Dare County Regional Water System

North Reverse Osmosis Water Treatment Plant

Arsenic Reduction Project

Preliminary Design Report

March 30, 2004

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DARE COUNTY WATER SYSTEM IMPROVEMENTS

Preliminary Design Report

North Reverse Osmosis Water Treatment Plant

Arsenic Reduction Project

Prepared for

Dare County Water System,
Manteo, North Carolina

Prepared by

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March 30, 2004

CERTIFICATION

I hereby certify that this North Reverse Osmosis Plant Capacity Expansion, Preliminary Design Report for a Dare County Water System was prepared by me or under my direct supervision.

This report was prepared for the Water Department of Dare County, North Carolina.

Signed, sealed and dated this 30th day of MARCH, 2004

NORTH CAROLINA
PROFESSIONAL
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IAN C. WATSON, P.E.

Reg. No. 12532
Expires 12/31/2004

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1.0 INTRODUCTION

1.1 Project Background

The North RO plant (NRO) operated by the Dare County Regional Water System at Kill Devil Hills, North Carolina, is the only water treatment plant in the County system that has an elevated level of arsenic in the raw water source. At the time the plant entered service in August 1989, the Maximum Contaminant Level (MCL) for arsenic in the Federal and State drinking water standards was 50 micrograms/liter (μg/l). The product water produced from the NRO plant was well in compliance with this MCL, with an average value from compliance testing of 15.5 μg/l between 1989 and 2001. During this period of time the average arsenic concentration in the NRO plant feedwater was approximately 60 μg/l. Speciation of the arsenic revealed that two forms are present, As(III) and As(V). Arsenic (V) is very well rejected by the NRO plant's membranes, but As(III) is not. Virtually 100% of the arsenic in the permeate was found to be As(III).

In 2002, the MCL for arsenic in drinking water was lowered from 50 μg/l to 10 μg/l. Public notification of non-compliance was mandated for January of 2003, and full compliance with the MCL is currently scheduled for January 22nd, 2006.

In July of 2002, RosTek Associates, Inc. delivered to the County an initial report on arsenic reduction strategies.[1] This report reviewed the history of arsenic in NRO plant waters; reviewed emerging technologies for arsenic reduction; examined the potential for alternate water sources; provided conceptual costs; and recommended the next step of pilot testing those technologies that best fit the situation at the NRO.

As the result of action by the Board of County Commissioners, a pilot test program was authorized for the NRO as Task 2, based on the recommendations in the RosTek Task 1 report. Five processes were tested, beginning in March of 2003, and continuing into May of 2003. The five processes tested were:

1. USFilter GFH™ adsorption process. RO permeate.
2. Severn Trent Water Sorb-33™ adsorption process. RO permeate.
3. Water Remediation Technologies Z-33™ adsorption process. RO permeate.
4. Manganese greensand. RO feedwater.
5. Nanofiltration (2nd Pass). RO permeate.

[1] "Arsenic Reduction Project, North Reverse Osmosis Plant. Task 1 ~ Overview Study." Rostek Associates, Inc. July 2002

A report[2] on the results of the pilot test program was submitted to the County Water Department in November, 2003. A presentation to the County Commissioners was made in December, 2003. RosTek Associates, Inc. was authorized to proceed with the design of a new addition to the NRO treatment plant, using an adsorption process, in January of 2004.

The adsorption process efficiency will be enhanced by utilizing Mn greensand adsorption to reduce the arsenic concentration in the brackish water used for blending. With this conservative approach, the finished water arsenic concentration will always be less than 5μg/l, 50% of the 2006 MCL.

1.2 Report Purpose and Scope

This report will establish design criteria for the following:

1. Addition to the existing RO process building to house the arsenic treatment equipment
2. Modifications necessary to the underground piping
3. Disposal of the new treatment process residuals
4. Expansion the existing electrical system to accommodate the new processes
5. Modifications to the existing RO plant to relocate the blend water piping and controls, and the post-treatment chemical feeds and controls
6. Modifications to the existing control system to incorporate the controls for the new treatment processes

The level of design included in this document is assumed to be about 30-35%. New treatment process design and equipment sizing has been done and outline equipment and materials specifications prepared. The civil/structural work necessary for configuration of the building addition has been done, together with foundation requirements, site grading and drainage revisions, and preliminary electrical design.

Included in this report are the following:

1. Process flow diagram
2. Preliminary P&IDs
3. Preliminary equipment layouts
4. Preliminary building details
5. Equipment and pipe sizing
6. Preliminary equipment selection
7. Electrical system discussion and single line diagram
8. List of specifications and drawings
9. Opinion of probable cost

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[2] "Arsenic Reduction Project, North Reverse Osmosis Plant. Task 2 ~ Pilot Plant Test Report." Rostek Associates, Inc. November 2003

2.0 PROJECT DESCRIPTION

2.1 Overall Process

Dare County has experienced a significant quality issue at NRO, namely the ability to reach compliance with the current arsenic Maximum Contaminant Level (MCL) of 10 µg/l, to take effect in January of 2006. Completion of Tasks 1 and 2 of the Arsenic Reduction Project has resulted in the decision to use one of three proprietary adsorption technologies successfully tested by the County in Task 2. The process decision is two-fold. By taking As(III) out of the RO permeate, but not reducing the total arsenic in the raw wellwater that bypasses the RO, the finished water arsenic concentration has been estimated to be 6-8µg/l, depending on the wells in operation. If Mn greensand is used to reduce the raw wellwater arsenic to 10µg/l, the finished water will have an estimated arsenic concentration of <5 µg/l, allowing a margin of error for analytical inaccuracies, and the potential for bypassing some permeate. Therefore Mn greensand is included as a unit process in the new building.

For both treatment schemes, the process mechanism is similar, namely adsorption of the arsenic on to an iron oxide or hydroxide surface. In the case of the Mn greensand system, iron in the raw water is oxidized to the ferric state, and contributes to the arsenic adsorption. The addition of sodium hypochlorite converts As(III) to As(V), thus improving the efficiency of the adsorption by ferric hydroxide.

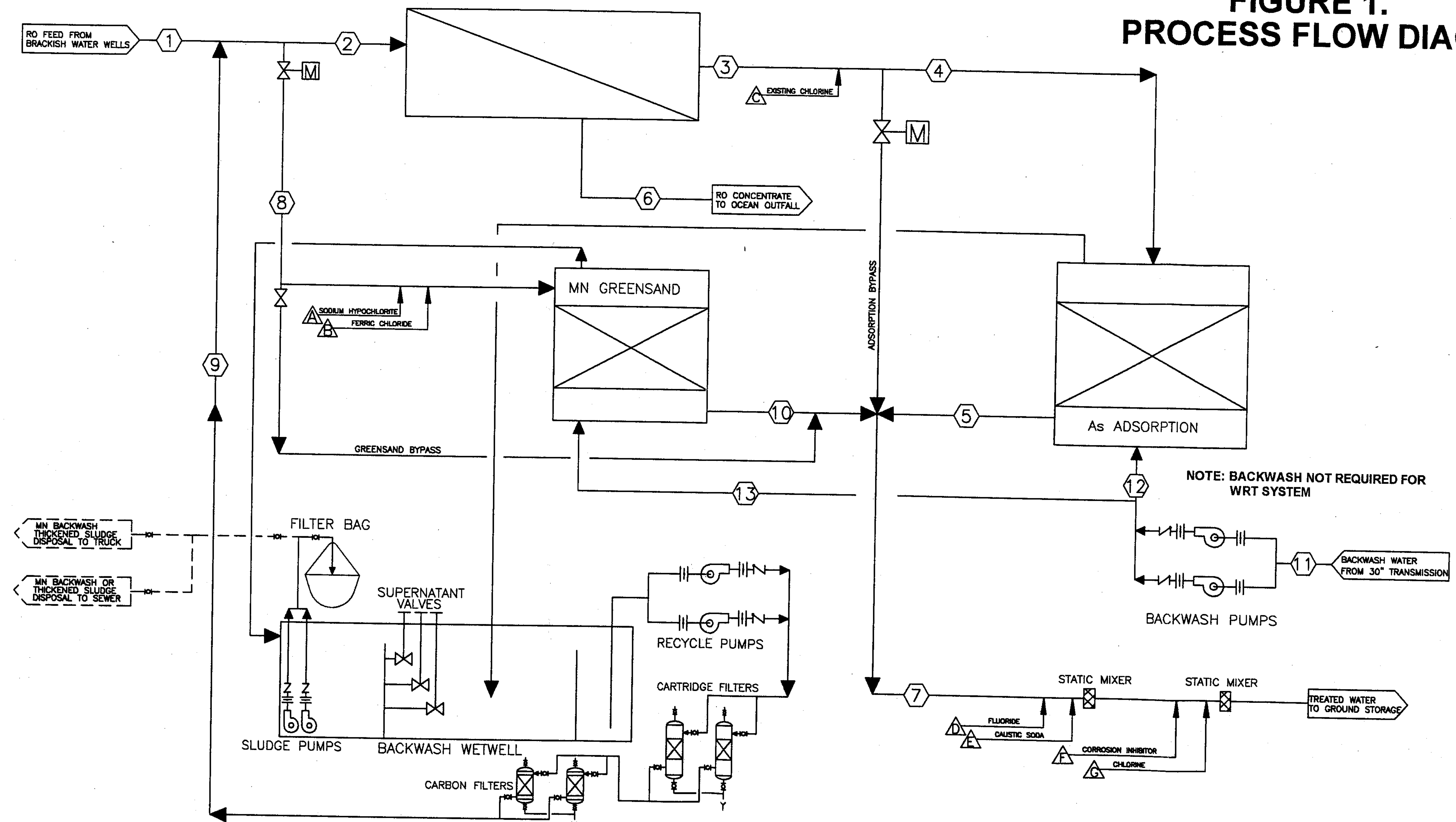
The overall process flow scheme proposed can be seen in Figure 1.

Permeate will enter the new building through new 20" diameter piping, below grade. Once inside the building, the piping arrangement will permit the permeate flow to be split into two streams, feed to the arsenic adsorption columns, and a full capacity bypass.

The bypass is provided to permit the operators maximum flexibility in maintaining the target finished water arsenic concentration, particularly in future operations when it is expected that the ambient arsenic concentration in the feedwater to the RO plant will decline. When and if this occurs, and hydrogeologic data from current test wells indicates that it will, the NRO plant permeate arsenic concentration could be reduced to below 10 µg/l. Under this condition, some of the permeate could be bypassed around the arsenic adsorption columns. This would result in extended media life, and a reduction in the cost of treatment.

The bypass will be isolated by an electrically driven butterfly valve, and will be equipped with an insert magnetic flow meter. The quantity of water that is bypassed can be selected by the operator so that the finished water, consisting of treated and untreated permeate, and treated raw water, has an arsenic concentration less than the target concentration, which is considered to be 5 µg/l.

FIGURE 1.
PROCESS FLOW DIAGRAM



ATTRIBUTE	1	2	3	4	5	6	7	8	9	10	11	12	13	A	B	C	D	E	F	G
STREAM	RAW WELL WATER	RO FEED	PERMEATE	PERMEATE	TREATED PERMEATE	RO CONC.	FINISHED	RAW BLEND	BACKWASH RECYCLE	TREATED BLEND	BACKWASH	BW TO ADSORBERS	BW TO GREENSAND	Sodium Hypochlorite	Ferric Chloride	Chlorine	Fluoride	Caustic Soda	Corrosion Inhibitor	Chlorine
STATUS	EXISTING	EXISTING	EXISTING	NEW	NEW	EXISTING	NEW	NEW	NEW	NEW	NEW	NEW	NEW	NEW	NEW	Existing	Relocated	Relocated	Relocated	NEW
PRESSURE,psi	60	60	20	20	15	15	15	60	65	15	20	20	20	60	60	20	15	15	15	15
FLOW, gpm	4278	4118	3212	3212	3212	906	3472	260	100	260	1420	1420	1050	1.5mg/l	3.9mg/l	1.0mg/l	existing dose	existing dose	existing dose	2.0mg/l
PIPE SIZE, ins	20	20	20	20	20	10	20	8	4	8	12	12	10	1/2	1/2	1/2	1/2	1/2	1/2	1/2
PIPE MAT'L	FRP	FRP	FRP	304SS	304SS	PVC	304SS	PVC	PVC	PVC	DI	DI	DI	PVC	PVC	PVC	PVC	PVC	PVC	PVC
PIPE CLASS	125#	125#	125#	S10	S10	S80	S10	S80	S80	S80	53	53	53	S80	S80	S80	S80	S80	S80	S80

Permeate that is not bypassed will enter the first stage of the two-stage adsorption columns. In initial operation this is expected to be 100% of the RO permeate. Several vessels will be arranged in parallel, the number depending upon the technology to be installed. A second stage treatment will take the effluent from the first stage vessels, providing a level of polishing. The fully treated water will exit the adsorption system, where it will be mixed with treated raw water that has bypassed the RO.

