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DESIGN MANUAL
for
ANIX COLOR REMOVAL SYSTEM
Skyco Water Treatment Plant
Dare County, North Carolina
System ID# 04-28-030

Prepared For:

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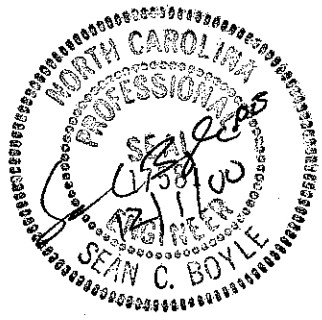

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CONSTRUCTION PLANS

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BOYLE ENGINEERING / ROS TEK PLAN SHEETS

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SECTION 01118. OWNER-FURNISHED EQUIPMENT

A. General

The Owner will furnish the following items of equipment:

Item	Quantity
1. 12ft diameter by 12ft Straight shell steel Anion Exchange vessels, electric valves and face piping	Five (5) vessel.
2. Backwash system, including pumps(2), electric valves, flow metering equipment.	One (1) lot.
3. Regeneration system, including brine pumps(3), brine tank fill pump(1), brine tanks(2), electric valves, and flow metering equipment	One (1) lot
4. Process Control system, including, Programmable Logic Controller, Supervisory computer.	One (1) lot
5. Resin Trap bag filter.	One (1).

B. Related Work Specified Elsewhere

1. Installing Owner-Furnished ANIX Color Removal System: Section 11001.

2. ANIX Color Removal System: Plans and Specifications, prepared by RosTek Associates/Boyle Engineering Corporation for the Dare County Water Department. Plans are included as part of the Contract Documents for this part of the project.

C. Custody

The Contractor shall assume custody of the above equipment when it is delivered to the project site -and shall assume liability for damage to the equipment thereafter. The Owner will not accept title to the equipment until the project is substantially complete in accordance with the General Provisions of the General Conditions.

D. Measurement and Payment

Payment for care, custody, and installation of the Owner-furnished equipment shall be included as part of the price for installing said equipment.

E. Inspection

Upon transferral of the Owner-furnished equipment to the Contractor, the Contractor and the Owner shall make a joint inspection of the condition of each piece of equipment and

shall note, in writing, the defects in said equipment. Damage or loss of equipment and materials after the date of their transfer to the Contractor shall be repaired or replaced at the Contractor's expense.

F. Delivery of Equipment

1. The ANIX Color Removal System manufacturer is responsible for arranging delivery of the equipment to the Project site. The Contractor will be notified of the proposed arrangements for shipping prior to the equipment being shipped. It is the responsibility of the Contractor to co-ordinate delivery and unloading of the equipment with the manufacturer and the trucking company. Contractor shall also keep Owners' personnel informed about the delivery and unloading schedule. The Contractor shall provide a crane and and other necessary lifting equipment, and labor experienced in heavy lifting of large equipment to unload the equipment.

2. After the equipment is unloaded and inspected as described in para E above, the Contractor shall store it in a safe and secure storage area on site, and make sure that the equipment is properly weatherproofed.. Storage for control and electronic equipment shall be provided in a secure climate-controlled environment on or off site.

G. Delivery Dates for Owner-Furnished Equipment

The Owner anticipates the following delivery dates for the Owner-furnished equipment to arrive at the project site:

Between June 15th and July 15th, 2001.

H. Owner-Furnished Technical Assistance

1. A field service representative from the manufacturer of the Owner-furnished equipment will be available to provide technical direction during installation of the equipment:

2. Contractor will be responsible for coordinating with manufacturer's representative for providing necessary services.

3. The representative of the Owner-furnished equipment manufacturers will provide the following services at no cost to the Contractor:

   a. One (1) day at the unloading and inspection of the equipment at the project site.

   b. One (1) day for preinstallation conference for discussion of the technical direction necessary to establish the installation planning, responsibilities, and scheduling methods employed during installation.

c. Thirteen (13) days for field assistance from the representative of the Owner-furnished equipment manufacturer for advisory assistance concerning installation of the equipment including alignment, doweling, and grouting of components, placement of concrete fill in ANIX vessels, installation of valves and face piping, installation of control system and control wiring and cabling, terminations, resin loading, installation of flow meters in Contractor-furnished piping, and all other Owner-furnished equipment installation features necessary for a complete and workable project.

d. Thirty (30) days on site by the representative of the Owner-furnished equipment manufacturer for equipment start-up, adjusting, and field testing, and operator training. Contractor shall provide support to the manufacturer of the Owner furnished equipment during this time. Skill requirements during this time will be primarily pipefitting, mechanical, and electrical.A total of four mandays on site by pump vendor service representatives

END OF SECTION

SECTION 11001 INSTALLING OWNER-FURNISHED EQUIPMENT(OFE)

PART 1 - GENERAL DESCRIPTION

This section includes installation, testing, and field painting of the Owner-furnished ANIX Color Removal System, described in Section 01118 of these specifications.

A. Related Work Specified Elsewhere

1. Owner-Furnished Equipment: 01118.
2. Cleaning and Painting Steel Structures, Equipment, and Piping: 02511.
3. Piping Schedule and General Piping Requirements: 15050.
4. Pressure Testing of Piping: 15144.
5. Disinfection of Piping: 15141.
6. Pressure Testing of Pipe: 15144.
7. Stainless Steel Piping: 15276.
8. PVC Piping, 3" and smaller: 15290.
9. PVC Piping, 4"-8" with Solvent Welded Joints: 15291.
10. Electrical General Provisions: 16010.
11. Electrical Conductors: 16220.

B. Owner-Furnished Data

Obtain the following data from the Owner:

1. Layout, arrangement, dimensional drawings, and mounting details for the ANIX vessels and other equipment.
2. Assembly drawings for erecting the ANIX Color Removal System, and associated appurtenances in place.
3. Valve dimensions including laying lengths.
4. Dimensions and orientation of valve actuators as installed on the valves.

5. Anchor bolt details.

6. Pump foundation requirements

7. Electrical drawings for conduit, wiring diagrams showing field wiring and terminal numbers and control features.

8. Piping and Instrumentation Diagrams (P&IDs)

C. Measurement and Payment

Payment for the work in this section shall be included as part of the lump-sum bid amount stated in the Proposal.

PART 2 - MATERIALS

A. Anchor Bolts

Provide concrete-embedded Type 316 stainless steel anchor bolts, nuts, and washers. Stainless bolts shall comply with ASTM A 193, Grade B8M; nuts shall comply with ASTM A 194, Grade 8M.

B. Gaskets, Bolts, and Nuts for Flanged Valves

Provide gaskets, bolts, and nuts for the Owner-furnished flanged valves. See detailed piping specifications Section 15050, Sections G, H, and I for gasket specifications.

PART 3 - EXECUTION

A. Installation

1. Install anchor bolts and mounting plates in cast-in-place concrete per the OFE equipment manufacturer's drawings.

2. Assemble and install pieces of equipment requiring field installation.

3. Provide the manufacturer's recommended lubricants in drives and other mechanical equipment.

B. Installing OFE Valves

1. Bolt holes of flanged valves shall straddle the horizontal and vertical centerlines of the pipe run to which the valves are attached. Clean flanges by wire brushing before

installing flanged valves. Clean flange bolts and nuts by wire brushing; lubricate threads with oil and graphite; and tighten nuts uniformly and progressively. If flanges leak under pressure testing, loosen or remove the nuts and bolts, reseat or replace the gasket, reinstall or retighten the bolts and nuts, and retest the joints. All joints shall be watertight. Do not mate flat faced and raised face flanges.

2. Provide spacers in the piping that is to be embedded in cast-in-place concrete in the event that the Owner-furnished valves do not arrive in time to be installed before pouring concrete. Spacers shall be steel pipe spools of at least the same length as the laying length of the valves.

3. Install valves per Section 15100.

C. Grouting Machinery Foundations

Grout foundations per OFE manufacturers directions.

