Memorandum

Date: January 30, 2015

To: Trevor Lashua, Town of Hinesburg
Rocky Martin, Town of Hinesburg

From: Joe Duncan, PE, A+E

RE: Town of Hinesburg Wells 4 & 5
Water Treatment Recommended Plan

RECOMMENDED PLAN

It is recommended that the Town pursue a nanofiltration (NF) membrane system as it provides a good softening system, the best overall treatment, the best improvement in taste, does not add sodium to the water, and can better address future compliance issues. It is further recommended that the Town utilize local funding sources (i.e. the MTBE settlement funds) to direct purchase the NF system from Industrial Services Inc. (ISI) in St. George, VT. ISI's local presence provides competitive pricing relative to the national manufacturers, local service, and the ability to tailor the system with the Town's preferred equipment (i.e. system controls, pumps, etc.). A State DWSRF loan is proposed to fund the overall project and the procurement policies of their funding do not allow for sole source direct purchases. In talking with the State, the Town can utilize their own local funding to direct purchase the NF system without compromising the DWSRF loan funding for the remaining project elements.

COSTS

A construction cost estimate was completed based on the recommended project. The construction cost is estimated at $650,000 for the NF water treatment system as summarized below.

Item	Cost Estimate (ENR10010)
Water Treatment System	$185,000
Site Work	$115,000
Wastewater Pump Station	$20,000
Emergency Generator	$50,000
Process Piping	$15,000
Treatment Building	$200,000
Heating/Ventilation	$30,000
Electrical	$35,000
Total	**$650,000**

Notes:
1. ENR 10100 = May 2015

The annual operation and maintenance (O&M) costs associated with the operation of the NF system are estimated to be approximately $20,000 per year as follows:

6 Market Place, Suite 2
Essex Junction, VT 05452
802.879.7733
www.AEengineers.com

Item	Annual O&M Cost
Membrane Replacement	$5,716.67
Cartridge Filter Replacement	$2,016.00
Spare Parts	$1,000.00
Chemical Cleaning	$1,000.00
Labor	$3,500.00
Power	$6,745.20
Total	**$ 19,977.87**

Notes:
1. Membrane life 6 years with cost of $34,300 to replace membranes
2. Cartridge filter 1x changer per month
3. Chemical cleaning, 2x per year by Town
4. Labor requirement for operations assumed at 5% person per day
5. Power assumed @ $0.14/kWh operating 12 hrs/day

BACKGROUND

Aldrich + Elliott, PC (A+E) was retained by the Town of Hinesburg to conduct source permitting and preliminary engineering for a new groundwater supply and treatment at Wells 4 and 5 located off Shelburne Falls Road. The new wells have high hardness, low iron, non-detect manganese, and non-detect MTBE. As part of the project the Town is planning to provide treatment for the high hardness, which has been a nuisance to the system users.

The Town requested that A+E review treatment alternatives and develop a recommended plan for the new groundwater supply and associated treatment. In December 12, 2014 A+E prepared a memo that reviewed treatment alternatives and recommended the Town pursue nanofiltration (NF) membrane treatment to provide the required softening. The Town has since requested that A+E further review NF to document the use of NF for softening at other municipal water systems and identify the capital costs, operation and maintenance (O&M) costs, and project schedule for the proposed NF system.

MEMBRANE SOFTENING OVERVIEW

Membrane filtration was introduced in drinking water treatment in the 1950s, mainly for desalination of seawater, brackish water, and groundwater. A membrane is a thin layer of semi-permeable material that separates substances when a driving force is applied across the membrane. Membrane filtration features the unique property that a membrane can be chosen that removes just the components that are needed from the actual raw water. Such components typically are:

- Inorganic or organic salts
- Metals (i.e. hardness which is primarily comprised of calcium and magnesium)
- Natural organic material
- Biodegradable organics
- Disinfection by-products
- Turbidity and particles
- Infectious species (bacteria, virus, parasites)

Traditionally the most common membrane applications in drinking water treatment have been:

- Desalination of seawater or brackish water
- Removal of hardness, typically from groundwater (membrane softening)
- Turbidity and bacteria removal

Membrane softening is a term applied to the water treatment process that uses nanofiltration (NF) membrane technology to reduce hardness and remove organics, color, bacteria, and other impurities from the raw water supply. NF is often referred to as modified reverse osmosis (RO) because it is based on very similar operating properties. Like RO, NF is a pressure-driven separation process that employs a semipermeable membrane and the principles of cross-flow filtration to split a feedwater stream into two parts: a purified "permeate" water stream and a waste "concentrate" stream containing a high percentage of the impurities found in the raw water.

In crossflow filtration the bulk flow in the filter is along the membrane surface and perpendicular to the direction of filtration. Water permeates the membrane as the feed flow passes by. The pressure across the membrane drives water and permeable particles through the membrane (purified "permeate) leaving the waste "concentrate" stream on the outside of the membrane. The treated permeate is captured for drinking water. The waste concentrate is collected separately and disposed of, typically to the municipal sewer system.