The bypassed raw water will be treated in a two-vessel Mn greensand system, to remove iron and arsenic from the brackish water. The vessels are arranged in parallel, with each sized to treat approximately 60% of the full flow expected at the planned plant buildout capacity of 8.0 mgd. Sodium hypochlorite and ferric chloride will be used to oxidize the As(III) to As(V), and form ferric hydroxide respectively. The ferric hydroxide, including a contribution from the iron present in the brackish water, will adsorb the As(V). Periodic backwashing will remove the sludge from the beds.

The treated water from the Mn greensand filters and from the adsorption columns will be blended, and post treated with chlorine, corrosion inhibitor, and fluoride. pH adjustment with caustic soda will also take place at this location, and the finished water will be sent to the existing storage tanks. The post-treatment system is existing, but the application points will be relocated from the existing RO process room to the new application point in the new building.

2.2 Civil Works

The new water treatment process equipment will be housed in a new addition to the existing process building. In addition to this structure, a wetwell will be constructed to accept the backwash water from the Mn greensand filter system discussed in 2.1 above. This wetwell will also be designed to accommodate the infrequent backwashing required to "fluff" the media in the adsorption columns of two of the three competing vendors. The third process, that of Water Remediation Technologies, operates in the upflow mode, thus requiring no backwashing at all. Since the water to be treated is RO permeate, there will be no accumulation of suspended solids on the adsorption media, thus there will be no solids in the backwash. Because of this, the wetwell will be designed with two chambers, one to receive the Mn greensand backwash and rinse, and the second to receive the infrequent "fluffing" backwash.

The new building addition will be constructed to match the existing RO process room. The finished floor elevation will match the current finished floor elevation. The existing west wall will remain, and the existing outside door will provide access to the new addition.

The space in which the addition will be constructed is presently unoccupied by any permanent structures. There is a small wooden shed that will be relocated, and some existing drainage features will need to be slightly modified. There is no vegetation on the site, and the geotechnical investigation shows consistency of material with good bearing load potential throughout the site. A more detailed discussion of the civil/structural design requirements can be found in Section 6.0.

2.3 Electrical

It is proposed that a small electrical room be included with the building addition. A feeder will bring power from the existing NRO electrical room to a new 480V distribution panel. The proposed electrical system is further described in Section 7.0

2.4 Instrumentation and Control

The new process addition will require limited expansion of the NRO control systems. It is proposed that the arsenic adsorption backwash sequence for the two systems that will be backwashed be entirely manual, due to infrequent backwashing requirements. The vessels will be equipped with a loss of head package that will include a differential pressure switch. These switches will be connected to the control room to alert the operators that backwashing is required. At this time it does not appear as though other controls or instruments will be associated with the adsorption system.

The manganese greensand system will be provided with a packaged control system that will enable automatic sequencing of the backwash cycle upon operator initiation. It is proposed that this be linked with the central control room only to provide status information.

There will be other miscellaneous instrumentation and control devices associated with the process addition, such as wetwell level instruments, the controls for the blend control valve, and the relocated finished water instruments. It is proposed that a small PLC be located in the electrical room to gather the various signals, and transfer them to the existing PLC in the control room by a data highway. Section 8.0 more fully describes the instrumentation and control requirements.

3.0 PROCESS DESIGN

3.1 Arsenic Adsorption Systems

Permeate from the existing RO system will enter the new building addition through a 20"diameter pipe. This pipe is sized for the future buildout capacity of the RO plant at 8.0 MGD. The pipe will be fabricated from either PVC, HDPE, or FRP, because of the extremely corrosive nature of un-buffered RO permeate. The pipe used will require the appropriate NSF certification for use in a potable water system.

Once the water is inside the new process room, it will split into two streams, one feeding the adsorption units, the other being a bypass. The bypass is provided for two reasons: 1) the bypass will allow permeate to be sent directly to storage in the event of a malfunction of the adsorption system, and 2) at times when the permeate arsenic concentration is low, some water may be bypassed at the discretion of the owner. This option can be used when the new, low arsenic wells are being used, particularly in the winter at times of low flow, and will reduce the load on the adsorption columns, extending the life of the media.

Water that enters the adsorption columns will contain residual chlorine. While it is proposed that new post-treatment chemical injection points be provided for the treated and blended water, the existing chlorination point will be retained at its current location in the RO process room. A small dose of chlorine will be added to the permeate, which will convert As(III) to As(V) prior to adsorption. According to the manufacturers, this will serve to enhance the adsorption process, since there is some evidence to suggest that As(V) is more efficiently adsorbed than As(III). The small residual remaining after the oxidation step will also keep the intermediate piping disinfected.

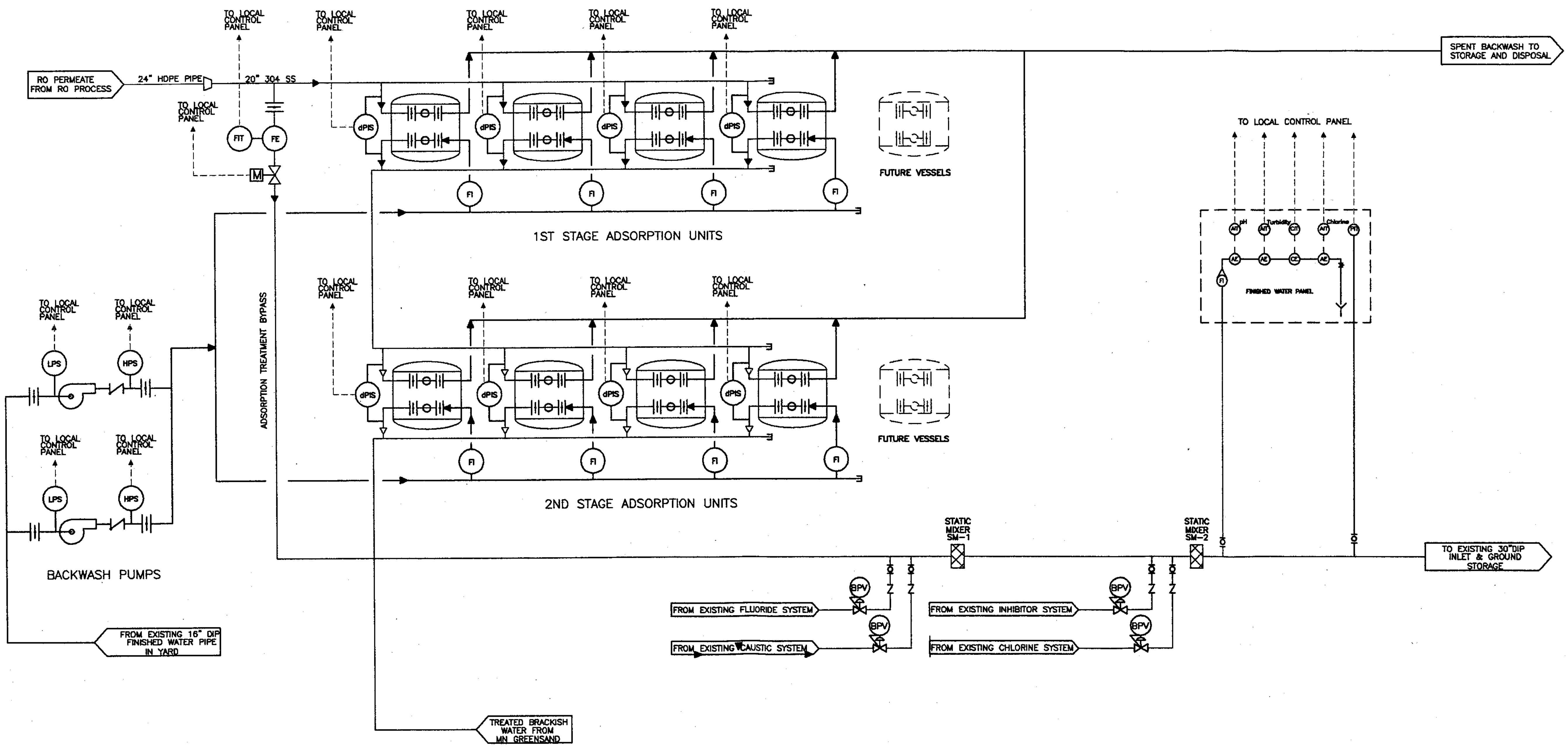
3.1.1 USFilter GFH™

The USFilter system consists of two stages of parallel vertical vessels, twelve feet in diameter, operating in the downflow mode. For the initial installation to handle 5.0 MGD, there will be four vessels in parallel in each stage, for a total of eight vessels. The loading rate will be 7.7 gpm/sq.ft. The face piping includes valving for isolation, service and backwashing, and for media fill and removal. An automatic air relief valve and associated piping, sample valves for inlet and outlet sampling, and a vessel drain will also be provided. A preliminary P&ID is shown in Figure 2.

The vessels will have a straight shell height of six feet, with dished heads top and bottom. Overall height of the vessels, including supports and air relief valves, will be about fourteen feet. Each vessel will contain twelve inches of graded gravel (113 cu. ft./vessel), and forty inches (377 cu. ft/vessel) of GFH™ media.

Because of the aggressive nature of RO permeate, the vessels will have to be lined with an NSF-approved corrosion resistant lining. Alternatively, the vessels and face piping can be fabricated from 304L stainless steel. If the latter option is chosen, there

FIGURE 2.
US FILTER P&ID



will be no interior lining and no exterior coating, thus eliminating lining maintenance and recoating of the exterior for the life of the vessels. It is proposed that the USFilter be requested to bid the system both as conventional carbon steel vessels, and as 304L stainless steel, so that the prices can be compared. It is also proposed that in either case, the face piping, which is ten and twelve inch diameter, be specified only as 304L stainless steel, or depending on size, schedule 80 PVC.

USFilter recommends that the media beds be "fluffed" periodically to expand the media, which can become compacted during operation, increasing the pressure drop across the bed. Since the feed water to the system is permeate, there will be no suspended solids in the water, so the backwash water will also be free from suspended solids, except possibly a limited amount of fines that are removed from the GFH™ beds.

Based on the results of the pilot testing conducted at the NRO in 2003, USFilter is predicting that backwashing will be required approximately once per month, based on full loading of the vessels. It has been calculated that the backwash volume generated per bed will be about 20,500 gallons. Therefore a total volume of backwash of about 164,000 gallons will be generated monthly. It is proposed that the backwash water be taken from the existing storage tank effluent line through a twelve inch diameter pipe, and that two vertical backwash pumps of approximately 1450 gpm capacity be provided to generate the relatively low head of 20 psig that USFilter indicates should be provided for backwashing, or "fluffing" the beds. Since each bed will be provided with a backflow rate of flow valve, and rate of flow indicator, the pumps will be constant speed. And will also provide the backwash water for the Mn greensand filters. Handling and disposal of this residual will be discussed in Chapter 5.0, Residuals Management.

Because of the long runtime between backwash events, it is recommended and proposed that all valves associated with the GFH™ operation be manual valves. The valves for inlet and backwash waste valves will be equipped with chain operators, and effluent, drain and backwash rate set valves will be equipped with hand wheels. All these will be butterfly valves. The media fill and removal valves will be full port ball valves. By making the system entirely manual, it will not be necessary to have a dedicated control system to operate the valve sequencing when backwash is required. The only instrumentation that will be required will be the backwash rate of flow indicators, and a loss of head gauge assembly with differential pressure switch and gauge. These will be located on each vessel.

3.1.2 Severn Trent Services Sorb 33™

The Severn Trent Services system consists of two stages of parallel vertical vessels, twelve feet in diameter, operating in the downflow mode. For the initial installation to handle 5.0 MGD, there will be three vessels in parallel in each stage, for a total of six vessels. The loading rate will be 10.2 gpm/sq.ft. The face piping includes valving for isolation, service and backwashing, and for media fill and removal. An automatic air relief valve and associated piping, sample valves for inlet and outlet sampling, and a vessel drain will also be provided. Figure 2 may be referred to as the preliminary P&ID, since the arrangement is very similar to that of USFilter.

The vessels will have a straight shell height of about seven feet, with dished heads top and bottom. Overall height of the vessels, including supports and air relief valves, will be about sixteen feet. Each vessel will contain a media retention plate, and approximately sixty inches (560 cu. ft/vessel) of Sorb 33™ media.

