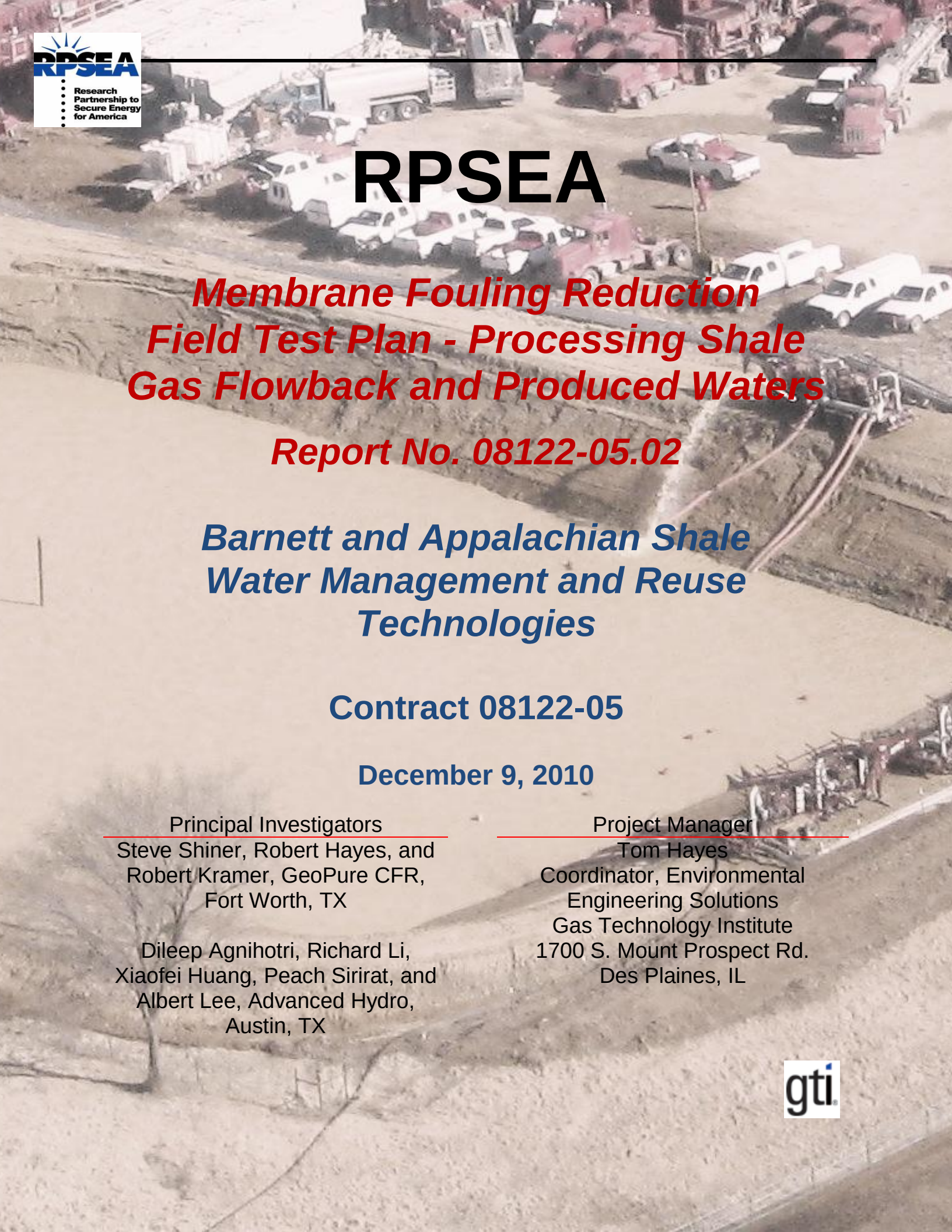

RPSEA

Membrane Fouling Reduction Field Test Plan - Processing Shale Gas Flowback and Produced Waters

Report No. 08122-05.02

Barnett and Appalachian Shale Water Management and Reuse Technologies

Contract 08122-05

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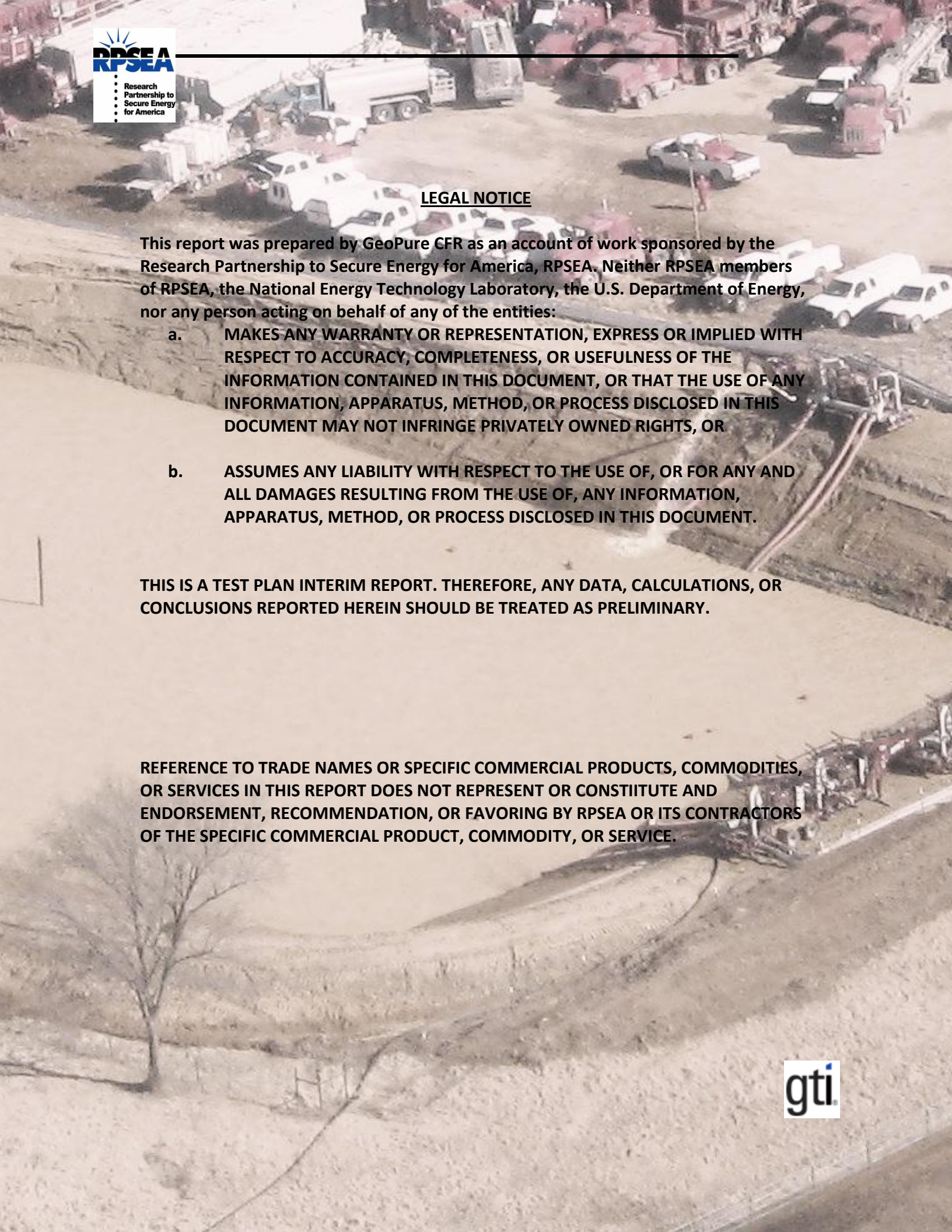
Principal Investigators
Steve Shiner, Robert Hayes, and Robert Kramer, GeoPure CFR, Fort Worth, TX