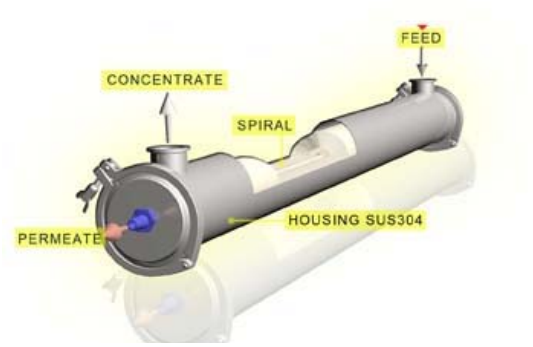


Figure 1 http://www.john-young.com.tw/JOHNYOUNG.php?r=e-c2-uf-ed5.htm

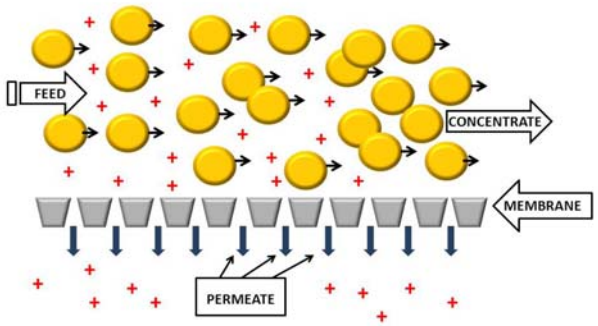


Figure 2 http://www.biotrans.uni.wroc.pl/en/filtration,19.html

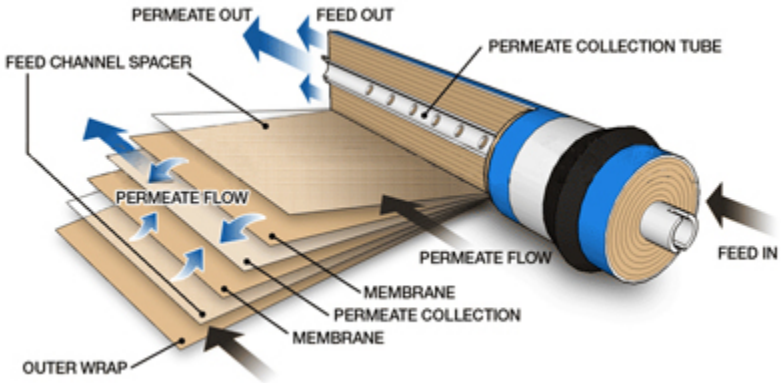


Figure 1 http://www.freshwatersystems.com/c-238-ro-membranes.aspx

The membrane pore size is a main factor in determining whether a solute will pass across the membrane. NF membranes have a nominal pore size of approximately 0.001 microns versus RO membranes which have a pore size of around 0.0001 micron. The chart below summarizes the types of particles that are removed from the water with each type of membrane filter. The arrow through the membrane indicates that the particle is small enough to pass through the filter, whereas the deflected arrow indicates the filter blocks the particle from passing through the filter.

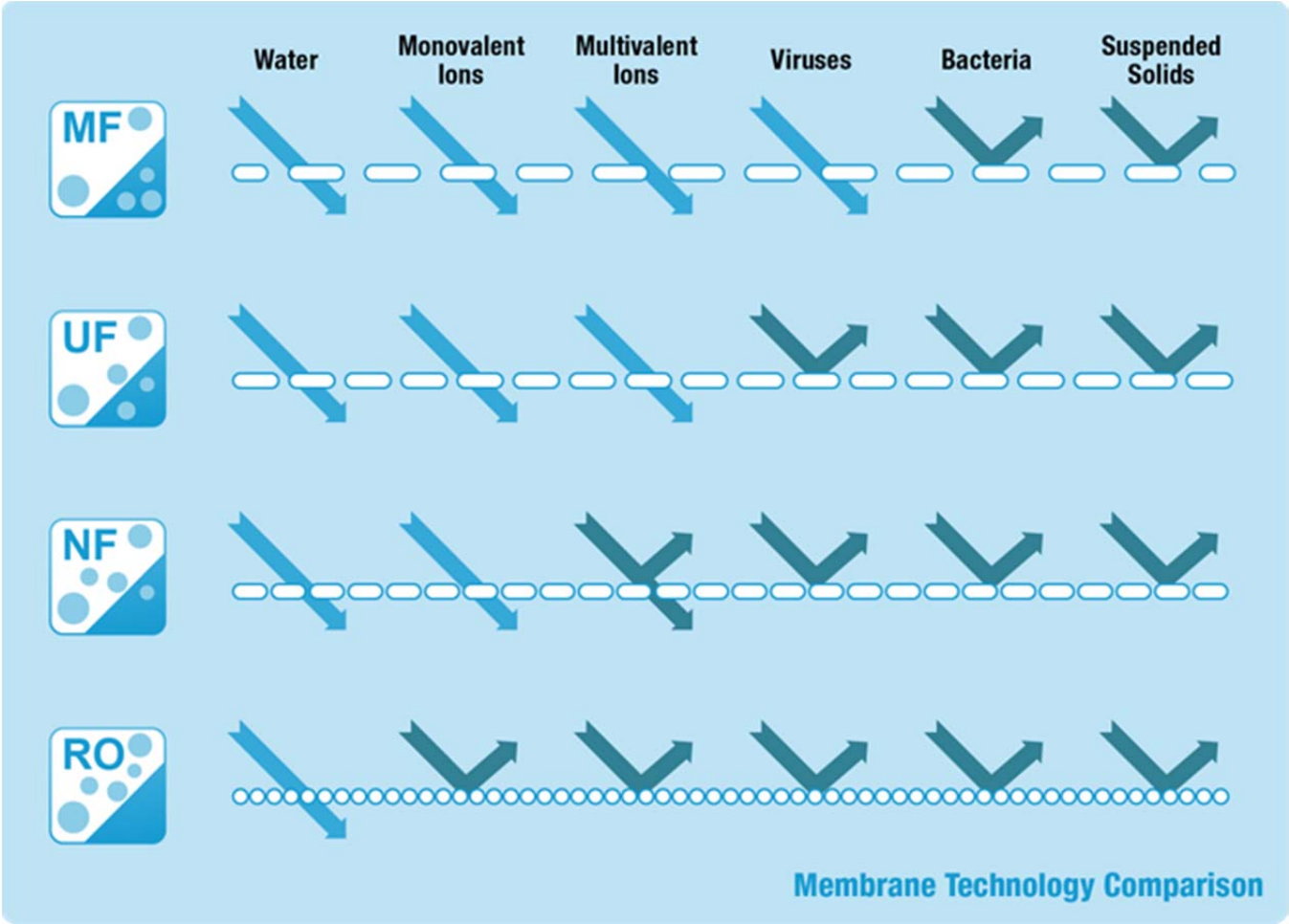


Figure 2 http://www.kochmembrane.com/Learning-Center/Technologies.aspx

Note: Hardness in water is defined as the presence of multivalent ions

Membrane material is usually manufactured from a synthetic polymer, although other forms, including ceramic and metallic membranes, may be available. Almost all membranes manufactured for drinking water are made of polymeric material, since they are significantly less expensive than membranes constructed of other materials. NF membranes are generally manufactured from polyamide materials as they can be used under a wide range of pH conditions and are not subject to biodegradation. These membranes do have a very limited tolerance for strong oxidants and should not be used with chlorinated feed water. The polyamide membranes require significantly less pressure to operate and have become the predominant material for NF applications.

Membrane filters are usually manufactured as flat sheet stock or as hollow fibers and then formed into one of several different types of membrane modules. Spiral-wound modules were developed to remove dissolved solids and are most often associated with NF processes. The basic unit is a sandwich of flat membrane sheets called a “leaf” wound around a central perforated tube. One leaf consists of two membrane sheets placed back to back and separated by a spacer called the permeate

carrier. Layers of the leaf are glued along three edges while the unglued edge is sealed around the perforated central tube.

Feed water enters the channel at the end of the spiral-wound element in a path parallel to the central tube. As feed water flows through the spacers, a portion permeates through either of the two surrounding membrane layers and into the permeate carrier, leaving behind any dissolved and particulate contaminates that are rejected by the membrane.

Filtered water in the permeate carrier travels spirally inward toward the center collector tube, while water in the feed spacer that does not permeate through the membrane continues to flow across the membrane surface, becoming increasingly concentrated with rejected contaminants. This "concentrate" stream exits the element parallel to the central tube through the opposite end from which the feed water entered (refer to Figures 1, 2 and 3). Because a portion of the water that enters the membrane will become reject there is some production loss experienced with the NF systems.