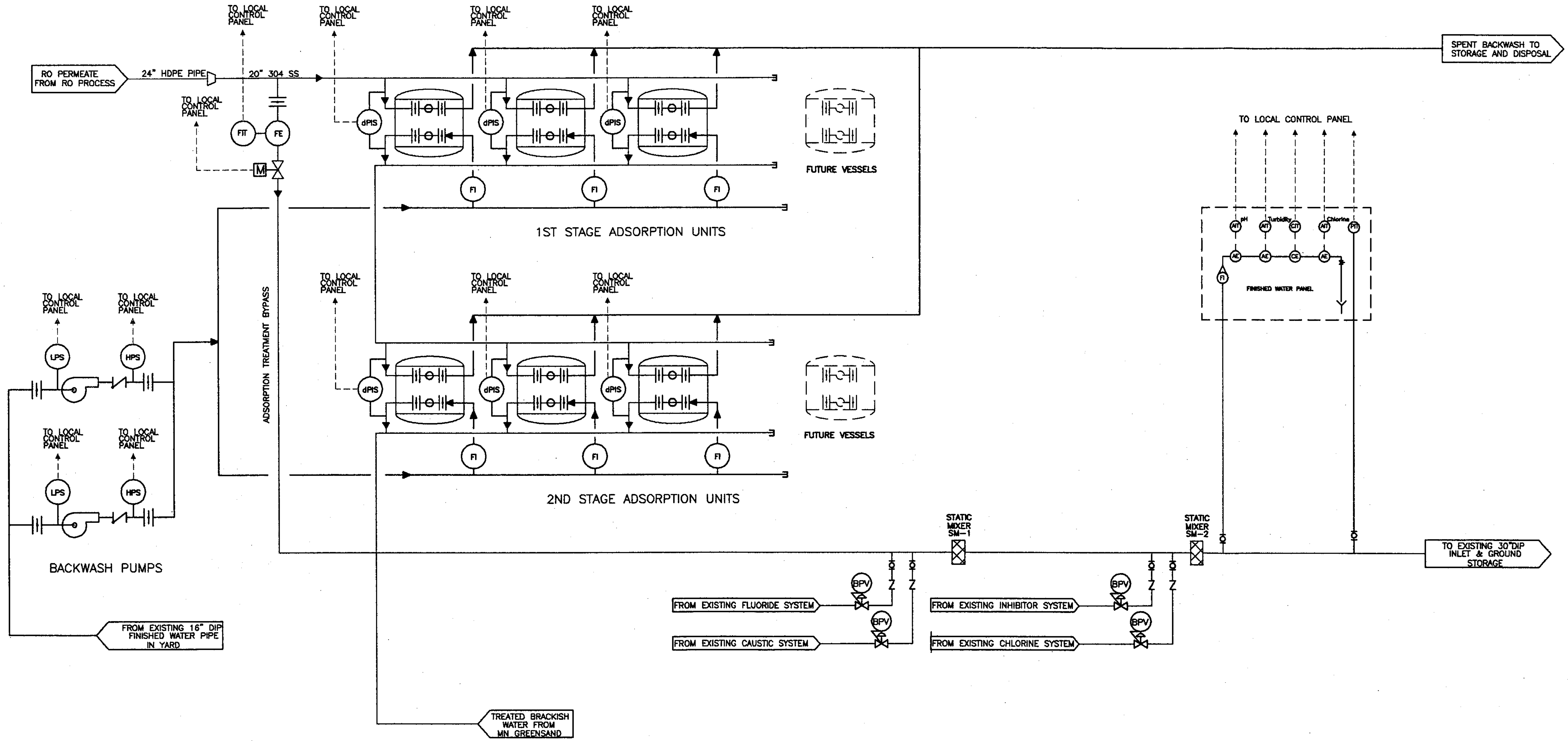
Because of the aggressive nature of RO permeate, the vessels will have to be lined with an NSF-approved corrosion resistant lining. Alternatively, the vessels and face piping can be fabricated from 304L stainless steel. If the latter option is chosen, there will be no interior lining and no exterior coating, thus eliminating lining maintenance and recoating of the exterior for the life of the vessels. It is proposed that the Severn Trent Services be requested to bid the system both as conventional carbon steel vessels, and as 304L stainless steel, so that the prices can be compared. It is also proposed that in either case, the face piping, which is ten and twelve inch diameter, be specified only as 304L stainless steel.

Severn Trent Services has indicated that the media beds be backwashed periodically to expand the media, which can become compacted during operation, increasing the pressure drop across the bed. Since the feed water to the system is permeate, there will be no suspended solids in the water, so the backwash water will also be free from suspended solids, except possibly a limited amount of fines that are removed from the Sorb 33™ beds.

Based on the results of the pilot testing conducted at the NRO in 2003, Severn Trent Services is predicting that backwashing will be required approximately once every five months, based on 75% loading of the vessels. It has been calculated that the backwash volume generated per bed will be about 28,000 gallons. Therefore a total volume of backwash of about 168,000 gallons will be generated each backwash event. It is proposed that the backwash water be taken from the existing storage tank effluent line through a twelve-inch diameter pipe, and that two vertical backwash pumps of approximately 1450 gpm capacity be provided to generate the relatively low head of 20 psig that Severn Trent Services indicates should be provided for backwashing the beds. Since each bed will be provided with a backflow rate of flow valve, and rate of flow indicator, the pumps will be fixed speed. Handling and disposal of this residual will be discussed in Chapter 5.0, Residuals Management.

Because of the long runtime between backwash events, it is recommended and proposed that all valves associated with the Sorb 33™ operation be manual valves. The valves for inlet and backwash waste valves will be equipped with chain operators,

FIGURE 3
SEVERN TRENT P&ID



and effluent, drain and backwash rate set valves will be equipped with hand wheels. All these will be butterfly valves. The media fill and removal valves will be full port ball valves. By making the system entirely manual, it will not be necessary to have a dedicated control system to operate the valve sequencing when backwash is required. The only instrumentation that will be required will be the backwash rate of flow indicators, and a loss of head gauge assembly with differential pressure switch and gauge. These will be located on each vessel.

3.1.3 Water Remediation Technologies Z 33™

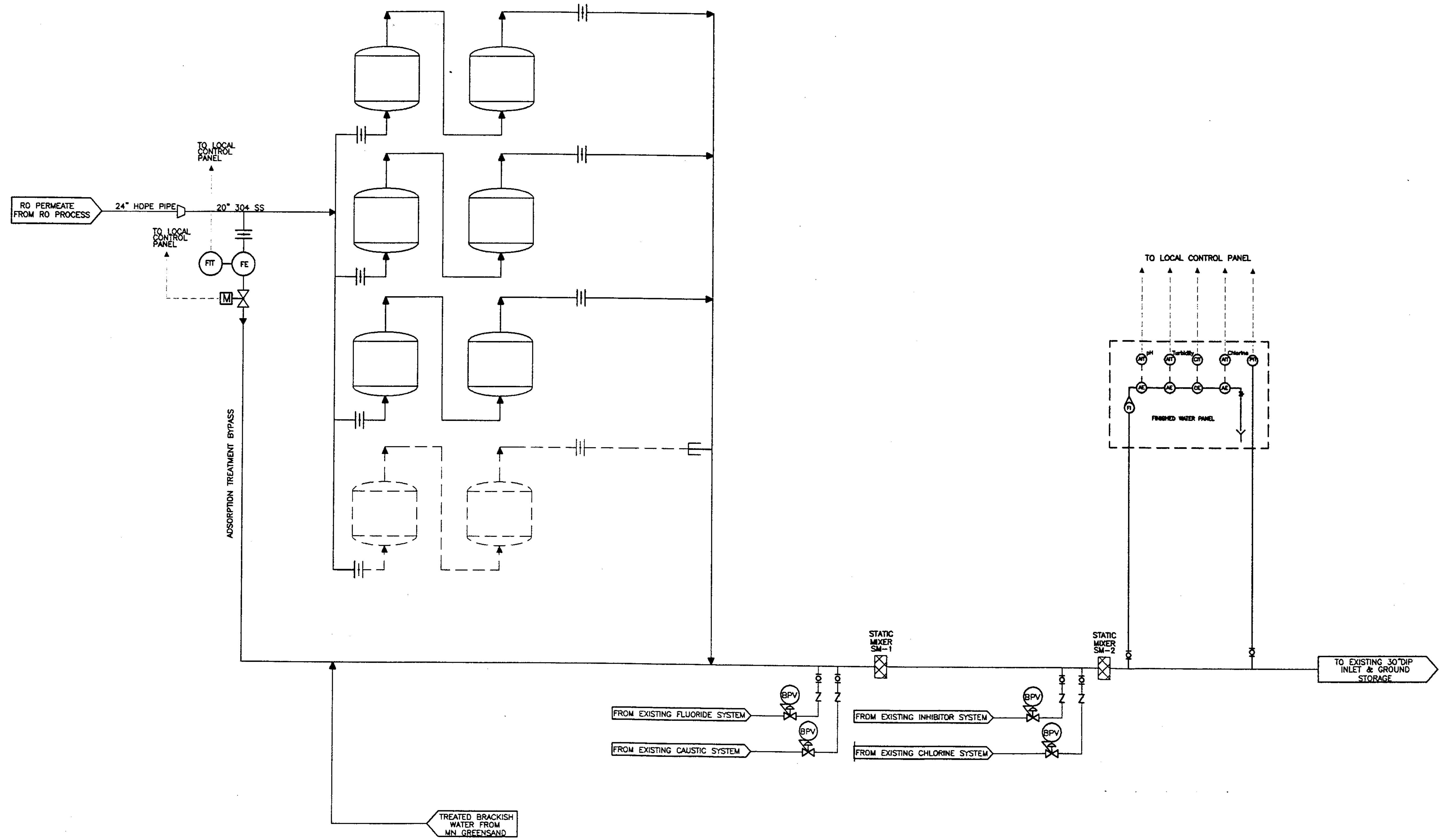
The Water Remediation Technologies (WRT) system consists of two stages of parallel vertical vessels, fourteen feet in diameter, operating in the upflow mode. For the initial installation to handle 5.0 MGD, there will be three vessels in parallel in each stage, for a total of six vessels. The loading rate will be 7.5 gpm/sq.ft. The face piping is significantly less complex than the downflow mode systems, there being only inlet and outlet isolation valves. No backwashing is required because the system operates in the upflow mode. At the present time it would appear that the second stage vessels will be fed directly from a companion first stage vessel, which will eliminate the need for an interstage header. An automatic air relief valve and associated piping, sample valves for inlet and outlet sampling, and a vessel drain will also be provided. A preliminary P&ID is shown in Figure 3.

The vessels will have a straight shell height of about twelve feet, with flattened dished heads top and bottom. Overall height of the vessels, including supports and air relief valves, will be about sixteen feet. Each vessel will contain a media retention plate, and approximately eighty inches (750 cu. ft/vessel) of Z 33™ media.

Because of the aggressive nature of RO permeate, the vessels will have to be lined with an NSF-approved corrosion resistant lining. Alternatively, the vessels and face piping can be fabricated from 304L stainless steel. If the latter option is chosen, there will be no interior lining and no exterior coating, thus eliminating lining maintenance and recoating of the exterior for the life of the vessels. It is proposed that WRT be requested to bid the system both as conventional carbon steel vessels, and as 304L stainless steel, so that the prices can be compared. It is also proposed that in either case, the feed and effluent piping, which is sixteen-inch diameter, be specified only as 304L stainless steel.

Because of the long runtime between backwash events, it is recommended and proposed that all valves associated with the Z 33™ operation be manual valves. The valves for inlet and effluent will be equipped with hand wheels. All the valves will be butterfly valves. The media fill and removal valves will be full port ball valves. By making the system entirely manual, it will not be necessary to have a dedicated control system to operate the valve sequencing when backwash is required. There will be no instrumentation required for this system, except possibly rate of flow indicators.

FIGURE 4
WATER REMEDIATION P&ID



Ian C. Watson, RosTek Associates, Inc., 3/22/2004 4:47 PM Fig 4 WRT P&ID.dwg

3.2 Manganese Greensand System

The existing RO plant includes a bypass feature whose purpose is to allow a fraction of the well water entering the plant to be blended with the RO permeate. The primary reason for this feature is to utilize the calcium hardness and bicarbonate alkalinity in the brackish water in the finished water post-treatment process. Since the RO permeate is almost completely devoid of calcium hardness and bicarbonate alkalinity, blending brackish water is an effective and inexpensive way to reduce the aggressiveness of RO permeate. However, because the blending operation also increases the concentration of all other constituents of the brackish water in the finished product, the amount that can be blended is limited by one or more of the potable water standards. In the case of the NRO, the limiting constituents are chloride and TDS. When the plant was first commissioned, the blend percentage was about 15%. However, as the brackish water has become more saline with time, the blend now makes up only 6-7% of the finished water production. A preliminary P&ID is shown in Figure 4.

