RO Performance: First Test- PFBA

First test - PFBA only Feed concentration	**Day 1 - 12 hour** PFBA- 10	**Day 2 - 30 hour** PFBA- 10	**Day 3 - 54 hour** PFBA- 10	**Day 4 - 78 hour** PFBA- 10	**Day 7 - 144 hour** PFBA-10	**Day 7 – 148 hour** PFBA-10
Culligan Aqua-Cleer - PM	DNQ	DNQ	0.4 ug/L	0.4 ug/L	2.3 ug/L	DNQ
Culligan Aqua-Cleer - PF	ND	ND	ND	ND	ND	ND
Cuno/Water Factory SQC-3	ND	ND	ND	*	ND	ND
Cuno/Water Factory SQC-3	ND	ND	ND	ND	ND	ND
Ecowater ERO-375 – PM	ND	ND	ND	ND	ND	ND
Ecowater ERO-375 – PF	ND	ND	ND	ND	ND	ND
GE Merlin - PM	1.2 ug/L	0.3 ug/L	0.3 ug/L	0.2 ug/L	1.9 ug/L	0.8 ug/L
GE Merlin - PF	1.6 ug/L	2.0 ug/L	1.5 ug/L	1.2 ug/L	2.0 ug/L	1.6 ug/L
GE Smartwater GXRM10G – PM	DNQ	DNQ	DNQ	0.2 ug/L	0.9 ug/L	DNQ
GE Smartwater GXRM10G – PF	ND	ND	ND	ND	ND	ND
Kinetico Plus Deluxe VX - PM	ND	ND	ND	ND	DNQ	ND
Kinetico Plus Deluxe VX - PF	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX – PM	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX – PAC	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX – post IX filter	ND	ND	ND	ND	ND	ND
Watts WP-4V - PM	DNQ	DNQ	DNQ	DNQ	0.2 ug/L	DNQ
Watts WP-4V - PF	ND	ND	ND	ND	ND	ND

Note: PM = Post Membrane sample
PF = Post Final Filter sample
PAC = Post AC Filter sample
IX = Ion Exchange Filter sample

ND = not detected (< 0.5) DNQ = detected, not quantified (0.05 to 0.2 *u*g/L) * = lost sample

Table 4-5
RO Performance: Second Test- PFOA + PFOS

Second Test PFOA + PFOS	Day 1 – 12 hour		Day 2 - 30 hour		Day 3 – 54 hour		Day 4 – 78 hour		First draw post stagnation Day 7-144hr hour		Day 7 – 148 hour	
	PFOA	PFOS	PFOA	PFOS	PFOA	PFOS	PFOA	PFOS	PFOA	PFOS	PFOA	PFOS
Culligan Aqua-Cleer - post Membrane	ND	ND	ND	ND	ND	ND	ND	ND	DNQ	ND	ND	ND
Culligan Aqua-Cleer - post Final Filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cuno/Water Factory SQC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cuno/Water Factory SQC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ecowater ERO-375 - post Membrane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ecowater ERO-375 - post Final Filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GE Merlin - post Membrane	0.3 ug/L	ND	0.4 ug/L	ND	0.5 ug/L	DNQ	0.6 ug/L	DNQ	0.9 ug/L	DNQ	ND	ND
GE Merlin - post Final Filter	DNQ	ND	DNQ	ND	DNQ	ND	0/4 ug/L	ND	0.2 ug/L	ND	ND	ND
GE Smartwater GXRM10G - pM	ND	ND	ND	ND	ND	ND	DNQ	ND	0.3 ug/L	ND	ND	ND
GE Smartwater GXRM10G - pF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kinetico Plus Deluxe VX - pM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kinetico Plus Deluxe VX - pF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX - post Membrane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX - post AC filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX - post IX filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Watts WP-4V - post Membrane	ND	ND	ND	ND	ND	ND	ND	ND	DNQ	ND	ND	ND
Watts WP-4V - post Filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = not detected (< 0.5) DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Table 4-6
RO Performance: Third Test- PFBA + PFOA + PFOS

3rd Test PFBA+PFOA + PFOS	Day 1 - 12 hour			Day 2 - 30 hour			Day 3 - 54 hour			Day 4 - 78 hour			First sample after stagnation Day 7 - 144hour			Day 7 - 148hour		
Concentrations; 10+ 3+ 3 *ug*/L	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
	----------all values in *ug*/L----------																	
Culligan Aqua-Cleer - post Membrane	0.6	ND	ND	0.4	ND	ND	0.4	ND	ND	0.4	DNQ	ND	2.5	DNQ	ND	DNQ	ND	ND
Culligan Aqua-Cleer - post Final Filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cuno/Water Factory SQC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cuno/Water Factory SQC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ecowater ERO-375 - post Membrane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ecowater ERO-375 - post Final Filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GE Merlin - post Membrane	1.5	0.3	DNQ	0.2	0.4	0.2	4.3	0.2	DNQ	4.8	0.2	DNQ	5.8	0.3	DNQ	4.6	DNQ	DNQ
GE Merlin - post Final Filter	3.0	DNQ	ND	2.3	DNQ	DNQ	1.0	0.3	DNQ	1.5	0.2	DNQ	1.8	0.3	DNQ	1.8	DNQ	DNQ
GE Smartwater GXRM10G - pM	0.4	ND	ND	0.5	ND	ND	0.2	DNQ	ND	0.4	DNQ	ND	1	0.3	ND	0.2	ND	ND
GE Smartwater GXRM10G - pF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kinetico Plus Deluxe VX - pM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	DNQ	ND	ND
Kinetico Plus Deluxe VX - pF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX - post Membrane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX - post AC filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentair RO-3500-EX - post IX filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Watts WP-4V - post Membrane	DNQ	ND	ND	DNQ	ND	ND	DNQ	ND	ND	DNQ	ND	ND	DNQ	DNQ	ND	DNQ	DNQ	ND
Watts WP-4V - post Filter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

KEY: ND = not detected (< 0.5 *u*g/L) DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

4.4 Performance Data – Lifetime

4.4.1 Adsorbent Technology

See section 4.3.1

4.4.2 Reverse Osmosis Technology

In general, the performance of the RO system membranes did not change over time. This is expected, since the main mechanism of removal of contaminants in a reverse osmosis system is their "physico-chemical" exclusion from the permeate stream. Such effects depend chiefly on the membrane characteristics, which should not change in the short term of this test. There is also some performance dependence on the operational characteristics of an RO-based system, such as pressure, flow rates and ratio of feed to permeate flow rates ("recovery"). This test was designed to standardize those operational effects, but not determine their effects. Since adsorption is not the primary mechanism of PFC removal within an RO system, saturation of adsorption sites is not a concern in interpreting the results. While there is an AC filter downstream of the RO membrane in all systems tested, PFCs that reach these post-RO filters will only be the amount passing through the membrane. In this test that amount was very low. Since membrane performance life is measured in years, lifetime was not expected to be an issue for RO systems in a test of 21 days. A test for lifetime in normal RO system operation would require a time scale of years.

However, RO system performance is fairly complicated and some nuanced results can be expected. One example is the behavior of solutes, including contaminants, during shutdown. When a system is not operating (shut down) and flow of feed, concentrate and permeate is not occurring, molecules will diffuse throughout the contained water, moving from higher concentration to lower. If small and active enough, such molecules may diffuse through the membrane from the feed to the permeate side. This phenomenon is understood to occur in RO systems, so an attempt to account for this is in the certification test protocol written into NSF/ANSI Standard 58. The first sample drawn after the "stagnation period" in this protocol is designed to sample that permeate subject to such diffusion. In this test, as expected, there was a strong trend that the highest PFC values in the permeate were in these post-stagnation samples.

Another potential phenomenon is the adsorption of small molecules by a membrane material – including any of the barrier layer, support membrane layer or fabric support layers. The authors are not aware of any studies indicating whether PFC molecules are adsorbed in RO membranes or not, but we consider any adsorption that occurred as unlikely to be significant in this test. To the extent that there is some adsorption, the RO device will appear to be performing better separation early in its life. This phenomenon possibly explains the decreased performance for the PFBA molecule of the worst performing RO system over time, in both the first and third test cycle (days 1-7, 15-21, respectively). This does not explain, however, why the post-RO AC filter values are higher for PFBA than in the permeate stream immediately after the RO, which is an unexpected result. It may be explained by sloughing phenomenon as a result of a minor flow surge during sampling – due to opening the sample valves. However, this was not seen on any of the other post-RO filters, and would indicate very weak adsorption of the PFBA molecule by that AC media. No strong conclusions on the relatively poorer performance on this unit are made.

4.5 QA/QC Results

4.5.1 Initial Background Contamination

Both the WQA Laboratory's incoming makeup water, and test devices (by recirculating water through the test bench and sampling it) were samples for background PFC readings before any testing was started. These were sent to the MDH PHL for analyses. There were not any PFCs present at above detection level in either sample.

4.5.2 Initial Challenge Solution PFC Concentration Verification

Step I -Determine if WQA can spike challenge water with PFC and maintain tank stability (one week timeline).

1. Three 50 gallon challenge tanks were prepared with PFOA (3 ug/l), PFOS (3 ug/l) and PFBA (10 ug/l).

- A 50% challenge tank was made by pipetting 100µl of stock solution into a 1L flask filled with the challenge tank water. The flask was mixed and 500mL of this solution was then poured into the challenge tank. The tank was mixed.
- A 100% challenge tank was made by pipetting 100µl of stock solution into a 1L flask filled with the challenge tank water. The flask was mixed and poured into the challenge tank. The tank was mixed.
- A 150% challenge tank was made by pipetting 150µl of stock solution into a 1L flask filled with the challenge tank water. The flask was mixed and poured into the challenge tank. The tank was mixed.

2. Initial samples were taken on 9/20/07 at 1 PM and sent to MDH PHL the same day for analysis. Another sample was taken at 6:30 PM on 9/20/07 and a 24-hour sample was taken at 1 PM on 9/21/07. These samples were sent on 9/21/07 to MDH PHL.

Results were as follows in Table 4-7.