Pushing water through these small NF membrane pores usually require operating pressures ranging from 90 psi to 150 psi. Because NF membranes also remove alkalinity, the permeate water can be corrosive. Typically in NF softening processes a portion of the raw water is bypassed around the membranes and blended back into the permeate to reduce corrosivity of the finished water. Since the hardness is removed in the permeate, this blending also provides for some level of hardness in the finished water. AWWA recommends a finished water hardness of 80 mg/l but it is typical for systems with high hardness to create a blended finished water of 100 to 125 mg/l of hardness.

Given the small pore sizes, a prefilter is essential in a membrane system to prevent particles larger than the size of the narrow channels between the membranes, commonly 0.7 to 2 mm, from entering the modules. Still some accumulation of matter on the membrane surface takes place and eventually reduces the flux and the capacity of the membrane system. This phenomenon is referred to as fouling. Avoiding and controlling fouling is the most important challenge for successful membrane filtration. Chemical cleaning, typically utilizing citric acid, is the primary means of removing foulants in NF systems. The goal of chemical cleaning is to restore the trans-membrane pressure (TMP) of the system back to its original clean level. Any foulant that is removed by the chemical cleaning process is known as reversible fouling. Over time, membrane processes also experience some degree of irreversible fouling which cannot be removed through chemical cleaning. Irreversible fouling occurs in all membrane systems and eventually requires membrane replacement.

NF systems began to achieve widespread acceptance in the mid-1980s with the introduction of thin-film composite NF membranes capable of operating at significantly lower pressure and offering high resistance to biodegradation. In talking with NF system manufacturers we have not been able to document any municipal membrane softening facilities in the northeast. The majority of NF softening applications we have been made aware of are in the southeast and midwest where hardness is regionally prevalent. Below is a listing of existing known water treatment facilities that utilize NF membrane softening.

Plant	**Location**	**Capacity**	**Commissioned**
City of Boynton Beach WTP	Boynton Beach, FL	8.4 mgd	1994
Village of Willshire WTP	Willshire, OH	0.16 mgd	1998
City of Boca Raton WTP	Boca Raton, FL	40 mgd	2005
City of Waupun WTP	Waupun, WI	1.1 mgd	2007
Peele Dixie WTP	Fort Lauderdale, FL	12 mgd	2008
Village of Deshler WTP	Deshler, OH	0.450 mgd	2008
Town of Jupiter WTP	Jupiter, FL	14.5 mgd	2010
West Salem WTP	West Salem, OH	0.288 mgd	--

NF Treatment System Manufacturers

During the development of a recommended treatment approach, several NF treatment system manufacturers were contacted to understand their systems and estimated capital costs for their recommended NF system. These manufacturers included several national water treatment system manufacturers, including Westech, Wigen Technologies, Layne, and Tonka Water. In addition to the national manufacturers, there is a local membrane treatment system manufacturer, Industrial Services Inc. (ISI), located in St. George, VT. We have worked with ISI to identify a recommended nanofiltration system that can be manufactured at their St. George facility and locally installed by them at the new well site. Based upon information received from ISI and previously presented in our December 12, 2014 memo, the cost for ISI's NF system is the lowest cost alternative relative to the other national manufacturers.

ISI has been providing design-build services for water treatment and desalination equipment applications locally since 2002. In reviewing ISI's reference list for projects over the past 12 years it is evident that ISI has significant experience in the design and manufacturing of membrane treatment systems. The majority of ISI's work has been outside of the United State for RO desalination plants ranging in capacity from 60,000 gpd to 2.4 mgd. To date ISI does not have an NF installation. In addition they only have a handful of installations in the United States. In working with ISI to date, it is evident that their experience with RO systems provides them with the capability to manufacturer the required NF system.

Proposed NF System

We have worked with ISI to develop a proposed NF system with a capacity of 260 gpm to treat the raw water from the new Wells 4 and 5, which has a hardness of approximately 330 mg/l.

Initial Design Criteria

Parameter	Value	Unit
Inlet Water Hardness	330	mg/l as $CaCO_3$
Raw Water Flow	260	Gpm
Target Hardness	115	mg/ l as $CaCO_3$
Treated Hardness	5	mg/l as $CaCO_3$
RO Recovery	92.6%	
Turbidity	<1.0	mg/l
Original Design RO Feed Flow	176	gpm
RO Permeate Flow	163	gpm
RO Concentrate Flow to Waste	13.1	gpm
Percent Loss of Total Flow	5.0%	
Untreated Bypass Flow	84	gpm
Total Flow	247	gpm
Calculated Blended Total Hardness	115	mg/l as $CaCO_3$

Pretreatment

The water samples indicate that the turbidity of the water is low. This suggests that the pretreatment required for the system is minimal. As a result bag filtration at 100 µm followed by micron filtration at 5 micron is all that is required for prefiltration of the raw water.

NF Membrane Train

The NF system train will be supplied as a single train with spiral wound composite polyamide NF membranes.

Figure 4 RO system with micron filters (photo courtesy of ISI)

Clearwell and Distribution Pumping

The permeate from the NF system will be combined with a raw water bypass to create a blended water with a target hardness of 115 mg/l. This blended water will be discharged to a new below grade clearwell since the NF system needs to discharge to atmosphere and not into the pressurized distribution system. The blended water from the clearwell will be pumped into the water distribution system through two new distribution pumps. The water from the clearwell will be used for periodic cleaning of the membranes. Therefore chlorination will not occur in the clearwell and will be added on the discharge side of the distribution pumps, along with fluoride. Provisions for pH adjustment will be provided in the event the pH of the blended water drops below 6.5 SU.

Wastewater Pump Station

A new wastewater pump station will be installed at the site to pump the concentrate to the Town sewer system.

Membrane Cleaning

Periodic cleaning using an acid solution is required every 2 to 4 months. The NF system cleaning will require 4 to 6 hours of downtime while the system soaks in the citric acid solution. The blended water from the clearwell will be used as make-up water for the cleaning system.

Control System

A new control panel will be installed to tie the NF system into the Town's existing SCADA system. The NF system will operate when the reservoir reaches a low set point. When that occurs the wells will start pumping water to the NF system and blended water will be produced which will be pumped into distribution by the distribution pumps. The NF system along with the wells and distribution pumps will shut down when the tank is full and reaches a high set point.

WTF Building

The NF system will be housed in a new Water Treatment Facility (WTF) building.