D. Electrical Work

1. Install electrical conduit, wire, and junction boxes, nd terminal blocks to provide complete installation of the equipment. Make terminations at the mechanical equipment locations.

2. At control panels, consoles, and local control stations, identify and tag the control wires to facilitate termination, checkout, and future wire tracing by the owner.

E. Painting and Coating

1. Repair any damaged prime coat per Section 02511.

2. Apply intermediate and finish coats to exposed equipment (including motors and baseplates) per Section 02511. Color shall match the connecting piping.

3. Intermediate and finish coats shall be compatible with the prime coat.

F. Placing Equipment in Service

1. After the equipment has been installed and is ready for field testing, notify the Owner. The Owner will arrange a meeting with a representative of the equipment manufacturer to test the equipment's operation.

2. The Contractor shall be present at the meeting with the Owner and the equipment supplier's representative.

G. Field Testing

1. Contractor shall provide support to the ANIX Color Removal System supplier's field personnel during start up and testing of the System, as described elsewhere in these specifications.

END OF SECTION

SECTION 13206 FRP CHEMICAL STORAGE TANKS

PART 1 - GENERAL

A. Description

This section describes materials, fabrication, testing, and installation of aboveground fiberglass-reinforced plastic (FRP) tanks for chemical storage service.

B. Submittals

1. Submit shop drawings in accordance with the General Provisions.

2. Submit tank layout drawings showing dimensions, wall thickness, mounting brackets, knuckle radii, nozzle location and orientation, and nozzle construction.

3. Submit installation instructions for installing tank on a concrete slab.

4. Submit tank manufacturer's recommended bolt torques for flanges.

5. Submit a certificate listing the type of resin to be used, describing the manufacturer's brand name or designation, composition, chemical resistance, and characteristics.

6. Submit design calculations for structural and wind design of walls and design of tie-down lugs (number, size, and embedment length of anchor bolts) signed and stamped by a structural or civil engineer registered in the state of North Carolina.

7. Submit manufacturer's certification that tank construction complies with ASTM D 3299, D 2563, Level II (as modified herein), and these specifications.

8. Submit sample copies of the data forms and report forms for recording and reporting laboratory test data.

9. Submit copies of a laboratory report showing the results of tests conducted on cutouts from the tank shells. Perform the following tests on each tank:

   a. Glass content, degree of cure, and physical properties as described in ASTM D 3299, Sections 10 and 11.

   b. Glass content of total tank wall thickness per ASTM D 2584.

   c. Strain gauge testing on each tank, full size. Provide at least four tests on each shell.

Submit test reports before shipping tanks to the project site. Do not ship tanks until after the Owner has reviewed the test reports.

C. Measurement and Payment

Payment for the work in this section shall be included as part of the lump-sum bid amount stated in the Proposal.

PART 2 - MATERIALS

A. Manufacturers

Fiberglass tanks shall be manufactured by Tankinetics, Ershigs, Jones and Hunt, MFG Justin, Process Equipment Corporation, or equal.

B. Design Criteria

Volume shown in the drawings is measured from the tank bottom to the top of the straight shell. Tanks shall be filament-wound fiberglass manufactured in accordance with ASTM D 3299, except delete Subsection 14.6. Resin shall be Derakane 411, Ashland Hetron 922, or equal. Resin shall be suitable for continuous immersion in the liquid described in the subsection herein on "Service Conditions," and shall be resistant to those fluids as defined by ASTM C 581. See drawings for tank dimensions, nozzle sizes, and nozzle orientation.

C. Laminate Construction

1. Provide at least three inner laminated layers as a corrosion barrier on the tank interior totaling a minimum of 120 mils in thickness and an exterior filament-wound layer for structural strength. The inner layer shall be resin rich, shall consist of polyester organic fiber, and shall be a minimum of 20 mils thick. Glass content in the inner layer shall be 20% ±5% by weight.

2. The remaining two layers (inner liner) shall be composed of chopped strand mat having a glass content of 25% ±5% applied at a rate of 3 ounces per square foot. The inner liner shall be formed not sprayed. Chopped roving fibers shall be 1/2 to 2 inches in length.

3. The average glass content of the inner three layers shall be 27% ±5% by weight.

4. The exterior layer shall be filament wound. Minimum glass content in the filament-wound layers shall be 65%.

5. The total tank wall thickness (excluding additional thickness provided for knuckle reinforcement) shall have an average glass content of 55% by weight ±5% per ASTM D 2584.

D. Additional Requirements for Tanks in Sodium Hypochlorite (NaOCl) Service

1. No thixatrope shall be used in any of the laminates.

2. The tanks shall be postcured with a BPO/DMA cure system and heat cured at a minimum temperature of 180°F for a minimum of two hours.

E. Anchors and Anchor Bolts

Design anchors and anchor bolts per the following requirements:

1. Seismic Design Parameters--Conform to API 650:

Seismic Zone	1
Zone Coefficient, Z	0.075
Essential Facility Factor, I	1.25
Horizontal Force Factor, Cp	0.19

2. See subsection on "Liquids Stored" herein for the specific gravities of the tank contents.

3. An unreinforced concrete housekeeping pad above the reinforced concrete structural slab shall not be considered to have structural value in the design of the anchor bolts. Maximum hoop stress shall not exceed 1/10 of the ultimate hoop strength of the laminate.

F. Nozzles

Nozzles shall have conical gusset supports and shall be designed for a minimum torque of 2,000 foot-pounds and a minimum bending moment of 1,500 foot-pounds. The gusset shall be attached to the full perimeter of the flange and at the intersection with the tank wall to provide 360-degree distribution of stresses. Nozzle construction shall be of the molded type per ASTM D 3299. Nozzles shall be flanged, minimum 2-inch size. Flange dimensions shall conform to ANSI B16.5, Class 150.

G. Flat Bottom Heads

Construct flat bottom heads integrally with the tank shell as one seamless piece.

H. Ultraviolet Protection

Provide ultraviolet protection in the form of a surface coating of a permanent resin-rich exterior layer, pigmented white. Surfaces shall be smooth, hard, and glossy. Thickness of this external layer shall be at least 10 mils.

I. Quality Control

Construction shall comply with ASTM D 2563, Level II, except that maximum frequency of air bubble in liner portion of laminate shall be 10 per square inch of laminate with maximum bubble size of 1/16 inch. Wall hardness shall be at least 90% of the resin manufacturer's recommended Barcol hardness, with a minimum Barcol hardness of 35,

with the resin fully cured. Maximum strain in the laminate shall be 0.001 inch/inch. Appearance of the tank interior and exterior shall comply with ASTM D 3299, Section 9.

J. Liquids Stored

Liquids stored within the tanks are described below. See the section on "Service Conditions" to determine which tanks contain the particular liquid described.

Liquid contained	12.5% sodium hypochlorite
Specific gravity	1.15
Temperature	45°F to 120°F

K. Radius of Turns and Knuckles

Tanks shall have minimum knuckle radii of 1-1/2 inches.

L. Lifting Lugs

Provide at least two side-mounted lifting lugs on tanks having a capacity of 200 gallons and less. Provide four side-mounted lifting lugs on tanks having a capacity of more than 200 gallons.

M. Tie-Down Lugs and Anchor Bolts

Tie-down lugs and anchor bolts shall be Type 316 stainless steel. Bolts shall conform to ASTM A 193, Grade B8M. Nuts shall conform to ASTM A 194, Grade 8M. All lugs shall be integrally filament wound into the tank walls. Provide washers (minimum 1/8 inch thick) of the same materials as the nuts.

N. Wall Thickness

Determine wall thickness per ASTM D 3299, Section 5, assuming a fluid specific gravity as described above. Minimum total wall thickness shall be 3/16 inch for tanks having a diameter 4'-0" or less and a height of 8'-0" or less. Wall thickness for larger tanks (in either diameter or height dimension) shall be at least 1/4 inch.

