# North Dakota State Water Commission and the Garrison Diversion Conservancy District

# Northwest Area Water Supply Project Biota Transfer Control Measures *UPDATE*

April 2001


**HOUSTON ENGINEERING**
**MONTGOMERY WATSON**

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April 30, 2001

Mr. Jim Lennington
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505

Subject: Biota Transfer Control Measures – Update

Dear Mr. Lennington:

Since the preparation of the Biota Transfer Control Measures report in September 1998, a number of technical evaluations and design activities have been completed. These have included the preparation of the first phase of the pipeline design and consultations with the Bureau of Reclamation and the U.S. Environmental Protection Agency.

Based on the continuing studies, design efforts, and Federal agency consultation, several elements of the Biota Transfer Control Report have been modified to reflect this additional information and study. This report addresses those items and serves as an update to the material and content presented in the 1998 document.

Specifically, the use of chlorination for biota inactivation followed by residual pipeline chloramination replaces ozone followed by residual pipeline chloramination as the proposed pretreatment method. Additionally, pipeline isolation values have been evaluated and included in the project at critical locations to reduce the potential spill volume of a catastrophic pipeline failure. Several elements of the Minot WTP facilities and operations require further description, particularly for sludge disposal. UV disinfection of the finished water, prior to distribution is also planned.

We appreciate the opportunity to prepare this document to further define the proposed facilities associated with the NAWS project.

Respectfully submitted,

William G. Lynard

William G. Lynard

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## BIOTA TRANSFER CONTROL MEASURES UPDATE

## INTRODUCTION

Since the preparation of the Biota Transfer Control Measures report in September, 1998 a number of activities and technical evaluations have occurred to further define the proposed facilities for the Northwest Area Water Supply Project (NAWS). The major change from the initial report is the recommended use of chlorination as the pretreatment method to achieve 3-log *Giardia* and 4-log virus inactivation on the raw water supply. Other additions include pipeline isolation valves at critical locations on the pretreated water pipeline above the Minot WTP. Additional processes and operational modifications at the Minot WTP include filter waste washwater handling and sludge disposal. UV disinfection will also be added following the conventional water treatment processes prior to distribution of the finished water.

A revised Figure 2-1, Water Supply and Pretreatment Process Flow Schematic is presented in the following. This figure updates the location and type of pretreatment facilities, revises the proposed pipeline sizes based on the most current hydraulic analysis, and revises the segment lengths between major NAWS system components. Three motor operated pipeline isolation valves are located on the lower portion of the pretreated water pipeline to reduce potential flows to natural water courses in the event of catastrophic pipeline breaks.

The following sections present detailed information and descriptions of the current NAWS facilities that have changed or have been modified since 1998.

## PRETREATMENT FACILITIES

The Chloramine Challenge Study – Final Report (December 1995) identified both chlorine/chloramine and ozone as effective disinfection strategies to achieve inactivation requirements for the project. The Biota Transfer Control Measures report assumed that ozone would be carried forward as the method of pretreatment, pending additional water quality evaluations.

Since that time, additional evaluations have been conducted and issues of potential ozone byproduct formation have been investigated, including AOC's (assimilable organic carbon). Based on these issues, the current recommended method to achieve the 3-log *Giardia* and 4-log virus inactivation is to use chlorine. Ammonia would be added after the necessary chlorine contact time to form a chloramine residual in the pipeline.

The pretreatment facilities will be located at the raw water intake pump station. This section describes the design criteria, facilities, facilities layout and operation and control of the chlorine pretreatment system and the residual chlorine system.

## Chlorine System Design Criteria

The design criteria and facilities layout for the chlorine pretreatment facilities are presented in the following sections. Design criteria is based on the results of the Chloramine Challenge Study, which indicated that greater than a 3-log inactivation of *Giardia* and 4-log inactivation of virus could be achieved with a free chlorine contact time of five minutes at doses of 4.5 mg/l for the source water. Disinfection byproduct formation did not exceed potential Stage II MCLs for free chlorine contact times ranging from ten minutes to over 60 minutes depending on the water source and the time of year the water sample was collected, and temperature.

Based on the results of the Chlorine Challenge Study, the following design criteria was developed for the chlorine pretreatment facilities.