Table 4-7
Challenge Water Samples

Initial Sample	PFBA	PFOA	PFOS
50% PFOA, PFOS, PFBA	4.2ug/l	1.1 ug/l	2.1 ug/l
100% PFOA, PFOS, PFBA	10.3 ug/l	2.7 ug/l	6.6 ug/l
150% PFOA, PFOS, PFBA	14.8 ug/l	3.7 ug/l	8.0 ug/l
6:30PM Sample	**PFBA**	**PFOA**	**PFOS**
50% PFOA, PFOS, PFBA	4.9 ug/l	1.2 ug/l	2.0 ug/l
100% PFOA, PFOS, PFBA	10.6 ug/l	2.7 ug/l	4.6 ug/l
150% PFOA, PFOS, PFBA	13.1 ug/l	3.2 ug/l	6.0 ug/l
24 Hour Sample	**PFBA**	**PFOA**	**PFOS**
50% PFOA, PFOS, PFBA	4.8 ug/l	1.3 ug/l	2.1 ug/l
100% PFOA, PFOS, PFBA	10.6 ug/l	2.7 ug/l	4.8 ug/l
150% PFOA, PFOS, PFBA	13.9 ug/l	3.4 ug/l	5.8 ug/l

3. Three 50-gallon challenge tanks were prepared with PFOA (3 ug/l) and PFOS (3 ug/l).

- A 50% challenge tank was made by pipetting 100µl of stock solution into a 1L flask filled with the challenge tank water. The flask was mixed and 500mL of this solution was then poured into the challenge tank. The tank was mixed.
- A 100% challenge tank was made by pipetting 100µl of stock solution into a 1L flask filled with the challenge tank water. The flask was mixed and poured into the challenge tank. The tank was mixed.
- A 150% challenge tank was made by pipetting 150µl of stock solution into a 1L flask filled with the challenge tank water. The flask was mixed and poured into the challenge tank. The tank was mixed.

4. Initial samples were taken on 9/25/07 at 1:30PM and sent to MN DEP the same day for analysis. Another sample was taken at 9:30AM on 9/26/07 and a 24-hour sample was taken at 1:30PM on 9/26/07. These samples were sent on 9/26/07 to MN DEP

4.5.3 Daily QA/QC Results

The PFC levels were tested daily after mixing and results were within acceptable ranges. They are presented in Table 4-8.

Relevant naturally occurring water constituents and conditions of the water used for make-up were analyzed daily, and found to be acceptable. They are presented in Table 4-9.

Table 4- 8
PFC Concentration of Feed Tanks

Day 1	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.2 ug/L	N/A	N/A
Tank B	500	8.8 ug/L	N/A	N/A
Tank C	500	8.7 ug/L	N/A	N/A
Tank D	500	9.0 ug/L	N/A	N/A
Average Influent	2000	8.9 ug/L	N/A	N/A
Day 2	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	8.8 ug/L	N/A	N/A
Tank B	500	8.8 ug/L	N/A	N/A
Tank C	500	8.6 ug/L	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	8.7 ug/L	N/A	N/A
Day 3	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.0 ug/L	N/A	N/A
Tank B	500	8.3 ug/L	N/A	N/A
Tank C	500	8.9 ug/L	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	8.7 ug/L	N/A	N/A
Day 4	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.4 ug/L	N/A	N/A
Tank B	500	9.5 ug/L	N/A	N/A
Tank C	500	10 ug/L	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.6 ug/L	N/A	N/A
Day 5	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.3 ug/L	N/A	N/A
Tank B	500	9.2 ug/L	N/A	N/A
Tank C	500	9.1 ug/L	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.2 ug/L	N/A	N/A
Day 6	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS

Tank A	500	9.4 ug/L	N/A	N/A
Tank B	500	N/A	N/A	N/A
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.4 ug/L	N/A	N/A
Day 7	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	8.8 ug/L	N/A	N/A
Tank B	500	N/A	N/A	N/A
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	8.8 ug/L	N/A	N/A
Day 8	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	2.6 ug/L	2.7 ug/L
Tank B	500	N/A	2.6 ug/L	3.3 ug/L
Tank C	500	N/A	2.7 ug/L	3.3 ug/L
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	2.6 ug/L	3.1 ug/L
Day 9	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	2.6 ug/L	2.9 ug/L
Tank B	500	N/A	2.5 ug/L	2.9 ug/L
Tank C	500	N/A	2.6 ug/L	2.8 ug/L
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	2.6 ug/L	2.9 ug/L
Day 10	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	2.6 ug/L	2.6 ug/L
Tank B	500	N/A	2.5 ug/L	2.7 ug/L
Tank C	500	N/A	2.7 ug/L	3.1 ug/L
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	2.6 ug/L	2.8 ug/L
Day 11	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	3.0 ug/L	3.2 ug/L
Tank B	500	N/A	3.0 ug/L	3.2 ug/L
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	3.0 ug/L	3.2 ug/L

Day 12	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	2.8 ug/L	3.1 ug/L
Tank B	500	N/A	2.8 ug/L	3.1 ug/L
Tank C	500	N/A	2.9 ug/L	3.1 ug/L
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	2.8 ug/L	3.1 ug/L
Day 13	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	2.8 ug/L	3.1 ug/L
Tank B	500	N/A	N/A	N/A
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	2.8 ug/L	3.1 ug/L
Day 14	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	N/A	2.9 ug/L	3.5 ug/L
Tank B	500	N/A	N/A	N/A
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	N/A	N/A	N/A
Day 15	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	10 ug/L	2.1 ug/L	3.5 ug/L
Tank B	500	10 ug/L	2.2 ug/L	3.3 ug/L
Tank C	500	9.8 ug/L	2.1 ug/L	3.2 ug/L
Tank D	500	9.9 ug/L	2.2 ug/L	3.0 ug/L
Average Influent	2000	9.9 ug/L	2.2 ug/L	3.3 ug/L
Day 16	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.1 ug/L	2.3 ug/L	3.1 ug/L
Tank B	500	9.5 ug/L	2.2 ug/L	3.4 ug/L
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.3 ug/L	2.3 ug/l	3.3 ug/L
Day 17	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.4 ug/L	2.4 ug/L	3.2 ug/L
Tank B	500	10 ug/L	2.3 ug/L	3.5 ug/L

Tank C	500	9.2 ug/L	2.0 ug/L	3.2 ug/L
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.5 ug/L	2.2 ug/L	3.3 ug/L
Day 18	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.1 ug/L	1.9 ug/L	3.3 ug/L
Tank B	500	10 ug/L	2.2 ug/L	3.8 ug/L
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.6 ug/L	2.1 ug/L	3.6 ug/L
Day 19	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.5 ug/L	2.0 ug/L	3.4 ug/L
Tank B	500	9.1 ug/L	2.2 ug/L	3.3 ug/L
Tank C	500	9.4 ug/L	2.0 ug/L	3.6 ug/L
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.3 ug/L	2.1 ug/L	3.4 ug/L
Day 20	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.8 ug/L	2.1 ug/L	3.2 ug/L
Tank B	500	N/A	N/A	N/A
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.8 ug/L	2.1 ug/L	3.2 ug/L
Day 21	**Volume (gallons)**	**Influent**		
		PFBA	PFOA	PFOS
Tank A	500	9.8 ug/L	2.3 ug/L	3.3 ug/L
Tank B	500	N/A	N/A	N/A
Tank C	500	N/A	N/A	N/A
Tank D	500	N/A	N/A	N/A
Average Influent	2000	9.8 ug/L	2.3 ug/L	3.3 ug/L

Table 4-9
WQA Lab Feed Influent Water Characteristics

Day	Alkalinity	Hardness	TDS	pH	TOC	Chloride	Sulfate
1	109 mg/L	133.5 mg/L	218.5 mg/L	7.96	2.42 mg/L	14.3 mg/L	29.1 mg/L
2	108 mg/L	134.5 mg/L	217.2 mg/L	7.90	2.80 mg/L	13.0 mg/L	27.4 mg/L
3	106 mg/L	140.0 mg/L	210.3 mg/L	7.96	3.26 mg/L	13.3 mg/L	28.2 mg/L
4	105 mg/L	134.0 mg/L	219.2 mg/L	7.97	3.02 mg/L	13.3 mg/L	28.2 mg/L
5	107 mg/L	135.5 mg/L	219.9 mg/L	7.92	2.78 mg/L	13.4 mg/L	28.3 mg/L
6	106 mg/L	136.0 mg/L	221.9 mg/L	7.90	4.16 mg/L	13.9 mg/L	28.8 mg/L
7	106 mg/L	136.0 mg/L	224.0 mg/L	7.96	3.01 mg/L	13.6 mg/L	28.4 mg/L
8	108 mg/L	135.5 mg/L	224.0 mg/L	7.97	2.87 mg/L	13.9 mg/L	29.0 mg/L
9	110 mg/L	140.0 mg/L	214.4 mg/L	7.68	2.31 mg/L	13.8 mg/L	29.2 mg/L
10	105 mg/L	138.0 mg/L	215.1 mg/L	7.54	2.14 mg/L	13.5 mg/L	28.8 mg/L
11	107 mg/L	146.0 mg/L	219.2 mg/L	7.55	2.49 mg/L	14.3 mg/L	28.6 mg/L
12	105 mg/L	136.0 mg/L	215.8 mg/L	7.61	2.32 mg/L	13.8 mg/L	28.6 mg/L
13	105 mg/L	140.0 mg/L	217.8 mg/L	7.67	2.15 mg/L	14.3 mg/L	28.7 mg/L
14	100 mg/L	146.0 mg/L	214.4 mg/L	7.37	2.05 mg/L	14.0 mg/L	28.8 mg/L
15	103 mg/L	142.0 mg/L	215.8 mg/L	7.30	1.98 mg/L	14.3 mg/L	30.9 mg/L
16	105 mg/L	136.0 mg/L	215.8 mg/L	7.35	3.15 mg/L	14.2 mg/L	28.8 mg/L
17	102 mg/L	138.0 mg/L	215.1 mg/L	7.32	2.97 mg/L	14.2 mg/L	28.6 mg/L
18	105 mg/L	138.0 mg/L	215.1 mg/L	7.42	1.99 mg/L	13.9 mg/L	28.1 mg/L
19	104 mg/L	140.0 mg/L	214.4 mg/L	7.37	1.87 mg/L	13.8 mg/L	27.9 mg/L
20	101 mg/L	140.0 mg/L	213.7 mg/L	7.08	2.16 mg/L	14.0 mg/L	27.9 mg/L
21	105 mg/L	140.0 mg/L	214.4 mg/L	7.15	2.14 mg/L	14.3 mg/L	28.7 mg/L
Range	**101-110**	**133.5-146**	**213-224**	**7.15-7.97**	**1.87-3.02**	**13-14.3**	**27.4-28.8**

4.6 Analytical Laboratory QA/QC

The Public Health Laboratory provided this information on their QA/QC samples for perfluorochemical analysis as performed by the Minnesota Department of Health Public Health Laboratory. Sample analysis followed MDH LIMS analysis code 555 utilizing high-pressure liquid chromatography/mass spectrometry/mass spectrometry. LIMS code 555 includes robust QA/QC incorporating the following criteria within every batch.