O. Reinforcement at Openings

1. Where nozzles, manways, or openings are provided, reinforce the wall thickness per ASTM D 3299, Section 6.

2. For openings 12 inches and larger, provide additional reinforcing plies of woven roving and chopped glass in the structural layers of the tank base wall laminate at the opening location point when the tank shell is built.

P. Gaskets for Flanged Nozzles and Manways

Provide 1/8-inch-thick fullface ethylene propylene rubber (EPR) gaskets having a 40 to 60 durometer A hardness for nozzles and manways. When the mating flange has a raised face, provide a flat ring gasket filler between the FRP flange gasket and the adjacent flange.

Q. Bolts and Nuts for Flanged Nozzles and Manways

Bolts shall be Type 316 stainless steel, per ASTM A 193, Grade B8M. Nuts shall conform to ASTM A 194, Grade 8M. Provide washer for each nut and bolthead. Washers shall be of the same material as the nuts.

R. Pipe Supports

Pipe supports shall be FRP integrally laminated into the tank shell. Bolts, nuts, washers, and screws shall be Type 316 stainless steel. Provide washer under each nut, bolthead, and screw head. Provide supports for all conduit and level indicators.

S. Leakage Testing

Test each tank at the factory or place of manufacture by filling with water. Allow the water to stay in the tanks for at least two hours. Check tank and nozzles and knuckles for leaks. Repair leaks and retest the tank until no leaks are observed.

PART 3 - EXECUTION

A. Shipment and Inspection

1. Unload tanks in accordance with ASTM D 3299, Appendix XI, and the manufacturer's recommendations regarding holding, supporting, and restraining.

2. After delivery to the site, the Owner will check tanks for cracks, holes, and other characteristics listed in ASTM D 2563, Table I. Remove any tank not complying with ASTM D 2563, Table I, Level II, from the project site and replace with tanks meeting the specifications.

B. Installation

Install tanks level as shown in the drawings. Erect vertical tanks in accordance with ASTM A 3299, Appendix X1.2. Provide a rubber pad or layers of roofing felt between the tank bottom and the underlying slab as recommended by the tank manufacturer.

C. Service Conditions

1. Tank service conditions shall be as shown below.

2. Tank Tag Number: T-500A and T-500B

Description:	Sodium Hypochlorite Storage Tanks
Liquid Contained:	Sodium Hypochlorite
Size: (diameter X straight shell height)	7 X 10-feet
Capacity: (minimum)	2850 gallons each

D. Field Testing

1. Fill each tank with water and allow tank to set for seven days. Do not attach connecting piping until after the test period to allow for any differential settlement. Check for leaks and correct or repair any leaking areas.

2. During the tank filling, check that liquid level gauges operate smoothly without binding. Assure that floats and targets move up and down without sticking.

END OF SECTION

SECTION 13209 HIGH DENSITY POLYETHYLENE STORAGE TANKS

PART 1 - GENERAL

A. Description

This section includes materials and installation of high density polyethylene storage and day tanks for aboveground storage service.

B. Submittals

1. Submit shop drawings in accordance with the General Provisions.

2. Submit tank layout drawings showing dimensions, wall thicknesses, mounting brackets, nozzle locations, nozzle construction.

3. Submit manufacturers data showing materials of construction and chemical resistance.

C. Measurement and Payment

Payment for the work in this section shall be included as part of the lump-sum bid stated in the Proposal.

PART 2 - MATERIALS

A. Manufacturers

Crosslinked Polyethylene tanks shall be manufactured by Nalgene, Rotational Molding Inc, Chemtainer, or equal.

B. Tank Construction

1. Tanks shall be manufactured of high density rotationally molded polyethylene. The day tanks shall be vertical with an integral domed top. The tank shall incorporate bulkhead type nozzles.

C. Design Criteria

Design tanks to withstand the maximum internal pressure created by a full tank of stored chemical with a safety factor of 2.

D. Fittings

Fittings shall be PVC flanged or threaded fittings, unless otherwise noted. Gaskets for the fittings shall be teflon or viton.

E. Anchor Bolts

Anchor bolts shall be Type 316 stainless steel. Bolts shall conform to ASTM A 193, Grade B8M. Nuts shall conform to ASTM A 194, Grade 8M.

PART 3 - EXECUTION

A. Service Conditions

1. Description: Hypochlorite Day Tank

Liquid Contained: 12.5% Sodium Hypochlorite

Minimum Capacity: 300 gallons

Inside Diameter: 3 feet maximum

Minimum Height: 5.5 feet

Provide outlets as required to connect chemical feed and transfer equipment.

B. Installation

Install tanks level, per the manufacturer's recommendation, as shown in the drawings.

C. Field Testing

Fill each tank with water and allow the tanks to set for 7 days without leaking. Do not connect the connecting piping until the tanks have passed the test.

END OF SECTION

SECTION 13514 SODIUM HYPOCHLORITE FEED EQUIPMENT

PART 1 - GENERAL

A. Description

This section provides for the supply, installation and placing in service of the Sodium Hypochlorite Feed System. The system shall consist of two FRP bulk storage tank, polyethylene day tank, calibration tubes, metering pumps, and associated piping, valves, fittings and controls.

B. Quality Controls

1. All components must be products of qualified manufacturers regularly engaged in the manufacture of these components.

2. All components must comply with the applicable codes and standards, as described elsewhere in this specification.

3. All components shall be made available for inspection at the manufacturer's facility by the Owner or his representative prior to shipment.

C. Submittals

1. Submit shop drawings in accordance with the General Provisions.

2. Submit dimension drawings showing size and arrangement of all tanks, valves, and equipment.

3. Submit manufacturer's catalog data and descriptive literature for equipment showing materials of construction.

4. Submit manufacturer's certification that the equipment supplied including the piping, valves, pumps, etc., are manufactured from materials suitable for the intended chemical service.

D. Measurement and Payment

Payment for the work in this section shall be included as part of the lump sum bid amount stated in the Proposal.

PART 2 - MATERIALS

A. Calibration Tube

A clear Pyrex glass calibration tube shall be provided and installed between the bulk tanks and the metering pump suction manifold, as shown on the P&ID. The calibration tube shall be graduated, with engraved calibrations, and shall be valved so that the tube may be filled by gravity flow from the bulk tanks, isolated, and used as a suction chamber for the pumps. The calibration tubes will be firmly mounted on the wall. Contractor shall provide supports for all chemical feed piping and appurtenances. Devices shall have a minimum capacity of 200 mL of sodium hypochlorite and calibrated in 5 mL increments. Vent the top of the calibration chamber to the top of the day tank.

B. Piping

1. Piping and fitting for the chemical fill station shall be manufactured from Schedule 80 PVC.

2. Piping from bag filter to the bulk tanks and from the bulk tanks to the day tank shall be manufactured from Schedule 80 PVC.

3. All calibration columns, pressure control devices, valves, and pump suction and discharge headers shall be piped with Schedule 80 PVC.

C. Tubing

Tube and tube fittings shall be manufactured from polyethylene. Pipe suction and discharge lines shall be tubing. Tubing shall be run to all injection points. Tubing shall be one continuous piece from chemical pump discharge header to the injection point. All tubing outside of the chemical feed area shall be housed in a 2-inch schedule 80 PVC encasement. Unions must be provided in the containment piping at each change of direction to aid in assembly.

D. Valves

1. The ball valves for hypochlorite service shall be manufactured from Schedule 80 PVC, as supplied by Asahi/America, or equal.

2. The contractor shall drill a 1/8-inch hole in the downstream side of the "ball" when valve is shut. The hole shall be de-burred and valve shall operate without binding. This will relieve the vapor pressure in the valve when in the closed position.

E. Hypochlorite Metering Pumps

Provide four (4) metering pumps (Tag numbers FP-1, FP-2, FP-3 and FP-4).