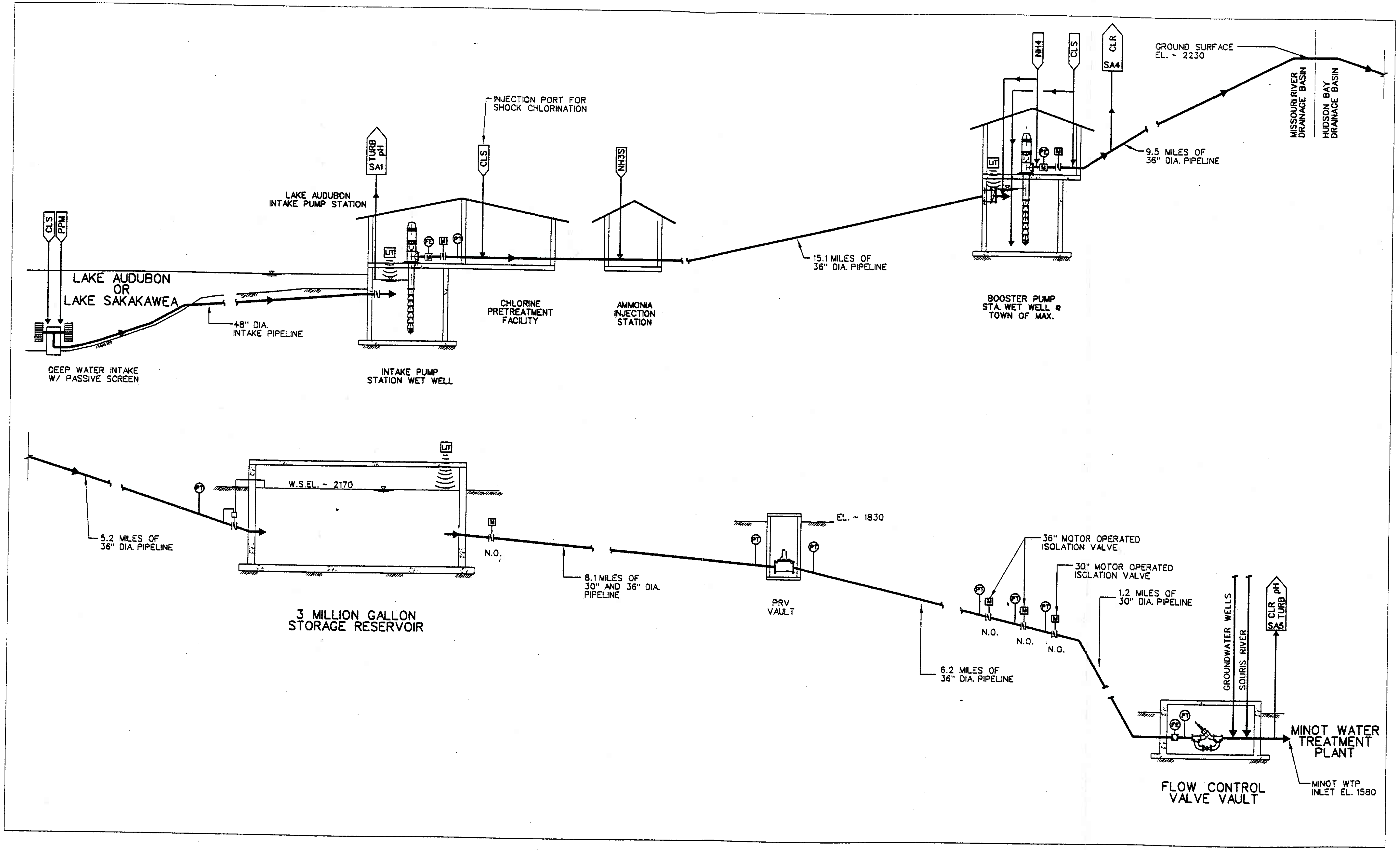
**Chlorine Dose and Contact Time.** The Chloramine Challenge Study (1995) indicated that 4 logs of virus inactivation could be achieved in less than 30 seconds of free chlorine contact time at residuals of between 3.5 and 4.0 mg/l. A five-minute free chlorine contact time was used in the *Giardia* inactivation experiments followed by ammonia addition to form chloramines. At this chlorine dosage, greater than 3 logs *Giardia* inactivation was achieved in less than 180 minutes. Under maximum day flow conditions (26 mgd), the travel time to the Hudson Bay basin divide is over 380 minutes. Therefore, this dose strategy would provide a safety factor of over two at maximum flow conditions. At average flow conditions, the safety factor would be over five.

A chlorine dose of 4.5 mg/l and a free chlorine contact time of five minutes is recommended as the target design criteria to achieve a 3-log *Giardia* and a 4-log virus inactivation. This criteria provides a safety margin of over two during maximum day conditions. This criteria also results in DBP formation well below projected Stage II MCLs for DBPs. This design criteria permits considerable flexibility to extend the free chlorine contact time and concentration modifications to account for seasonal supply variations, increase inactivation levels, and simplify operations, without exceeding potential DBP target MCLs.

**Chlorine Contactor.** Chlorine will be injected at the intake pump station, just upstream of the pump station flow meter. The chlorine contactor will be a series of four, 42-inch diameter pipes placed in parallel (see Figure 1). The required contact time for each incremental flow rate will be controlled by the number of pipes in service, and the design length of the pipe.

Each pipe, representing a contact chamber, will be approximately 250 feet long, and controlled by a motor operated valve. Depending on flow, one or more chambers will be used to meet the contact time criteria. Also, adjustment of the dose rate can be used to achieve the desired CT (concentration x time) criteria.

This configuration will permit construction of the ammonia feed facilities as an integral part of the structure housing the chlorine facilities. This allows the use of a single injection location for the ammonia (rather than at multiple stations) and the use of one location to measure residual free chlorine.