ATTACHMENTS

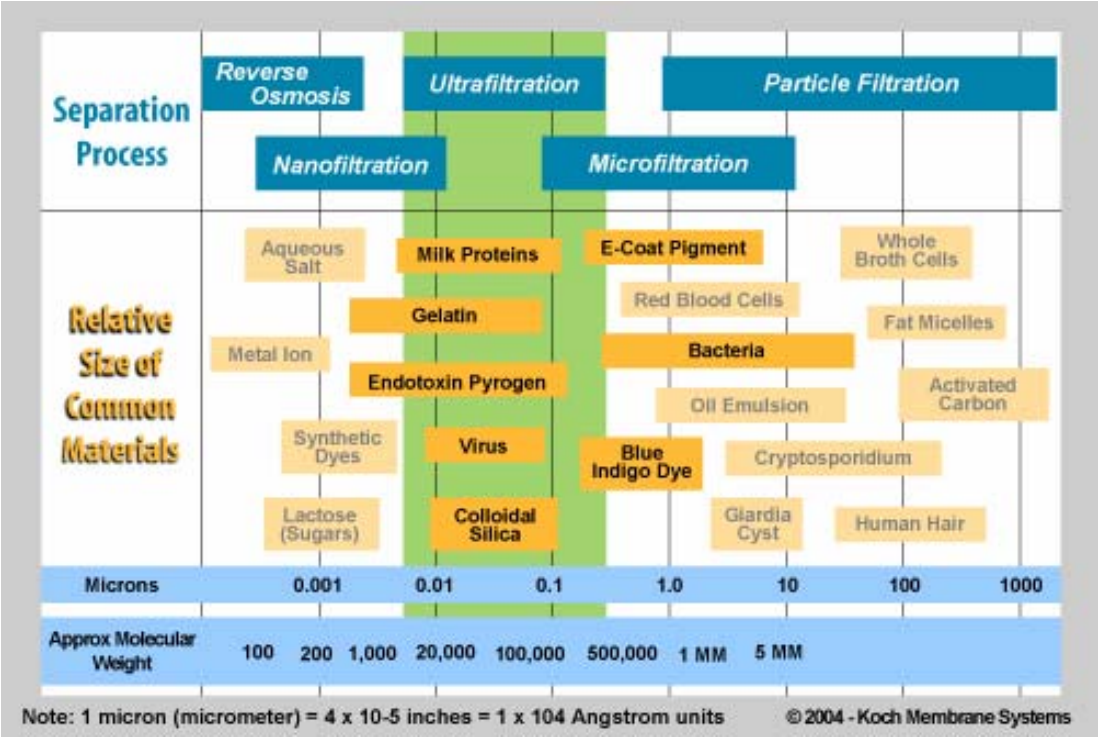
- Safe Drinking Water Foundation Brochure on Ultrafiltration, Nanofiltration and Reverse Osmosis
- Dow Filmtec Membrane Nanofiltration Element Product Information
- Hydraunautics Membrane Nanofiltration Element Product Information
- ISI Proposed Water Treatment Softening Process and Instrumentation Diagram

ULTRAFILTRATION, NANOFILTRATION AND REVERSE OSMOSIS

What is filtration?

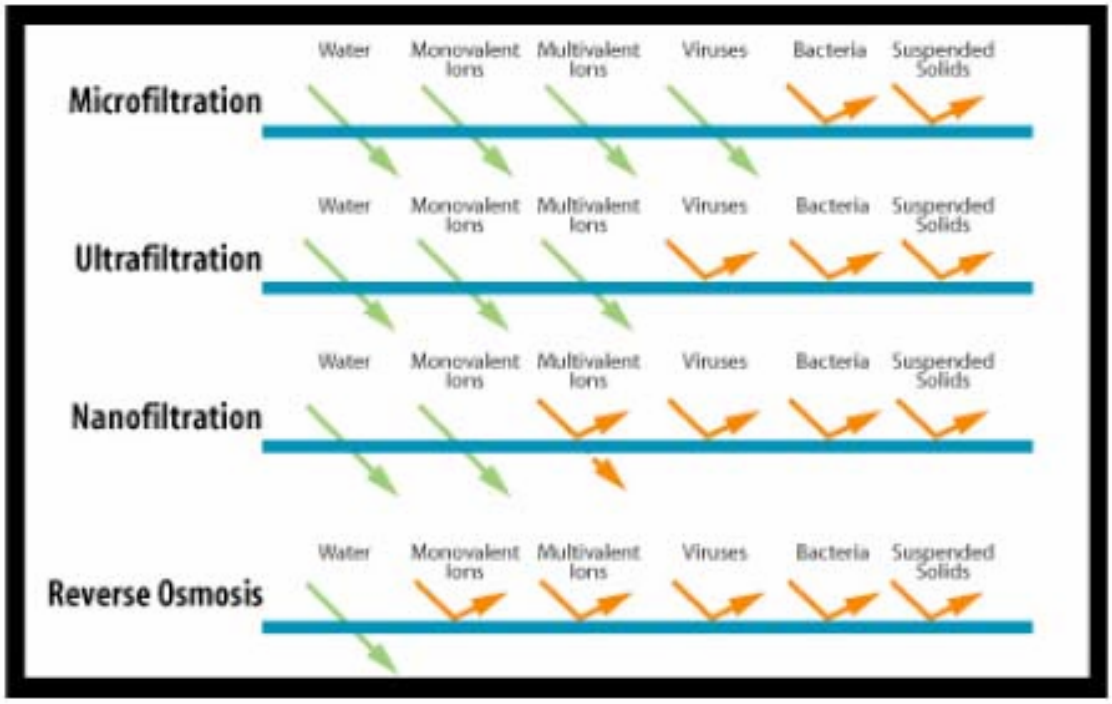
Filtration is a process of removing particulate matter from water by forcing the water through a porous media. This porous media can be natural, in the case of sand, gravel and clay, or it can be a membrane wall made of various materials. Sometimes, large particles are settled before filtration; this is called sedimentation. For information on sedimentation and filtration, in general, see the Conventional Water Treatment: Coagulation and Filtration fact sheet.

The size of materials that can be removed during filtration depends upon the size of the pores of the filter. The chart below summarizes the various separation processes relative to common materials that would be filtered out through each process. Particle filtration refers to conventional media filtration, while the other types are membrane filtrations.



Size of Materials That Are Removed By Various Separation Processes;
http://www.kochmembrane.com/sep_uf.html

The chart below summarizes the types of particles that are removed from the water with each type of membrane filter. The green arrow indicates that the particle is small enough to pass through the filter, whereas the deflected orange arrow indicates that the filter blocks the particle from passing through the filter.



Membrane Process Characteristics

Substances Removed From Water By Membrane Filtration Processes;
http://www.kochmembrane.com/sep_uf.html

What is ultrafiltration?

An ultrafiltration filter has a pore size around 0.01 micron. A microfiltration filter has a pore size around 0.1 micron, so when water undergoes microfiltration, many microorganisms are removed, but viruses remain in the water. Ultrafiltration would remove these larger particles, and may remove some viruses. Neither microfiltration nor ultrafiltration can remove dissolved substances unless they are first adsorbed (with activated carbon) or coagulated (with alum or iron salts).

What is nanofiltration?

A nanofiltration filter has a pore size around 0.001 micron. Nanofiltration removes most organic molecules, nearly all viruses, most of the natural organic matter and a range of salts. Nanofiltration removes divalent ions, which make water hard, so nanofiltration is often used to soften hard water.

What is reverse osmosis?