The chemical feed pumps for sodium hypochlorite shall be electronically operated diaphragm pumps with non-metallic bodies and manual control of stroke. Speed shall be controlled by a 4-20mA output from the PLC. The pump bodies shall be fabricated from glass reinforced polypropylene, with electronic controls permanently encapsulated in a corrosion-resistant polymer.

The liquid end and fittings shall be fabricated from PVC, and shall be equipped with a four-way, multi-function valve assembly with the pressure relief set to 50 psig. The ball valves shall be fabricated from ceramic material, and be installed in self-centering valve system.

The pump shall be driven by a 120VAC, 60 Hz, 1 phase, electric motor, plugged into a controlled outlet.

The pumps shall be B Series electronic metering pumps, as manufactured by the Liquid Metronics Division of Milton Roy.

F. Sodium Hypochlorite Injector Assemblies

The injector shall be fabricated entirely from PVC, and shall have an integral check valve in the injector quill. Injector quill shall have an outlet jet at the end of the quill and shall project a minimum of 3-inches into the pipe body. The sodium hypochlorite injector for pre-chlorination shall be inserted into the connection shown on the drawings. The post chlorination injector quill shall be inserted into the existing injection point prior to the booster pumps. The injector shall be screwed into a female NPT nipple incorporated into the body of the pipe.

G. Hypochlorite Tank Level Indicators

The tank level indicators for the bulk and day tanks shall be supplied as a complete assembly by one manufacturer. All parts in contact with hypochlorite shall be manufactured from PVC suitable for use in 12.5% sodium hypochlorite. The assembly shall include an indicating scale and ball valves top and bottom for isolation. The device shall be a magnetic flag type liquid level indicator, Gems "Suresite", or approved equal.

H. Hypochlorite Bulk Tank Ultrasonic Level Indicating Transmitter

1. The system shall use ultrasonic ranging to measure the level of liquid and shall consist of a sensor with interconnecting cable and control transmitter unit which can be located up to 1200 feet from the sensing unit. Transmitter shall be microprocessor based. Level sensing shall be automatically compensated over the system temperature range of at least 0°C to 50°C and shall incorporate digital algorithmic echo extraction and filtering. Synchronization capability shall be provided. When synchronized, no transmitter shall transmit a signal within a certain time interval of the prior one. Application parameters shall be stored in non-volatile EEPROM. Calibration shall require no reference targets. Accuracy shall be +/-0.25% or better. Output shall be 4

mA to 20 mA proportional to the range of level sensing. Ultrasonic transmitter shall also have a minimum of three contact outputs (SPDT each) with adjustable setpoints and deadbands which can be used for pump control and alarming. In the case of momentary signal loss, relays shall maintain their last state. The transducer shall be FM approved for Class I, Division 1 and housed in a NEMA 4X enclosure. The ultrasonic unit shall be powered by 115 volts ac. Transducer to transmitter interconnecting cable shall be provided.

2. Ultrasonic unit shall be Milltronics HydroRanger Plus with XPS 10 transducer, or equal.

3. Provide analog indicator for each level transmitter. The location for the indicator shall be at the chemical unloading station as shown in the drawings.

LEVEL TRANSMITTER

GENERAL		
Tag No.	LIT-510	LIT-511
Service	Sodium Hypochlorite Tank Level	Sodium Hypochlorite Tank Level
Type	Sonic	Sonic
Function	Transmit Level	Transmit Level
TRANSDUCER		
Material	PVDF	PVDF
Range, feet	0-12	0-12
Cable, feet	200	200

I. External Back Pressure (Anti-Siphon) Valve

The external back pressure valve shall be field adjustable but shall be shipped from the supplier set at a pressure of 50 psi. The valves shall be constructed of PVC with a PTFE diaphragm. The valves shall have a maximum operating pressure of at least 75 psig. The valve shall be globe type. End connections shall be a minimum 1/2 inch threaded NPT. Locate the anti-siphon/back pressure valve at the point of injection. Provide all supports necessary for the anti-siphon valve.

J. Pulsation Dampeners

1. Provide pulsation dampeners for the chemical feed system. The pulsation dampener shall be of the appendage type having a gas-charged bladder in a PVC or Teflon pressure vessel. Design dampener as a pressure vessel per the ASME Boiler and Pressure Vessel Code, Section IX. Minimum air volume shall be 1 pint. Pulsation dampeners shall be Greer Bladder Accumulator, Pulsafeeder Pulsatrol, or equal.

2. Provide a steel support bracket with rubber seating cushion for dampner. Connections shall be threaded per ANSI B1.20.1.

END OF SECTION

SECTION 15276 STAINLESS-STEEL PIPE

PART 1 - GENERAL

A. Description

This section includes materials and installation of stainless-steel pipe and fittings 18 inches in diameter and smaller conforming to ASTM A 312 or A 778 and having a maximum design pressure of 150 psi.

B. Related Work Specified Elsewhere

1. Painting and Coating: 09900.
2. Piping Schedule and General Piping Requirements: 15050.
3. Equipment, Piping, Duct, and Valve Identification: 15075.
4. Manual, Check, and Process Valves: 15100.
5. Pressure Testing of Piping: 15144.

C. Submittals

Submit shop drawings in accordance with Special Provisions and Section 01300. Submit spool drawing prior to fabrication.

D. Measurement and Payment

Payment for the work in this section shall be included as part of the lump-sum bid amount stated in the Proposal.

PART 2 - MATERIALS

A. Pipe

1. Pipe smaller than 3 inches shall conform to ASTM A 312, Grade TP 316L. Pipe 3 inches and larger shall conform to ASTM A 312 or A 778, Grade TP 316L.
2. Pipe sizes and wall thicknesses shall conform to ANSI B36.19 as follows:

Pipe Size	Wall Thickness
1 inch and smaller	Schedule 80S
1-1/4 inches through 3 inches	Schedule 40S
3-1/2 inches through 8 inches	Schedule 10S
Larger than 8 inches, through 18 inches	Schedule 10S

B. Fittings

1. Fittings 3 inches and smaller shall be socket welded, conforming to ANSI B16.11, 3,000-pound CWP. Material for socket welded fittings shall conform to ASTM A 403, Class WP316L or ASTM A 182, Grade F316L.

2. Fittings for buried or submerged pipe larger than 3 inches through 24 inches shall be butt-welded, conforming to ASTM A 403, Class WP or ASTM A 774, same material and wall thickness as the pipe, conforming to ANSI B16.9. Elbows shall be short radius.

3. Fittings for aboveground or exposed pipe larger than 3 inches through 18 inches shall be butt-welded or flanged, conforming to ASTM A 403, Class WP or ASTM A 774, same material and wall thickness as the pipe, conforming to ANSI B16.9. Elbows shall be short radius.

C. Pickling, Passivating, and Final Cleaning

Pipe and fittings shall be final cleaned, pickled, and passivated per ASTM A 380. After final cleaning, wet surfaces with water and inspect for rust spots after 24 hours. Reclean if there is any evidence of rusting.

D. Quality Control

Include the "Hydrostatic Test" and "Flattening Test" requirements described in ASTM A 530.

E. Protective End Caps

Provide protective end caps on each piece of pipe or fabricated section, completely sealing the piece from contamination during shipment and storage. Provide the same type of seals on each fitting, or ship and store fittings in sealed boxes or containers.

F. Joints

1. Joints for pipes 3 inches and smaller shall be socket welded, same material as specified for fittings, 3,000-pound WOG, conforming to ANSI B16.11.

2. Joints for buried or submerged pipe larger than 3 inches shall be butt-welded.

3. Joints for aboveground or exposed pipe larger than 3 inches shall be flanged or butt-welded.

G. Outlets and Nozzles

1. Outlets of size 3 inches and smaller in piping 4 inches and larger shall be of the Thredolet type, per MSS SP-97 and AWWA Manual M11 (1989 edition), Figure 13-23. Outlets shall be 3,000-pound WOG stainless steel per ASTM A 182, Grade F316L, or ASTM A 403, Grade WP316L. Threads shall comply with ANSI B1.20.1. Outlets shall be Bonney Forge Co. "Thredolet," Allied Piping Products Co. "Branchlet," or equal.