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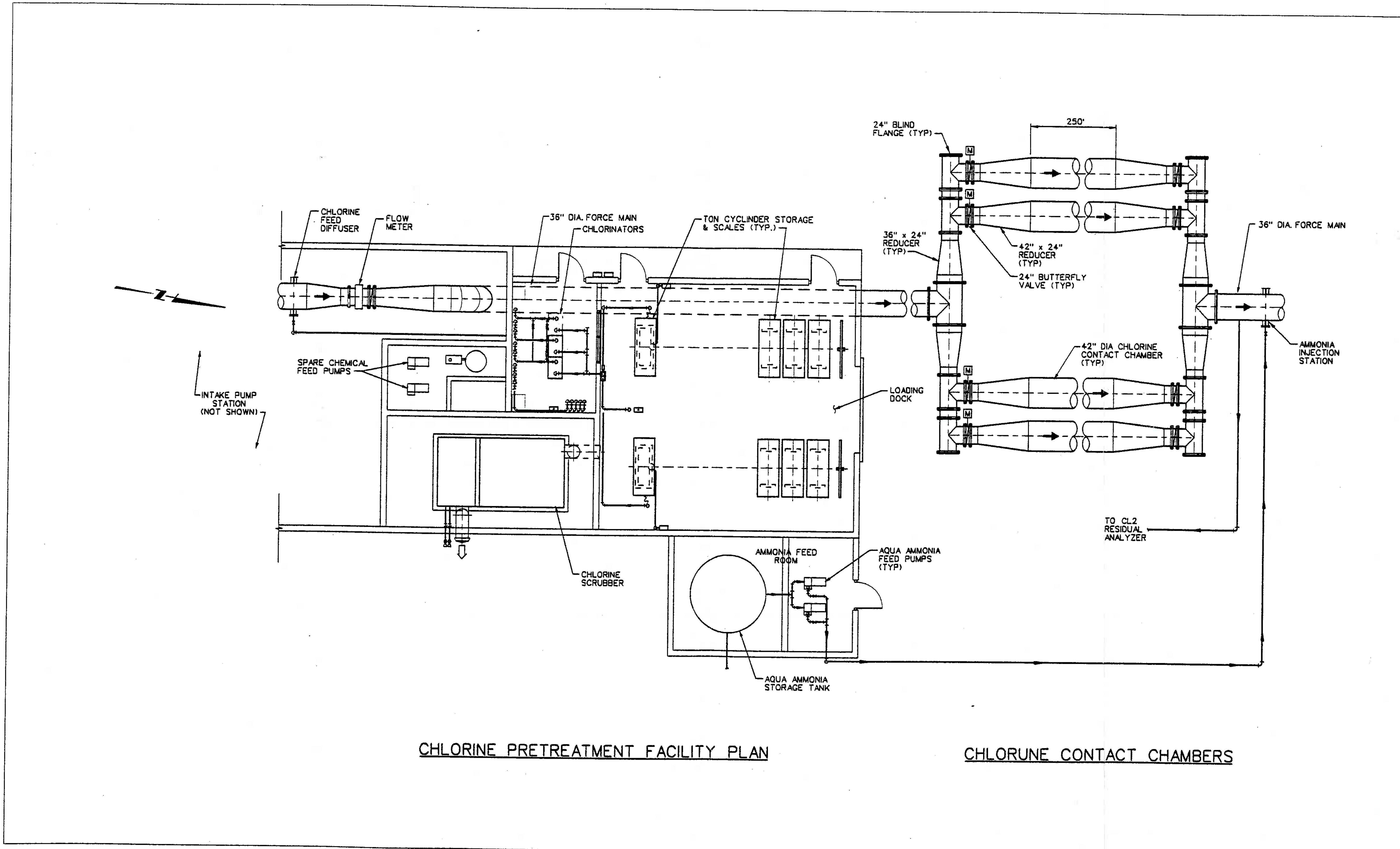
Water Supply and Pretreatment
Process Flow Schematic
Figure 2-1

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NAWS Pretreatment Facilities
Figure 1

This system is designed to give in excess of five minutes contact time for flow increments of 5.2 mgd per chamber. At 26 mgd (maximum day flow), use of all four chambers will yield at total contact time of about 4.3 minutes. This is well within the safety factor of free chlorine contact time. For high flow rates in which contact times are less than five minutes, chlorine dose will be adjusted to provide the desired CT.

**Chlorinators.** Three chlorinators would be provided. At 26 mgd, with two units would be online with one unit in standby. Each chlorinator would be sized for 13 mgd at a dose of 4.5 mg/l, or 500 pounds chlorine per day, each. The chlorinator would have a range of about 100 lbs/day to 500 lbs/day, at a dose rate of 4.5 mg/l.

**Chlorine.** Chlorine would be supplied in gaseous form using one-ton gas cylinders. A thirty-day chlorine supply would be maintained in storage at average day flow rates. This would equate to six cylinders in storage, with two cylinders in service.