Reverse osmosis filters have a pore size around 0.0001 micron. After water passes through a reverse osmosis filter, it is essentially pure water. In addition to removing all organic molecules and viruses, reverse osmosis also removes most minerals that are present in the water. Reverse osmosis removes monovalent ions, which means that it desalinates the water. To understand how reverse osmosis works, it is helpful to understand osmosis.

Osmosis occurs when a semi-permeable membrane separates two salt solutions of different concentrations. The water will migrate from the weaker solution to the stronger solution, until the two solutions are of the same concentration, because the semi-permeable membrane allows the water to pass through, but not the salt. In the following diagram, (A) and (B) illustrate the process of osmosis.

In reverse osmosis, the two solutions are still separated by a semi-permeable membrane, but pressure is applied to reverse the natural flow of the water. This forces the water to move from the more concentrated solution to the weaker. Thus, the contaminants end up on one side of the semi-permeable membrane and the pure water is on the other side. In the diagram below, reverse osmosis is represented in (C).

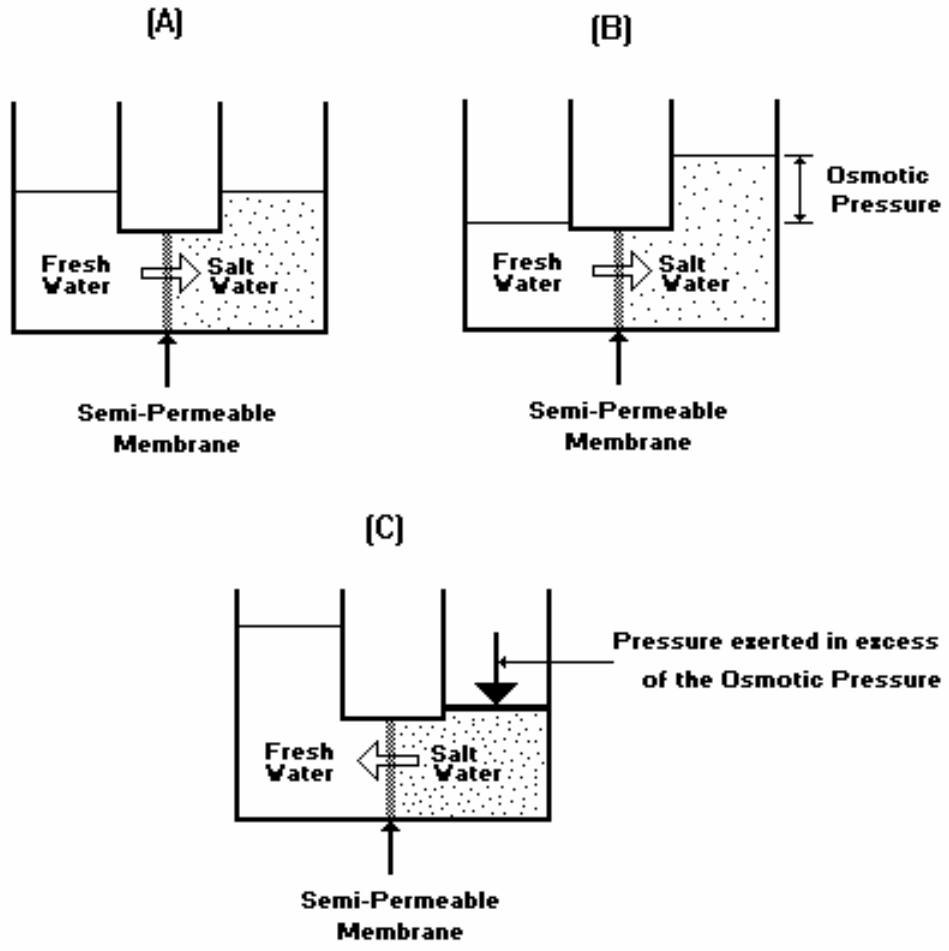


Figure 1 - Osmosis/Reverse Osmosis

Osmosis and Reverse Osmosis;
http://www.osmoflo.com.au/index.php/selectedContent/1706971244

What do these three processes remove?

Ultrafiltration removes bacteria, protozoa and some viruses from the water. Nanofiltration removes these microbes, as well as most natural organic matter and some natural minerals, especially divalent ions which cause hard water. Nanofiltration, however, does not remove dissolved compounds. Reverse osmosis removes turbidity, including microbes and virtually all dissolved substances. However, while reverse osmosis removes many harmful minerals, such as salt and lead, it also removes some healthy minerals, such as calcium and magnesium. This is why water that is treated by reverse osmosis benefits by going through a magnesium and calcium mineral bed. This adds calcium and magnesium to the water, while also increasing the pH and decreasing the corrosive potential of the water. Corrosive water may leach lead and copper from distribution systems and household water pipes.

What are the advantages of using ultrafiltration, nanofiltration or reverse osmosis to treat water?

All three of these membrane filtration processes are effective methods of treating water that cannot be treated using conventional treatment methods. Reverse osmosis, in particular, has been responsible for ending several nearly decade long Boil Water Advisories. For example, in 2003, a reverse osmosis system, together with a biological treatment process, was set up to successfully treat drinking water for the Yellow Quill First Nation, which had been on a Boil Water Advisory since 1995. The water in the First Nations community, which is located in Saskatchewan, contained high levels of organic matter, iron, manganese, ammonium and arsenic, to name a few. Besides the obvious benefit of providing safe drinking water to a community which had been under a Boil Water Advisory for approximately nine years, the reverse osmosis system (together with the biological treatment) allowed the community to treat their water using small quantities of chemicals. For more information about the water treatment facility at Yellow Quill First Nation, read the article by Dr. Hans Peterson, titled "The future of drinking water treatment," which was published in Municipal World in June 2004. You can also listen to a radio interview with Dr. Peterson from May 2007 or read Watered Down Excuse, According to one scientist, high cost is no excuse for lack of safe drinking water in First Nations communities, written by Kim Peterson and published in The Dominion.

A portable reverse osmosis unit was brought in to Kashechewan, a First Nations community in Ontario, in October of 2005. The community had experienced water contamination issues for years, and in October 2005, approximately 1,100 of the 1,900 residents were evacuated, after *E. coli* was found in their water. The reverse osmosis unit was brought in by the military, and could provide 50,000 litres of water each day for the residents of Kashechewan, until their water treatment plant could be fixed. The picture below compares the colour of the untreated water to that of the water after being treated with reverse osmosis.

Water Before and After Reverse Osmosis Treatment at the Kashechewan First Nation;
http://www.mdn.ca/site/Operations/canopy/index_e.asp

What are the disadvantages of using ultrafiltration, nanofiltration or reverse osmosis to treat water?

Compared with the benefits of using membrane filtration to treat water, there are very few disadvantages. If conventional water treatment processes can effectively treat the water, then constructing a reverse osmosis water treatment facility would be an unnecessary cost. But for the First Nations communities that have been on Boil Water Advisories for many years, a reverse osmosis treatment system can be a valuable investment that can provide safe drinking water for the residents.