1. Samples are collected in contaminant free containers
2. Samples are analyzed within holding time
3. Batch analysis includes no more than 20 samples not including QC
4. A valid analytical batch includes a calibration curve or calibration verification check sample, report level verification check sample, method blank, instrument blank, sample duplicate, spike and spike duplicate, and samples. All QC samples must pass method criteria for sample data to be acceptable. In cases where QC criteria are not met sample results must be “flagged” on the client report.
5. Quantitation is by the internal standard technique.

6. Qualitative identification is based on molecular ion transition to a primary or secondary ion and analyze retention time.
7. A report level of 0.2 ug/L has been determined for each analyze of interest. Positive identification, but estimated quantification, is reported down to 0.05 ug/L.

4.7 Comments and Recommendations

4.7.1 Comments

An important point to note is that the shut down periods are known to affect the two technologies tested here differently. Residence time during shut down in adsorptive media (AC filter) will increase removal of contaminants, while shut down time in an RO system allows potential diffusion through the membrane (for some molecules). These phenomena are discussed in more detail elsewhere in this report.

This test protocol was conservative relative to typical ways that POU filters are used to produce drinking water at the tap, and was designed for screening information. The adsorptive media (AC filters) test was run in a 20 minute on - 20 minute off cycle (flow vs. no-flow condition). Also, all flows were set at the filter's maximum rating. The sampling point was at 10 minutes after flow through the cartridge was initiated, in concert with ANSI/NSF Standard 53 technique. It is highly probable that the first water out of the filter after the shut down cycle would contain substantially less of any of the PFC molecules, and also that measured concentrations would increase steadily as more water passed through the filter. The degree of effect and residence time could vary considerably.

As an illustration, if a single person drew a glass of water through a filter at a kitchen tap that had not been used recently, the water would have had a long residence time in the media and adsorption would have been maximized as a result. In contrast, if an entire large family drew drinking water samples, and after water was drawn for cooking, etc, there should be a low residence time in the media for the last water drawn.

The PFBA molecule, perfluorobutanoic acid, is the smallest and presumably most active of the three PFC molecules tested. This may explain its higher passage, although scientific literature on AC removal of these molecules, especially PFBA, is sparse.

It is known PFC molecules identified in Minnesota groundwater are successfully being removed with activated carbon filtration media. This commercial scale filtration undoubtedly is engineered to maximize residence time and other separation factors. It is recommended that in the Phase II testing, sufficient sampling at early points after shut-down periods be made to generate a profile of removal vs. throughput (water volume) and also vs. filter's media volume and device construction. This information could then be used for subjective judgments on the typical use of a POU filter and their implication for filter performance and potable product safety.

4.7.2 Recommendations for Phase II

In addition to providing the means to evaluate performance of POU devices/technologies on the actual source water quality of their intended use as the primary subject matter of this study, the test plan for phase II will also address performance regarding how these devices are typically used within a residential installation.

To secure actual source water quality conditions wells located within the subject groundwater contamination sites will be used. One site (municipal well in St. Paul Park) will provide water with known concentrations of PFBA, another site (municipal well in Oakdale) will provide water with known concentrations of PFBA, PFOA, and PFOS. It is known higher levels of TOCs and lower temperatures from these groundwater sources (vs. water lab test water) will influence operational and PFC removal performance/capacity of devices/technologies included in Phase I.

4.7.2.1 Device Selection for Phase II

Results of Phase I suggest greater variances in PFC removal performance between the single unit devices alone (adsorptive/reverse osmosis) compared to multi-unit systems. While adsorptive, filters are commonly sold without an RO membrane, most or all POU RO systems include adsorptive technology. Adsorptive technologies sold as stand-alone devices offer a distinct set of features in comparison to RO systems, including initial cost, ease of installation, higher flow rates, and greater daily production capacities. Accordingly, WSM strongly recommends their continued evaluation during Phase II.

In contrast to the WSM original proposal where duplicate testing of devices was suggested, Phase I results lead us to recommend more performance data from as many different devices as feasible.

Accordingly, eleven (11) devices are recommended for Phase II testing including four (4) of the six (6) adsorptive (AC) systems and seven (7) of the eight (8) RO systems included in Phase I. Based on performance in Phase I the systems that should be excluded for Phase II are as follows: Of the AC systems the Aquion eSpring and the GE GXSL 55F, should be excluded. Of the RO systems, the GE Merlin should be excluded. The actual number selected by the MDH workgroup may be constrained by the project's schedule and available funding.

4.7.2.2 Test Plan

Phase I was designed to be conservative and accentuate differences in performance characteristics between technologies/devices. Based on the results for the adsorptive devices especially, WSM recommends that Phase II field testing should obtain performance data from a broader spectrum of usage conditions, accounting more for how the devices will typically be used in a residential setting.

WSM recommends that each POU device should be sampled by WSM three (3) times according to a schedule defined jointly by MDH and WSM. All POU devices that are tested and sampled

by WSM will be in parallel and subjected to hydraulic conditions similar to typical residential use; including repeated on/off cycling and extended no-flow conditions. Each POU device should be operated and tested in its entirety of water treatment components and/or stages. Automatic end-of-filter-life shut off valves that may exist should be disabled in order to test the devices beyond their design life.

Due to different operational characteristics, the RO-based systems should be operated in a different manner that the adsorptive media devices. Specifically:

Sampling Expendable (AC) Devices: Water sampling from the expendable AC POU devices should consist of a sequence of three (3) separate samples collected at: ½ minute, 1 minute and at 3 minutes after initiation of flow. This sequence of samples should be collected at each of 0, 50, 100, and 150% of the manufacturers' rated capacity. On/off cycling should be 6 minutes on and 54 minutes off. Testing of all AC devices are scheduled to conclude within 30 days after initiation of the Phase II test period.

Sampling RO-based Devices: The water sampling of the finished water, filtered through the entire treatment train of pre-filters, RO membrane and post-filters, should consist of two samples collected per week over a period of 90 days of continuous operation. On/off cycling should consist of draining each system's filtrate storage tank as it approaches its maximum capacity.

For RO systems one sample will be collected on a Friday, before a 48-hour stagnation period with a second sample collected on the following Monday after the stagnation period. Two 72-hour stagnation periods (sample collection on Tuesday) will be included within the 90-day test period during the two holiday weekends, Martin Luther King Jr. Day (January 21, 2008), and Presidents Day (February 18, 2008).

4.7.2.3 Test Station Design for Phase II

To accommodate Phase II objectives, two identical test stations have been designed for continuous operation (24 hrs/day). Each device selected will be tested simultaneously at both sites. The operation of each device will be controlled via programmable 24-hour timing mechanisms to initiate automatic shut-off valves located on filtrate streams. In addition, for AC devices a programmable logic controller will be used in conjunction with an automatic valve to discontinue flow at points representing targeted sample collection points defined above. Sample taps will be installed on the test station's common influent stream and one for each device's effluent stream. Isolation valves for each device will be included.

The following parameters will be measured for each expendable (AC) device:

1. Inlet and outlet pressure (psig)
2. Flow rate
3. Total gallons
4. Frequency and Time of on/off episodes (indirect)
5. Water Temperature

The following parameters will be measured for each non-expendable (RO) device:

1. Inlet and outlet pressure range (psig)
2. Concentrate and permeate flow rate (mL/min), plus concentrate and permeate conductivity/TDS (At recorded inlet pressure and 0 psi filtrate pressure).
3. Frequency and Time of on/off episodes (indirect)
4. Total gallons produced (by calculation)
5. Water Temperature

For the first 30 days of operation, data will be recorded in a logbook for each device on a daily basis with the exception of weekends and holidays. All After the initial 30 days of operation data will be recorded on Monday, Wednesday, and Friday of each week with the exception of Presidents Day (February 18, 2008. On that date, data will be recorded on Tuesday vs. Monday.

In order to facilitate the speed in which field-testing can begin after the Phase II test plan is finalized, fabrication of both test stations is near complete, allowing for flexibility for adjustment to final Phase II test plan specifics.

4.7.2.4 Sensor Accuracy

Accuracy of pressure gauges will be verified daily with a NIST traceable pressure gauge. Accuracy of flow meters will be verified by measurement of time/volume method using a graduated cylinder. Verification of accuracy for each sensor/gauge will be recorded within WSM's field notebook.

4.7.3 General Water Quality Characteristics for Field Application Testing

It is understood general water quality characteristics at each well house site are known and remain static. Unless notified of MDH's preference to conduct initial or ongoing analyses for these parameters, WSM believes the expense saved by not testing the contaminants other than TOC and the PFC levels) are better invested in other aspects of this evaluation.

Chapter 5
References

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Ohio Department of Health, (2007). *C-8 Perfluorooctanoic acid, commonly known as C-8, is also called PFOA and/or APFO A 2006 C-8 Physician Reference*. www.odh.ohio.gov/odhPrograms/eh/hlth_as/

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Appendix A
Survey and Letter of Introduction

Letter of Introduction, and
Point-of-Use, Water Treatment Device Survey Form

Opportunity to Participate in Minnesota Department of Health Project:

A study evaluating the ability of point-of-use (POU) water treatment devices to remove three perfluorochemicals (PFCs) from drinking water.

To:
.
Attention: Vice President Sales

14 September 2007

Greetings Potential Test Participant:

Minnesota Department of Health (MDH) has contracted Water Science and Marketing, LLC, (WSM) as an independent testing organization, to perform a study evaluating the ability of point-of-use (POU) water treatment devices to remove three perfluorochemicals (PFCs) from drinking water. The three PFCs are perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanoic acid (PFBA). This project will determine and test which point-of-use water treatment devices are effective in reducing PFCs to acceptable concentrations. MDH will share this information with the public.

We believe you may manufacture such products and would like to participate in this product evaluation by providing example POU products for testing. We believe this evaluation offers your company an opportunity to explore an important application in water treatment, and to potentially gain business as a result. **Please return this survey immediately.**

Products can include the following technologies: high grade activated carbon in granular and block form, ion exchange and mixed bed media, specialty adsorbents, reverse osmosis equipment and multi-stage treatment units. **Only products that are certified to an ANSI/NSF standard relating to drinking water, (or equivalent) and that are currently commercially available will be considered**.

To submit, please select three unused, untested adsorbent-based products, or two membrane-based products (including replacement cartridges/elements for a total of 3 testing cycles per device) of each model that you desire to have evaluated. Please include operating instructions and technical literature available for the products. The devices should be selected at random, and shipped in their original packaging to;

Water Quality Association
Product Certification Laboratory
4151 Naperville Road
Lisle, Illinois 60532-3696

The initial evaluation will take place at the Water Quality Association's (WQA) Certification Laboratory. The evaluation is scheduled to begin 24 September 2007. Products received at the

WQA's Lisle, IL laboratory by 20 September 2007 will receive first consideration for evaluation. **To be considered products must be received no later than 30 September 2007.**

There is some potential for the device to be selected for additional field site testing if it meets certain performance criteria and objectives defined by MDH.