Dileep Agnihotri, Richard Li, Xiaofei Huang, Peach Sirirat, and Albert Lee, Advanced Hydro, Austin, TX

Project Manager
Tom Hayes
Coordinator, Environmental Engineering Solutions
Gas Technology Institute
1700 S. Mount Prospect Rd.
Des Plaines, IL



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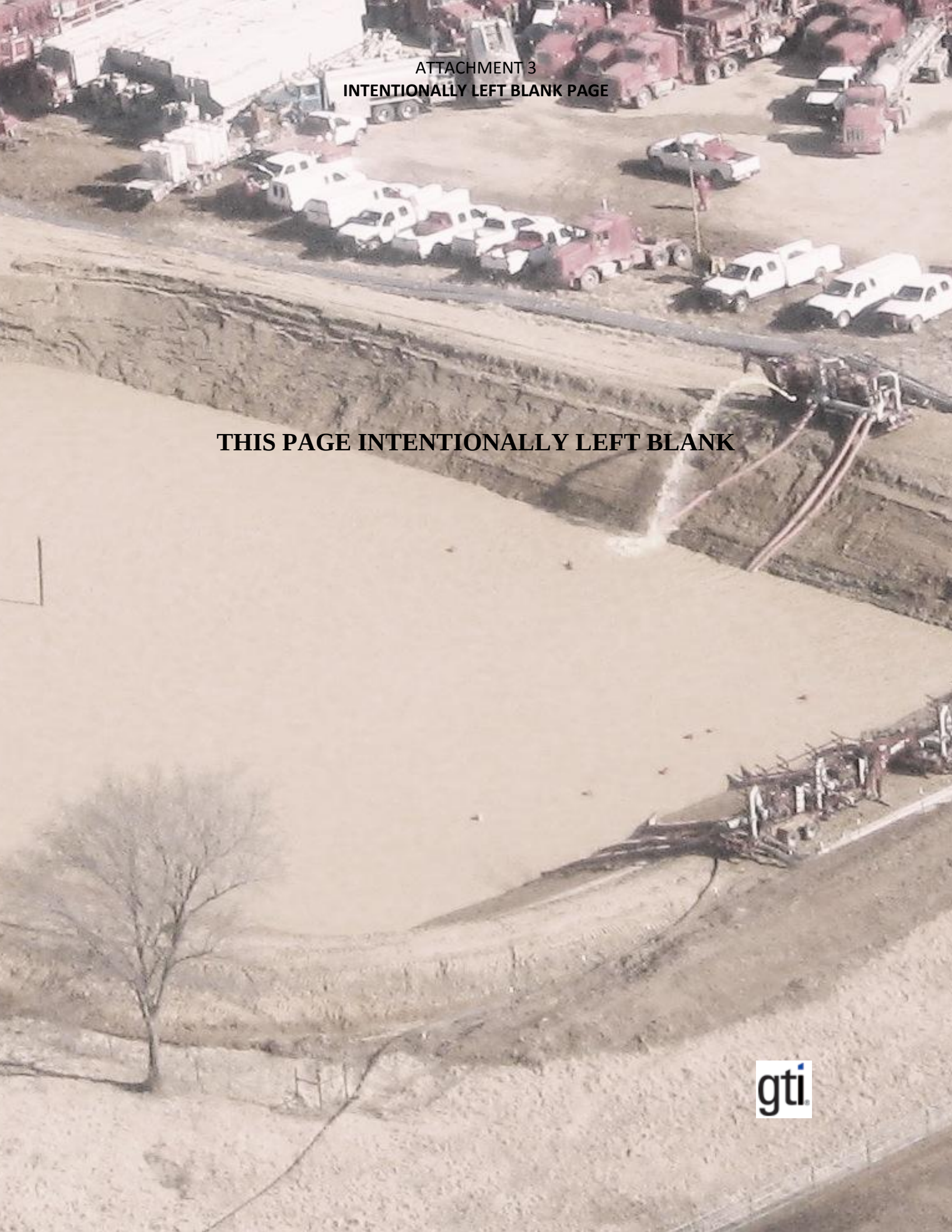

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FIELD TEST PLAN – MEMBRANE FOULING REDUCTION EVALUATION PROCESSING OIL FIELD FLOW-BACK AND PRODUCED WATER BRINES		
Location:	Fountain Quail – Devon Energy Maggie Spain Water Treatment Site – Rhome, TX	
Equipment:	• 6 gpm Hollow Fiber Outside-In UF Membrane Skid • 20 gpm Spiral Wound UF/RO Membrane Skid	
Date:	11/11/10 – 12/23/10 (Termination date to be determined)	
Participants	**Advanced Hydro** Dileep Agnihotri Richard Li Xiaofei Huang Peach Sirirat Albert Lee	**Geopure / Complete Filtration Resources (CFR)** Steve Shiner Robert Hayes Ryan Kramer

1. INTRODUCTION

The purpose of the pilot test is to compare the operational parameters of coated and uncoated UF and RO membranes while processing pretreated oilfield frac flow-back and produced waters. The coated membranes utilize Advanced Hydro fouling resistance coating technology.