Reverse osmosis removes a number of healthy minerals from water, in addition to the harmful minerals and particles. The removal of these minerals, including calcium and magnesium, can actually make water unhealthy, especially for people with inadequate diets and people who live in hot climates, as water can provide these necessary minerals. The addition of calcium and magnesium, as described above, can resolve these concerns.

The Safe Drinking Water Foundation has educational programs that can supplement the information found in this fact sheet. Operation Water Drop looks at the chemical contaminants that are found in water; it is designed for a science class. Operation Water Flow looks at how water is used, where it comes from and how much it costs; it has lessons that are designed for Social Studies, Math, Biology, Chemistry and Science classes. Operation Water Spirit presents a First Nations perspective of water and the surrounding issues; it is designed for Native Studies or Social Studies classes. Operation Water Health looks at common health issues surrounding drinking water in Canada and around the world and is designed for a Health, Science and Social Studies collaboration. Operation Water Pollution focuses on how water pollution occurs and how it is cleaned up and has been designed for a Science and Social Studies collaboration. To access more information on these and other educational activities, as well as additional fact sheets, visit the Safe Drinking Water Foundation website at www.safewater.org.

Resources:

Agriculture and Agri-Food Canada. 2003. Reverse osmosis: enjoy cleaner water. http://www.agr.gc.ca/pfra/flash/osmosis/en/revosmosistxt_e.htm.

Canada Mortgage and Housing Corporation. 2007. About Your House: Reverse Osmosis Water Treatment. http://www.cmhc-schl.gc.ca/en/co/maho/wawa/wawa_001.cfm.

Canadian Broadcasting Corporation. October 2005. Water purification unit heads to Kashechewan. http://www.cbc.ca/canada/story/2005/10/29/kashechewan051029.html.

Cooperative Research Centre for Water Quality and Treatment. December 2006. Consumer's Guide to Drinking Water. http://www.waterquality.crc.org.au/consumers/Consumersp9.htm.

United States Environmental Protection Agency. October 1999. EPA Drinking Water and Health: What You Need to Know! http://www.epa.gov/safewater/dwh/dw-health.pdf.

United States Environmental Protection Agency. 2007. Water & Health Series: Filtration Facts. http://www.epa.gov/safewater/faq/pdfs/fs_healthseries_filtration.pdf.

World Health Organization. 2004. Water Treatment and Pathogen Control: Process Efficiency in Achieving Safe Drinking Water. http://www.who.int/water_sanitation_health/dwq/en/watreatpath.pdf.

FILMTEC™ Membranes

FILMTEC NF90-400/34i Nanofiltration Element

Features

The DOW FILMTEC™ NF90-400/34i nanofiltration element is a high area and high productivity element offering an industry wide unique combination of features:

- High removal rate of salts, including nitrates and iron,
- High removal rate of organic compounds such as pesticides, herbicides, and THM precursors.
- A 34 mil feed spacer to lessen the impact of fouling on pressure drop across a vessel and to enhance cleaning effectiveness.

The DOW FILMTEC™ NF90-400/34i is listed to ANSI/NSF61.
For more information visit: http://www.nsf.org/Certified/PwsComponents

In addition, the DOW FILMTEC™ NF90-400/34i includes the typical DOW FILMTEC product features:

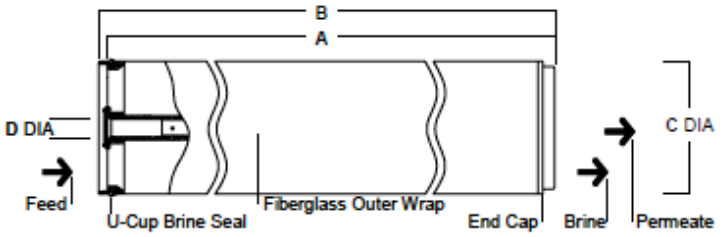
- iLEC™ interlocking end caps reduce system operating costs and the risk of o-ring leaks.
- The oxidative free membrane manufacturing process results in high membrane robustness and long term stable performance.
- The widest pH range for cleanings (pH1 to pH13) allows effective cleanings even in cases of severe fouling.
- The automated, precision fabrication gives a greater number of shorter membrane leaves thus reducing fouling while maximizing element efficiency.

Product Specifications

Product	Part number	Nominal Active Surface Area ft² (m²)	Product Water Flow Rate gpd (m³/d)	Stabilized salt rejection (%)
NF90-400/34i	11023067	400 (37)		
NaCl			7,500 (28.4)	85 – 95
$MgSO_4$			10,000 (37.9)	>97

1. Permeate flow and salt passage based on the following test conditions:
   2,000 mg/l NaCl, 70 psi (0.48 MPa), 77°F (25°C) and 15% recovery.
   2,000 mg/l MgSO4, 70 psi (0.48 MPa), 77°F (25°C) and 15% recovery.
2. Flow rates for individual elements may vary +/-15%.
3. The above specifications are benchmark values. Please be sure to operate according to our system design guidelines.

Figure 1



Product	Single-Element Recovery	Dimensions – inches (mm) A	B	C	D
NF90-400/34i	**15%**	**40 (1,016)**	**40.5 (1,029)**	**7.9 (201)**	**1.125 ID (29)**

1. Refer to FilmTec Design Guidelines for multiple-element applications and recommended element recovery rates for various feed sources. 1 inch = 25.4 mm
2. Element to fit nominal 8.00-inch (203 mm) I.D. pressure vessel.

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Operating Limits

Membrane Type	Polyamide Thin-Film Composite
Maximum Operating Temperature[a]	113°F (45°C)
Maximum Operating Pressure	600 psig (41 bar)
pH Range, Continuous Operation[a]	3 - 10
pH Range, Short-Term Cleaning (30 min.)[b]	1 - 13
Maximum Feed Flow	SDI 5
Free Chlorine Tolerance[c]	<0.1 ppm

a. Maximum temperature for continuous operation above pH 10 is 95°F (35°C).
b. Refer to Cleaning Guidelines in specification sheet 609-23010.
c. Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty. FilmTec recommends removing residual free chlorine by pretreatment prior to membrane exposure. Please refer to technical bulletin 609-22010 for more information.

Important Information

Proper start-up of reverse osmosis water treatment systems is essential to prepare the membranes for operating service and to prevent membrane damage due to overfeeding or hydraulic shock. Following the proper start-up sequence also helps ensure that system operating parameters conform to design specifications so that system water quality and productivity goals can be achieved.

Before initiating system start-up procedures, membrane pretreatment, loading of the membrane elements, instrument calibration and other system checks should be completed.

Please refer to the application information literature entitled “Start-Up Sequence” (Form No. 609-02077) for more information.

Operation Guidelines

Avoid any abrupt pressure or cross-flow variations on the spiral elements during start-up, shutdown, cleaning or other sequences to prevent possible membrane damage. During start-up, a gradual change from a standstill to operating state is recommended as follows:

- Feed pressure should be increased gradually over a 30-60 second time frame.
- Cross-flow velocity at set operating point should be achieved gradually over 15-20 seconds.
- Permeate obtained from first hour of operation should be discarded.