Please call Dave Paulson of WSM at xxx xxx xxxx between 9 am and 4 pm CST to discuss any questions you have in order to complete this survey. We are sorry we could not locate a website or email address dor you. Please respond by email to expedite consideration. We request you return this survey even if you decide not to participate.

Thank You,
David Paulson,
Partner WSM
Phone: XXX-XXX-XXXX
Email: dave@waterthinktank.com

Point-of-Use, Water Treatment Device Survey Form

1. Product Names and Model numbers:_____

2. Generic description of the separating media: _____.

3. Current product lifetime specifications _____(Volume or time).

4. Which certifying body has certified this product _____

5. Which ANSI/NSF Standard is it certified to _____

6. Literature designation for these products_____

7. Is this media proprietary to _____

8. Will _____ Inc share the description and nature of this media?

9. Who is the technical contact at _____ who we can call to discuss this product further? Name _____ Title_____

   Phone number_____ Email _____

   Best day and hours to contact_____

Please return (electronically, via email preferred) to
David Paulson
Partner, WSM
Phone: XXX XXX XXXX
Email: dave@waterthinktank.com

Appendix B
Manufacturer's Operation and Maintenance Manual

Provided in Digital Format

Appendix C
Data Spreadsheets (RO and AC Excel spreadsheets)

Activated Carbon
Kinetico MACguard 7500

AC Filter Test Unit Number: 6248.0701L13 - Kinetico MACguard 7500									
0.75 gpm - 500 gallon capacity									
Day	Time Sample Taken	Gallons Treated	% Filter Capacity	Average Influent (ppb)			Effluent (ppb)		
				PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
1	3:20 PM	150	30%	8.9			DNQ		
2	3:20 PM	300	60%	8.7			0.2		
3	3:20 PM	450	90%	8.7			4.2		
4	10:20 AM	495	99%	9.6			5.0		
5	3:20 PM	750	150%	9.2			4.7		
6									
7									
8	9:00 AM	initial						<0.2	<0.2
8	3:20 PM	150	30%		2.6	3.1		<0.2	<0.2
9	3:20 PM	300	60%		2.6	2.9		<0.2	<0.2
10	3:20 PM	450	90%		2.6	2.8		1.9	2.1
11	10:20 AM	495	99%		3.0	3.2		DNQ	DNQ
12	3:20 PM	750	150%		2.8	3.1		0.2	DNQ
13									
14									
15	9:00 AM	initial					<0.2	<0.2	<0.2
15	3:20 PM	150	30%	9.9	2.2	3.3	0.2	<0.2	<0.2
16	3:20 PM	300	60%	9.3	2.3	3.3	0.9	<0.2	<0.2
17	3:20 PM	450	90%	9.5	2.2	3.3	1.8	DNQ	<0.2
18	10:20 AM	495	99%	9.6	2.1	3.6	2.5	DNQ	<0.2
19	3:20 PM	750	150%	9.3	2.1	3.4	3.3	DNQ	DNQ
20									
21									

DNQ = detected, not quantified (range is 0.05 - 0.2 ppb)
All samples taken were analyzed for PFBA, PFOA and PFOS. Blank PFC entries where a sample was taken are technically non-detects (no analyte in influent and no analyte detected).

Activated Carbon
Culligan RC-EZ-4

AC Filter Test Unit Number: 6248.0701L11 - Culligan RC-EZ-4									
0.60 gpm - 500 gallon capacity									
Day	**Time Sample Take**	Gallons Treated	**% Filter Capacity**	**Average Influent (ppb)**			**Effluent (ppb)**		
				PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
1	6PM	150	30%	8.9			<0.2		
2	6PM	300	60%	8.7			<0.2		
3	6PM	450	90%	8.7			DNQ		
4	11AM	504	101%	9.6			DNQ		
5	6PM	750	150%	9.2			DNQ		
6									
7									
8	9AM	initial						<0.2	<0.2
8	6PM	150	30%		2.6	3.1		<0.2	<0.2
9	6PM	300	60%		2.6	2.9		<0.2	<0.2
10	6PM	450	90%		2.6	2.8		<0.2	<0.2
11	11AM	504	101%		3.0	3.2		<0.2	<0.2
12	6PM	750	150%		2.8	3.1		<0.2	<0.2
13									
14									
15	9:20 AM	initial					<0.2	<0.2	<0.2
15	6PM	150	30%	9.9	2.2	3.3	<0.2	<0.2	<0.2
16	6PM	300	60%	9.3	2.3	3.3	<0.2	<0.2	<0.2
17	6PM	450	90%	9.5	2.2	3.3	<0.2	<0.2	<0.2
18	11AM	504	101%	9.6	2.1	3.6	<0.2	<0.2	<0.2
19	6PM	750	150%	9.3	2.1	3.4	<0.2	<0.2	<0.2
20									
21									

DNQ = detected, not quantified (range is 0.05 - 0.2 ppb)
All samples taken were analyzed for PFBA, PFOA and PFOS. Blank PFC entries where a sample was taken are technically non-detects (no analyte in influent and no analyte detected).

Activated Carbon
6248.0701L10 - Sears Kenmore Elite

AC Filter Test Unit Number: 6248.0701L10 - Sears Kenmore Elite									
0.60 gpm - 500 gallon capacity									
Day	**Time Sample Taken**	**Gallons Treated**	**% Filter Capacity**	**Average Influent (ppb)**			**Effluent (ppb)**		
				PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
1	4:30 PM	150	30%	8.9			<0.2		
2	4:30 PM	300	60%	8.7			DNQ		
3	4:30 PM	450	90%	8.7			1.9		
4	12:00 PM	504	101%	9.6			4.7		
5	4:30 PM	750	150%	9.2			3.9		
6									
7									
8	9:00 AM	initial						<0.2	<0.2
8	4:30 PM	150	30%		2.6	3.1		<0.2	<0.2
9	4:30 PM	300	60%		2.6	2.9		<0.2	<0.2
10	4:30 PM	450	90%		2.6	2.8		<0.2	<0.2
11	4:30 PM	504	101%		3.0	3.2		<0.2	<0.2
12	4:30 PM	750	150%		2.8	3.1		DNQ	<0.2
13									
14									
15	9:20 AM	initial					<0.2	<0.2	<0.2
15	4:30 PM	150	30%	9.9	2.2	3.3	<0.2	<0.2	<0.2
16	4:30 PM	300	60%	9.3	2.3	3.3	1.3	<0.2	<0.2
17	4:30 PM	450	90%	9.5	2.2	3.3	1.6	<0.2	<0.2
18	4:30 PM	504	101%	9.6	2.1	3.6	2.9	<0.2	<0.2
19	4:30 PM	750	150%	9.3	2.1	3.4	4.5	DNQ	<0.2
20									
21									

DNQ = detected, not quantified (range is 0.05 - 0.2 ppb)
All samples taken were analyzed for PFBA, PFOA and PFOS. Blank PFC entries where a sample was taken are technically non-detects (no analyte in influent and no analyte detected).

Activated Carbon
Aquion/Rainsoft Hydrefiner P-12 9878

AC Filter Test Unit Number: 6248.0701L14 - Aquion/Rainsoft Hydrefiner P-12 9878									
0.70 gpm - 1000 gallon capacity									
Day	**Time Sample Taken**	**Gallons Treated**	**% Filter Capacity**	**Average Influent (ppb)**			**Effluent (ppb)**		
				PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
1	10:20 PM	300	30%	8.9			<0.2		
2	10:20PM	600	60%	8.7			<0.2		
3	10:20PM	900	90%	8.7			0.5		
4	2:00 PM	1005	100%	9.6			1.7		
5	10:20 PM	1500	150%	9.2			2.6		
6									
7									
8	9:00 AM	initial						<0.2	<0.2
8	10:20 PM	300	30%		2.6	3.1		<0.2	<0.2
9	10:20PM	600	60%		2.6	2.9		<0.2	<0.2
10	2:00 PM	1005	90%		2.6	2.8		<0.2	<0.2
11	10:20PM	1200	100%		3.0	3.2		<0.2	<0.2
12	10:20PM	1500	150%		2.8	3.1		<0.2	<0.2
13									
14									
15	9:00 AM	initial					DNQ	<0.2	<0.2
15	10:20 PM	300	30%	9.9	2.2	3.3	DNQ	<0.2	<0.2
16	10:20 PM	600	60%	9.3	2.3	3.3	DNQ	<0.2	<0.2
17	10:20 PM	900	90%	9.5	2.2	3.3	0.3	<0.2	<0.2
18	2:00 PM	1005	100%	9.6	2.1	3.6	1.4	<0.2	<0.2
19	10:20PM	1500	150%	9.3	2.1	3.4	1.5	<0.2	<0.2
20									
21									

DNQ = detected, not quantified (range is 0.05 - 0.2 ppb).
All samples taken were analyzed for PFBA, PFOA and PFOS. Blank PFC entries where a sample was taken are technically non-detects (no analyte in influent and no analyte detected).

Activated Carbon
GE SmartWater GXSL55F

AC Filter Test Unit Number: 6248.0701L12 - GE SmartWater GXSL55F									
0.60 gpm - 1200 gallon capacity									
Day	Time Sample Taken	Gallons Treated	% Filter Capacity	Average Influent (ppb)			Effluent (ppb)		
				PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
1	10PM	250	21%	8.9			7.3		
2	10PM	500	42%	8.7			8.7		
3	10PM	750	63%	8.7			8.9		
4	10PM	1000	83%	9.6			10		
5	10PM	1250	104%	9.2			9.1		
6	10PM	1500	125%	9.4			9.3		
7	10PM	1750	146%	8.8			8.8		
8	9AM	initial						<0.2	<0.2
8	10PM	250	21%		2.6	3.1		<0.2	<0.2
9	10PM	500	42%		2.6	2.9		0.4	<0.2
10	10PM	750	63%		2.6	2.8		0.9	DNQ
11	10PM	1000	83%		3.0	3.2		2.0	0.9
12	10PM	1250	104%		2.8	3.1		2.1	1.7
13	10PM	1500	125%		2.8	3.1		2.2	0.5
14	10PM	1750	146%		2.9	3.5		2.2	0.6
15	9AM	initial					<0.2	<0.2	<0.2
15	10PM	250	21%	9.9	2.2	3.3	7.8	DNQ	<0.2
16	10PM	500	42%	9.3	2.3	3.3	9.3	0.8	0.4
17	10PM	750	63%	9.5	2.2	3.3	9.5	0.8	0.4
18	10PM	1000	83%	9.6	2.1	3.6	10	1.2	0.8
19	10PM	1250	104%	9.3	2.1	3.4	9.6	1.4	1.7
20	10PM	1500	125%	9.8	2.1	3.2	10	1.5	1.6
21	10PM	1750	146%	9.8	2.3	3.3	11	1.3	0.2

DNQ = detected, not quantified (range is 0.05 - 0.2 ppb).
All samples taken were analyzed for PFBA, PFOA and PFOS. Blank PFC entries where a sample was taken are technically non-detects (no analyte in influent and no analyte detected).