Pretreatment is provided the Fountain Quail water recycling facility and comprises the following steps:

a. pH adjustment up to 10.0 – 10.5 with caustic soda (NaOH) to cause partial softening via precipitation of $CaCO_3$. This also causes a reduction in TSS via the coagulation effect of the precipitated solids.
b. Addition of anionic flocculant to enhance settling of precipitated/coagulated solids
c. pH adjustment down to 3.5 – 4.0 using HCl to stabilize the treated water to minimize downstream scaling.

Two membrane systems will be evaluated.

System (A) is a skid-mounted hollow fiber (HF) ultrafiltration (UF) system with a max capacity of 15 gpm.

System (B) is a skid-mounted spiral-wound UF followed by reverse osmosis (RO) with a max capacity of 20 gpm.

Data and water samples will be collected to evaluate the performance of both systems as well as coated and un-coated membranes.

2. EQUIPMENT SPECIFICATIONS

o SYSTEM (A) – 20 GPM Spiral UF/RO Skid

UF Segment

The UF portion of the membrane skid comprises two 8″ spiral-wound elements. The system has a max design recirculation rate of 80 gpm with a design permeate rate of 20 gpm depending upon feed water quality. The following process parameters can be monitored:

- Inlet pressure
- Outlet pressure
- Permeate pressure
- Inlet flow
- Recycle flow
- Reject flow

Membrane data can be found under Attachment 1.

RO Segment

The RO portion of the membrane skid comprises two 8″ vessels sized to hold (5)- 8″ spiral-wound elements each. The two vessels can be run in series, or isolated to run one vessel at a time. For this test, one vessel will be used to house (3) coated membranes, and the second used to house (3) un-coated membranes. Three membranes are being used to maximize the design reject flows per element as specified by the manufacturer. The system has a

maximum operating pressure of 1,000 psi, and incorporates a 1,000 psi pressure relief valve. The following process parameters can be monitored:

- Inlet pressure
- Outlet pressure
- Permeate pressure
- Permeate flow (each vessel)
- Permeate conductivity
- Permeate temperature
- Inlet flow
- Reject flow
- Reject (back-pressure) valve position (% open)

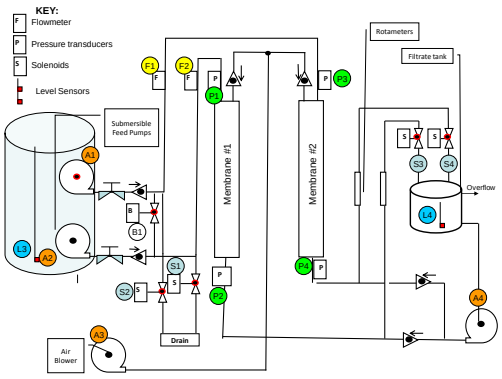
Membrane data can be found under Attachment 1.

The system does not have a PLC or data acquisition system. Operational parameters will be recorded every 20 minutes.

A P&ID of the system in included under Attachment 2.

- **SYSTEM (B) – 15 GPM Hollow Fiber UF Skid**

A standalone UF skid is also put in operation to test side-by-side outside-in membrane configuration for fouling experiments. This skid has two PAN membranes. Each membrane operates independent of each other and one of the membranes has been coated to study to fouling performance for the given water. The skid is completely isolated from the core UF/RO skid and gets feed water from the main feed tank and sends permeate to the common holding tank for RO. The back flush/reject water is sent to a temporary tank holding the discharge water. Skid is fully automated and logs data once every minute for feed pressure, feed flow, permeate pressure, and permeate flow. A picture of the skid and a PID layout is included below



The following process parameters can be monitored:

- Inlet pressure
- Permeate pressure
- Permeate flow

The system utilizes dead-end hollow fiber membranes, thus there is no reject flows or pressures.

Both systems are contained in a 40-foot Inter-Modal shipping container set inside a secondary containment barrier for spill control.

3. PROCESS DESCRIPTION

Both systems (A) and (B) utilize the following components:

- 1,000 gallon poly Feed Tank fed via centrifugal pump from 500 bbl pretreated water supply tank. Two submersible pumps feed System (B).
- 1,400 gallon UF Permeate Tank. Both systems discharge to this tank and a submersible pump in the tank supplies UF permeate to System (A) RO system.
- 1,000 gallon Reject Tank. A float activated pump transfers reject water from both UF systems and the RO system to the Fountain Quail reject tank for off-site disposal.
- 2,200 gallon RO Permeate Tank. Both systems utilize this tank for flushing and CIP of their respective membranes.

- **SYSTEM (A) – 20 GPM Spiral UF/RO Skid**

- Feedwater is drawn into the container via a skid-mounted centrifugal pump for feeding the UF feed balance tank.
- The feed is pre-filtered via 5-micron cartridge filters to reduce gross turbidity caused by pretreatment upsets.
- Desired feed flow, recycle and reject flows are set by the operator
- Feed pressures range from 40 to 70 psi depending upon feedwater quality
- Permeate flows range from 10 to 21 gpm depending upon feedwater quality
- UF permeate flows under pressure to the UF permeate storage tank
- UF reject flows under pressure to the UF/RO reject storage tank
- UF permeate from the UF permeate storage tank is pumped to the RO feed balance tank via submersible pump.
- A centrifugal pump provides boost pressure to the positive displacement RO feed pump.
- Scale inhibitor is fed anytime the RO is operating
- RO permeate flows under pressure to the RO Permeate Storage tank.
- RO reject flows under pressure to the UF/RO Reject Storage Tank.
- The reject back-pressure valve is set to maximize permeate flow and limit operating pressure. The feed rate is maintained constant at 15 gpm with a maximum target recovery of 50% (7.5 gpm) to minimize scale formation. Recovery is more often dictated by operating pressure depending on the TDS of the feedstream, which can range from 30,000 to 100,000 mg/l depending upon the mix of flow-back and produced waters. Since the feedstock is maintained between a pH of 3.5 – 4.5, acid feed is not required for scale inhibition.
- Each RO vessel (containing coated and uncoated membranes) will be operated for 12-hours prior to being flushed with RO permeate and switched.