**Chlorine Scrubber.** A chlorine scrubber will be used in conjunction with an emergency leak detection system to satisfy chlorine gas use safety regulations. In the event of an emergency or chlorine leak, the scrubber will evacuate and chemically neutralize chlorine in the air volume in either the chlorination room or the chlorine gas storage area. The emergency leak detection system will provide an alarm, initiate the scrubber operation and will notify the system operators through the SCADA system.

## Summary of Design Criteria

The layout of the chlorine pretreatment facilities is shown in Figure 1. This figure also shows the ammonia injection station which is located on the 36-inch pipeline downstream from the chlorine contact chambers. The design criteria for the chlorine pretreatment facilities is presented in Table 1.

## Operation and Control Strategy

The chlorine disinfection system will be designed for automatic and manual control. Automatic control mode will provide full control, monitoring, and emergency shutdown through the SCADA system and locally at the pretreatment facility. Manual control constitutes complete manual setting of all system components directly at the facility.

The major components for automatic control of the chlorine system includes the following:

- Programmable Logic Controllers (PLCs)
- Man/Machine Interface (MMI) and Software
- Raw Water Flow Meter
- Chlorine Residual Analyzer
- Chlorine Ambient Air Gas Analyzer

## TABLE 1

## CHLORINE PRETREATMENT DISINFECTION SYSTEM DESIGN CRITERIA

| Description | Units | Criteria |
|---|---|---|
| System Flow Rates | | |
| Maximum day flow | mgd | 26 |
| Average day flow | mgd | 10.4 |
| Minimum day flow | mgd | 5.2 |
| Chlorine System (Gaseous) | | |
| Dosage, maximum | mg/l | 4.5 |
| Dosage, minimum | mg/l | 1.0 |
| Gas feed rate, maximum | lbs/day | 1000 |
| Gas feed rate, minimum | lbs/day | 50 |
| Chlorinators (2 duty, 1 standby) | No. | 3 |
| Chlorinator capacity | lbs/day | 500 |
| Normal operational range | lbs/day | 100-500 |
| Chlorine gas | type | one ton cylinders |
| One ton cylinders (2 online, 6 standby) | No. | 8 |
| Days storage at average flow (standby cylinders) | days | 30.7 |

PLCs will provide the automatic control link between the equipment and the MMI. The MMI software will provide the window for operator input of the desired applied chlorine dose (mg/l) and chlorine residual (mg/l). The input desired chlorine dosage and the flow rate will provide the primary values for control of chlorine feed rate (lb/day). The allowable range for operator input of applied dosage will be 1.0 mg/l to 10.0 mg/l with the target dose at 4.5 mg/l.

The chlorine residual analyzer will measure the free chlorine residual (mg/l) after the chlorine contact facilities prior to the ammonia injection station. Chlorine residual will also be used for pacing the ammonia dose rate. The measured chlorine residual, compared to the operator input chlorine residual will provide the secondary (trim) control for the chlorine feed rate. This primary and secondary control loop will provide stable chlorination of the raw water under varying influent flow rates and chlorine demand.

In any mode of operation, the chlorine disinfection system will be programmed through the PLC to provide both a low-level alarm and a low/low level setpoint shutdown function should the chlorine residual at the end of the contactor drop to unacceptable levels or if the CT (chlorine residual concentration times the contact time) drops below preset values. It is presently anticipated that a chlorine residual low-level alarm setpoint will be in the range of 2.5 to 3.0 mg/l. The low/low level shutdown setpoint will be in the range of 1.0 to 2.5 mg/l.

The lower range of shutdown setpoints takes into account that longer contact times can be programmed into the PLC logic at lower raw water flow rates to preserve the desired CT requirements for free chlorine disinfection. For example, at average daily flow (10.4 mgd), the contact time can be doubled to 10 minutes. This would result in the equivalent CT at one half of the design residual chlorine concentration.

Under emergency situations, this shutdown feature will automatically shut down the intake pump station and the booster pump station. Therefore, no pretreated water not meeting the necessary CT will be allowed to cross the divide. Also, under system shutdown conditions, the water in the pipeline, with its residual chloramine concentration will actually result in a larger inactivation because of the longer contact times when the water resides in the pipeline.

The SCADA system will monitor all operating conditions of the chlorine disinfection system. It will also permit operations staff to adjust dose contact time and residual setpoints to maintain system operation within parameters necessary to achieve inactivation requirements.

**Ammonia System Design Criteria**

Following the free chlorine contact chamber, ammonia will be injected into the pipeline to form chloramine. Chloramine will be maintained in the pretreated water pipeline to control biofilm. A portion of the pipeline chloramine contact period is also integral to achieving the inactivation levels for *Giardia*. Ammonia will be fed to the system to maintain a 3.5:1 chlorine to ammonia ratio, based on the residual free chlorine concentration measured just upstream from the ammonia injection point.

Ammonia is typically supplied in either gaseous form (anhydrous ammonia) or in liquid form (aqueous ammonia). The proposed ammonia system uses aqueous ammonia. Ammonia will be stored in a tank of sufficient size to accept one full tank truck load. This is estimated to be 2,000 to 4,000 gallons.