Activated Carbon
Access Business Group--eSpring

AC Filter Test Unit Number: 6248.0701L09 - Access Business Group--eSpring									
0.90 gpm - 1320 gallon capacity									
Day	Time Sample Taken	Gallons Treated	% Filter Capacity	Average Influent (ppb)			Effluent (ppb)		
				PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
1	12:00 AM	400	30%	8.9			0.7		
2	12:00 AM	800	61%	8.7			3.7		
3	12:00 AM	1200	91%	8.7			6.1		
4	1:30 PM	1321	100%	9.6			8.4		
5	12:00 AM	2000	152%	9.2			8.0		
6									
7									
8	9:00 AM	initial						<0.2	<0.2
8	12:00 AM	400	30%		2.6	3.1		<0.2	<0.2
9	12:00 AM	800	61%		2.6	2.9		DNQ	<0.2
10	12:00 AM	1200	91%		2.6	2.8		0.4	<0.2
11	12:00 AM	1321	100%		3.0	3.2		0.4	DNQ
12	12:00 AM	2000	152%		2.8	3.1		0.9	0.3
13									
14									
15	9:20 AM	initial					<0.2	<0.2	<0.2
15	12:00 AM	400	30%	9.9	2.2	3.3	1.2	<0.2	<0.2
16	12:00 AM	800	61%	9.3	2.3	3.3	4.3	DNQ	<0.2
17	12:00 AM	1200	91%	9.5	2.2	3.3	5.6	DNQ	<0.2
18	12:00 AM	1321	100%	9.6	2.1	3.6	8.0	0.3	DNQ
19	12:00 AM	2000	152%	9.3	2.1	3.4	8.2	0.8	0.6
20									
21									

DNQ = detected, not quantified (range is 0.05 - 0.2 ppb).
All samples taken were analyzed for PFBA, PFOA and PFOS. Blank PFC entries where a sample was taken are technically non-detects (no analyte in influent and no analyte detected).

Reverse Osmosis
Culligan Aqua-Cleer

RO Test Unit Number: 6248.0701L.01 - Culligan Aqua-Cleer

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 1									
4 h	8.9 ug/L								
12 h	8.9 ug/L			DNQ			<0.2 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			DNQ			<0.2 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			0.4 ug/L			<0.2 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			0.4 ug/L			<0.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			2.3 ug/L			<0.2 ug/L		
148 h	8.8 ug/L			DNQ			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: 1 Gallon									

** Chlorine Sample not taken

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.01 - Culligan Aqua-Cleer

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 8									
4 h									
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		<0.2 ug/L	<0.2 ug/L	N/A	<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14		2.9 ug/L	3.5 ug/L						
144 h		2.9 ug/L	3.5 ug/L		DNQ	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: Approximately 1 Gallon									

RO Test Unit Number: 6248.0701L.01 - Culligan Aqua-Cleer

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 15									
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	0.6 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 6 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	0.4 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	0.4 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	0.4 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	2.5 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: 1 Gallon									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Reverse Osmosis
Ecowater ERO-375

RO Test Unit Number: 6248.0701L.06 - Ecowater ERO-375

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 1									
4 h	8.9 ug/L								
12 h	8.9 ug/L			<0.2 ug/L			<0.2 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 9.9 Liters (2.6 gals)									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 9.9 Liters (2.6 gals)									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			<0.2 ug/L			<0.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 9.9 Liters (2.6 gals)									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L		
148 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: Approximately 2 Gallons									

** Chlorine Sample not taken

RO Test Unit Number: 6248.0701L.06 - Ecowater ERO-375

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 8									
4 h									
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 9.9 Liters (2.6 gals)									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 9.9 Liters (2.6 gals)									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 9.9 Liters (2.6 gals)									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14									
144 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: Approximately 2 Gallons									

RO Test Unit Number: 6248.0701L.06 - Ecowater ERO-375

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 15	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 6 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 9.9 Liters (2.6 gals)									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 9.9 Liters (2.6 gals)									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 9.9 Liters (2.6 gals)									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: 2 Gallons									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Reverse Osmosis
GE Merlin

RO Test Unit Number: 6248.0701L.03 - GE Merlin

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 1	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h	8.9 ug/L								
12 h	8.9 ug/L			1.2 ug/L			1.6 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: 9 Gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			0.3 ug/L			2.0 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			0.3 ug/L			1.5 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			0.2 ug/L			1.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			1.9 ug/L			2.0 ug/L		
148 h	8.8 ug/L			0.8 ug/L			1.6 ug/L		
Total Water Treated by Post Filter Day 7: 3 Gallons									

**** Chlorine Sample not taken**

RO Test Unit Number: 6248.0701L.03 - GE Merlin

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 8	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h		2.6 ug/L	3.1 ug/L		0.3 ug/L	<0.2 ug/L		DNQ	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 9 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		0.4 ug/L	<0.2 ug/L		DNQ	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		0.5 ug/L	DNQ		DNQ	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		0.6 ug/L	DNQ		0.4 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14									
144 h		2.9 ug/L	3.5 ug/L		0.9 ug/L	DNQ		0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: 3 Gallons									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.03 - GE Merlin

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 15	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	1.5 ug/L	0.3 ug/L	DNQ	3.0 ug/L	DNQ	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 9 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	0.2 ug/L	0.4 ug/L	0.2 ug/L	2.3 ug/L	DNQ	DNQ
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	4.3 ug/L	0.2 ug/L	DNQ	1.0 ug/L	0.3 ug/L	DNQ
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	4.8 ug/L	0.2 ug/L	DNQ	1.5 ug/L	0.2 ug/L	DNQ
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	5.8 ug/L	0.3 ug/L	DNQ	1.8 ug/L	0.3 ug/L	DNQ
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	4.6 ug/L	DNQ	DNQ	1.8 ug/L	DNQ	DNQ
Total Water Treated by Post Filter Day 7: 3 Gallons									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Reverse Osmosis
GE Smartwater GXRM10G

RO Test Unit Number: 6248.0701L.08 - GE Smartwater GXRM10G

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 1	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h	8.9 ug/L								
12 h	8.9 ug/L			DNQ			<0.2 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			DNQ			<0.2 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 6.4 Liters									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			DNQ			<0.2 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 6.4 Liters									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			DNQ			<0.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 6.4 Liters									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			0.9 ug/L			<0.2 ug/L		
148 h	8.8 ug/L			DNQ			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: 2 Gallons									

** Chlorine Sample not taken

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.08 - GE Smartwater GXRM10G

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 8	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 6.4 Liters									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 6.4 Liters									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		DNQ	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 6.4 Liters									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14									
144 h		2.9 ug/L	3.5 ug/L		0.3 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: Approximately 2 Gallons									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.08 - GE Smartwater GXRM10G

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 15	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	0.4 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 6 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	0.5 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 6.4 Liters									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	0.2 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 6.4 Liters									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	0.4 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 6.4 Liters									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	1.0 ug/L	0.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: 2 Gallons									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Reverse Osmosis
Kinetico Plus Deluxe VX

RO Test Unit Number: 6248.0701L.07 - Kinetico Plus Deluxe VX

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 1	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h	8.9 ug/L								
12 h	8.9 ug/L			<0.2 ug/L			<0.2 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: Approximately 3.6 Gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			<0.2 ug/L			<0.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			DNQ			<0.2 ug/L		
148 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: Approximately 1.2 Gallons									

** Chlorine Sample not taken

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.07 - Kinetico Plus Deluxe VX

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 8	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: Approximately 3.6 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14									
144 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		DNQL	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: Approximately 1.2 Gallons									

RO Test Unit Number: 6248.0701L.07 - Kinetico Plus Deluxe VX

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 15	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 3.6 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 3 Gallons									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 3 Gallons									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 3 Gallons									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
Total Water Treated by Post Filter Day 7: 1.2 Gallons									

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Reverse Osmosis
Pentair RO-3500

RO Test Unit Number: 6248.0701L.04 - Pentair RO-3500

	Average Influent			Effluent (Membrane			Effluent (Anion Exchange Filter)			Effluent (Post Filter)		
Day 1	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h	8.9 ug/L											
12 h	8.9 ug/L			<0.2 ug/L			<0.2 ug/L			<0.2 ug/L		
16 h	8.9 ug/L											
Total Water Treated by Post filter Day 1: Approximately 6 Gallons (22.7 Liters)												
Day 2												
24 h	8.7 ug/L											
30 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L			<0.2 ug/L		
36 h	8.7 ug/L											
42 h	8.7 ug/L											
Total Water Treated by Post Filter Day 2: 4.3 Liters (1.1 Gallons)												
Day 3												
48 h	8.7 ug/L											
54 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L			<0.2 ug/L		
60 h	8.7 ug/L											
66 h	8.7 ug/L											
Total Water Treated by Post Filter Day 3: 4.3 Liters												
Day 4												
72 h	9.6 ug/L											
78 h	9.6 ug/L			<0.2 ug/L			<0.2 ug/L			<0.2 ug/L		
84 h	9.6 ug/L											
90 h	9.6 ug/L											
Total Water Treated by Post Filter Day 4: 4.3 Liters												
Day 5	9.2 ug/L											
Day 6	9.4 ug/L											
Day 7												
144 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L			<0.2 ug/L		
148 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: Approximately 2 Gallons (~ 7.6 Liters)												

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

	Average Influent			Effluent (Membrane)			Effluent (Anion Exchange Filter)			Effluent (Post Filter)		
Day 8	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h												
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h												
Total Water Treated by Post filter Day 1: Approximately 6 Gallons (~ 22.7 Liters)												
Day 9												
24 h												
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h												
42 h												
Total Water Treated by Post Filter Day 2: 4.3 Liters (1.1 Gallons)												
Day 10												
48 h												
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h												
66 h	N/A											
Total Water Treated by Post Filter Day 3: 4.3 Liters												
Day 11												
72 h		3.0 ug/L	3.2 ug/L									
78 h		3.0 ug/L	3.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L									
90 h		3.0 ug/L	3.2 ug/L									
Total Water Treated by Post Filter Day 4: 4.3 Liters												
Day 12		2.8 ug/L	3.1 ug/L									
Day 13		2.8 ug/L	3.1 ug/L									
Day 14												
144 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L

	Average Influent			Effluent (Membrane)			Effluent (Anion Exchange Filter)			Effluent (Post Filter)		
Day 15	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h												
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h												
Total Water Treated by Post filter Day 1: 6 Gallons												
Day 16												
24 h												
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h												
42 h												
Total Water Treated by Post Filter Day 2: 4.3 Liters												
Day 17												
48 h												
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h												
66 h												
Total Water Treated by Post Filter Day 3: 4.3 Liters												
Day 18												
72 h												
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h												
90 h												
Total Water Treated by Post Filter Day 4: 4.3 Liters												
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L									
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L									
Day 21												
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Reverse Osmosis
CUNO/Water Factory SQC-3

RO Test Unit Number: 6248.0701L.02 - CUNO/Water Factory SQC-3

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 1	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h	8.9 ug/L								
12 h	8.9 ug/L			<0.2 ug/L			<0.2 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: Approximately 3.6 gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 4.7 Liters									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			<0.2 ug/L			<0.2 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 4.7 Liters									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			*			<0.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 4.7 Liters									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L		
148 h	8.8 ug/L			<0.2 ug/L			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: Approximately 1.2 Gallons									
* Sample lost in transit.									