- **SYSTEM (B) – 15 GPM Hollow Fiber UF Skid**

- Feedwater is drawn into the container via two (2) submersible pumps, once for each membrane (coated and uncoated).
- No pre-filtration is available as on the 20 gpm system
- Both membranes run concurrently with the system being automated via PLC
- Each membrane operates for 15 minutes, and back-washes for 2 minutes
- Permeate flows under pressure to the UF Permeate Storage Tank for use by System (A) RO.

See Process Flow Diagram (PFD) under Attachment 3 for both systems

4. SITE PLAN

See Site Plan under Attachment 4 showing key component locations including generators and field office trailer.

5. DATA COLLECTION PLAN

This project has a plan to collect a total of 30 days of data after the initial setup. The data will be generated during the course of the daytime only due to safety restrictions at the site for night time operation. Initial setup is planned for several days to get the skid operation prior to the actual data collection.

- **Spiral Wound UF Data Collection Plan**

Spiral wound UF stage pretreatment provide water to RO stage treatment. The membranes we plan to use are purchased from Koch (8038 HFM-100, with MWCO equals 50000 daltons), coated with Advanced Hydro fouling resistance coating technology. The membranes will be run with 2 elements in series in a cross-flow mode with initial feed flow rate at 50 GPM, 16% bleeding rate and inlet feed pressure at around 55 PSI.

- **RO Data Collection Plan**

  RO membranes are purchased from Hydranautics (SWC3+). Two vessels of elements are prepared for this pilot research. Each vessel contains 3 elements in series. RO elements in one vessel are coated with Advanced Hydro fouling resistance coating layer, while elements in the other vessel are not. Two trays of membranes will be running in parallel alternately with initial inlet feed flow rate at 15 GPM and a maximum recovery rate at 50%.

- **Outside-in UF Data Collection Plan**

  Hollow fiber UF membranes are purchased from Ultra-Flo Pte (U630). Two membrane modules will be run in parallel with one coated and one uncoated. The initial flow for each membrane will be set at 5.8 GPM, with 15 minutes filtration time and 120 seconds backflush operation.

6. SAMPLING PLAN

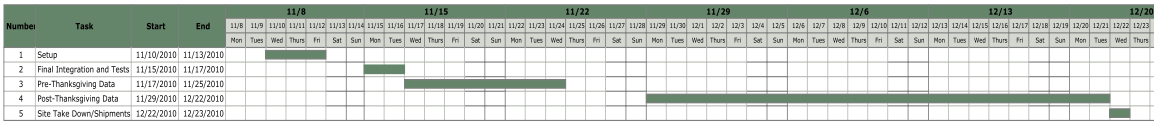
Data from System (A) will be manually logged every 20 minutes.

Data from System (B) is logged automatically every 60 seconds.

See System (A) data logging sheets under Attachment 5.

- **GANTT Chart**

GTI-AHI-UT-GP Pilot at Devon Site



Activity	Date	8am-6pm	5pm-5am	9pm-9am
Setup	11/10/2010	GP team	-	-
Setup	11/11/2010	GP team + AHI	-	-
Setup	11/12/2010	GP team	-	-
Training	11/15/2010	GP team + AHI + UT	-	-
Training + D0	11/16/2010	GP team + AHI + UT	AHI/UT[1]	AH2/UT[1]
Data D1	11/17/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D2	11/18/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D3	11/19/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D4	11/20/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D5	11/21/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D6	11/22/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D7	11/23/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D8	11/24/2010	GP team (until 2pm)	-	-

GP team	Steve Shiner, ??
AHI/UT[1]	Richard Li, Albert Lee
AHI/UT[2]	Xiaofei Huang, Peach Sirirat
Dileep at site	11/11/2010, 11/15/2010, 11/30/2010

Proposed shedule suggest a 1-person from 8a-6p and 2 people during 5p-9am (with 4 hr offset schedule). This will allow overnight people to take 2-3 hr shifts during wee hours

Activity	Date	8am-6pm	5pm-5am	9pm-9am
Training	11/29/2010	GP team + AHI + UT	AHI/UT[2]	AH2/UT[2]
Data D9	11/30/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D10	12/1/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D11	12/2/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D12	12/3/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D13	12/4/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D14	12/5/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D15	12/6/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D16	12/7/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D17	12/8/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D18	12/9/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D19	12/10/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D20	12/11/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D21	12/12/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D22	12/13/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D23	12/14/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D24	12/15/2010	GP team	AHI/UT[2]	AH2/UT[2]
Data D25	12/16/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D26	12/17/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D27	12/18/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D28	12/19/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D29	12/20/2010	GP team	AHI/UT[1]	AH2/UT[1]
Data D30	12/21/2010	GP team	AHI/UT[1]	AH2/UT[1]
Pull Down	12/22/2010	GP team + AHI + UT	-	-

- **Water Analysis**
  - **Conductivity:** Feed and permeate (from RO) conductivity data are logged every 20 minutes during the operation of the RO skid. In addition, pH and temperatures data are logged every 20 minutes.
  - **Turbidity:** Turbidity data is logged at feed side of the UF segment of the RO skid every 20 minutes during the operation of the skid. Permeate turbidity is occasionally checked to confirm UF membranes are operating normally.
  - **Cations/Hardness-ion (Ca, Mg):** Ca, and Mg are measured initially during the pilot startup and we plan to measure few more times and in case we observe significant conductivity changes during the operation.

- **Anions (Chloride, Alkalinity, Nitrate, Sulphate, Phosphate):** Chloride and alkalinity (bicarbonates) are measured initially during the pilot startup and we we plan to measure few more times and if we observe significant conductivity changes during the operation. We are not able to characterize sulphates, nitrates and phosphates at the site.

- **TOC:** Water samples from site will be analyzed at the UT-Austin laboratories for TOC content. Several samples have been collected and this analysis is in process.