**Ammonia Dose.** The ammonia will be dosed at a ratio of 3.5:1 chlorine to ammonia based on the residual free chlorine measured at the ammonia injection location. The average chlorine residual is expected to range from 3.0 to 3.5 mg/l. Therefore, the applied ammonia dose is expected to range from 0.86 to 1.0 mg/l. At maximum day flow, the maximum ammonia feed rate would be 217 lbs/day.

**Ammonia Feed System.** The ammonia feed system would consist of a storage tank, chemical feed pumps and an injection diffuser located in the 36-inch diameter pipeline. A 4,000-gallon storage tank is proposed, which would hold approximately a 100-day supply of ammonia at average flow conditions.

Two chemical feed pumps (one duty and one standby) would be provided. The feed rate for each pump would range from a minimum of 30 lbs/day to 217 lbs/day.

## Summary of Design Criteria

The layout of the ammonia feed facilities is shown on Figure 1. These facilities would be incorporated with the chlorine feed facilities at the intake pump station. An ammonia feed line would be constructed from the ammonia feed facilities at the pump station to the injection location downstream of the chlorine contact chambers. A summary of the design criteria is presented in Table 2.

**TABLE 2**

**CHLORAMINE SYSTEM DESIGN CRITERIA**

| Descriptions | Units | Criteria |
|---|---|---|
| System Flow Rates | | |
| Maximum day flow | mgd | 26 |
| Average day flow | mgd | 10.4 |
| Minimum day flow | mgd | 5.2 |
| Ammonia Feed Facilities (Aqueous-Liquid) | | |
| Concentration | % | 29.4 |
| Weight | lbs $NH_2$/gallon | 2.2 |
| Ratio Chlorine to Ammonia | No. | 3.5:1 |
| Ammonia dose, minimum | mg/l | 0.7 |
| Ammonia dose, maximum | mg/l | 1.0 |
| Liquid feed rate (neat), maximum | gallons/hour | 4.1 |
| Liquid feed rate (neat), minimum | gallons/hour | 0.6 |
| Metering pumps (one duty, one standby) | No. | 2 |
| Storage tank | No. | 1 |
| Tank volume | gallons | 4,000 |
| Days storage (average flow, maximum dose) | days | 100 |

## Operation and Control Strategy

The ammonia feed facilities will be designed for both automatic and manual control. The operation of the ammonia feed facilities will be linked to the operation of the chlorine feed facilities. Ammonia will only be fed when the chlorine facilities are operational. The automatic control mode will provide full control, monitoring and emergency shutdown through the SCADA system and locally at the pretreatment facility. The control of the facilities will use the chlorine feed PLC, with a control link from the PLC to a MMI which will provide a window for operator input to control the appropriate dose of ammonia based on the residual free chlorine at the ammonia application point. The ammonia dose will use the same control parameters used to feed chlorine (flow rate and residual chlorine monitoring). The allowable range for operator input of chlorine to ammonia ration will be 3.5:1 to 4.0:1.

The ammonia feed facilities operation will be programmed into the PLC and will include alarm and shutdown functions. However, a failure of the ammonia feed facilities will not automatically result in a shutdown of the balance of the system (raw water delivery, chlorination or pumping).

Alarm functions will include meter pump failure, residual chlorine analyzer failure, low storage tank level, and programming functions out of operational ranges.

**CT Estimates/Inactivation**

The Chloramine Challenge Study indicated that greater than 3 logs *Giardia* inactivation would be achieved in less than 180 minutes with a free chlorine (dose at 4.5 mg/l) contact time of five minutes followed by ammonia addition. This total contact time represents a point along the 36-inch diameter pipeline approximately 11.2 miles from the intake at peak flow. From this point to the divide is an additional 13.4 miles with an additional travel time of 209 minutes. At a residual chloramine concentration of 3.5 mg/l (CT=732 @ 20°C) an additional 2 logs of inactivation *Giardia* is estimated to be achieved. Considering the total travel time to the Minot WTP from the point 11.2 miles from the intake, an additional 4.5 logs of inactivation of *Giardia* is achieved. Similar estimates for virus inactivation were 4-log to greater than 6-log additional inactivation, respectively.

The estimates for virus and *Giardia* inactivation were derived from the USEPA Guidance Manual for inactivation using chloramine.

At average and minimum flows in the piping system, estimates of inactivation for both virus and *Giardia* generally exceeded 6 logs. This is in addition to the log inactivation achieved by the pretreatment system. A summary of the estimated additional log inactivation for various flow rates at the divide and at the Minot WTP, achieved in the pipeline are presented in Tables 3 and 4, respectively.