General Information

- Keep elements moist at all times after initial wetting.
- If operating limits and guidelines given in this bulletin are not strictly followed, the limited warranty will be null and void.
- To prevent biological growth during prolonged system shutdowns, it is recommended that membrane elements be immersed in a preservative solution.
- The customer is fully responsible for the effects of incompatible chemicals and lubricants on elements.
- Maximum pressure drop across an entire pressure vessel (housing) is 50 psi (3.4 bar).
- Avoid permeate-side backpressure at all times.

Regualtory Note

These membranes may be subject to drinking water application restrictions in some countries: please check the application status before use and sale.

DOW FILMTEC™ Membranes
For more information about DOW FILMTEC membranes, call the Dow Water & Process Solutions business:

North America:	1-800-447-4369
Latin America:	(+55) 11-5188-9222
Europe:	800 3 694 6367
Italy:	800 783 825
South Africa:	0800 99 5078
Pacific:	+800 7776 7776
China:	+800 889 0789

www.dowwaterandprocess.com

Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system.

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Form No. 609-50106-0413

Membrane Element

ESNA1-LF-LD-4040
(Low Fouling Technology)

Performance:

Permeate Flow:	1,600 gpd (6.1 m^3/d)
$CaCl_2$ Rejection:	89%
$CaCl_2$ Rejection (minimum/maximum)	86% / 95%

* Expected calcium rejection for a typical 500 ppm well water is 96% at 13 gfd operating flux and 25 C.

Type

Configuration:	Low Fouling Spiral Wound
Membrane Polymer:	Composite Polyamide
Membrane Active Area:	80 ft^2 (7.43 m^2)
Feed Spacer:	34 mil (0.864 mm) with biostatic agent

Application Data*

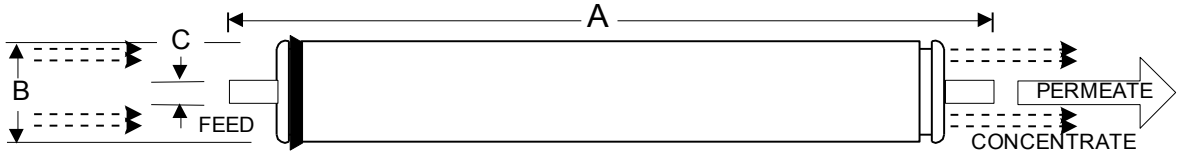
Maximum Applied Pressure:	600 psig (4.14 MPa)
Maximum Chlorine Concentration:	< 0.1 PPM
Maximum Operating Temperature:	113 °F (45 °C)
pH Range, Continuous (Cleaning):	2-10 (2-12)*
Maximum Feedwater Turbidity:	1.0 NTU
Maximum Feedwater SDI (15 mins):	5.0
Maximum Feed Flow:	16 GPM (3.6 m^3/h)
Minimum Ratio 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. For specific projects, operating at more conservative values may ensure the best performance and longest life of the membrane. See Hydranautics Technical Bulletins for more detail on operation limits, cleaning pH, and cleaning temperatures.

Test Conditions

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

500 ppm $CaCl_2$
75 psi (0.52 MPa) Applied Pressure
77 °F (25 °C) Operating Temperature
15% Permeate Recovery
6.5 – 7.0 Feed pH



A, inches (mm)	B, inches (mm)	C, inches (mm)	Weight, lbs. (kg)
40.00 (1016)	3.95 (100.3)	0.75 (19.1)	8 (3.6)

Core tube extension = 1.05" (26.7 mm)

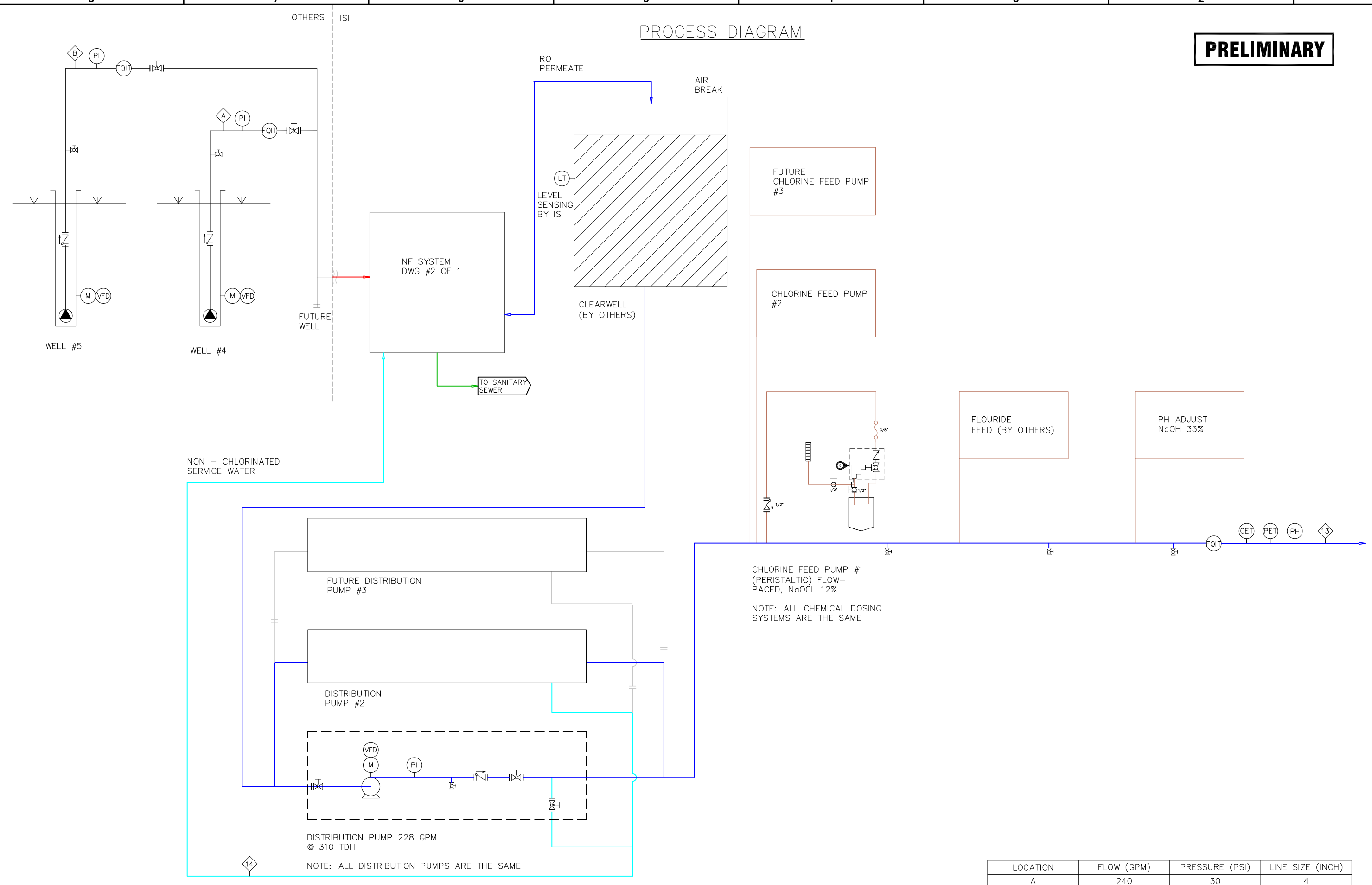
Notice: Permeate flow for individual elements may vary -20 or +25 percent. All membrane elements are supplied with a brine seal, interconnector, and o-rings. Elements are enclosed in a sealed polyethylene bag containing less than 1.0% sodium meta-bisulfite solution, and then packaged in a cardboard box.