- **TPH:** Water samples from site will be analyzed at the UT-Austin laboratories for TOC content. Several samples have been collected and this analysis is in process

- **Additional Analytes (Silica, Ba, Sr, Sulphates):** We plan to analyze water samples for additional analytes that could be provide significant potential for scaling of the membranes. These include Silica, Barium, Strontium and Sulphates

ATTACHMENTS

ATTACHMENT 1

System (A) 20 gpm Skid Membrane Data

KOCH MEMBRANE SYSTEMS

KMS HFM PVDF FOOD & DAIRY UF ELEMENTS

Sanitary Ultrafiltration Spiral Elements

PRODUCT DESCRIPTION

Membrane Chemistry:	Proprietary semi-permeable polyvinylidene difluoride (PVDF)
Membrane Type:	HFM-100™ with observed separation range of 50,000 daltons
	HFM-180™ with observed separation range of 100,000 daltons
Construction:	Sanitary spiral wound element with polysulfone permeate tube and net outer wrap
Regulatory Status:	Conform to USDA 3-A standards and FDA regulations (CFR Title 21)
Options:	Diameter: 3.8", 4.3", 6.3", 8.0", or 8.3"
	Length: 33" or 38"
	Feed Spacer: N (31 mil), V (46 mil), H (62 mil), F (80 mil) or E (135 mil)
	Outer wrap: Controlled (e.g. NYV) or trimmable (e.g. NYT)

SPECIFICATIONS

Model	Active Membrane Area									
	NYV/T Spacer (31 mil)		VYV/T Spacer (46 mil)		HYV/T Spacer (62 mil)		FYV/T Spacer (80 mil)		EYV/T Spacer (135 mil)	
	ft^2	(m^2)	ft^2	(m^2)	ft^2	(m^2)	ft^2	(m^2)	ft^2	(m^2)
3838 HFM-100/180	60	(5.6)	49	(4.5)	41	(3.8)	33	(3.1)	-	-
4333 HFM-100/180	-	-	66	(6.1)	-	-	41	(3.8)	-	-
6338 HFM-100/180	208	(19.4)	169	(15.7)	-	-	114	(10.6)	-	-
8038 HFM-100/180	319	(29.6)	-	-	-	-	167	(15.5)	117	(10.9)
8338 HFM-100/180	-	-	290	(26.9)	229	(21.3)	194	(18.0)	-	-

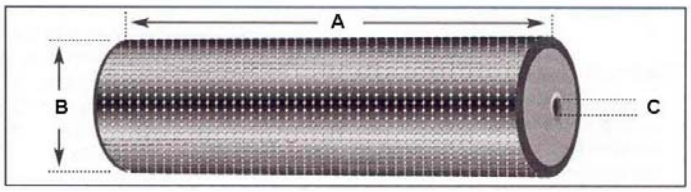
Note: Not all combinations are available.

OPERATING AND DESIGN INFORMATION*

Typical Operating Pressure:	30 - 120 psi (2.1 - 8.3 bar)
Maximum Operating Pressure:	140 psi (9.7 bar)
Recommended Operating Temperature Range:	41 - 130°F (5 - 54°C)
Maximum Operating Temperature:	
At pH 6.0 - 7.5:	150°F (65.5°C)
At pH 3.5 - 6.0:	140°F (60°C)
At pH 2.0 - 3.5 and 7.5 – 10.0:	130°F (54°C)
Cleaning Temperature Range:	105 - 130°F (40 - 54°C)
Allowable pH - Continuous Operation:	2.5 - 10.5
Allowable pH - Clean-In-Place (CIP):	1.5 - 11.0
Design Pressure Drop Per Element:	N spacer: 12-15 psi (0.8-1.0 bar)
	V spacer: 15-20 psi (1.0-1.4 bar)
	H, F or E spacer: 15-25 psi (1.0-1.7 bar)
Design Pressure Drop Per Vessel (3 in series):	N spacer: 36-45 psi (2.5-3.1 bar)
	V spacer: 45-60 psi (3.1-4.1 bar)
	H, F or E spacer: 45-75 psi (3.1-5.2 bar)
Design Pressure Drop Per Vessel (4 in series):	N spacer: 48-60 psi (3.3-4.1 bar)
	V spacer: 60-75 psi (4.1-5.2 bar)

* Consult KMS Process Technology Group for specific applications.

NOMINAL DIMENSIONS



Model	A inches (mm)	B inches (mm)	C inches (mm)
3838 HFM-100/180	38.0 (965)	3.8 (96)	0.831 (21.1)
4333 HFM-100/180	33.0 (838)	4.3 (109)	0.831 (21.1)
6338 HFM-100/180	38.0 (965)	6.3 (160)	1.138 (28.9)
8038 HFM-100/180	38.0 (965)	7.9 (201)	1.138 (28.9)
8338 HFM-100/180	38.0 (965)	8.3 (211)	1.138 (28.9)

Notes: Not all combinations are available.
Dimensions are provided for reference only and should not be interpreted as accurate specifications.

Membrane Characteristics:

- The membrane used in these modules consists of a semipermeable polyvinylidene difluoride (PVDF) layer cast on backing material.
- Pure water flux of these HFM-100™ membranes is 1.5-3.0 gfd/psi (35-75 l/m^2/h/bar) at 77°F (25°C).
- Pure water flux of these HFM-180™ membranes is 2.0-4.0 gfd/psi (50-100 l/m^2/h/bar) at 77°F (25°C).

Operating Limits:

- Operating Pressure: Maximum operating pressure is 140 psi (9.7 bar).
- Permeate Pressure: Permeate pressure should not exceed baseline (concentrate) pressure at any time (including on-line, off-line and during transition). Reverse pressure will damage the membrane.
- Differential Pressure: The maximum differential pressures per element are listed on the front of this document, including design values for multi-element housings.
- Temperature: Maximum operating temperature is 150°F (65.5°C). Refer to the "Operating and Design Information" section on the front of this document for detailed information. Maximum cleaning temperature is 130°F (54°C).
- pH: Allowable range for continuous operation is 2.5 to 10.5. Allowable pH range for cleaning is 1.5 to 11.0.

Water Quality for Cleaning & Diafiltration:

- Guidelines: Please refer to the KMS "Water Quality Guidelines for CIP and Diafiltration" for more detailed information.