RO Test Unit Number: 6248.0701L.02 - Cuno/Water Factory

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 8									
4 h									
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: Approximately 3.6 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 4.7 Liters									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 4.7 Liters									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 4.7 Liters									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14									
144 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L

RO Test Unit Number: 6248.0701L.02 - Cuno/Water Factory

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 15									
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 3.6 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 4.7 Liters									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 4.7 Liters									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 4.7 Liters									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L

DNQ = detected, not quantified (0.05 to 0.2)

Reverse Osmosis
Watts Premier WP-4V

RO Test Unit Number: 6248.0701L.05 - Watts WP-4v

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
Day 1	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
4 h	8.9 ug/L								
12 h	8.9 ug/L			DNQ			<0.2 ug/L		
16 h	8.9 ug/L								
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 2									
24 h	8.7 ug/L								
30 h	8.7 ug/L			DNQ			<0.2 ug/L		
36 h	8.7 ug/L								
42 h	8.7 ug/L								
Total Water Treated by Post Filter Day 2: 5.1 Liters									
Day 3									
48 h	8.7 ug/L								
54 h	8.7 ug/L			DNQ			<0.2 ug/L		
60 h	8.7 ug/L								
66 h	8.7 ug/L								
Total Water Treated by Post Filter Day 3: 5.1 Liters									
Day 4									
72 h	9.6 ug/L								
78 h	9.6 ug/L			DNQ			<0.2 ug/L		
84 h	9.6 ug/L								
90 h	9.6 ug/L								
Total Water Treated by Post Filter Day 4: 5.1 Liters									
Day 5	9.2 ug/L								
Day 6	9.4 ug/L								
Day 7									
144 h	8.8 ug/L			DNQ			<0.2 ug/L		
148 h	8.8 ug/L			DNQ			<0.2 ug/L		
Total Water Treated by Post Filter Day 7: Approximately 2 Gallons									

** Chlorine Sample not taken

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.05 - Watts WP-4v

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 8									
4 h									
12 h		2.6 ug/L	3.1 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: Approximately 6 Gallons									
Day 9									
24 h									
30 h		2.6 ug/L	2.9 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 5.1 Liters									
Day 10									
48 h									
54 h		2.6 ug/L	2.8 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 5.1 Liters									
Day 11									
72 h		3.0 ug/L	3.2 ug/L						
78 h		3.0 ug/L	3.2 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
84 h		3.0 ug/L	3.2 ug/L						
90 h		3.0 ug/L	3.2 ug/L						
Total Water Treated by Post Filter Day 4: 5.1 Liters									
Day 12		2.8 ug/L	3.1 ug/L						
Day 13		2.8 ug/L	3.1 ug/L						
Day 14									
144 h		2.9 ug/L	3.5 ug/L		DNQ	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L
148 h		2.9 ug/L	3.5 ug/L		<0.2 ug/L	<0.2 ug/L		<0.2 ug/L	<0.2 ug/L

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

RO Test Unit Number: 6248.0701L.05 - Watts WP-4v

	Average Influent			Effluent (Membrane)			Effluent (Post Filter)		
	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS	PFBA	PFOA	PFOS
Day 15									
4 h									
12 h	9.9 ug/L	2.2 ug/L	3.3 ug/L	0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
16 h									
Total Water Treated by Post filter Day 1: 6 Gallons									
Day 16									
24 h									
30 h	9.3 ug/L	2.3 ug/L	3.3 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
36 h									
42 h									
Total Water Treated by Post Filter Day 2: 5.1 Liters									
Day 17									
48 h									
54 h	9.5 ug/L	2.2 ug/L	3.3 ug/L	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
60 h									
66 h									
Total Water Treated by Post Filter Day 3: 5.1 Liters									
Day 18									
72 h									
78 h	9.6 ug/L	2.1 ug/L	3.6 ug/L	0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
84 h									
90 h									
Total Water Treated by Post Filter Day 4: 5.1 Liters									
Day 19	9.3 ug/L	2.1 ug/L	3.4 ug/L						
Day 20	9.8 ug/L	2.1 ug/L	3.2 ug/L						
Day 21									
144 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	DNQ	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L
148 h	9.8 ug/L	2.3 ug/L	3.3 ug/L	DNQ	DNQ	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L	<0.2 ug/L

DNQ = detected, not quantified (0.05 to 0.2 *u*g/L)

Appendix D
Laboratory Chain of Custody Forms (PDF file)

Appendix D Files in electronic format

PDF Format – COC Chain of Custody

Appendix E
Data Log Book

Provided in Digital Format

Appendix F
Laboratory Reports

Provided in Digital Format

Appendix G
Bench Test Photos

Photo 1 – Culligan, RC-EZ-4 AC System

Photo 2- Culligan, AquaCleer RO System
(Note: This RO system uses a RC-EZ-4 for post-filter)