The brackish water contains about 60μg/l of arsenic. By blending this untreated with the water from the proposed arsenic reduction project at the current blending rate, the arsenic concentration in the finished water will be 5-8μg/l, which meets the requirement of the new arsenic rule. However, given the variability of the analytical results experienced thus far in the arsenic reduction studies, there is some concern that even though the arsenic concentration is below the MCL of 10μg/l, the analytical results may inaccurately report something higher. Therefore, as part of the pilot testing program, a brackish water treatment system to remove arsenic from the blend water was tested. This system is based on the manganese greensand process, which has been used for many years to remove iron and manganese from water. In the NRO application, in addition to removing the arsenic, the process will also remove the iron that is in the brackish water (about 0.6mg/l on average) so the finished water will be iron-free.

The manganese greensand process for arsenic removal uses the iron in the water by oxidizing it to the ferric state with chlorine, which forms ferric hydroxide, and then adsorbing the arsenic on to the newly formed floc. In the oxidation process, the As(III) in the brackish water is converted to As(V), a form that is more efficiently adsorbed. The natural iron is insufficient for complete removal of the arsenic, so additional iron must be added, in the form of ferric chloride or sulphate solution. The floc is then filtered out on the greensand bed, which must be periodically backwashed to remove the accumulated iron floc. A preliminary P&ID is shown in Figure 4.

It was found as a result of pilot testing that the process could remove up to 80% of the arsenic present in the brackish water with the addition of 1.2mg/l of sodium hypochlorite and 3.5-4.0mg/l of ferric chloride. When this treated water is blended with the treated permeate, assuming a conservative bleed-through of 2μg/l for the adsorption columns, the arsenic concentration in the finished water will be consistently less than 4μg/l.

The County is in the process of adding new wells to provide feed water to the NRO. Preliminary indications from the test well program are that this water will be lower in TDS than the existing ten wells, and more significantly will have much lower arsenic concentration. In anticipation of an overall reduction in TDS, chlorides and arsenic in the NRO feed water, the manganese greensand system has been sized to treat about 9% of the total finished water at the buildout capacity of 8.0MGD, or 0.72MGD. Initially, it is projected that the system will operate at a maximum of about half capacity during the summer peak days, which will tend to extend the frequency of backwashing, which at design capacity is a twenty-four hour cycle. This in turn will reduce the waste backwash water and iron sludge production.

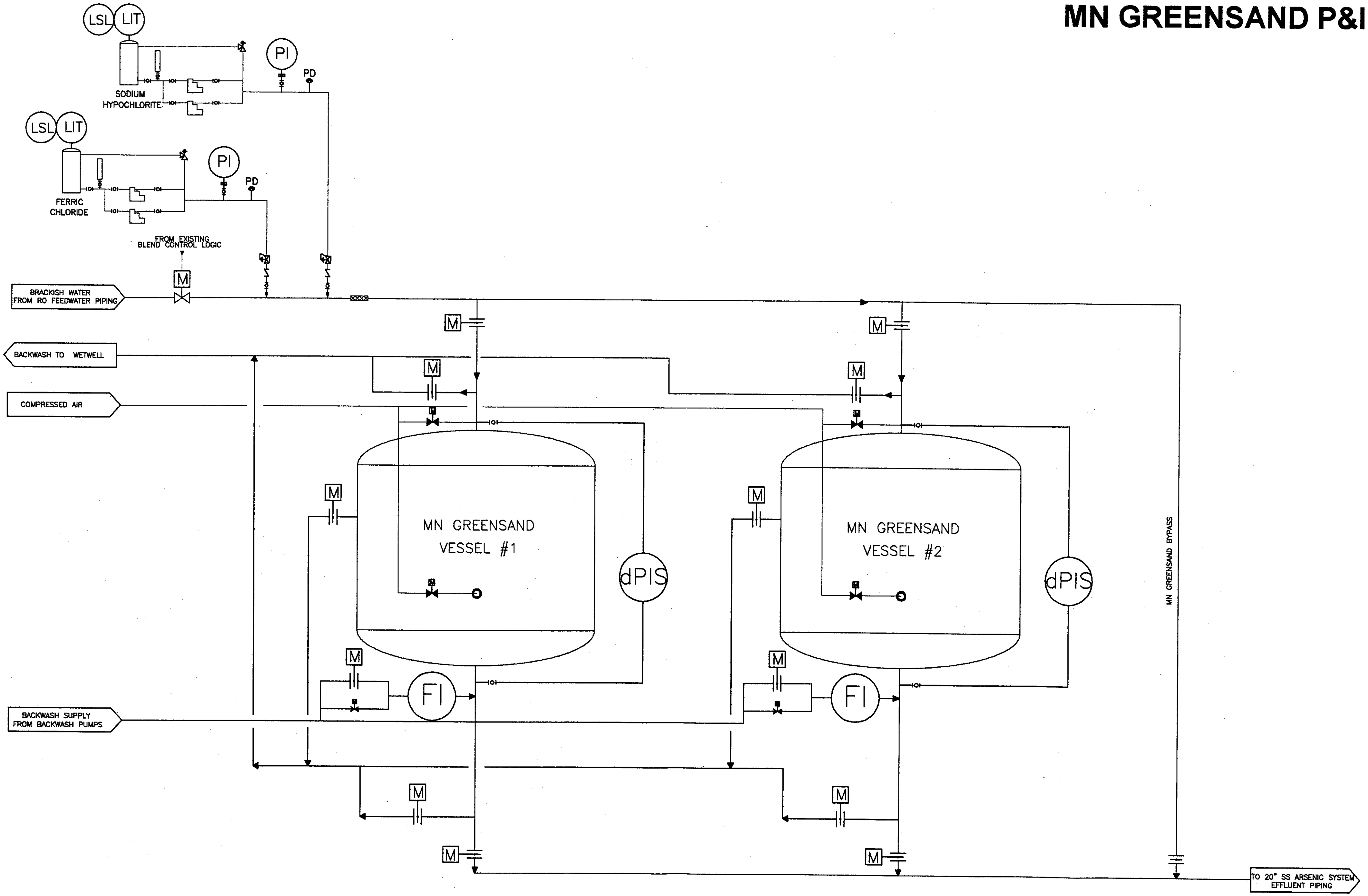
To control the flow through the system, a new brackish water bypass will be constructed. This pipe will be connected to the existing twenty-inch raw water pipe outside of the existing building, and will enter the new building on the south side. The existing flow control valve will be relocated from its current location, and the existing bypass abandoned. The existing control loop and logic, based on conductivity, will be maintained.

The manganese greensand system will consist of two vertical tanks, ten feet six inches in diameter, five feet straight shell, fabricated from carbon steel, and lined with an approved NSF corrosion resistant lining. The exterior will be painted. The face piping will be fabricated from Schedule 80 PVC. A bypass will be provided for emergency use. The system will include a PLC-based control system, but it is recommended that this system be semi-automatic only, requiring that an operator initiate the backwash cycle upon notification that the limiting pressure drop has been reached. The control logic will be contained in this PLC, with selected parameters transmitted to the central NRO control system for operator information.

The system will be supplied with its own compressed air system for air scouring the bed, and with two chemical feed systems, for sodium hypochlorite and ferric chloride. Because of the small dosages of both chemicals involved, it is proposed that the feed systems be designed to draw directly from drums, removing the need for day tanks, as was done at the County's Stumpy Point RO plant. The chemical feed systems will be installed inside portable plastic containments.

The backwash rate for the vessels is such that it is slightly below that required for either the USFilter or Severn Trent Services adsorption vessels, the rate being 1,050gpm. It is therefore proposed that common backwash pumps be used for both adsorption and manganese greensand systems. The infrequent need for adsorption system backwashing should not interfere to any great degree with the routine operation of the manganese greensand system. If WRT should be the successful adsorption vendor, the backwash pumps will be sized specifically for the manganese greensand system.

FIGURE 5
MN GREENSAND P&ID



Ian C. Watson, RosTek Associates, Inc., 3/29/2004 10:19 AM Fig 5 Mn greensand P&ID.dwg

3.3 Post Treatment System

The existing post-treatment systems will be used for the plant addition, but the point of application will be changed to a point after the arsenic removal equipment, in the new building. The caustic soda, corrosion inhibitor and fluoride systems presently in use will be abandoned, and new piping installed to deliver the chemicals to the new feed location. The new piping will be installed with shut valves at the tie-in points, so that the existing system remains operational while the new system is being constructed. Piping sizes and materials will duplicate the existing systems. Chemicals will be injected into ports in the new twenty-inch diameter, 304L stainless steel piping, located in the new pipe trench inside the building. There will be two plate type static mixers, each with two chemical injection points preceding them.

As discussed earlier, the chlorine addition in the existing plant will remain, and a second chlorine addition point will be located in the new building. The overall chlorine demand should be marginally reduced, since the finished water will no longer have the demand imposed by the residual iron. Tests have shown that the adsorption media has some capacity for chlorine, so the second point is required to trim the chlorine residual of the finished and blended water prior to storage.

All of the existing instrumentation and control logic for post-treatment will remain the same. A new finished water panel will be installed in the new building, with new devices as required.

4.0 PROCESS EQUIPMENT

4.1 Introduction

The following paragraphs provide general specifications for the major process equipment to be procured for the new treatment facility. The equipment required for the wastewater clearwell is described in Chapter 5.0 of this report.

The information provided here is based generally on vendor information provided to the design team during this preliminary design phase. It must be emphasized that design is not complete, and some equipment may change as a result of future design decisions.

4.2 Component Details

4.2.1 Arsenic Adsorption Equipment.

4.2.1.1 USFilter. For 5.0MGD of treatment capacity.

Base Design

Number of vessels/stage	4
Number of stages	2
Diameter of vessels	12 ft.
Support media/vessel	113 cu.ft.
Volume of adsorption media/vessel	377 cu.ft.
Backwash rate	12 gpm/sq.ft.
	1,357 gpm
Backwash duration	15 minutes
Backwash volume/vessel	20,355 gallons
Backwash frequency (estimated from pilot data)	Monthly
Estimated media life	1.5-2.0 years

Alternate Design

Number of vessels/stage	3
Number of stages	2
Diameter of vessels	14 ft.
Volume of support media/vessel	154 cu.ft.
Volume of adsorption media/vessel	666 cu.ft.
Backwash rate	12 gpm/sq.ft.
	1,848 gpm
Backwash duration	15 minutes
Backwash volume/vessel	27,720 gallons
Backwash frequency (estimated from pilot data)	Monthly
Estimated media life	1.5-2.0 years

4.2.1.2 Severn Trent Services. For 5.0MGD of treatment capacity.

Base Design

Number of vessels/stage	3
Number of stages	2
Diameter of vessels	12 ft.
Support media	Plate support.
Volume of adsorption media/vessel	559 cu.ft.
Backwash rate	12.4 gpm/sq.ft. 1,403 gpm
Backwash duration	20 minutes
Backwash volume/vessel	28,060
Backwash frequency (estimated from pilot data)	5 months
Estimated media life	1.5-2.0 years

Alternate Design

Number of vessels/stage	2
Number of stages	2
Diameter of vessels	14 ft.
Support media	Plate support.
Volume of adsorption media/vessel	761 cu.ft.
Backwash rate	12.4 gpm/sq.ft. 1,910 gpm
Backwash duration	20 minutes
Backwash volume/vessel	38,200
Backwash frequency (estimated from pilot data)	Monthly
Estimated media life	1.5-2.0 years

4.2.1.3 Water Remediation Technologies. For 5.0MGD of treatment capacity.

Base Design

Number of vessels/stage	3
Number of stages	2
Diameter of vessels	14 ft.
Support media	Upflow.
Volume of adsorption media/vessel	924 cu.ft.
Backwash rate	N/A.
Backwash duration	N/A.
Backwash frequency (estimated from pilot data)	N/A
Estimated media life	1.0-1.5 years

4.2.2 Manganese Greensand Filters

To treat blend water for the buildout capacity of 8.0MGD.