**TABLE 3**

**ADDITIONAL VIRUS AND *GIARDIA* INACTIVATION IN THE PIPELINE AT THE DIVIDE BY CHLORAMINATION**

| Flow, mgd | Additional Travel Time, min | CT at 3.5 mg/l Chloramine | Temp, °C | Additional Log Inactivation | |
|---|---|---|---|---|---|
| | | | | Virus | *Giardia* |
| 26 (peak) | 209 | 732 | 20 | 4 | 2 |
| 10.4 (avg) | 784 | 2,744 | 15 | >6 | 5.5 |
| 5.2 (min) | 1,744 | 6,104 | 5 | >6 | >6 |

## TABLE 4

## ADDITIONAL VIRUS AND *GIARDIA* INACTIVATION IN THE PIPELINE AT THE MINOT WTP BY CHLORAMINATION

| Flow, mgd | Additional Travel Time, min | CT at 3.5 mg/l Chloramine | Temp, °C | Additional Log Inactivation | |
|---|---|---|---|---|---|
| | | | | Virus | *Giardia* |
| 26 (peak) | 502 | 1,757 | 20 | >6 | 4.5 |
| 10.4 (avg) | 1,515 | 5,302 | 15 | >6 | >6 |
| 5.2 (min) | 3,207 | 11,214 | 5 | >6 | >6 |

## PIPELINE ISOLATION VALVES

Based on the final design of the pretreated water pipeline from the pressure reducing valve (PRV) station to the Minot WTP, revised estimates of pretreated water release volumes resulting from a catastrophic pipeline failure (total breach) were calculated. The release volumes were estimated at four locations that were determined to be critical sites. These sites represent potential pipe failures within streams and coulees tributary to the Souris River and at the Minot WTP. The revised release volumes are summarized in Table 5. The pipeline design was prepared utilizing natural topographic features to limit release volumes at critical locations. The release volumes represent the maximum release assuming a catastrophic break, response time to close upstream control valves, and drainable upstream volumes (by gravity). The release volumes are not reduced to account for volumes that would continue to flow down the pipeline to the Minot WTP.

## TABLE 5

## CATASTROPHIC PIPELINE BREAK RELEASE VOLUMES

| Location | Breach Site Description | Pipe Station No. | Volume, $ft^2$ |
|---|---|---|---|
| 1 | Second Larson Coulee | 2274 + 00 | 26,110 |
| 2 | First Larson Coulee | 2385 + 00 | 52,800 |
| 3 | Drainage Upstream from Minot WTP | 2550 + 00 | 71,370 |
| 4 | At Minot WTP | 2591 + 20 | 78,630 |

Placing pipeline isolation valves on the system at strategic locations upstream of critical potential break locations could further reduce these release volumes. Through consultation with the EPA, critical sites were identified for pipeline isolation valve installation.

**Pipeline Isolation Valve Locations**

The pretreated water reservoir and the PRV vault within the Hudson Bay basin incorporate isolation valves. Three additional pipeline isolation valves are proposed for the segment of the pipeline between the PRV station and the Minot WTP. These valve locations are shown on Figure 2.

**Isolation Valve at Station 2377 + 60.** This valve is located just upstream of Breach Site 2, on top of the ephemeral stream bank at the location of the proposed air release valve. With an isolation valve at this location, all upstream volumes drainable to this point would be contained by the valve. The only volume which could be released to the First Larson Coulee would be the volume of the pipeline within the topographic depression of the coulee.

**Isolation Valve at Station 2480 + 40.** This isolation valve location is at a small ephemeral stream, identified as Breach Site 2A on Figure 2. This ephemeral stream flows to the Souris River. A pipeline isolation valve at this location would reduce potential release volumes which could get into this drainage and would require mitigation under the emergency response plan.

**Isolation Valve at Station 2527 + 20.** This isolation valve is located on top of the hill above Minot and the steep portion of the 30-inch pipeline leading to the Minot WTP. The valve would be located at the transition point between the 36-inch and the 30-inch diameter pipeline just south of the US-2 and 52 Bypass. This location would reduce the release volumes at potential breach locations on the 30-inch pipeline (Breach Site 3) and the Minot WTP.

**Breach Volumes**

An analysis of the potential breach volume reduction at critical locations along the pipeline was performed to determine the affect of the additional pipeline isolation valves. The potential breach volumes are summarized in Table 6.

**TABLE 6**

**REDUCTION OF BREACH VOLUMES AT CRITICAL LOCATIONS ALONG THE PRETREATED WATER PIPELINE**

| Breach Location | Pipeline Station No. | Breach Volume w/o Valves, $ft^3$ | Breach Volume with Valves, $ft^3$ | Valve Location |
|---|---|---|---|---|
| 1. | 2275 + 00 | 26,110 | 26,110 | -- |
| 2. | 2385 + 00 | 52,800 | 21,940 | Valve above 2 |
| 2A. | 2483 + 00 | 52,760 | 8,300 | Valve above 2A |
| 2B. | 2501 + 20 | 47,250 | 6,040 | Valve above 2A |
| 3. | 2550 + 00 | 71,370 | 17,330 | Valve at Sta. 2527+ 20 |
| 4. | 2591 + 20 | 78,630 | 24,590 | Valve at Sta. 2527+ 20 |