2. See Section 15201 for additional requirements.

H. Thread Lubricant

Use Teflon thread lubricating compound or Teflon tape.

I. Flanges

1. Provide weld-neck flanges (conforming to ANSI B16.5) for piping 3 inches and smaller to connect to flanged valves, fittings, or equipment. Provide weld-neck or slip-on flanges for piping larger than 3 inches. Flanges shall be Class 150 per ANSI B16.5. Flanges shall match the connecting flanges on the adjacent fitting, valve, or piece of equipment. Flanges shall be flat face. Van Stone flanges are unacceptable.

2. Material for weld-neck and slip-on flanges shall conform to ASTM A 182, Grade F316L.

J. Bolts and Nuts for Flanges

See Section 15050.

K. Lubricant for Stainless-Steel Bolts and Nuts

See Section 15050.

L. Gaskets for Flanges

See Section 15050.

PART 3 - EXECUTION

A. Fabrication, Assembly, and Erection

1. See Section 15201. Use an inert or shielding gas welding method. Do not use oxygen fuel welding. The interior of the pipe shall be purged with inert gas prior to the root pass.

2. Welded butt joints (both longitudinal and circumferential) shall comply with AWWA C220, Section 4. Do not allow heat tint to form in the heat affected zone (HAZ) or remove heat tint completely from the HAZ of the finished weld. The maximum depth of grinding or abrasive blasting to remove defects shall not exceed 10% of the wall thickness. Do not perform abrasive blasting with steel shot, grit, or sand.

3. Welding electrodes shall comply with AWS A5.4. Bare wire shall comply with AWS A5.9. Use electrodes E 316 for Type 316 stainless steel.

B. Installing Flanged Piping

See Section 15050.

C. Installation of Stainless-Steel Bolts and Nuts

See Section 15050.

D. Installing Aboveground or Exposed Piping

See Section 15050.

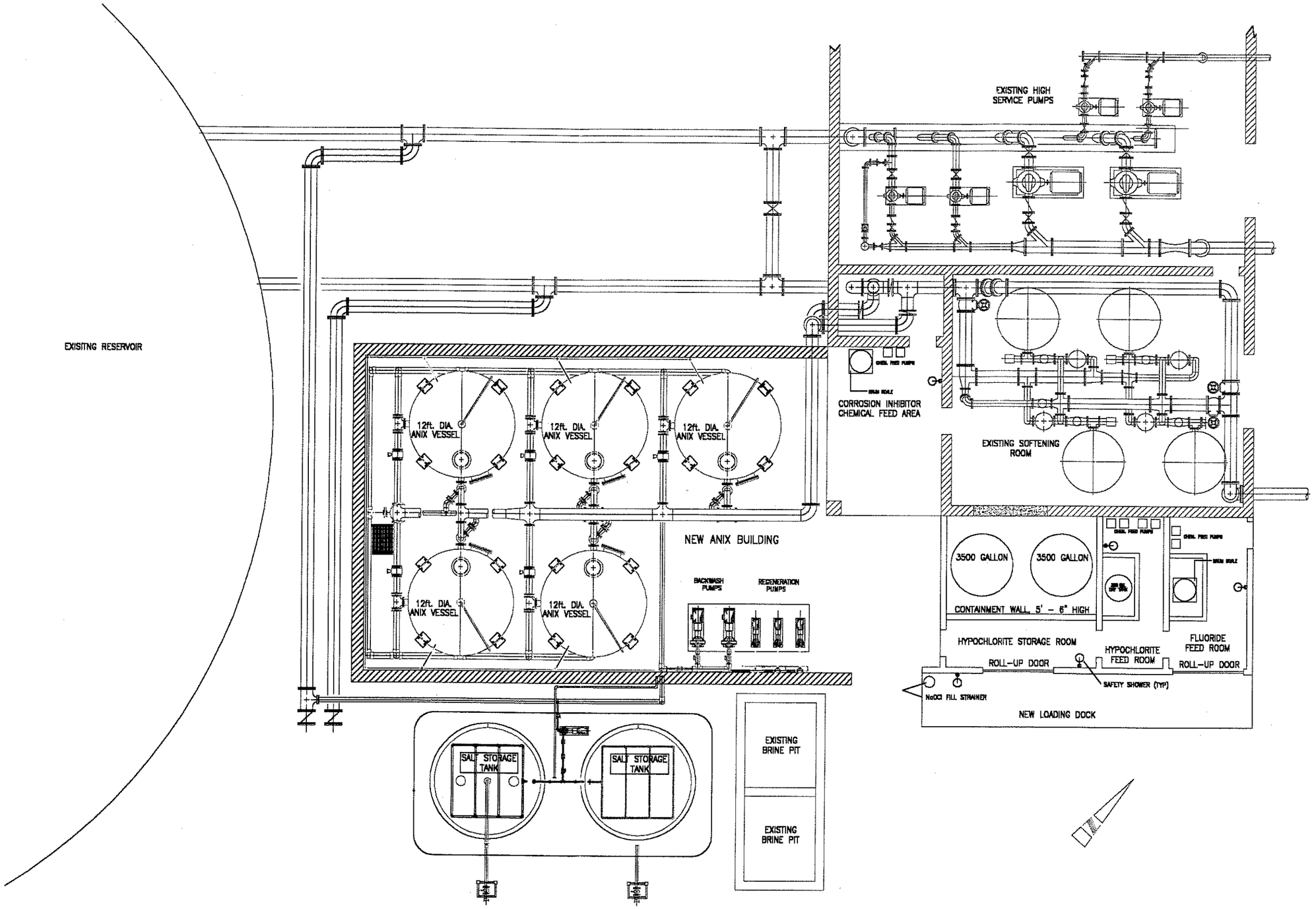
E. Installing Buried Piping

Install in accordance with Sections 02223 and 15201.