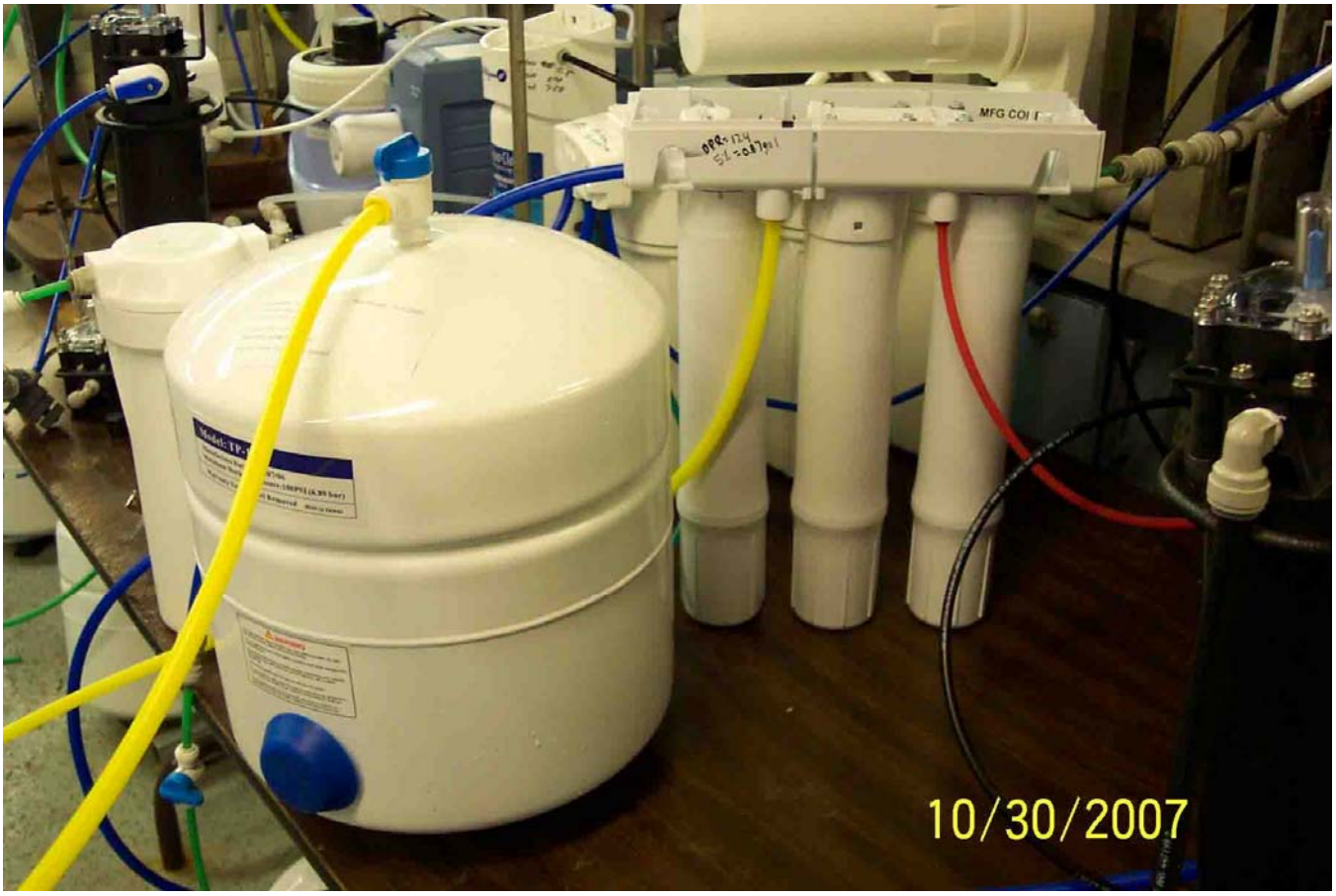

Photo 3 – Ecowater, ERO-375E-CP RO System

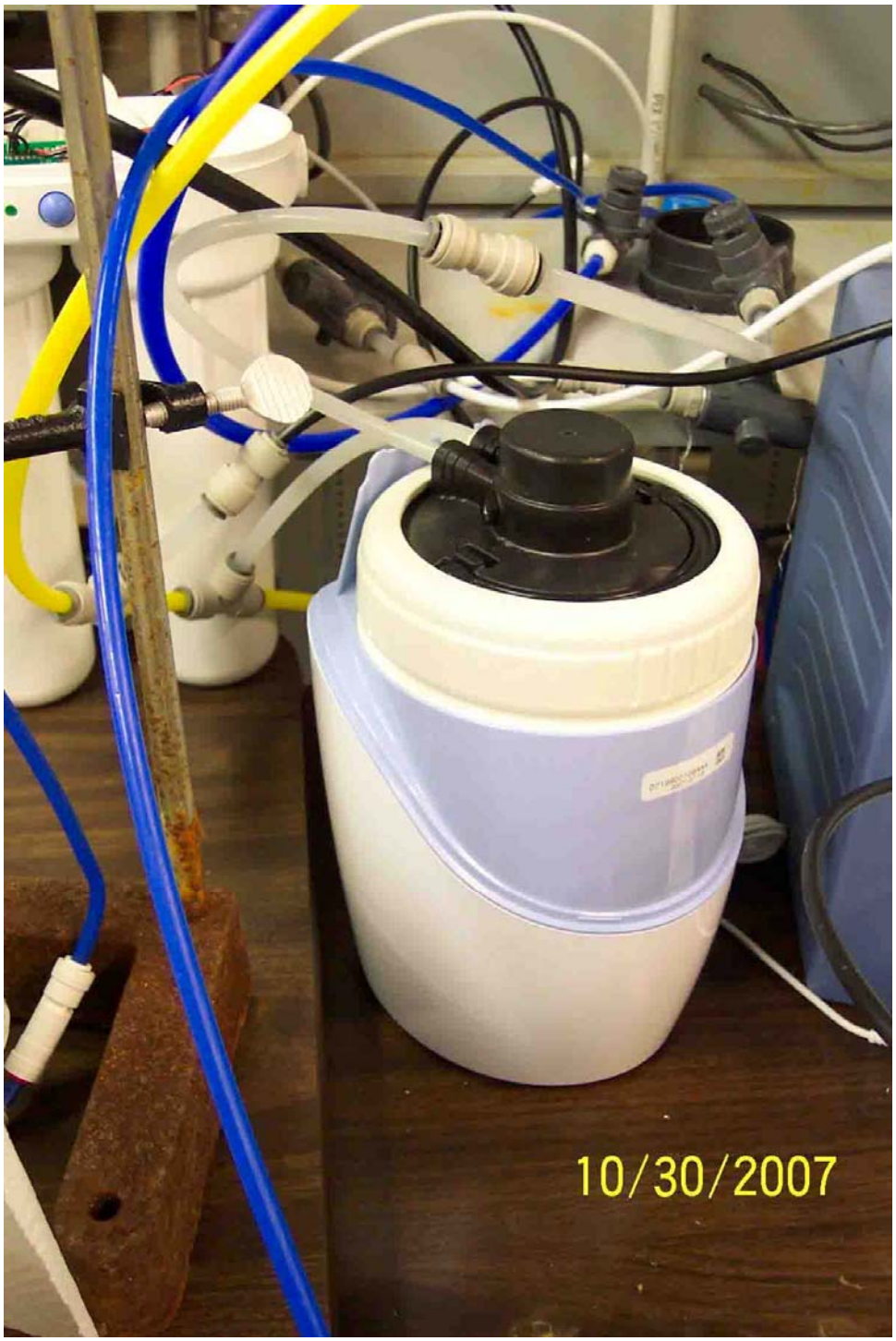

Photo 4 – Access Business Group, eSpring AC System

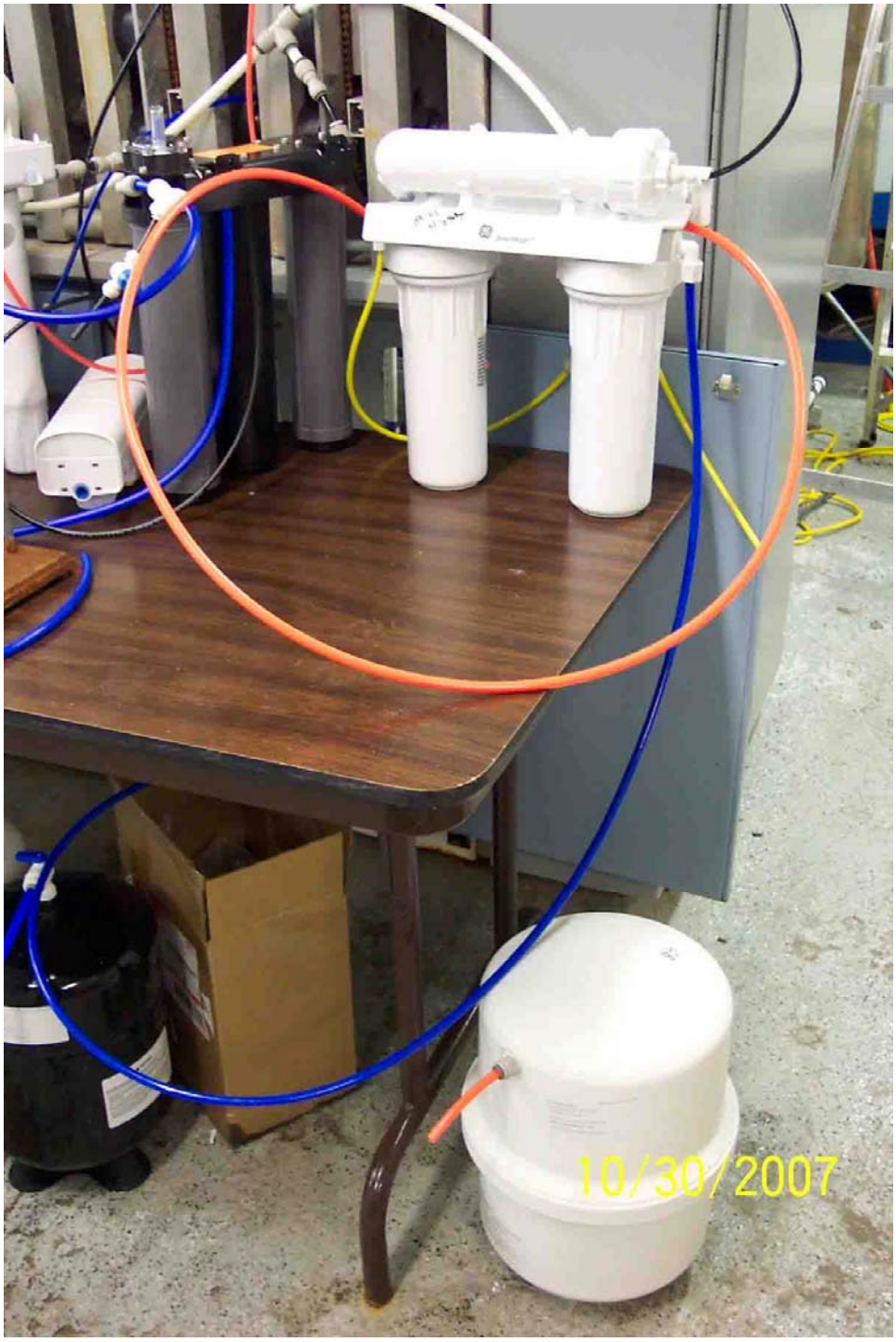

Photo 5 - GE SmartWater, GXRM10GBL RO System

Photo 6 – GE SmartWater, GSXL55F AC System

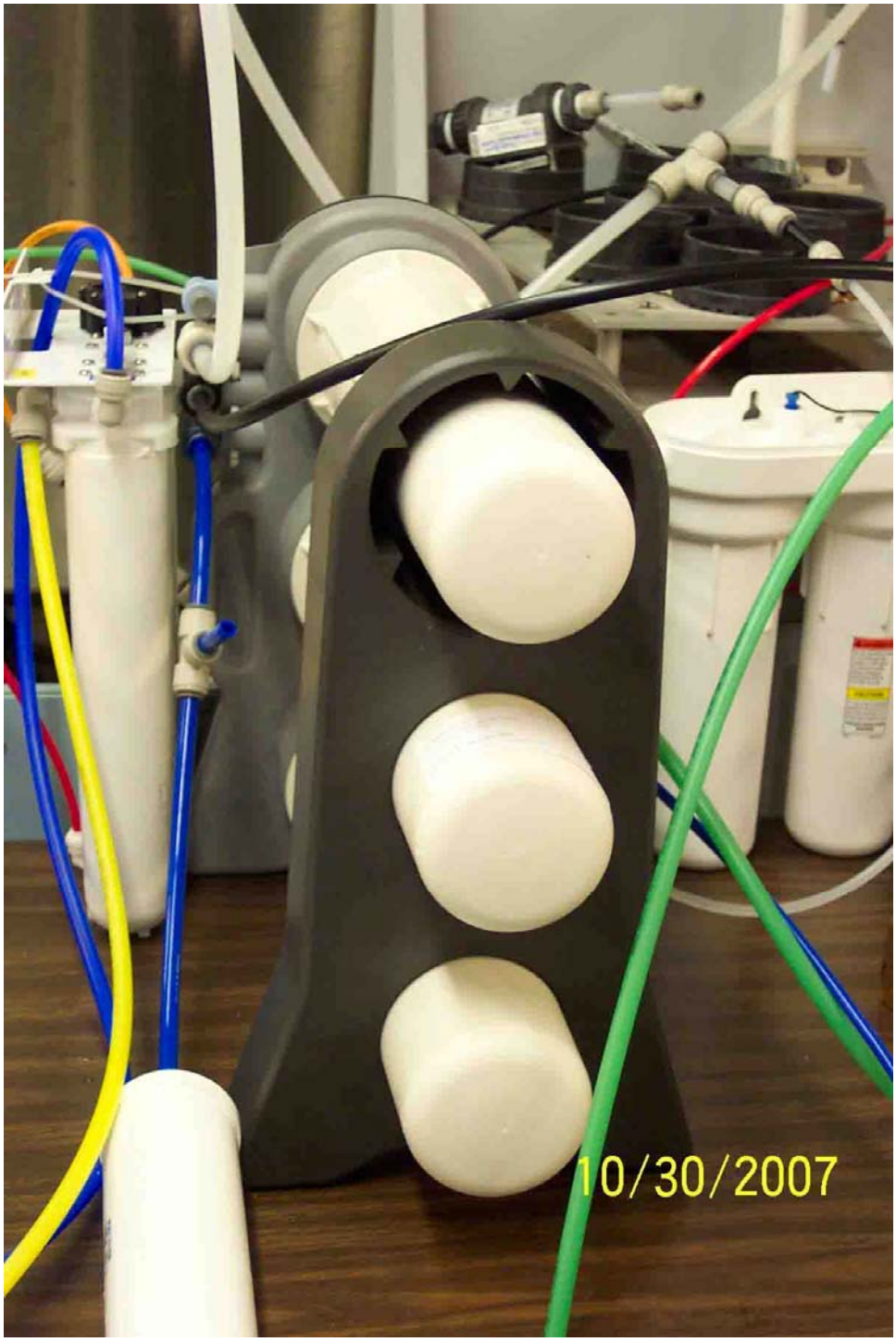

Photo 7 – GE Merlin, tankless, high flow rate, RO System

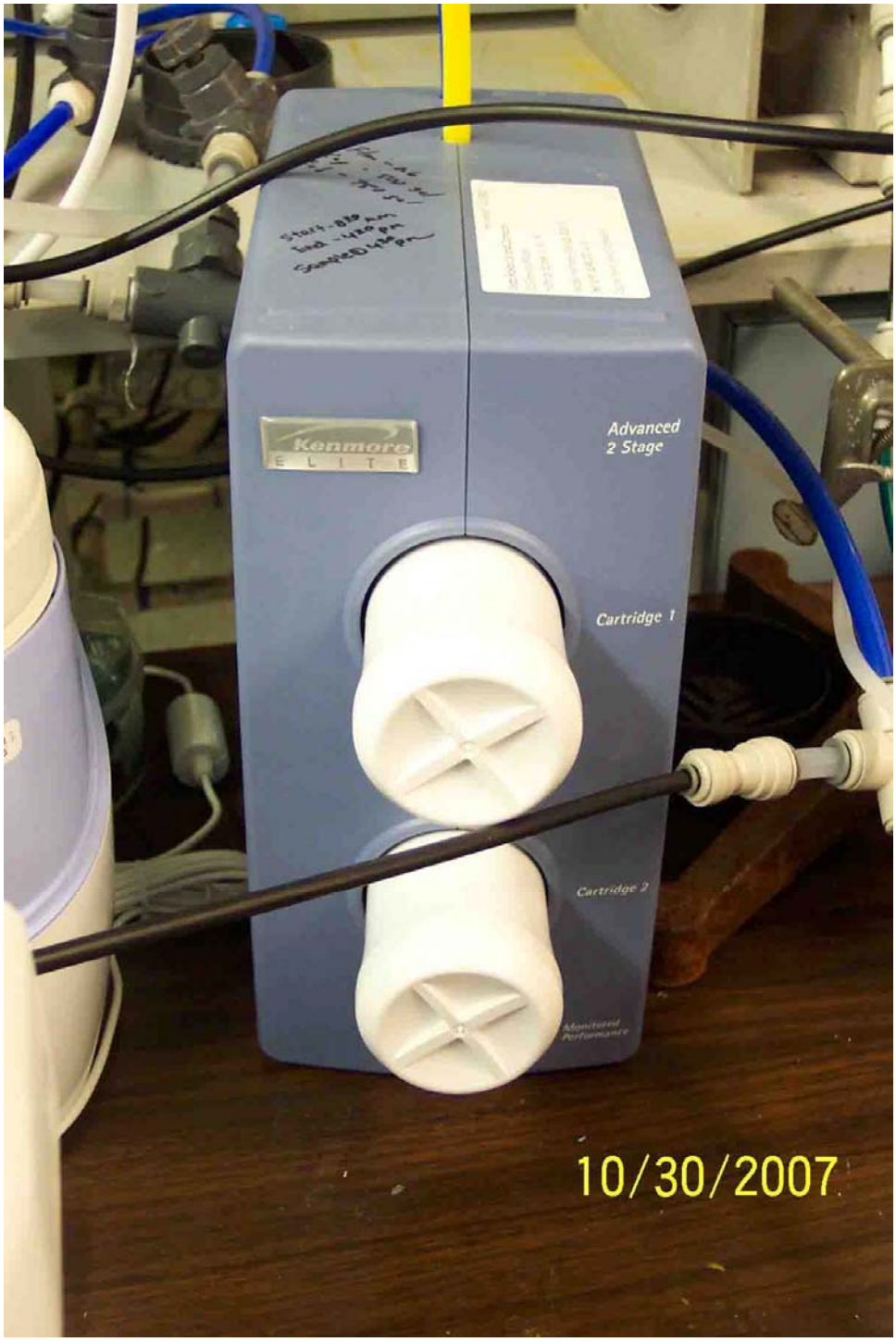

Photo 8 – Kenmore Elite AC System

Photo 9 – Kinetico, MACguard 7500 AC System

Photo 10 – Kinetico, Plus Deluxe VX RO System

Photo 11 – Pentair, RO-3500EX w/ GS RO System

Photo 12 – Rainsoft (Division of Aquion),
Hydrefiner P-12 9878 AC System

Photo 13 – Water Factory Systems (Division of Cuno, Inc. a 3M company), SQC-3 (04-045) RO System

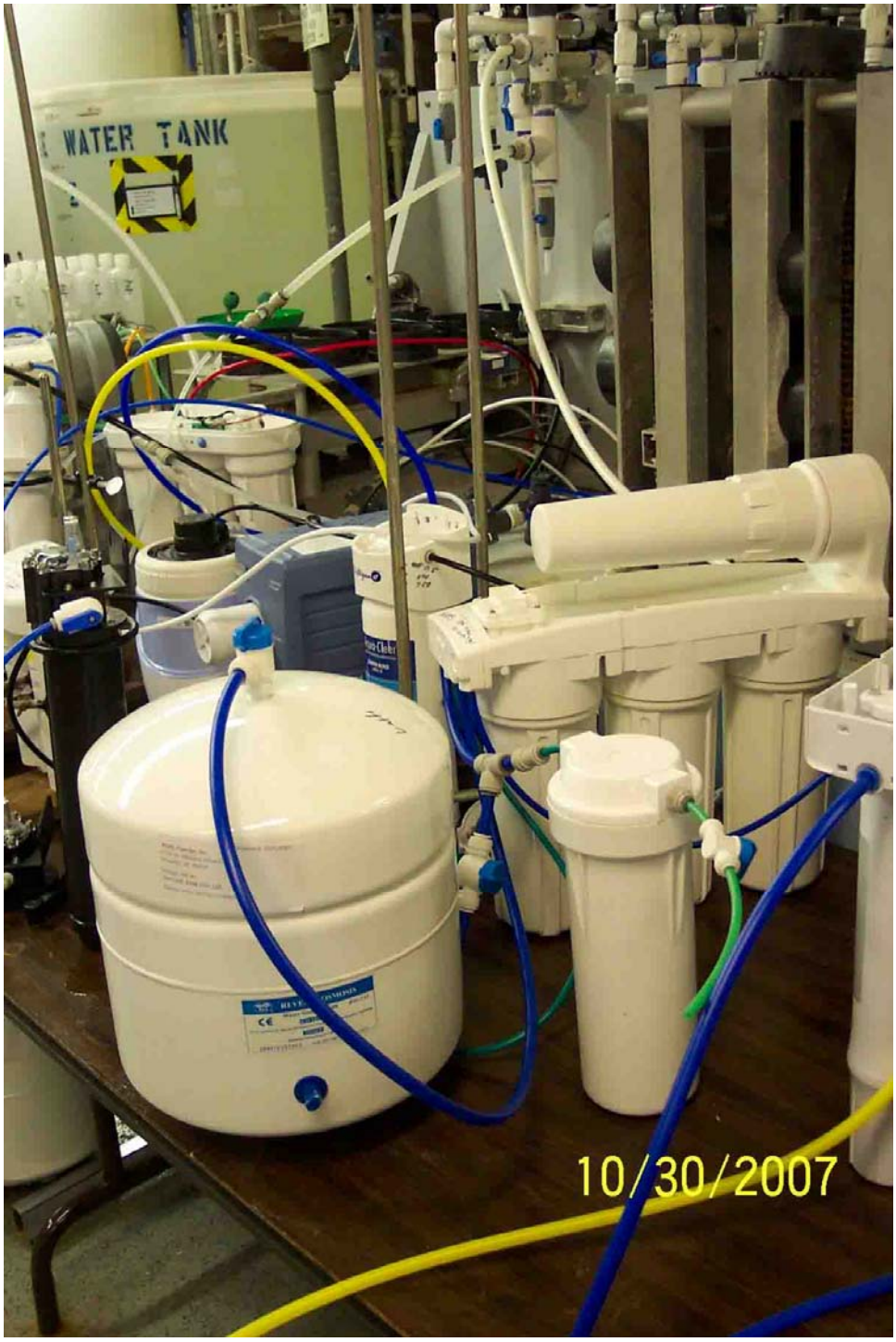

Photo 14 – Watts Premier Inc., WP-4V RO System

Photo 15 - Lab Setup

Photo 16 - Technician taking samples

Appendix H
Testing & Calibration

Appendix H Files provided in digital format

Excel file – Influent Characteristics
Word File – WQA QC Policy
Word File – QA_QC DOC
Word File – PFC Influent Data
PDF File – Thermometer Calibration
PDF File – Pressure Gauge Calibration

Appendix I
QA/QC Documentation

Provided in Digital Format

Appendix J
MN PFC Test Plan (Phase I – WQA)

General Information

1. Contact Information: Paul Swedenborg (MN Department of Health) – (651) 201-5333; Email - Paul.Swedenborg@state.mn.us
2. PFC standards supplied by MN DEP
3. Sample bottles supplied by MN DEP
4. Shipping costs and coolers supplied by WQA – **Keep tract of all costs**
5. **Keep track of all technician time worked on this study**
6. WQA shall be Water Science and Market for all work conducted