# Proposed Pipeline Isolation Valve Locations

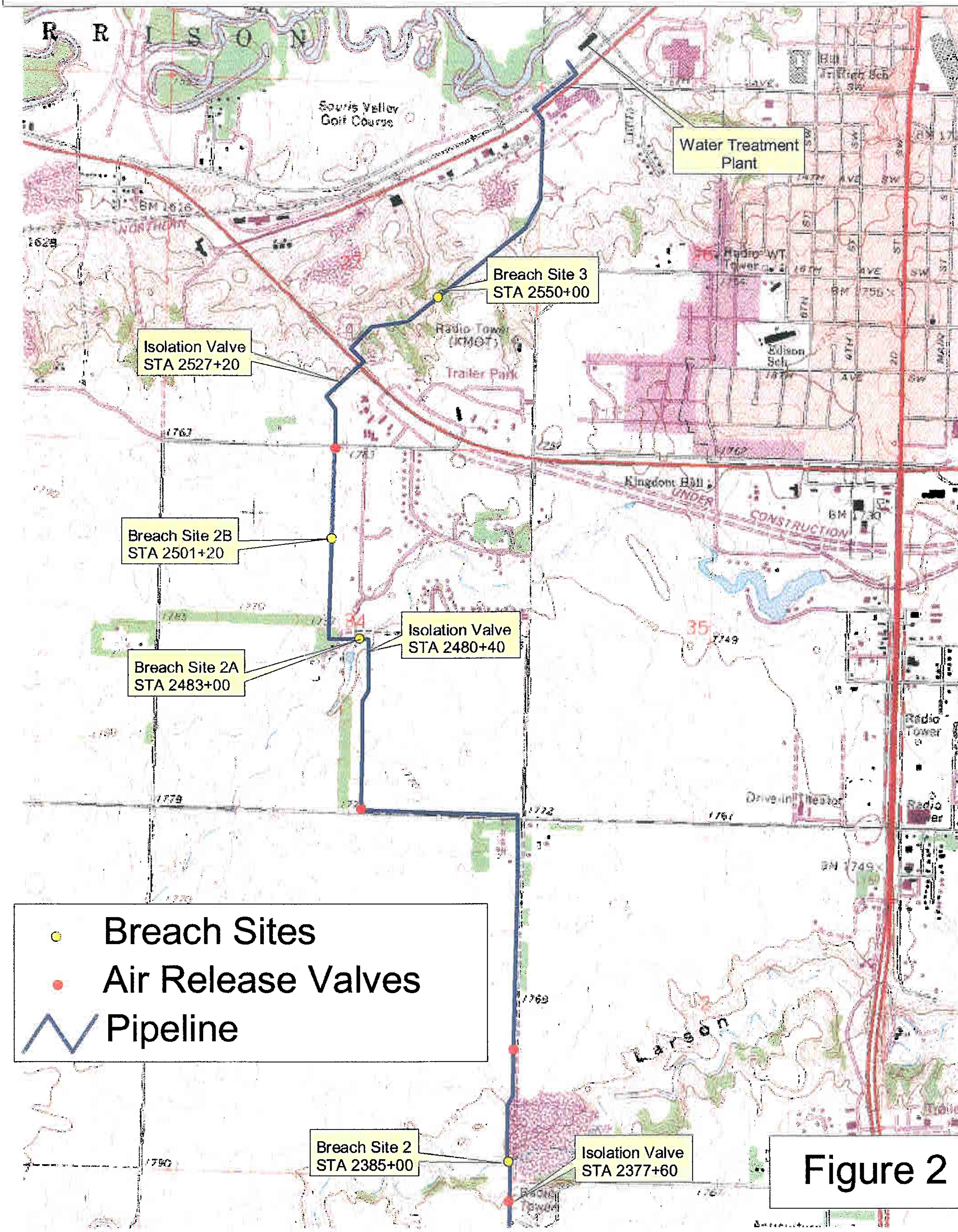



Figure 2

Potential breach location 2B is located along the pipeline on a natural low area adjacent to existing development near Station 2500 + 00. Placement of the isolation valve above point 2A effectively controls the release volume at this location.

While a catastrophic pipeline breach is an extremely improbable event, pipeline isolation valves provide an additional fail-safe measure to the system to control release volumes should a complete pipe break occur. Further, where the pipeline crosses a coulee or drainage, the pipeline joints will be welded or constructed with restrained joint fittings. The pipeline will also be encased in concrete at the actual crossing. On steeper slopes, particularly on the 30-inch pipeline leading to the Minot WTP, the pipeline will be constructed with welded or restrained joints.

**Equipment and Facilities**

Pipeline isolation valves will be constructed as automatic, motor operated butterfly valves on the 36 and 30-inch pipeline. Each valve station will be contained in a valve vault and equipped with a valve and motor operator, an air-vacuum valve located downstream of the isolation valve, a pressure gauge and pressure transmitter, a six-inch bypass pipe with a shutoff valve and a SCADA telemetry system. Each station will require a power source to operate the equipment.