Chlorine and Chemical Exposure:

- Adherence to cleaning and sanitizing procedures including chemical concentrations, pH, temperature, and exposure time is necessary to achieve maximum useful element life. Accurate records should be maintained.
- KMS standard cleaning procedures for dairy applications should be followed. Recommended chlorine exposure time at the defined conditions is 30 minutes per day.
- Residual chlorine concentration during cleaning cycle (CIP) should be 150 ppm @ pH 10.5 or higher. Chlorine concentration should never exceed 200 ppm.
- Chlorine should only be added to the cleaning solution after the pH has been adjusted to 10.5 or higher.
- Iron or other catalyzing metals in the presence of free chlorine or hydrogen peroxide will accelerate membrane degradation.
- Sanitizing should be done only after a complete cleaning cycle and with water of acceptable quality. Refer to cleaning instructions and feedwater quality technical bulletins.

Cationic Polymers and Surfactants:

HFM-100 and HFM-180 membranes may be irreversibly fouled if exposed to cationic (positively charged) polymers or surfactants. Exposure to these chemicals during operation or cleaning is not recommended and will void the warranty.

Lubricants:

For element installation, use only water or glycerin to lubricate seals. The use of petroleum or vegetable-based oils or solvents may damage the element and will void the warranty.

Supplemental Technical Bulletins:

- UF Element Cleaning Procedures
- Water Quality Guidelines for CIP and Diafiltration

Service and Ongoing Technical Support:

KMS has an experienced staff available to assist end-users and OEM's for optimization of existing systems and development of new applications. KMS also offers a complete line of KOCHKLEEN® membrane pretreatment, cleaning, and maintenance chemicals.

KMS Capability

KMS is the leader in crossflow membrane technology, manufacturing reverse osmosis, nanofiltration, microfiltration, and ultrafiltration membranes and membrane systems. The industries we serve include food, dairy and beverage, semiconductor, automotive, water and wastewater, chemical and general manufacturing. KMS adds value by providing top quality membrane products and sharing our experience in the design and supply of thousands of crossflow membrane systems worldwide.

Koch Membrane Systems, Inc., www.kochmembrane.com

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European Headquarters: Koch Chemical Technology Group Ltd., Units 3-6, Frank Foley Way, Stafford ST16 2ST, GB, Telephone: +44-178-527-2500, Fax: +44-178-522-3149

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Membrane Element SWC3+

Performance:

Permeate Flow:	7,000 gpd (26.5 m^3/d)
Salt Rejection:	
nominal:	99.8 %
minimum:	99.7 %

Type

Configuration:	Spiral Wound
Membrane Polymer:	Composite Polyamide
Nominal Membrane Area:	400 ft^2

Application Data*

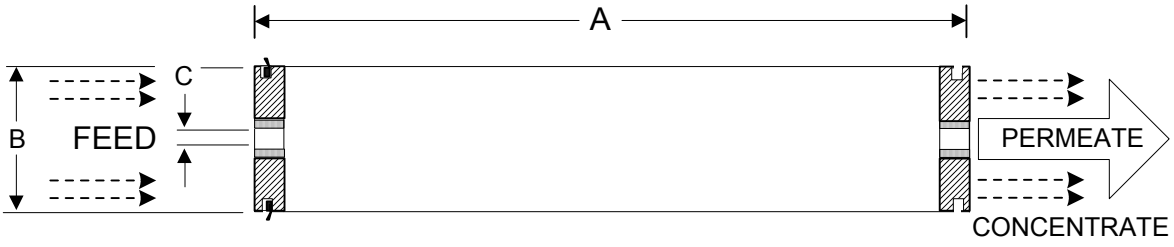
Maximum Applied Pressure:	1200 psig (8.27 MPa)
Maximum Chlorine Concentration:	< 0.1 PPM
Maximum Operating Temperature:	113 °F (45 °C)
Feedwater pH Range:	3.0 - 10.0
Maximum Feedwater Turbidity:	1.0 NTU
Maximum Feedwater SDI (15 mins):	5.0
Maximum Feed Flow:	75 GPM (17.0 m^3/h)
Minimum Ratio of Concentrate to Permeate Flow for any Element:	5:1
Maximum Pressure Drop for Each Element:	10 psi

* The limitations shown here are for general use. The values may be more conservative for specific projects to ensure the best performance and longest life of the membrane.

Test Conditions

The stated performance is initial (data taken after 30 minutes of operation), based on the following conditions:

32,000 ppm NaCl
800 psi (5.5 MPa) Applied Pressure
77 °F (25 °C) Operating Temperature
10% Permeate Recovery
6.5 - 7.0 pH Range



A, inches (mm)	B, inches (mm)	C, inches (mm)	Weight, lbs. (kg)
40.0 (1016)	7.95 (201.9)	1.125 (28.6)	36 (16.4)

Notice: Permeate flow for individual elements may vary + or - 15 percent. All membrane elements are supplied with a brine seal, interconnector, and o-rings. Elements are vacuum sealed in a polyethylene bag containing less than 1.0% sodium meta-bisulfite solution, and then packaged in a cardboard box.

ATTACHMENT 2

System (A) 20 gpm Skid P&ID

NOTE: ALL SHADED COMPONENTS TO BE SUPPLIED/INSTALLED BY OTHERS
ALL BOLD LINES TO BE SUPPLIED/PIPED BY OTHERS
NO UTILITY PIPING SUPPLIED BY CFR