Hydranautics believes the information and data contained herein to be accurate and useful. The information and data are offered in good faith, but without guarantee, as conditions and methods of use of our products are beyond our control. Hydranautics assumes no liability for results obtained or damages incurred through the application of the 9presented information and data. It is the user's responsibility to determine the appropriateness of Hydranautics' products for the user's specific end uses. 12/17/2014

Hydranautics Corporate: 401 Jones Road, Oceanside, CA 92058
1-800-CPA-PURE Phone: 760-901-2500 Fax: 760-901-2578 info@Hydranautics.com

PROCESS DIAGRAM

PRELIMINARY



LOCATION	FLOW (GPM)	PRESSURE (PSI)	LINE SIZE (INCH)
A	240	30	4
B	90	30	4

* IN FUTURE PUMPS WILL BE SIZED FOR A TOTAL CAPICITY OF 514 GPM @ 310 TDH

Chk	Drw	Auth	Revision-Record	Sym	Date

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INDUSTRIAL SERVICES, INC.

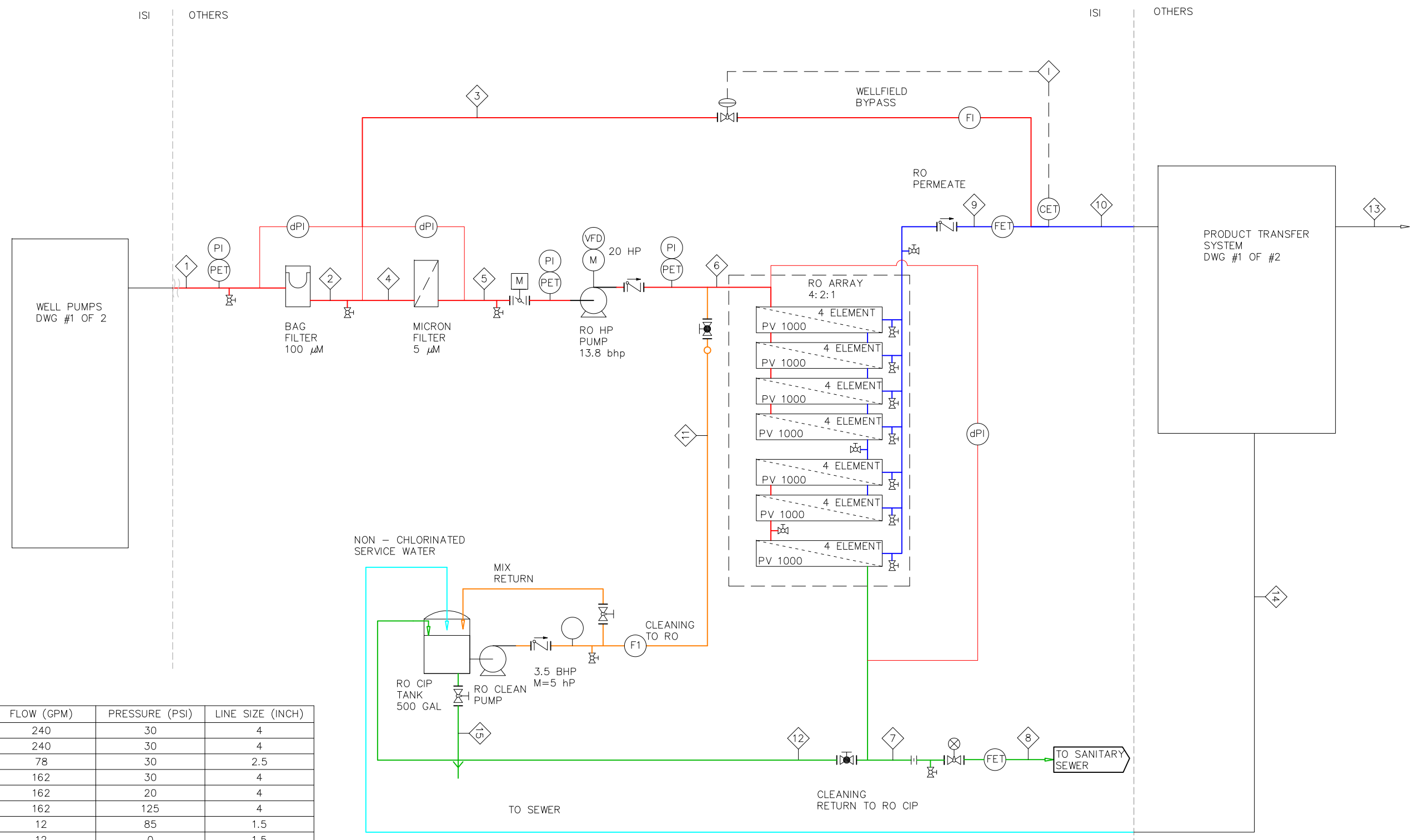
HINESBURG WATER TREATMENT SOFTENING
328 KGPD BLENDED CAPACITY
PROCESS AND INSTRUMENTATION DIAGRAM

Drawn By: J. BRINE
Checked: S. SHUMWAY
Approved: S. SHUMWAY
Sheet No.: 1 Of: 2
Weight: N/A
Date: 20JAN2015
Rev: 1
Drawing No.: 1501-01P

SCALE: 1'-0" = 1'-0"

PROCESS DIAGRAM

PRELIMINARY



LOCATION	FLOW (GPM)	PRESSURE (PSI)	LINE SIZE (INCH)
1	240	30	4
2	240	30	4
3	78	30	2.5
4	162	30	4
5	162	20	4
6	162	125	4
7	12	85	1.5
8	12	0	1.5
9	150	5	4
10	228	0	4
11*	120	30	3
12*	120	5	3
13	228	ADVISE	ADVISE
14*	50	5	2
15*	50	0	2
*	INTERMITTENT		

NOTE: GRAY-BACK ITEMS CAN BE ADDED TO ISI SCOPE. HOWEVER ADDITIONAL INFORMATION REQUIRED.

Date	Sym	Revision-Record	Auth	Drw	Chk

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