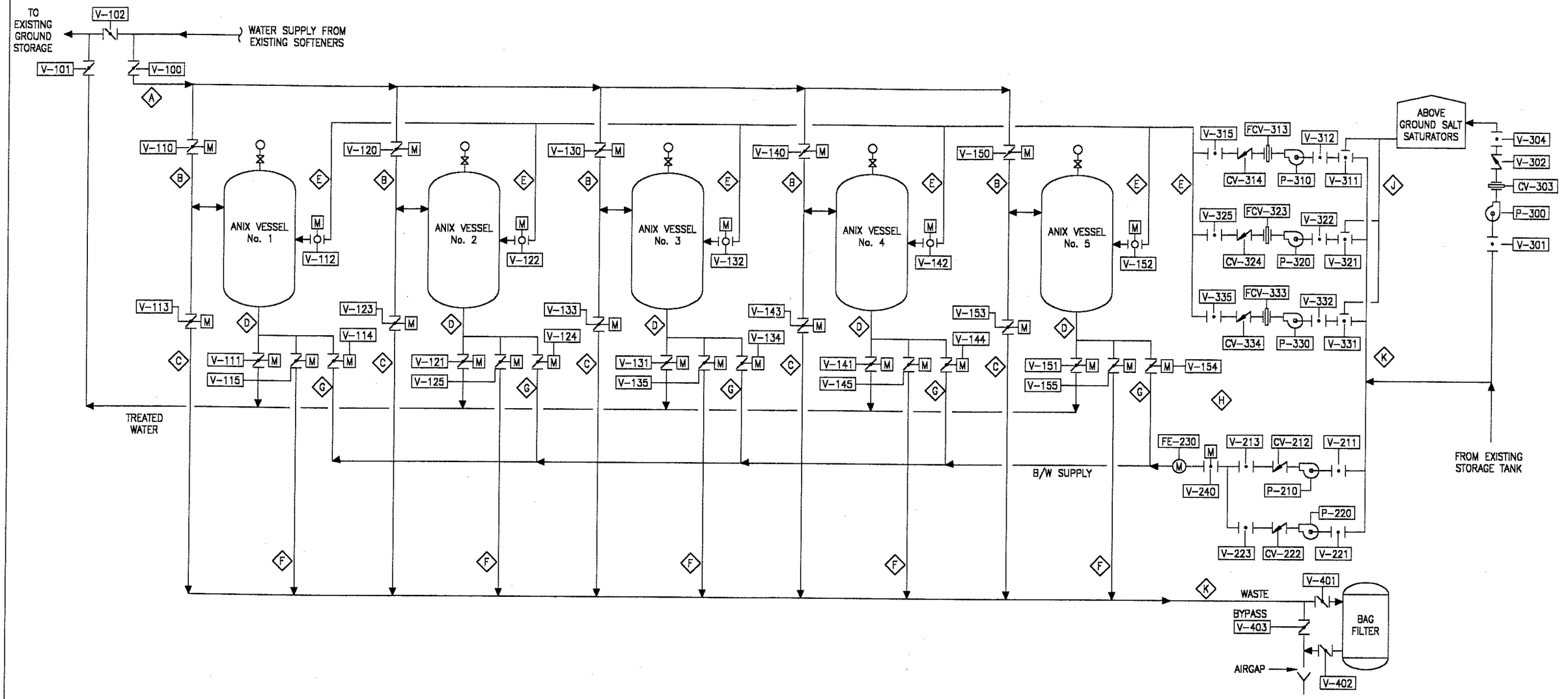
F. Field Hydrostatic Testing

See Section 15144.

END OF SECTION

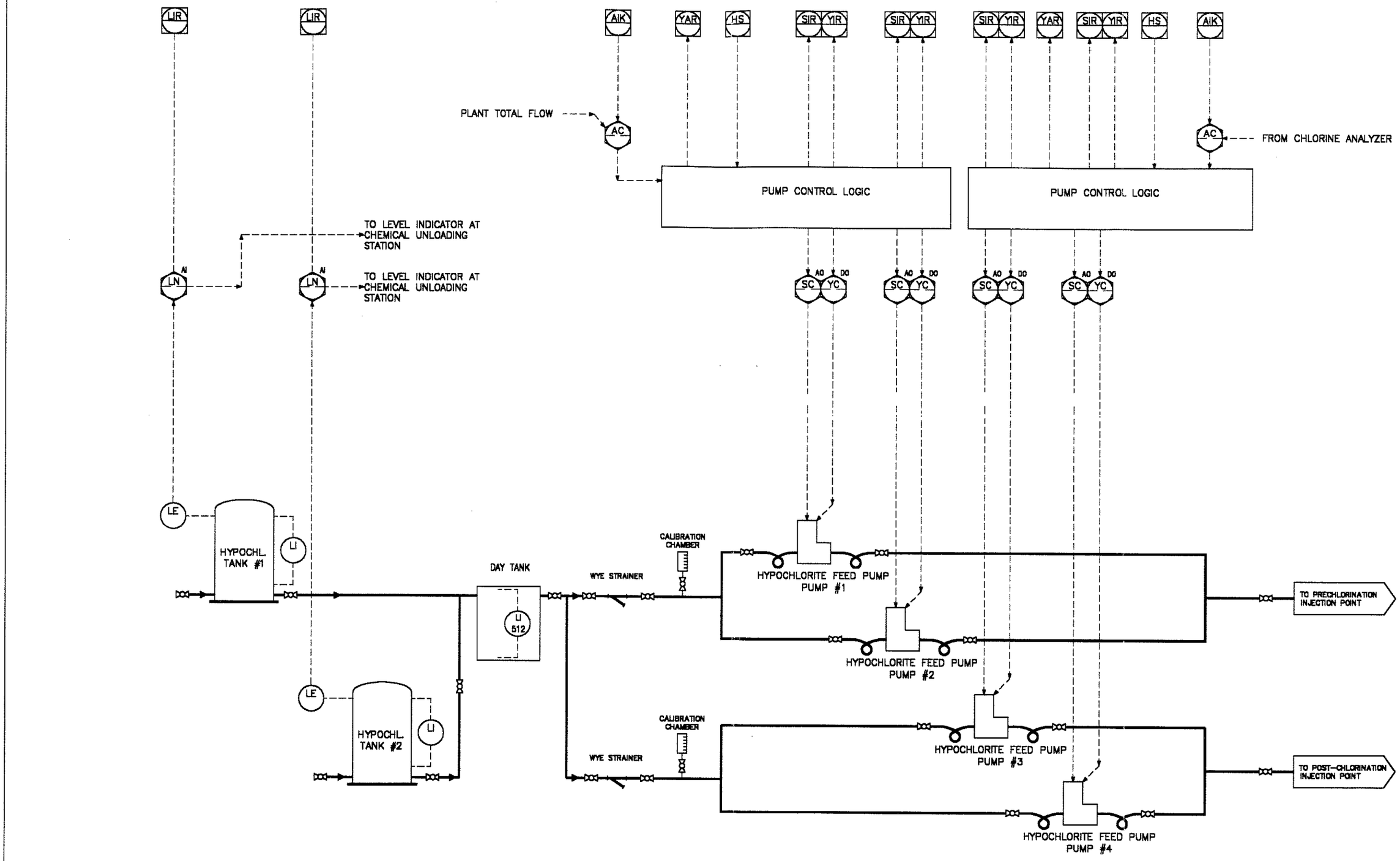


GENERAL ARRANGEMENT DRAWING



Line Designation	A	B	C	D	E	F	G	H	I	J	K
Description	Softened	Vessel Feed	B/W to Waste	Treated Water	Regenerant	Rinse to Waste	B/W Supply	Treated	Saturated Brine	Dilution	Waste
Flow (gpm)	3125	625	340	625	52	52/340	340	3125	26	26	340
Size (inches)	16	8	8	8	2	8	6	16	2	2	8
Material	Sch. 10 SST	Sch. 10 SST	PVC	Sch. 10 SST	PVC	PVC	PVC	Sch. 10 SST	PVC	PVC	PVC

PROCESS FLOW DIAGRAM



SODIUM HYPOCHLORITE FEED SYSTEM

TECHNICAL MEMORANDUM

BASIS OF DESIGN

ANIX COLOR REMOVAL SYSTEM

SKYCO WTP, MANTEO, NORTH CAROLINA

prepared for

DARE COUNTY WATER DEPARTMENT

ROBERT ORESKOVICH, DIRECTOR

by

ROSTEK ASSOCIATES, INCORPORATED – PROGRAM MANAGER

BOYLE ENGINEERING CORP. – PROCESS CONSULTANT

QUIBLE & ASSOCIATES, PC – BUILDING/CIVIL CONSULTANT

Draft, August, 2000

Final, November 2000

BASIS OF DESIGN MEMORANDUM

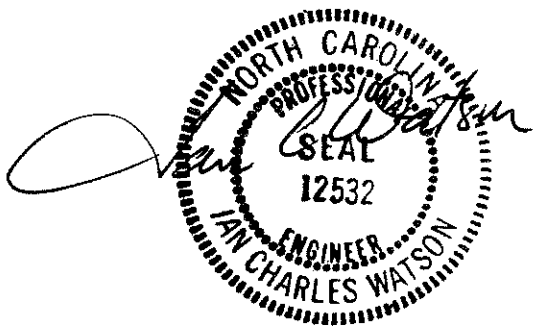
ANIX COLOR REMOVAL SYSTEM

SKYCO WATER TREATMENT PLANT

MANTEO, NORTH CAROLINA

AFFIDAVIT.

This affirms that the work described and summarized in this Technical Memorandum has either been performed by me, or under my direct supervision.