FEED SUPPLY FROM ~10,000GAL FEED TK
22GPM

RO CONC TO ~5000GAL BRINE TK2
8GPM

RO PERM TO ~5,000GAL CLEAN WATER TK3
12GPM

UF CONC & RINSES TO ~5000GAL WASTE TK1
2–80GPM

FP101 CONNECTIONS
PROCESS
CIP

PROCESS: 22GPM @ 25PSI
CIP: 20GPM @ 10PSI

5 MICRON CARTRIDGE

HOT WATER

~5 PSI

UF FEED/CIP BALANCE TK120 50 GAL PLASTIC

DRAIN

FEED: PROCESS: 80GPM CIP: 80GPM

PROCESS: 80GPM @ 75PSI
CIP: 80GPM @ 50PSI

8–80 CONC: PROCESS: 58GPM CIP: 60GPM

0.5–6 CONC: PROCESS: 2GPM CIP: 0GPM

3–30 PERM: PROCESS: 20GPM CIP: 20GPM

STAGE 1 8"–1V/S–2E/V–31MIL

STAGE RECIRC: PROCESS: 80GPM CIP: 80GPM

CHEMICAL ADDITION 1/2" NPT

HOT WATER

TURBINE

ELECTRIC

PERM: PROCESS: 12GPM CIP: 12GPM

8–80 CONC: PROCESS: 8GPM CIP: 68GPM

2–20 PERM: PROCESS: 5GPM CIP: 12GPM

STAGE 1B 8"–1V/S–5E/V–31MIL

STAGE FLOW: PROCESS: 13GPM CIP: 80GPM

2–20 PERM: PROCESS: 7GPM CIP: 12GPM

STAGE 1A 8"–1V/S–5E/V–31MIL

STAGE FLOW: PROCESS: 20GPM CIP: 80GPM

RO FEED/CIP BALANCE TK220 50 GAL PLASTIC

FEED: PROCESS: 20GPM CIP: 80GPM

PROCESS: 20GPM @ 130PSI
CIP: 80GPM @ 130PSI

MYCELX SNIPPETS

MYCELX CARTRIDGE

~800 PSI

PROCESS: 20GPM @ 800PSI

DRAWING LEGEND:
PROCESS:
CIP/S:
CIP/R:
STEAM:
COOLING:
WATER:
FUTURE:
CONTROLS:

PUMP NOTES:

ID TAG	PP120	PP220	PP221	PP100	–	–	–	–	–	–
MAKE	WCB	WCB	WANNER	WCB	–	–	–	–	–	–
MODEL	2065LV	2085LV	HYDRACELL	2045	–	–	–	–	–	–
IMP	6.5"	8.7"	H25E	4"	–	–	–	–	–	–
IN/OUT	2/1.5	2/1.5	1.5/1 (NPT)	1.5/1.5	–	–	–	–	–	–
HP/RPM	10/3500	15/3500	15/1750	3/3500	–	–	–	–	–	–
V/HZ	230–460/60	230–460/60	230–460/60	230–460/60	–	–	–	–	–	–
DRIVE	VFD	VFD	VFD	VFD	–	–	–	–	–	–

Rev	By	Date	Description
0	JA	10/18/06	REVISED PER LAYOUT – RELEASED FOR FABRICATION
A	JA	10/06/06	REVISED PER DAVID CROWE

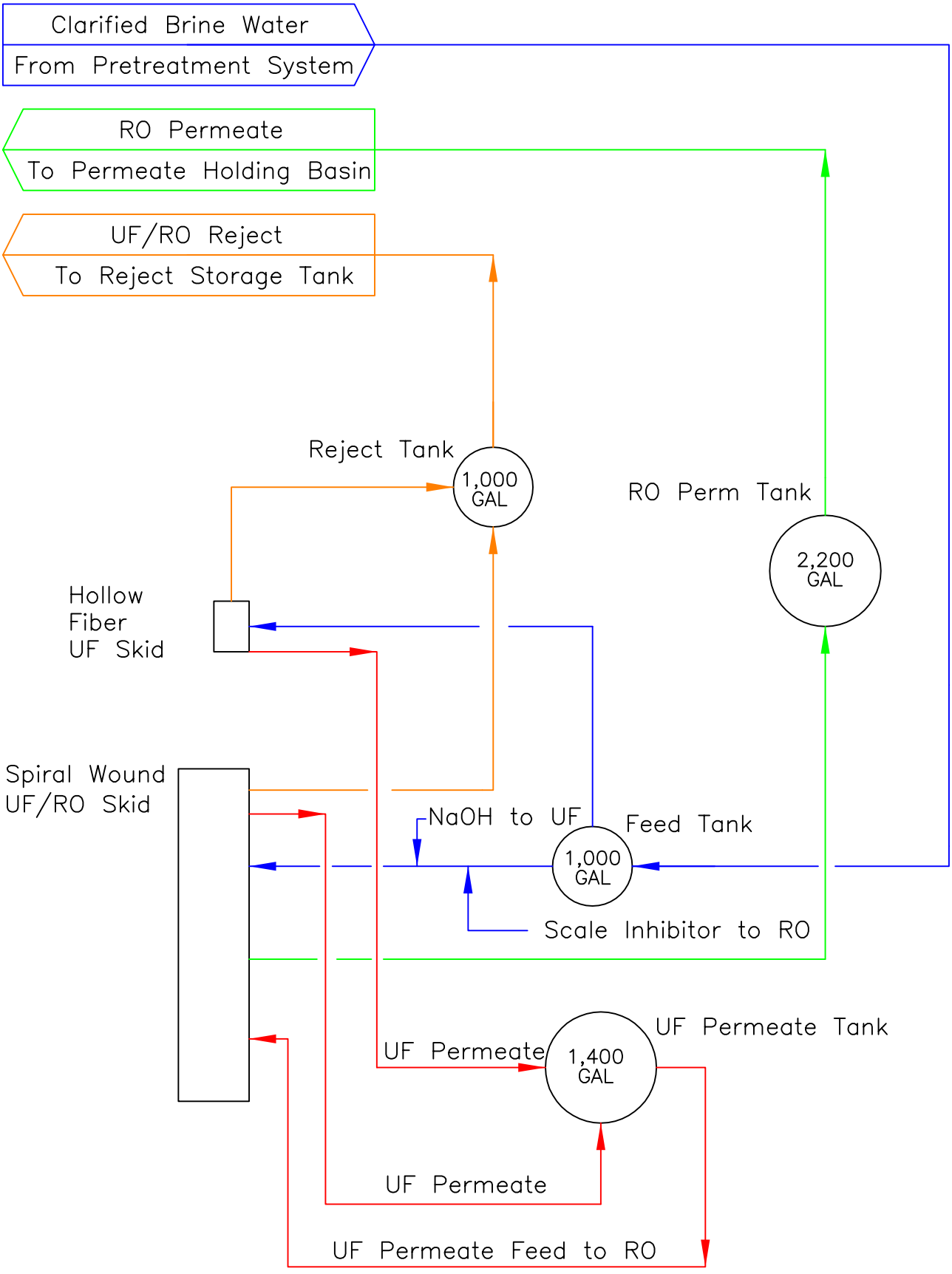
CFR
Complete Filtration Resources, Inc.
1932 East 26th Street
Marshfield, WI 54449
Phone: (800) 301–3254
Fax: (715) 384–3768

ENERGY LABORATORIES, INC.
COLLEGE STATION, TX
UF & RO P&ID

Date: 09/11/06	Eng By: GL/JA	Job No: 11229–0018	SHT: 1	REV: 0
Scale: N/A	Drawn By: JA	SO–Dwg No: J06–17047–F001		