Number of vessels	2
Diameter of vessels	10'-6".
Volume of gravel/vessel	86.5 cu.ft.
Volume of Mn greensand/vessel	173 cu.ft.
Volume of anthracite/vessel	86.5 cu.ft.
Backwash rate	12 gpm/sq.ft.
	1,040 gpm
Backwash duration	10 minutes
Backwash volume/vessel	10,400 gallons
Draindown volume/vessel(brackish)	1,750 gallons
Rinse volume/vessel(brackish)	750 gallons
Air scour/vessel	69 cfm for 5 minutes
Backwash frequency (estimated from pilot data)	24 hours @ 500gp

Number of chemical systems	2
Sodium hypochlorite dose(12%)	1.5mg/l
Daily consumption	9#/day
	0.95 gals/day
Metering pump	2.5 ml/minute
Ferric chloride dose(34%)	4.0mg/l
Daily consumption	24#/day
	6.2 gals/day
Metering pump	16.5 ml/minute
Manufacturer	Hungerford & Terry, or equal

4.2.3 Backwash pumps

Number of pumps	2, 1 service, 1 backup
Pump type	Vertical in-line, single stage centrifugal
Pump capacity, base design	1,410 gpm @ 50 ft of H_2O
Pump suction	Flooded
Speed	1,750 rpm, fixed speed
Pump horsepower @ full load	25 hp, with 1.1 SF
Pump motor	ODP or TEFC
Manufacturer	Afton, Goulds, or equal

4.2.4 Static Mixer

Size	24"
Material	304L SS, with 316L SS lobes

Type	Vortex shedding
Number required	2, two injection ports for each
Manufacturer	Westfall, or approved equal.

5.0 RESIDUALS MANAGEMENT

5.1 Introduction

The proposed addition to the NRO plant for arsenic removal will generate a number of residuals requiring prudent management and disposal. In addition, it is desirable to minimize unnecessary wastage of water, by recycling as much of the liquid waste as possible through the existing RO treatment plant.

The waste streams expected consist of both solid and liquid materials. These have been identified as:

a. Periodic backwash from the arsenic adsorption units
b. Approximately daily backwash from the Mn greensand units
c. Spent arsenic adsorption media
d. Spent Mn greensand
e. Mn greensand ferric hydroxide sludge
f. Cartridge filters

Each of these will be addressed in the following paragraphs

5.2 Arsenic Adsorber Backwash

Two of the three competing arsenic adsorption systems will require periodic backwashing. Since the water to be treated in these units is RO permeate, there will be no accumulation of suspended solids on the adsorption beds. Backwashing is required to "fluff" the beds, which will naturally compact with time. The two manufacturers, USFilter and Severn Trent Services, have indicated that the backwash will not desorb the arsenic, which is tightly bound to the iron-based media, but that some fines may be washed out as a result of wear and tear on the media. In both cases this is expected to be a relatively minor amount.

The frequency of backwashing varies with the manufacturer, ranging from one month for USFilter to 5 months for Severn Trent Services. Because of the process differences between the two systems (discussed in Section 3.0), the volume of backwash generated per event is not the same for each process. In addition, because of the variable loading rates on the systems due to the County's service area demand fluctuations, the expected frequency of backwash may vary between the high and low demand seasons.

It is proposed that the County's finished drinking water be utilized for backwashing. Both manufacturers have provided assurances that the presence of chlorine in this water will not adversely affect their respective media, and both indicated that their media has an affinity for chlorine. This means that the backwash effluent will be essentially free from chlorine. This was confirmed by County staff using the two pilot units at the NRO plant. A backwash was performed on the pilots, and the chlorine residual in the backwash water was reduced to less than 0.05mg/l.

After several discussions with the County, it was suggested to recycle the backwash water to the feed water inlet of the existing RO plant, for two reasons. By recycling, the water is conserved, and the diluting effect of the low TDS water will provide a benefit, albeit small, to the cost of operation of the RO plant, mainly in reduced energy cost. Because there will be no discharge off-site a modification to the existing NPDES permit will not be required.

The backwash volume generated by each vessel will be approximately 25,000 gallons of water. To manage this volume in a cost effective, but efficient manner, it is proposed that a wet well be constructed outside the new building. This wetwell will be sized to accept the backwash from two vessels, and will have a separate cell to receive the backwash from the manganese greensand filters. The proposed volume of the clearwell is 75,000 gallons. As the backwashing of the adsorbers takes place, the recycle pumps will be pumping the waste backwash water into the RO raw water piping, at a proposed rate of 100gpm. It will take approximately four hours to pump out the wetwell from one adsorption vessel. Since backwashing can be scheduled in advance, it can be carried out when the RO plant is in operation, and can accept the spent backwash. The piping system will include a duplex cartridge filter arrangement, to trap any fines that may be washed out of the adsorption beds. Because of the adsorption of chlorine on to the media, it is not believed to be necessary to provide dechlorination equipment at this time. However, space will be provided so that carbon canisters can be installed at a future date, if found to be a benefit.

The pump-out equipment will have the following characteristics:

Pumps	
Number of pumps	2
Pump type	Vertical
Pump Material	Plastic
Pump capacity	100gpm @ 140 ft of H_2O
Pump speed	1,750 rpm
Motor HP	7.5
Motor type	TEFC
Manufacturer	Vanton, Fybroc, or equal
Filters	
Number of filters	2, in parallel
Material	FRP shell, aluminum closures
Number/length of cartridge	12/30"
Piping and Valves	
Pipe diameter	3"
Pipe material	Schedule 80 PVC
Valve type	Wafer style butterfly

Valve material	PVC

5.3 Manganese Greensand Backwash

The manganese (Mn) greensand filters will require backwashing once every twenty-four hours when operating at buildout capacity of 500gpm. However, initial operation will be at a lower loading rate, which will extend the backwash schedule accordingly.

The backwash volume that is generated for each vessel for each cycle is made up of three discrete flows.

- Drain down, brackish 750 gallons
- Backwash product 10,400 gallons
- Rinse to waste brackish 1,250 gallons

The backwash water will contain the ferric hydroxide sludge that has been created by the addition of ferric hydroxide, and the oxidation of the iron in the brackish water. At the dose of ferric chloride required for reduction of the arsenic to 10µg/l, the weight of dry solids in the backwash water will be approximately twenty five pounds, or about 0.02% by weight. Because of the brackish water involved in the Mn greensand operation, the TDS of the wastewater going to the wetwell will be about 1,000mg/l.

The wastewater will be sent to a dedicated cell in the wetwell, where the floc will be allowed to settle. Since iron floc is heavy, it should settle fairly rapidly, allowing the supernatant to be decanted to the clean cell of the wetwell, for disposal to the RO feed water system. Two options are available for decanting, either a series of valves set in the dividing wall of the cells at three or four elevations, or a small transfer pump. The valve option allows the operator to select the level down to which he will transfer the supernatant, in the event that complete settlement has not occurred. However, since the valves will be submerged, maintenance will be more difficult, since both sides of the cell must be empty to allow access to the valves. A pump system is less difficult to maintain, but will require additional electrical service, and some control equipment. It is suggested that the options for decanting be discussed with the County staff prior to the final design.

An alternative disposal method currently under investigation is to discharge the Mn greensand backwash wastewater in to the local sewer system. A lift station is located within a few hundred feet of the NRO, to the west. This lift station delivers municipal wastewater to a sewage treatment plant located nearby, owned by the Outer Banks Beach Club, and operated under contract by EnviroTech. The Bissell Professional Group is the utility's consulting engineer. Bissell has been contacted and requested to look into the feasibility of accepting all of the waste flow from the Mn greensand filter system, or if this is too large a volume, to accept the settled sludge, while the supernatant is recycled as described above. A response to the County's request had not been received at the time this

PDR was prepared. Therefore the design assumption at this point for design development is that the Mn greensand residuals will be handled on site as described in this report.

5.4 Spent Arsenic Adsorption Media

It has been estimated by the three competing vendors that the life expectancy of the arsenic adsorption media will be eighteen months to two years. The media cannot be regenerated, so when arsenic breakthrough appears, the exhausted media must be removed, and fresh media placed in the system.

The County has proposed, and the three vendors have agreed, that the successful vendor enter into a long-term contract with the County to take full responsibility for media maintenance and replacement. This agreement will include disposal of the spent media in an environmentally sound manner, at a location to be arranged by the vendor. Thus the County will not be faced with this residuals disposal issue.

5.5 Spent Manganese Greensand Media

Based on experienced gained in the application of the Mn greensand treatment of water, one of the leading vendors has indicated that the life expectancy of the media typically is ten to fifteen years. There are some installations where the media has lasted for up to twenty-five years. Assuming that a ten-year life can be expected, the media will need to be replaced once during the assumed twenty-year life of the equipment.

There are several vendors of Mn greensand media, so that the County will be in a competitive bid situation when media replacement is needed. It is recommended that the County prepare a bid specification that covers both the supply of the new media, and the replacement of the exhausted media. This is analogous to the approach that has been used previously by the County when replacing membrane elements in the NRO plant.

5.6 Manganese Greensand Ferric Hydroxide Sludge

As discussed in 5.3 above, the County is investigating the possibility that either the settled sludge or all of the Mn greensand backwash waste can be disposed of to the local sewage treatment plant. Failing this option, the sludge will be dewatered on site, and sent to the Dare County landfill.

The dewatering proposal is to utilize filter bags, hanging on top of the clearwell, and draining back into the clearwell. These bags are constructed of a tightly woven polyester material, and measure about three feet by three feet by forty two inches tall. These dimensions represent a usable volume of about thirty cubic feet. The dry weight of ferric hydroxide generated by each vessel backwash is about twenty five pounds, which has a volume of approximately one quarter of a cubic foot. The sludge is expected to drain to about fifty percent by weight in the bags, so one bag will hold the sludge from twenty five to thirty regenerations, or about one month of operation. When full the bag can be sent to the county landfill for disposal.

5.7 Cartridge Filters

The spent cartridge filters used to filter the recycled backwash water will be disposed of in the same manner as the spent cartridges from the existing RO operation.

6.0 CIVIL/STRUCTURAL DESIGN

6.1 Introduction

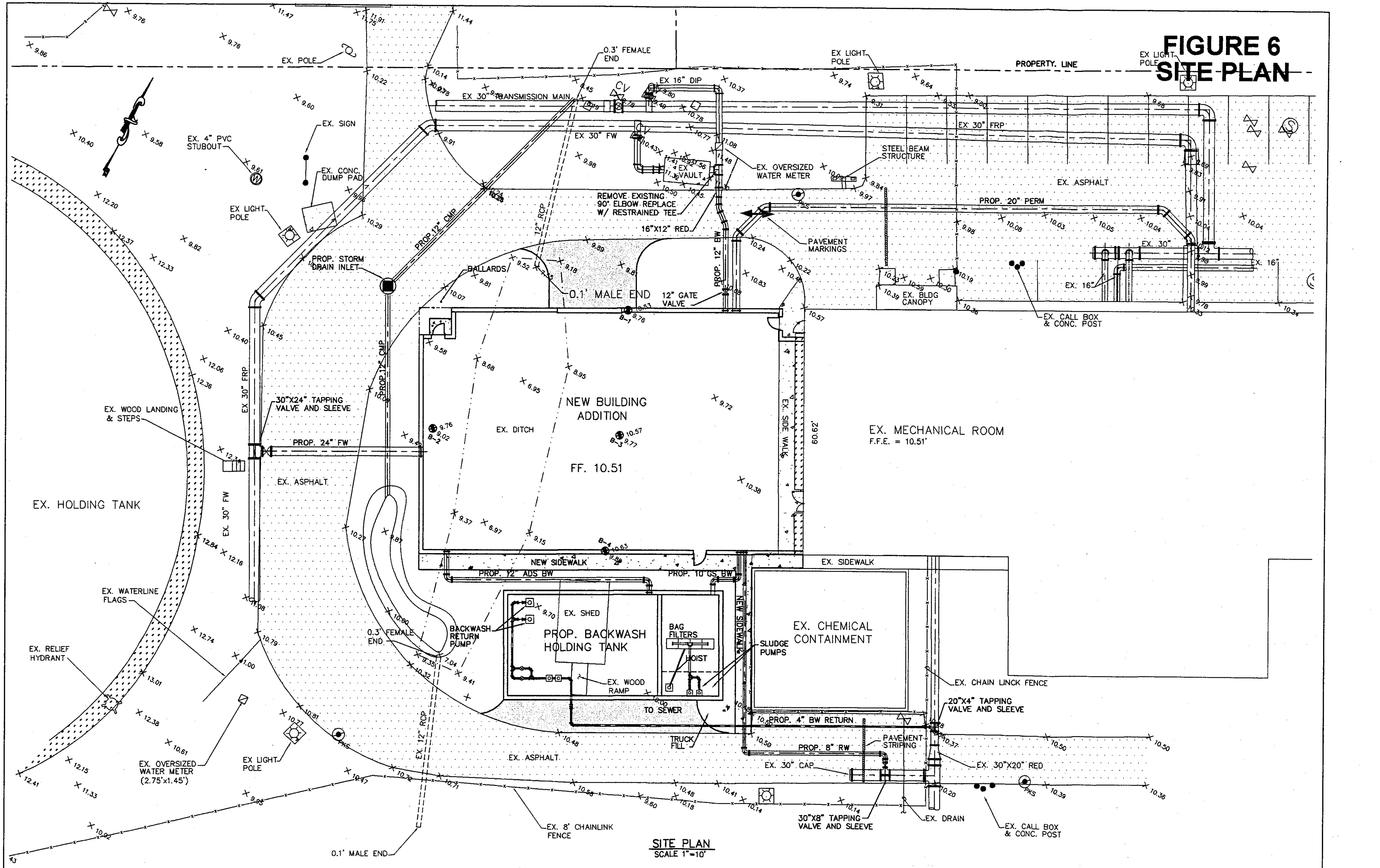
The existing RO building consists of fully grouted 12" CMU walls in stack bond supported on a shallow 8" thick floating slab on grade thickened on building perimeter to 18". The bottom of the foundation bears on fine sand sub grade. Slab and wall foundations were built integrally in one continuous pour without shrinkage dissipating joints. The roof structure is of timber trusses with cementitious unblocked wood diaphragm panels. The roof diaphragm is split into two sub-diaphragms at the roof ridgeline by skylight construction and by cupola towers spaced along the roof ridgeline. Lateral load is shared between the two sub-diaphragms. The roof diaphragm is connected to the perimeter walls through a vertical closure plate attached to the wall sill plates. Perimeter walls serve as shear walls for load transfer to the foundation. The proposed addition to the RO building will generally match the existing building except as indicated below.