Ian C. Watson, PE

November 9, 2000

NC License # 12532

Expires: December 31st, 2000

BASIS OF DESIGN MEMORANDUM
ANIX COLOR REMOVAL SYSTEM
SKYCO WATER TREATMENT PLANT
MANTEO, NORTH CAROLINA

BACKGROUND

Dare County Water Department serves the residents and visitors to the Outer Banks with potable water. The Department currently operates four water treatment plants and non-contiguous water transmission and distribution systems. Potable water is also wholesaled to the Towns of Nags Head, Kill Devil Hills and Manteo.

One of the four water treatment systems is located on Roanoke Island, at the Skyco plant. This was the County's first water treatment plant, and it went into service in 1980. The treatment process is sodium cycle ion exchange softening, using groundwater as the feed source. The nominal design capacity is 5.0 mgd.

The water treatment system consists of 10 freshwater wells (170-220ft); a raw water booster station (currently not in operation); the treatment building, with laboratory and office space; high service pumping; post treatment equipment for chlorination, fluoridation, and corrosion inhibition; a ground storage tank of 2.0 mg capacity; and a 200,000 gallon elevated storage tank. Treated water from the facility is pumped to the Town of Manteo, and through a sub-aqueous transmission main to the northern Outer Banks.

The water quality from the freshwater well system is generally good, except for hardness and slightly elevated Total Organic Carbon (TOC). After the softening and post-treatment process, the finished water quality is consistently in compliance with the current requirements of the State of North Carolina. However, the organic content of the water, when exposed to the chlorination process, forms trihalomethanes (THM) in the system at

a concentration close to the current MCL (maximum contaminant level). It is expected that even with changes to the disinfection strategies that the water from the current Skyco treatment process will not consistently meet the future MCL for THM.

Since the current treatment process performs well, a completely new treatment process is not indicated, nor would it be cost effective at this time. Based on this decision, the approach is either to reduce the formation potential of THM by removing the organic material from the water; or alternatively to change the disinfection strategy to chloramination. The latter option was discarded because the County and all three Towns practice chlorination, and to change the entire system to chloramines would be impractical. Therefore, removal of the organics, and thus the THMFP, became the preferred treatment strategy.

TREATMENT OPTIONS

The three options for organics removal examined by the County were:

- Absorption on activated carbon. A limited bench scale testing was performed at the Rodanthe-Waves-Salvo reverse osmosis water treatment plant.
- Adsorption on anion exchange resin. Pilot testing was done at Skyco, Hatteras, Rodanthe-Waves-Salvo RO plant, and Kill Devil Hills RO plant.
- Removal by Nanofiltration. No pilot testing was performed. Potential performance and costs were evaluated based on experience elsewhere.

The County staff conducted a series of small-scale tests at the Rodanthe-Waves-Salvo RO plant with activated carbon filters in 1998. Organics absorption was limited, with the removal efficiencies experienced not high enough to guarantee future compliance with Disinfection/Disinfection By Products rules.

Pilot testing with anion exchange was conducted at all of the County's water treatment plants over the past three years. The initial testing was done at Cape Hatteras in

anticipation of a new water treatment plant at that location. As a result, an anion exchange system was installed in parallel with the new reverse osmosis (RO) plant, to remove THMFP from a shallow ground water to be used as blend for the RO permeate. The results of the pilot testing were reported by Kim[1] to the County in 1998. The results of the testing done at Skyco indicated that TOC removal of 75% and an exhaustion cycle of 750-1000 bed volumes could be expected. Conceptual cost estimates placed the capital expense at $0.55/gpd, including engineering and contingency; and O&M cost at $0.11/kgal. Compared to the membrane option, at about $0.75/kgal and $0.40-$0.50/kgal O&M cost, the ANIX option appeared to be the best economically, and was selected for implementation by the County.

DESIGN BASIS

Based upon pilot testing, the ANIX beds will be sized based on an empty bed contact time of 8 minutes. The design parameters for the ANIX system are shown in the following table:

Design Feature	Value	Unit
Vessel Diameter	12	Feet
Number of Vessels	5	
Resin Depth	6	Feet
Resin Volume Per Vessel	679	Ft^3
Vessel Flow	625	gpm
EBCT	8.1	Min
Surface Loading	5.5	gpm/ft^2
Backwash Flow	340	gpm

[1] "Color and THMFP Removal Pilot Test at Dare County Water Treatment Facilities", Philip H. Kim, PhD, PE. June 1998.

Regenerant Flow (10% sol'n) Brine)	52	gpm
Slow Rinse Flow	52	gpm
Fast Rinse Flow	625	gpm
Regeneration Period	5.5	Hours
Backwash	10	Min
10% Brine	2.5	Hours
Slow Rinse	2.5	Hours
Fast Rinse	20	Min
Regeneration Mode	Down-flow	

Regeneration provides a salt loading rate of 10 lbs/ft^3 of resin. Flow rate for the regeneration is 0.5 gpm/ft^2. That equates to approximately 52 gpm. Backwashing at 3 gpm/ft^2 yields the flow rate of 340 gpm.

ANIX PROCESS FLOW DESCRIPTION

The Skyco Water Treatment Plant improvements will be designed to treat a nominal 4.5mgd of softened water from the current softening system, with peak capability to 5.0mgd.

The proposed treatment process for the Skyco Water Treatment Plant will utilize softened well water as feed water. The water will pass through 5 anion exchange (ANIX) vessels in parallel. The ANIX equipment has been sized for a design flow of 4.5mgd of softened water from the existing treatment system. This may be increased to 5.0mgd for peak needs, but will increase the frequency of regeneration. Because of the additional hydraulic losses through the ANIX equipment, the existing raw water booster pump located in the plant yard in front of the softener building will be repaired or replaced, and returned to service. The pump motor will be equipped with a variable frequency drive for

operating flexibility. *This work will be performed by the Dare County staff outside of the contract for the construction of the ANIX addition.*

Flow shall remain uninterrupted while any single vessel is in its regeneration cycle. The flow rates shown in the process flow diagram reflect all vessels in service. The flow into each vessel will be monitored using a magnetic type flow meter and totalized in the control system PLC. This vessel total will be the parameter used to schedule regeneration. Treated water will be piped back to the existing chlorine room for chemical addition.

The ANIX vessels are sized for a design flow rate of 625gpm/vessel. Volumetrically the vessels are sized for an empty bed contact time (EBCT) of about 8 minutes. The maximum surface application rate at the service flow is about 5.5 gpm/ft^2. The design exhaustion cycle is based on a very conservative 600 bed volumes.

After each production cycle has been completed, the vessels will backwash. Backwash flow rate will be controlled using a modulating valve and a flow meter. Regeneration will follow the backwash. Sample points will be provided so that operators can monitor the progress of the regeneration and exhaustion cycles throughout the process.

The regenerant system will draw saturated salt brine from new, vented saturation tanks, and dilute it to a 10%± solution with water from the ground storage tank. The regeneration system will consist of 3 identical pumps, and associated piping, valves, and controls. All three pumps will have a connection to both saturated brine and to the product water using a motorized three-way ball valve. Two pumps, one pumping saturated brine from the brine storage tanks and one pumping product water from the existing ground storage tank, will be used for each regeneration cycle, with one pump in standby. Each pump will have a flow control valve designed to maintain flow at 26gpm each, or a total regeneration flow rate per ANIX vessel of 52gpm.

The new saturation tanks will also provide brine to the existing softener regeneration system. The existing underground salt pit will be gutted, repaired and utilized as a drain pit for the building floor drains.

After each regeneration cycle, the regeneration pump pumping saturated brine will be automatically switched over utilizing the motorized three-way ball valve to pump product water. This will start the slow rinse process and flush the seals of the pump that is pumping saturated brine. This will extend pump life by maintaining a clear seal without the use of external seal water. The flow rate will be maintained at 52 gpm for the slow rinse process. A lockout on regeneration shall prevent two vessels from being regenerated at any one time. Wastewater generated during backwash and regeneration will be piped to a common drain line to the existing disposal area.