ATTACHMENT 3

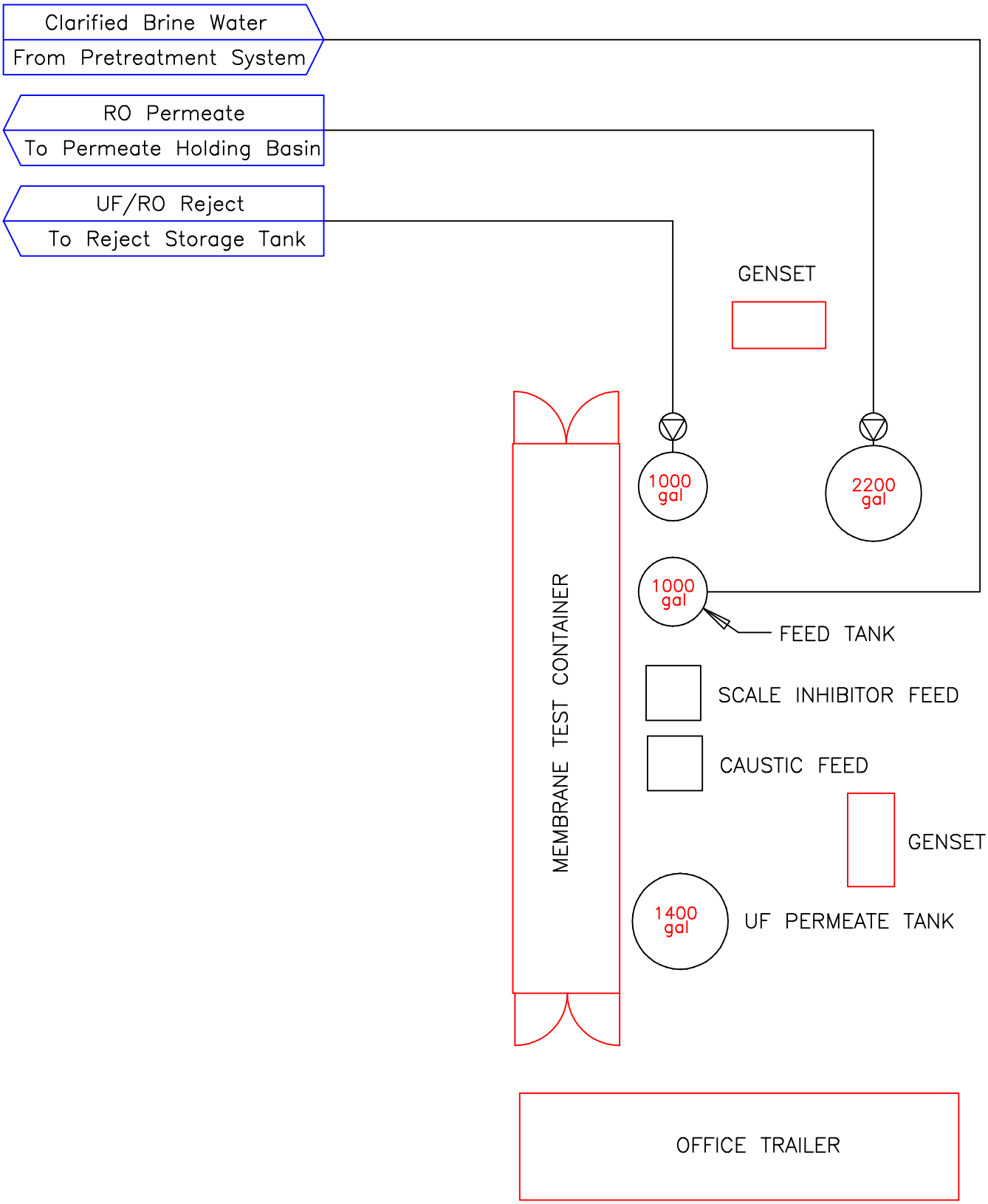
Process Flow Diagram (PFD)



PROCESS FLOW DIAGRAM (PFD)

ATTACHMENT 4

Site Plan


Clarified Brine Water
From Pretreatment System
RO Permeate
To Permeate Holding Basin
UF/RO Reject
To Reject Storage Tank
GENSET
1000 gal
2200 gal
1000 gal
FEED TANK
SCALE INHIBITOR FEED
CAUSTIC FEED
GENSET
1400 gal
UF PERMEATE TANK
MEMBRANE TEST CONTAINER
OFFICE TRAILER

ATTACHMENT 5

Data Logging Sheets

	Mem shift	1=uncoated 2=coated									
	Date	MM/DD/YY									
	Time	HH:MM									
Filters	**Inlet P**	psi									
	Outlet P	psi									
UF	**Inlet P**	psi									
	Outlet P	psi									
	Feed flow	gpm									
	Recycle flow	gpm									
	Reject flow	gpm									
	Perm flow	gpm									
	Feed Turbidity	NTU									
	Feed conductivity	ms/cm									
	Temperature	F									

	Mem shift	1=uncoated 2=coated									
	Date	MM/DD/YY									
	Time	HH:MM									
Filters	**Inlet P**	psi									
	Outlet P	psi									
UF	**Inlet P**	psi									
	Outlet P	psi									
	Feed flow	gpm									
	Recycle flow	gpm									
	Reject flow	gpm									
	Perm flow	gpm									
	Feed Turbidity	NTU									
	Feed conductivity	ms/cm									
	Temperature	F									

RO	**Mem shift**	1=uncoated 2=coated															
	Data	MM/DD/YY															
	Time	HH:MM															
	pH																
	Inlet P	psi															
	Outlet P	psi															
	Perm P	psi															
	Inlet flow	gpm															
	Perm flow	gpm															
	Feed conductivity	ms/cm															
	Perm conductivity	ms/cm															
	Temperature	F															

RO	**Mem shift**	1=uncoated 2=coated															
	Data	MM/DD/YY															
	Time	HH:MM															
	pH																
	Inlet P	psi															
	Outlet P	psi															
	Perm P	psi															
	Inlet flow	gpm															
	Perm flow	gpm															
	Feed conductivity	ms/cm															
	Perm conductivity	ms/cm															
	Temperature	F															