6.2 New Treatment Building Addition

The proposed Arsenic Treatment Facility building is approximately 95 feet long and 60 feet wide. The new building will be as an extension to the existing building with a similar exterior finish. The new building will consist of one level with a ceiling height of approximately 16'-7" and 12" partially grouted reinforced CMU walls built with a ½" offset from the existing end wall to allow for temperature expansion. After discussion with the County, it is proposed to use CMU walls in running bond to avoid hairline cracks that are normally observed in stack bond walls. A new building foundation, poured against the existing footing with a bond breaker between the existing and new concrete, will be similar to the existing building with the exception of splitting the floor with shrinkage dissipating joints at 3 different areas to avoid shrinkage cracks. Slab supporting the wall and heavy equipment will be 18" deep slab on grade. This slab will be designed as slab on elastic foundation. Slabs with light traffic will be 8" slab on grade and will be thickened to 18" under the exterior walls. Based on the result of the recent geotechnical report by McCallum Testing and due to high concentration of loads along the west wall of the existing building, it is suggested to modify the soil under the foot print of the new Greensand filters by installing several 2'-0 to 2'-6" diameter stone columns of 6-0' c/c in this area. Stone columns will be carried to the competent bearing strata to prevent differential settlement along the existing west wall. Soil improvement outside the Greensand filter area will consist of soil replacement to a depth of 24" with 6" of proof rolled recycled concrete that will serve as a sub-base for slab on grade, supporting Arsenic Adsorption tanks and perimeter walls.

Roof trusses will match the geometry of existing trusses and will be designed for loads outlined in the section "Components and Cladding" of IBC 2000 with appropriate North Carolina amendments and requirements. Roof trusses will be attached to the walls with uplift hurricane clips. The new roof will be bridged by a flexible EPDM strip connected to

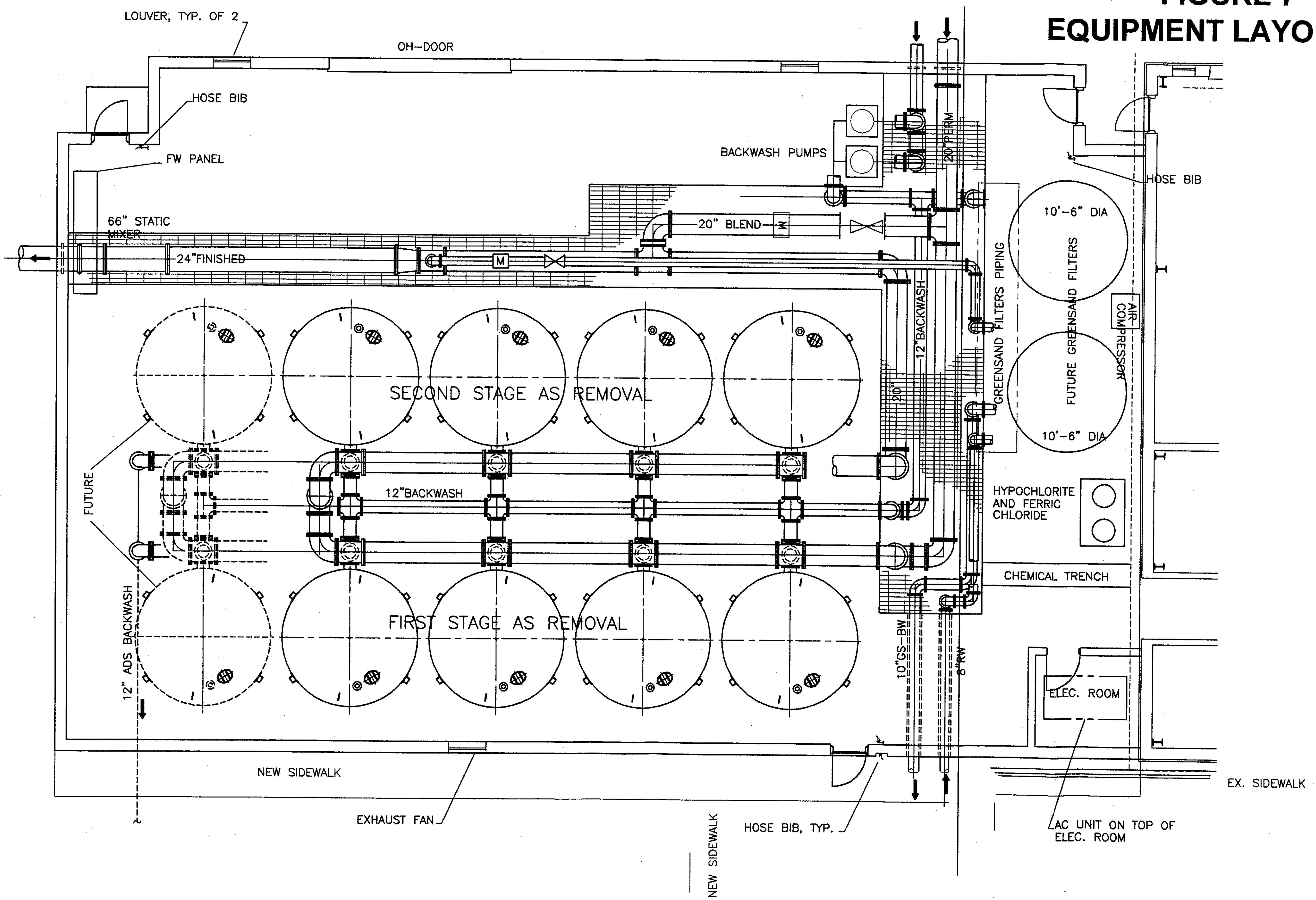
FIGURE 6
SITE PLAN



SITE PLAN
SCALE 1"=10'

Ian C. Watson, RosTek Associates, Inc., 3/29/2004 9:13 AM FIG 6 SITEPLAN.dwg

FIGURE 7
EQUIPMENT LAYOUT



the roof diaphragm panels. Flexible roof connection will be used to bridge the ½" gap between the existing and new roof. The new roof will be wood shake shingles matching existing roof.

A main pipe trench covered with FRP grating will accommodate process piping for any of the three potential adsorption equipment manufacturer arrangements as well as the Mn greensand filter system feed, effluent and backwash piping. The trench will be constructed with 12" walls and bottom slab to accommodate ~~most~~ all of the major process piping. The pipe trench will be cast with a full depth isolation joint between the trench wall and the slab. A sub-trench will be used to accommodate the pipe which will carry the plant effluent water from the Arsenic adsorption units to the storage tank 36" intake line, as shown on the drawings.

Based on the available office space in the existing building, no additional office space will be required for the new building addition. All the available space built will be dedicated to process equipment, piping and electrical room.

Surfaces of the interior concrete floors will have a non-slip finish. Both interior and exterior CMU walls will be coated with colors matching existing building.

Due to concerns with condensation and humidity, doors will be 1 ¾" thick constructed of aluminum alloy rails and Stiles, joined with steel tie rods, inner core of foamed-in-place urethane with fiberglass reinforced polyester face sheets locked in with extruded interlocking edges. All doors will have panic hardware with kick plates.
A 16' wide roll-up aluminum door on the North side of the new building will provide access to vehicles for equipment removal/delivery, and chemical delivery. This overhead ceiling type door will be face mounted and motor operated. The curtain will be two-faced aluminum with interlocking slats to resist wind pressure of 30 psf. Guides will be of aluminum structural angles. The motor will have an auto safety bar to reverse when obstruction is met and an internal pre-wiring to one terminal block, push bottom station. Interior brackets on sides of rolling door will be installed similar to the existing plant overhead door for installing lumber during hurricane season.

An 8' wide aluminum walkway with stairs and handrails will be installed between Arsenic adsorption units to provide access to panels and to facilitate the repairs of the vessels.

Standards and Codes IBC 2000 with North Carolina amendments.

6.3 Site Work, Grading and Drainage

6.3.1 Pavement

As most of the paved area to the North, West and South side on the existing building will be disturbed to install new piping, it is proposed to completely mill and resurface the paved area after trench patching at these locations. Underground gate sensor cables will also be replaced.

6.3.2 Storm Drain

Length of the new proposed addition will overlap with the existing ditch behind the existing building. It is proposed that the existing storm drain ditch be rerouted with additional new storm drain inlet on the West side of the new building, as shown on the site plan. This will bring the run off to the existing inlet of the outfall storm drainpipe.

6.3.3 Grading

The proposed new building surrounding will be graded so that the rainwater is collected at the new proposed storm drain inlets and carried to the existing outfall storm drainpipe.

6.3.4 Existing Containment Area Fence

Since the West Side of the existing building is protected by a chain link fence and two gates, it is proposed to remove the existing inner fence around the existing containment area and replace it with aluminum handrail.

6.3.5 Floor Drains

Interior floors will be sloped at a minimum rate of 1/16" per linear foot to facilitate floor water drain into the pipe trenches. Bottom of the pipe trenches will also be sloped at a rate of minimum 1/8" per linear foot to collect the drained water into a 6" wide gutter, located in the center of the pipe trenches. This gutter will collect all the drain water in a 12"x12"x12" sump (with grating). Collected water will be discharged into the existing Chemical Containment area using a sump pump.

6.4 <u>HVAC and Mechanical</u>

6.4.1 Plumbing

Plumbing water pipe will be copper and four 1/2" hose bibs will be provided with hose and hose rack. Three hose bibs will be located inside the proposed building near each exit door. One (Non Freeze Type) will be provided outside the proposed building near the Southern exit door and the Backwash holding tank.

6.4.2 Air Conditioning

An Air Conditioning unit will be installed on top of the Electrical Room with fresh intake from outside. A continuous perforated Fiberglass duct, extending from the unit to the West Side of the building will be provided. This duct will be on top and center of the walkway between Arsenic Removal vessels to reduce condensation of the pipes. The unit is expected to be used mostly during summer and high temperature months.

6.5 Other Work

It is suggested that the existing trash Dumpster be relocated. The existing wooden shed behind existing building will need to be relocated. These relocations will be coordinated with the county operations staff.

6.6 Backwash Wetwell

The backwash water from both the arsenic adsorption system, and the Mn greensand filters will be sent to an outside wet well. This wetwell will be divided in to two cells. One cell will receive the backwash from the adsorption system, while the second cell will receive drain down, backwash and rinse from the Mn greensand system. The wet well will have a useful volume of 80,000 gallons.

The wet well will be located South of the building extension and will be built as a buried concrete water holding structure with a foot print of 53'-0 x 25'-0 and estimated water depth of 8'-0 (10'-0 structure with 2'-0 of freeboard). Walls of the tank will be designed as short-cantilevered concrete of 12" thickness. The tank will have partial roof slab that will be supported from the baffle walls, exterior walls, beam or both. Sub-base of the tank will consist of 6" thick proof rolled recycled concrete.

7.0 ELECTRICAL DESIGN

7.1 Standards and Codes

Standards and applicable codes will be implemented for the design of the electrical system at the NRO WTP Arsenic Reduction Project. The power distribution system, lighting, surge protection, and other electrical components of the design will comply with the latest edition of the applicable national and local codes. In areas that may require code interpretation or authorization of the local standards, the project team will provide recommendations with regard to the code requirements, which provides the best safety and design measures for the project.