Step I - Determine if WQA can prepare challenge water (not spiked with PFC)

1. Determine if WQA's city water and challenge water currently contains PFC's
2. Total Number of samples to complete phase I (2 Rush Samples)
   - Sample WQA City water and send to MN DEP for analysis (Rush Testing)
   - Sample WQA tank challenge water (if we plan on modify the water to meet all the influent requirements) and send to MN DEP for analysis (Rush Testing)

Step II - Determine if WQA can spike challenge water with PFC and maintain tank stability (One Week Timeline)

1. MN DEP shall send WQA stock solutions of specific concentration
2. When using stock solutions mix thoroughly before use
3. Stock solutions shall be added to 1 Liter of city water before it is added to challenge tank
4. Challenge tank shall be mixed and re-circulated thoroughly (1/2 hour) after Stock is added
5. Prepare challenge tanks (two 500 gallon tanks) with PFOA (3 ppb) and PFOS (3 ppb)
   a. Sample tanks after mixing (Initial)
   b. Sample tanks after 24 hours (Final)
   c. Total number of rush samples (4)
6. Prepare challenge tanks (two 500 gallon tanks) with PFBA (10 ppb)
   a. Sample tanks after mixing (Initial)
   b. Sample tanks after 24 hours (Final)
   c. Total number of rush samples (4)
7. Prepare challenge tank (two 500 gallon tanks) with PFOA (3 ppb), PFOS (3 ppb) and PFBA (10 ppb)
   a. Sample tanks after mixing (Initial)
   b. Sample tanks after 24 hours (Final)
   c. Total number of rush samples (4)

Step III – Test Units to determine performance of PFC reduction

1. Set up test units
2. Test units using PFOA (3 ppb) and PFOS (3 ppb) challenge water for 5 days
3. Test units using PFBA (10 ppb) challenge water for 5 days
4. Test units using PFOA (3 ppb), PFOS (3 ppb) and PFBA (10 ppb) 5 days