Before placing each bed back into service, a fast rinse will flush the remaining salt from the bed. The fast rinse cycle consists of producing to waste at approximately the same flow rate as the production cycle. The fast rinse will continue until the conductivity measured at the outlet of the vessel reaches a pre-determined conductivity.

PROPOSED MODIFICATIONS TO EXISTING PLANT

The new ANIX system is an add-on to the existing IX softening plant. Therefore it will be necessary to modify the existing chemical systems, consisting of chlorination, and the addition of fluoride and corrosion inhibitor. These chemicals are currently added to the softener effluent at the location where the existing piping will be modified to transfer softened water to the ANIX system. In the proposed scheme, the chemical injection point will be at the same general location, but because of additions to the existing building, and the addition of the new building for the ANIX system, the storage of these chemicals, and the pumping equipment associated with the storage, will need to be relocated.

In addition to the physical changes, the Owner has decided to change the disinfection method from gaseous chlorine to liquid, using commercial strength sodium hypochlorite (12-14% NaOCl).

As part of the building additions proposed, a new chemical area will be constructed on the south side of the existing building, adding to and enclosing the existing loading dock. This addition will include a new loading dock. This area will provide enclosed, independently ventilated storage for two (2) bulk hypochlorite storage tanks, each with a full capacity of approximately 3800 gallons, a day tank of 500 gallons, and two (2) metering pumps each for pre- and post-storage disinfection of the treated water. The system has been sized for the addition of 2mg/l of equivalent chlorine to the ANIX effluent, and 2mg/l of equivalent chlorine to the water from storage as it is pumped to distribution. The metering pumps have been selected with sufficient capacity to increase either dose rate if required to approximately 3.5mg/l at each location.

A second room, also independently ventilated, will provide drum storage, and the relocated chemical metering pumps for the fluoride addition system. The fluoride dosing rate will remain unchanged from current practice.

The existing corrosion inhibitor system will be relocated to the area now occupied by the chlorinators, which will be removed. There will be no other change, and the same inhibitor as is currently in use at the Skyco plant will continue to be used.

The hypochlorite loading station will be located on the new loading dock area, and will consist of a truck fill point, a liquid strainer, valves and piping arranged so that either tank can be filled. The tanks will be equipped with ultrasonic level transmitters, and remote indicators will be mounted at the fill point so that the operators have real time indication of the tank levels.

The chemical areas will be equipped with containment areas, and with safety shower/eyewash equipment, and with hose bibs for housekeeping washdown.

MATERIALS OF CONSTRUCTION

Material of construction for the ANIX vessels shall be carbon steel. The vessels will be factory lined with a 100% solids epoxy. The lining shall be subject to a witnessed holiday test prior to shipment to the site. The vessel external coating will be a shop applied inorganic zinc primer. The vessels will be top coated in the field.

Due to high chloride concentration during the regeneration cycle, all vessel internals shall be Schedule 80 PVC. All face piping shall be 316L schedule 10 stainless steel pipe. Regeneration and backwash piping will be solvent welded Schedule 80 PVC.

Valves shall be fully lugged, wafer style high performance butterfly valves for on/off service. All PVC valves will be ball valves.

Backwash and regenerant pumps will be FRP, as will the brine saturators. Sodium hypochlorite tanks and metering pumps will be made from materials compatible with this service.

INSTRUMENTATION AND CONTROLS

The operation of the ANIX system will be controlled by a PLC and monitored through the existing HMI.

Each vessel will be monitored with a magnetic flow meter, and an in-line conductivity meter. Color monitoring will be performed manually by the operating staff, until sufficient experience has been accumulated to allow an operation based on volumetric regeneration. *The County will purchase the necessary laboratory analytical equipment outside of the contract for the ANIX addition.* As part of the ongoing monitoring and compliance testing, the County will include an on-line TOC monitor in its next budget cycle.

The backwash/regeneration cycle will be initiated automatically based on an operator selectable set point for total vessel flow. Thereafter, the cycle will progress automatically according to the logic preprogrammed in the PLC. Upon completion, the vessel will return to service, or be placed in a stand-by mode, depending upon the number of vessels designated by the operator to be in service.

ARCHITECTURAL/ CIVIL

The ANIX system will be housed in a new concrete block structure to be added to the existing building. The exterior shall be red brick to match the existing building. The equipment will be arranged in the new building as shown in the attached drawing.

In addition to the new process area, the existing dock area will be enclosed and expanded, and divided into chemical rooms for fluoride and sodium hypochlorite. A new dock area is included in the building addition.

Also during the construction period, the disinfection system will be changed from gas chlorine to hypochlorite. Two plastic storage tanks, together with a chemical feed system will be installed in the new chemical storage area. Since this area will now be inside the building and not exposed to sunlight, commercial grade bleach can be stored undiluted. The area requires independent ventilation, however, and both bulk tanks will be vented through a piped vent through the new addition roof.

The salt brine used to regenerate the existing softener units is stored in a below-grade concrete saturator pit. Although this pit has operated well, it is subject to periodic inundation during flood events. Since additional salt storage capacity will be needed for the ANIX system, an above ground system will be installed on a slab on grade, adjacent to the existing saturator. This system will consist of two FRP tanks, associated piping, a transfer pump to fill the tanks with water from the existing ground storage, and associated controls. This system will also provide brine to the existing softener system.

HYDRAULICS

As mentioned earlier, a booster station was installed several years ago between the well field and the softening system. This booster station has never operated correctly, and is currently being bypassed.

Based on pressure tests conducted by Dare County staff, and a design assumption of 10 psi pressure loss through the ANIX system at design flow, a maximum flow thorough both systems appears to be of the order of 3000 gpm, or about 88% of design. It will therefore be necessary to repair, upgrade and reactivate the existing raw water booster station to return the completed plant to its design flow rate. Dare County staff will perform this work independently.

ELECTRICAL

Limited modifications to the electrical system will be required for this plant addition. Power supply for the backwash and regeneration pumps will be added to the existing motor control center through a new 277/480V 3ph panel, and a new 120/208V panel will be added for fractional hp metering pumps, and other single phase needs. High bay lighting will be provided in the new ANIX room, and fluorescent lighting in the new chemical areas. Outside lighting will be provided as appropriate.

The County will independently budget for the replacement of the existing emergency generator. This will be relocated form the present location in the high service pump room to an outside site. The County is also planning to upgrade the existing transmission pump MCC; upgrade the existing softener controls; replace the existing raw water flow meter; and replace the existing SCADA system RTU.

COST OPINION

The following opinion of project construction cost has been developed with the use of vendor quotes, standard cost estimating practice, and from experience with like projects. The accuracy of the cost opinion will be affected by a number of factors, both local and regional, and it is expected that the accuracy will be ± 20%.

The process equipment cost opinion is shown in the following table:

COST ITEM	COST OPINION
IX vessels with internals	$375,000
Resin	$459,000
Regeneration pumps, piping and valves	$75,000
Backwash pumps, piping and valves	$60,000
16" stainless steel piping	$18,000
12" stainless steel piping	$3,000
8" stainless steel piping	$11,250
16" Butterfly valves	$32,000
Resin trap, piping and valves	$15,000
Flow meters	$52,500
Salt tanks and internals	$50,000
Hypochlorite system	$100,000
Process control system	$125,000
Misc. Instrumentation	$25,000
Installation supervision, testing & training	$30,000
ANIX Bldg, 2000 sq. ft @ $150	$300,000
Chemical area, 900 sq.ft. @ $100	$90,000
Site work	$60,000

GC Installation of Owner Furnished Equipment	$55,000
GC Commissioning and Acceptance testing	$15,000
Subtotal	**$1,950,750**
Contingency at 10%	$195,075
Opinion of Total Construction Cost	**$2,145,825**