The design for the electrical power distribution system will conform to the following standards:

- ANSI C2 – National Electrical Safety Code
- NFPA 70 – National Electrical Code

Lighting design will incorporate energy saving technology and will be in compliance with the following standards:

- IES Lighting Handbook
- NFPA 70 – National Electrical Code

Lighting levels in applicable areas will be in compliance with the IES Lighting Handbook, Industrial Group. The IES Lighting Handbook has no specific recommendations for lighting levels for wastewater treatment plants. Lighting levels for similar type industrial spaces were reviewed to develop lighting levels for the remaining areas. Based upon this evaluation, maintained lighting levels at the work plane will be as indicated in the following table.

RECOMMENDED LIGHTING LEVELS

AREA NAME	Foot-candles
Process Area Lighting	30
Electrical Room Lighting	40
Site/Yard Lighting	2

7.2 Power Distribution System

The existing power system into NRO WTP is a single utility feed 480 volt, 3-phase power system. Emergency power is provided via a standby duty generator rated at 750 KW. The power enters the facility through a 2000-Ampere Main Circuit Breaker in existing switchgear located in the electrical room.

The emergency generator feeds the entire electrical bus of the system. A 2000 ampere automatic transfer switch provides the transfer to the generator upon loss of utility power. The existing main switchboard feeds power to the high service pump variable frequency drives (VFDs) and to two Motor Control Centers (MCCs), MCC-1 and MCC-2.

For this project, the capacity of the existing generator was not evaluated, however, Dare County has indicated that previous studies have been performed and the capacity of the generator is estimated to be sufficient for additional loads.

Currently, the plant has two 480 volt, three phase motor control centers located in the electrical room. Based on additional equipment required for the Arsenic Reduction project, the new connected electrical loads, are estimated to include:

THE NEW CONNECTED LOADS

DESCRIPTION	Load (KVA)
Greensand Filters	15
Absorption System & Valves	1
Sludge Pumps	18.3
Heating and Air Conditioning	45
Chemical Feed Equipment	3.5
Utilization Power/Miscellaneous	8.7
Lighting	8.7
Backwash Pumps	56.5
Recycle Pumps	23.3
TOTAL ESTIMATED LOADS	**180.0**

From our preliminary evaluation, the existing system has adequate power to feed the proposed loads identified above. Therefore, it is proposed to provide a new circuit breaker in the existing MCC-1, in a spare section, for power to the new electrical room. The circuit breaker would be rated at 225 Amperes and provide a new 480/277 volt, 3 phase power feed to the new electrical room in the proposed addition. The power would then be distributed throughout the new addition via power distribution equipment located in the new electrical room. This will minimize the conduit, wire, and equipment required in the existing process for powering of the new equipment.

A new 480/277 volt, three-phase panel board is proposed to be installed in the new electrical room and provide power to the 480 volt equipment, such as valve actuators and manufacturers control panels. A new MCC will be provided in the electrical room to provide the required motor controls for the rotating machinery, which is not included with the manufacturer panels, such as the dewatering equipment if required.

A single phase 25 KVA distribution transformer with secondary ratings of 240/120 volt will be provided for receptacles, lighting, controls, and other miscellaneous loads. This panel, along with all other electrical equipment will be installed in the proposed electrical room in the new addition.

A single line diagram showing the proposed electrical connection of the new process equipment, lighting and utilization power is included as Figure 8.

7.3 Lighting

Mercury vapor and fluorescent lamps will be provided with electronic ballasts for energy savings. Ballasts for fluorescent lamps will have a power factor greater than 90 and a total harmonic distortion (THD) of less than 15 percent. High-pressure sodium lamps will have a CRI of 22 and be provided with high power factor ballasts.

For indoor lighting, indirect fluorescent luminaries will be used in the electrical room to minimize glare. Process equipment areas will be provided with Mercury Vapor type Low Bay fixtures similar to the existing process area. Several low bay fixtures will be provided with quartz re-strike feature to provide a limited amount of light when the lights are turned on. The fixtures in all areas will be enclosed and gasketed luminaries, suitable for damp or wet locations, as applicable. Emergency lighting will be designed to provide 2 foot-candles of illumination along the paths of egress during a power failure.

Exterior wall mounted high-pressure sodium fixtures with cut-off optics will be provided around the perimeter of the new building. Fixtures will be provided on walls as required to maintain even site illumination.

The proposed lighting will be rated at 240 volt, single phase.

7.4 Electrical Materials

Enclosures and Cabinets:

Interior	Electrical Room	NEMA 12
Interior	Process Area	NEMA 4X
Exterior		NEMA 4X

Conduit and fittings:	
Rigid Galvanized Steel	All areas, except underground concrete ductbanks
Schedule 40 PVC	Underground, concrete encased
Wire:	
Stranded copper	All systems
Type XHHW	Underground feeders
Type THHN/THWN	Power, control, lighting, and receptacle circuit

7.5 Special Systems

7.5.1 Telephone
No provisions are being made to extend standard telephone service.

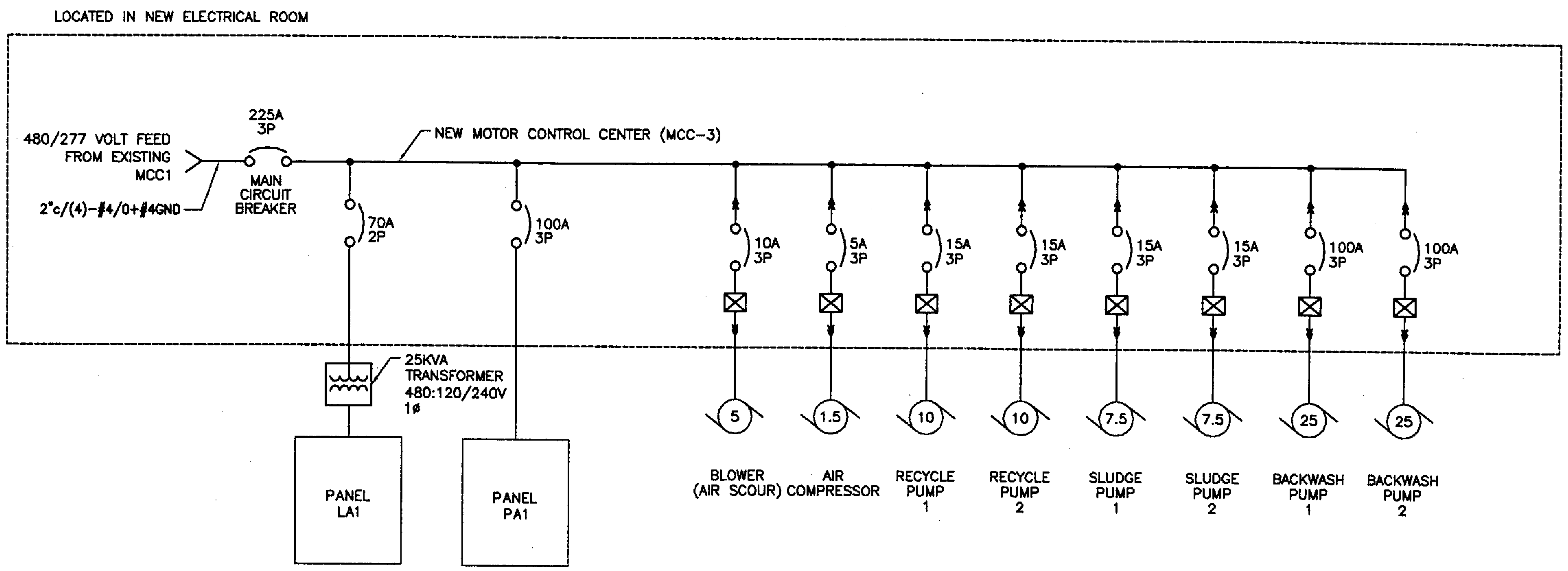
7.5.2 Surge Protection
Electrical surge and lightning protection will be provided at the new panelboard and motor control center.
Programmable logic controllers, variable frequency drives, instrumentation, and other electronic equipment devices will be provided with power surge protection and lightning protection on signal and power cables as applicable.

7.5.3 Power Factor Correction
On all new three phase, motors (3 horsepower and greater) the specified minimum power factor will be 93 percent. It is not anticipated to include power factor correction on any new equipment for the facility.

7.5.4 Voltage Drop
The design will limit the voltage drop on power cables, at full load, to:

Feeders and Subfeeders	2-3 percent
Branch Circuits	4-5 percent

FIGURE 8
ELECTRICAL SINGLE LINE DIAGRAM



PANEL LA1
240/120 VOLT, 1 PHASE, 3 WIRE
100A MAIN CIRCUIT BREAKER
24 CIRCUIT
LOCATION: ELECTRICAL ROOM

CKT #	BREAKER			SERVING	REMARKS
	POLE	FRAME	TRIP		
1	1	100	20	CHEMICAL FEED EQUIPMENT	
2	1	100	20	GREENSAND FILTER SYSTEM	
3	1	100	20	REFRIGERATION AIR DRYER	
4	1	100	20	ABSORPTION SYSTEM	
5	1	100	20	RECEPTACLES - ELECTRICAL ROOM	
6	2	100	30	FeCL3 PUMP	
7	1	100	20	NaOCL PUMP	
8	1	100	20	LIGHTING ELECTRICAL ROOM	
9	2	100	20	PROCESS AREA LIGHTING	
10	2	100	20	PROCESS AREA LIGHTING	
11	-	100	-	-	
12	-	100	-	-	
13	2	100	20	EXTERIOR LIGHTING	
14	1	100	20	RECEPTACLES - PROCESS AREA	
15	-	100	-	-	
16	1	100	20	RECEPTACLES - PROCESS AREA	
17	1	100	20	RECEPTACLES - EXTERIOR	
18	1	100	-	SPARE	
19	1	100	-	SPARE	
20	1	100	-	SPARE	
21	1	100	-	SPARE	
22	1	100	-	SPARE	
23	1	100	-	SPARE	
24	1	100	-	SPARE	

PANEL PA1
480/277 VOLT, 3 PHASE, 4 WIRE
100A MAIN LUG ONLY
36 CIRCUIT
LOCATION: ELECTRICAL ROOM

CKT #	BREAKER			SERVING	REMARKS
	POLE	FRAME	TRIP		
1	3	100	20	ELECTRICAL UNIT HEATER 1	
2	3	100	20	ELECTRICAL UNIT HEATER 2	
3	-	100	-	-	
4	-	100	-	-	
5	-	100	-	-	
6	-	100	-	-	
7	3	100	20	ELECTRICAL UNIT HEATER 3	
8	3	100	20	ELECTRICAL UNIT HEATER 4	
9	-	100	-	-	
10	-	100	-	-	
11	-	100	-	-	
12	-	100	-	-	
13	3	100	20	ELECTRICAL UNIT HEATER 5	
14	3	100	20	ELECTRICAL UNIT HEATER 6	
15	-	100	-	-	
16	-	100	-	-	
17	-	100	-	-	
18	-	100	-	-	
19	3	100	30	AC-1	
20	3	100	-	SPARE	
21	-	100	-	-	
22	-	100	-	-	
23	-	100	-	-	
24	-	100	-	-	
25-36	1	100	-	SPACE	

8.0 INSTRUMENTATION AND CONTROL

8.1 Existing Control System

The existing Process Control System (PCS) located at the NRO WTP was implemented in the original system configuration for operation of the RO process. Dare County has since upgraded some equipment and software, however, the general system configuration remains the same. The system utilizes programmable logic controllers (PLC) as a means of controlling and monitoring the current process. The system consists of a supervisory architecture with redundant hot standby PLCs located in the Control Room. The Control Room also houses remote I/O bases for connection of the existing process equipment. The PLCs are Allen Bradley PLC 5s with 1771 input/output (I/O) modules. Supervisory workstations are also located in the Control Room and serve as the man machine interface (MMI) for the operation of the plant.

8.2 Proposed System Hardware

The programmable logic controller hardware proposed for installation at the NRO WTP for this project includes the following equipment:

- Allen Bradley SLC 5/05 Programmable Logic Controller
- Operator Interface Terminal (OIT)

Although, the existing system utilizes remote I/O (input/output) bases for local connection to the distributed PLC structure, we proposed an independent PLC located in the electrical room of the proposed addition. This will provide a standalone, independent operation for the new process equipment, while communicating to the PCS for monitoring and control at the Control Room. The proposed I/O modules will operate at 24 VDC or 120 VAC power for digital devices, and 4 –20 mA signals for analog devices.

An operator interface terminal will be mounted on the front of the PLC cabinet located in the new electrical room for local indication and limited control functions.

8.3 Proposed System Software

The existing Man Machine Interface (MMI) software implemented at the workstation in the Control Room is developed by iFix from Intellution. This product is a strong foundation software package, which will be modified for the Arsenic Reduction project. The MMI graphics, database configuration, PLC programming, control strategies, and system logic of the new processes will be incorporated into the Intellution software to illustrate the monitoring of the system and to provide the required control of the facility. Additionally, the database will be expanded to include the new process implemented into the PCS.

This PLC programming software for the SLC 5/05 will be via RSLogix500, latest version, and will be provided to Dare County upon completion of the project.

8.4 Proposed System Architecture

The Process Control System for the NRO WTP Expansion project will be configured in a distributed architecture to provide a reliable means for operation of the new equipment. The PCS configuration for the new PLC will connect via an Ethernet network from the existing connection in the current electrical room back to the new electrical room in the expanded facility. This Local Area Network (LAN) communications structure will be designed based on an Ethernet TCP/IP protocol using a 10BaseT wiring system.

The following objectives are considered for the PCS configuration design:

- Standalone operation of the new processes
- Reliable communications
- Incorporation of technological advances to increase reliability and flexibility

8.5 Control Strategies

Detailed control strategies will be developed for each process of the proposed systems. The control strategies will provide specific information with regard to each device and process being modified. The control strategies will complement the Process and Instrumentation Diagrams (P&IDs) to provide an overall system operation, which will be followed and detailed throughout the system design and construction.

An Input/Output (I/O) point list will be developed for the additional processes as a method for updating the existing PCS. The I/O point list will be developed based on the process design and through communications with the process engineers.

8.6 Instrumentation

Proven and reliable instrumentation is essential for accurate process control and monitoring of the facility. The majority of the instrumentation provided will be selected through the manufacturers, based on the specifications. All process instruments will transmit a 4 – 20 mA analog signal to the proposed PLC for interfacing into the PCS.

9.0 OPINION OF PROBABLE PROJECT COST

9.1 Introduction

This chapter of the report provides an update on the cost opinions included in the Pilot Test Phase Report, which was presented to the County Commission and staff in December, 2003. This update benefits from more detailed design input than was available for the December submittal, particularly in the details of the proposed building addition to the NRO plant, a better understanding of the residual s handling issues and proposed solutions, and more current material and equipment pricing. The chapter also includes an opinion of probable operation and maintenance costs, and their impact on the unit cost of water produced from the NRO facility.

9.2 Capital Cost Opinion

The cost opinions presented in this chapter are based on a combination of vendor quotes, current industry pricing, and commonly used unit prices for civil works.

It is generally accepted that the accuracy of the cost opinions presented here for the level of detail available at this stage in the project (approximately 30% design) is in the range of -5 to +15%. Thus a contingency of 10%-15% is typically applied to the construction cost opinion. There is current volatility in the steel and other construction commodity prices, therefore a contingency of 15% is recommended for this stage in the design. Contractor's overhead and profit has been reduced to 15% to reflect the inclusion of some of these costs in the body of the construction cost estimate.

Process and civil works construction estimates are adjusted on the following basis.

- Interest during construction (15 month schedule) 5%
- Contingency 15%
- Contractors O/H and Profit 15%

All estimates are based on the installation of an arsenic reduction plant capacity of 5.0 MGD. However, the adsorption process building cost, blend water treatment process cost, and the cost of parts of the infrastructure such as the electrical room and wetwell, are costs based on the NRO buildout capacity of 8.0 MGD.

The capital cost opinions for the two treatment process options are tabulated below. The detailed costs for individual components have been listed on a spreadsheet, and grouped according to discipline. In each case only the proposed base bid item for each category where alternate bids will be solicited, such as stainless steel in lieu of lined and coated carbon steel.

Site work and drainage	$88,000
Building addition, including foundations, walls, floor trenches, etc	$581,000
HVAC and Plumbing	$81,700
Electrical	$79,200
Arsenic adsorption equipment	$1,300,000
Mn greensand system	$275,000
Balance of Process	$194,500
Instrumentation and control	$73,100
Subtotal	**$2,672,500**
Contingency @ 15%	$401,000
Contractors O/H & Profit @ 15%	$461,000
Total Construction Cost	**$3,534,500**
7-1/2 months Interest during construction @ 5%	$110,500
Engineering, fixed	$349,900
Total Capital Cost	**$3,994,900**

9.3 Operating Cost Opinion

Operating costs have been calculated using the pilot test data, input from the vendors, and chemical costs currently being charged the Dare County Water System. Ferric chloride was priced by regional chemical suppliers. Based on vendor input, the media replacement for the arsenic system is based on an 18 month life, and ten years for the greensand media. The costs are based on the production of 900 MGY

System operating costs include pumping power, the additional RO feed pump power needed to push the water through the adsorption columns (this backpressure should not exceed 12-15 psig), and the Mn greensand chemicals. Costs are also included for the removal and replacement of the adsorption column media, and the manganese greensand the media removal and replacement.

Media maintenance cost(based on vendor quotes)	$180,000
Sodium Hypochlorite	$3,500
Ferric Chloride	$1,500
Replacement Greensand	$1,250
Additional power (based on $0.05/kwhr)	$24,800
Total annual cost	**$211,050**
Incremental unit cost, $/kgal	**$0.23**

9.4 Reconciliation with Study

In the time that has elapsed since the preparation of the opinion of cost included with the pilot plant report, there has been a significant increase in the cost of steel, stainless steel, copper, and other construction commodities. This increase has apparently been sparked by a strong demand in foreign markets, particularly in China for steel products, and a significant increase in crude oil pricing. These factors have caused the current cost opinion for the arsenic reduction project in Dare County to experience a significant increase since October of 2003.

In addition, at the meeting with the Public Water Supply section representatives in January, it was requested that the arsenic system be a two stage system, in lieu of the single stage process that we were proposing at the time. This has essentially doubled the cost of the process equipment, and cause an increase in the new building footprint area from 3,000 square feet used in the October, 2003 opinion, to the current 5,570 square feet. At the same meeting, the potential difficulty in permitting waste discharge was discussed. As a result, the current design includes waste handling equipment and structures. These were not included in the earlier cost opinion.

The arsenic removal equipment for treating the RO blend water is also included in the current opinion, but was not included in the earlier work. This has added $275,000 in base construction cost, not including contingency, and contractor's overhead and profit

The table below compares the two opinions. The current opinion is in more detail than the pilot plant report opinion, which included vendor quotes for the arsenic equipment, but estimated the building on a unit cost basis of $125 per square foot.

Cost Item	October 2003	March 2004	Difference
Building Cost and site work	$555,000	$669,000	$114,000
Yard piping	$45,000	$32,000	($13,000)
Adsorption equip't & piping	$900,000	$1,300,000	$400,000
Electrical & other work	$450,000	$316,500	($133,500)
Blend treatment	-	$275,000	$275,000
Waste handling system	-	$80,000	$80,000
Total Cost	**$1,950,000**	**$2,672,500**	**$722,500**
Contingency	$292,500	$401,000	$108,500
Contractors O/H & Profit	$560,600	$461,000	($99,600)
Total Constructed Cost	**$2,803,100**	**$3,534,500**	**$731,400**
Interest during construction 5%	70,100	$110,500	$40,400
Engineering Fees	$420,500	$349,900	($70,600)
Total Capital Cost	**$3,293,700**	**$3,994,900**	**$701,200**

Examination of the difference column makes it clear that there a significant portion of the cost increase is due to the second stage of arsenic adsorption equipment, and the additional building area needed to house it.

APPENDIX A

PROPOSED LIST OF DRAWINGS

SHEET. NO.	TITLE	DWG.
GENERAL		
1.	COVER SHEET	G-1
2.	LEGEND, SYMBOLS, ABBREVIATIONS	G-2
3.	PIPE & VALVE SCHEDULES	G-3
DEMOLITION		
4.	DEMOLITION PLAN AND NOTES	D-1
SITE & CIVIL		
5.	SITE PLAN	C-1
6.	SITE DETAIL / CIVIL	C-2
PROCESS		
7.	NEW YARD PIPING PROFILE	P-1
8.	EXISTING PLANT PROCESS MODIFICATIONS	P-2
9.	PROCESS PLAN, USFILTER/SEVERN TRENT	P-3
10.	PROCESS PLAN, WRT	P-3A
11.	PROCESS PLAN, GREENSAND FILTERS	P-4
12.	PROCESS SECTIONS & DETAILS	P-5
13.	PROCESS SECTIONS & DETAILS	P-6
14.	PROCESS SECT'S & DETAILS, GREENSAND	P-7
15.	PROCESS PLAN, BACKWASH SYSTEM	P-8
16.	SECTIONS & DETAILS, BACKWASH SYSTEM	P-9
ARCHITECTURAL		
17.	BUILDING ELEVATIONS	A-1
18.	BUILDING DETAILS	A-2
19.	BUILDING FINISH SCHEDULE	A-3
STRUCTURAL		
20.	STRUCTURAL PLAN	S-1
21.	STRUCTURAL SECTIONS	S-2
21.	STRUCTURAL SECTIONS	S-3
22.	STRUCTURAL DETAILS	S-4

SHEET. NO.	TITLE	DWG.
23.	STRUCTURAL DETAILS	S-5
24.	FRAMING PLAN	S-6
25.	ROOF SECTIONS	S-7
26.	ROOF DETAILS	S-8
27.	WETWELL PLAN	S-9
28.	WETWELL SECTIONS & DETAILS	S-10
MECHANICAL		
29.	MECHANICAL PLAN	M-1
30.	MECHANICAL DETAILS	M-2
31.	PLUMBING PLAN	M-3
32.	BUILDING DRAIN PLAN	M-4
33.	PLUMBING DETAILS	M-5
ELECTRICAL		
34.	SYMBOLS, NOTES AND ABBREVIATIONS	E-1
35	ELECTRICAL SINGLE LINE	E-2
36.	ELECTRICAL PLAN	E-3
37.	NEW ELECTRICAL ROOM LAYOUT	E-4
38.	ELECTRICAL DETAILS	E-5
39.	ELECTRICAL DETAILS	E-6
INSTRUMENTATION		
40.	INSTRUMENT LEGEND & ARCHITECTURE	I-1
41.	P&ID, USF/STS	I-2
42.	P&ID, WRT	I-3
43.	P&ID, BACKWASH WETWELL	I-4
44.	P&ID, GREENSAND FILTER	I-5
45.	INSTRUMENT DETAILS	I-6

March 30, 2004

APPENDIX B

PROPOSED TECHNICAL SPECIFICATIONS

SECTION	TITLE
02016	Existing Utilities and Underground Structures
02016A	Subsurface Information
02065	Demolition
02110	Site Clearing
02150	Dewatering
02200	Earthwork
02281	Termite Control
02510	Pavement Restoration
02607	Inlets, Manholes, and Drainage Pipe
03100	Concrete Formwork
03200	Concrete Reinforcement
03300	Cast-in-Place Concrete
04340	Reinforced Masonry
05500	Miscellaneous Metals
05501	Anchor Bolts and Fasteners
06100	Rough Carpentry and Wood Members
06173	Metal Plate Connected Wood Trusses
06174	Wood Roof Decking
06175	Wood Roof Shingles
06200	Finish Carpentry
07112	Waterproofing
07210	Building Insulation
07631	Gutters and Downspouts
07920	Joint Sealants
08130	Overhead Coiling Doors
08220	Fiberglass (FRP) Doors and Frames
08711	Door Hardware
09900	Painting
09910	Chemical Resistant Coatings
11209	Submerged Sump Pumps
11211	Plastic Vertical Recycle Pumps

PROPOSED TECHNICAL SPECIFICATIONS (CONTINUED)

SECTION	TITLE
11212	Vertical Inline Centrifugal Pumps
11214	Air Compressors
11226	In-line Static Mixers
11660	Filter Bag Hoist Assembly
13100	PVC Tube Settlers15501
13209	Polyethylene Storage Tanks
13228	Cartridge Filters
13502	Starting and Placing Equipment in Operation
13510	USFilter Adsorption Equipment (Base Bid)
13511	Severn Trent Adsorption Equipment (Base Bid)
13512	WRT Adsorption System (Base Bid)
13513	Mn Greensand Equipment
13515	Chemical Feed Equipment
13520	Finished Water Instrument Panel
15058	PVC Pipe and Fittings, 12 Inches and Smaller
15066	Stainless-Steel Pipe
15100	Process Valves
15118	Electric Motor Actuators
15132	Pressure Gauges
15152	Magnetic Flow Meters
15410	Plumbing Piping
15440	Plumbing Specialties
15440	Plumbing Fixtures
15501	HVAC Equipment
15800	Fabric Duct
15990	Adjusting. Balancing, System Testing
16000	Electrical General Requirements
16110	Lightning Protection
16210	Raceways, Fittings and Boxes
16220	Conductors
16330	Wiring Devices
16410	Lighting Fixtures
16426	Panel Boards
16480	Motor Control Centers
16690	Electric Motors
16943	Programmable Logic Controller
16944	Process Control Logic
16950	Custom Control Panels