**Operation and Control**

Each isolation valve will operate in a normally open mode. The pressure sensors will monitor pressure of the operating system at each location. Under normal operating conditions, the pressure range of the pipeline will fall between established limits ranging from near static head at low flows, to lower operating pressures (at the hydraulic gradeline) at maximum flow. These limits will be programmed in the PLC, and under automatic operation, operating line pressures will be transmitted to the PLC through the SCADA system and compared to the preset limits. Operating conditions will be logged and monitored.

Under an emergency situation, should a catastrophic pipeline break occur, the pressure of the pipeline at the break will go to near atmospheric pressure. This will result in pressure sensor readings at the isolation valve locations and the PRV station to fall outside of normal operating ranges and trigger an alarm.

If the change in pressure reading remains constant over a pre-established period of time (not pressure fluctuations consistent with a pressure transient or oscillating pressure wave), the PLC, through the SCADA system will close the affected isolation valve.

Under an emergency pipeline breach condition, the Minot WTP inlet valve will remain open to permit drainage of the pipeline, by gravity, downstream of the closed valve. This operation will further reduce release volumes depending on the specific location of the breach. The air-vacuum valve, located downstream of the closed isolation valve will open permitting the downstream line to drain under gravity flow conditions and to prevent negative surge and negative pressure conditions which could further damage the line.

Once the pipeline is placed back in service, the isolation valve bypass valve will be opened to fill the downstream line and equalize pressure around the isolation valve to permit its opening. The bypass valve operation is a manual operation.

The isolation valve will also be capable of being manually operated at the valve station. In case of power outage at the valve station, the motor operator can be manually bypassed to close the valve should such an emergency occur.

Under a pipeline breach condition, the entire pretreated water system will be shut down. This will occur either through the SCADA system or through the automatic cascading shutdown operation should the SCADA system also be in a failure mode.

## MINOT WATER TREATMENT PLANT

The Biota Transfer Control Measures report briefly described the existing water treatment operations performed at the Minot WTP, and recommended upgrades to the plant to treat NAWS water. Several issues, clarifications and further descriptions of treatment processes and operations require additional discussion. A number of these have been discussed or evaluated since the distribution of the Biota Transfer Control Measures Report (September 1998). These issues include the lime softening process, filter waste washwater handling, sludge handling and disposal and anticipated upgrades planned for the Minot WTP.

### Lime Softening

Lime softening at the Minot WTP is practiced to reduce hardness in the current water supply. This practice will be continued for the NAWS water supply. Minot practices excess lime softening for the removal of calcium and magnesium carbonate hardness. The additional lime increases the pH of the water to values above 11. Excess lime softening will also be used on the NAWS water source to remove magnesium hardness, which exceeds 10 mg/l in both the Lake Audubon and the Lake Sakakawea source.

As has been explained in the 1998 document, the excess lime softening process produces a lime sludge that has a very high pH (>11). Lime sludge, at this pH, is essentially insoluble and at this elevated pH, biological activity essentially ceases to exist.

### Filter Waste Washwater

Filter waste washwater (filter backwash) is sent to the Backwash Equalization/Sedimentation Basin. This facility is a chambered 110,000-gallon tank used to settle solids from the backwash prior to recycling the clarified water to the head of the plant.

During the first several minutes of backwash of a filter, the flow containing the dirtiest water is diverted to one of the chambers of the basin. The remaining cleaner water is diverted to the other chamber. The dirtiest backwash water containing the majority of the solids is pumped to the lime sludge thickeners and is removed from the treated water system. The chamber containing the cleaner water is pumped to the head end of the plant for recycle.

No backwash water is discharged to the Souris River, or to the sanitary sewer system. Controls on the volume of water contained within the backwash basin will override filter backwash cycles to prevent over-filling of the basin. Under future operations, if more frequent backwash cycles are needed or if higher backwash rates are required, the equalization basin will be expanded.

**Sludge Handling and Disposal**

Sludge from the lime softening process and the filter backwash operations is sent to the sludge thickeners prior to being dewatered. The sludge dewatering equipment produces a sludge cake with an approximate 40 to 50 percent solids concentration. Presently, sludge production is in the order of about 10 tons of wet solids per million gallons treated. With the NAWS source of supply (lower hardness), the sludge production rate is expected to decrease to approximately two tons of wet solids per million gallons treated.

Present operations at the Minot WTP contain the sludge within the sludge processing, handling and loading areas. No sludge or process water is discharged or allowed to accumulate in an area where it could be washed into the Souris River or the sanitary sewer system. This operation will be maintained under future conditions with the NAWS supply. Since the sludge is produced at 50 percent cake, wind blown lime sludge is not considered an issue, assuming daily disposal and soil cover at the landfill.

Based on recent investigations and the consultative effort with the Federal Agencies for this project, the following sludge handling and disposal programs will be implemented. Disposal of sludge within the existing Minot landfill (RCRA subtitle D landfill) will include placement in lined cells and the sludge will be covered daily. Leachate collected from the landfill will not be discharged to a waterway in the Hudson Bay drainage nor to the sanitary sewer system. Any sludge collected in the leachate system will be disposed of in the lined cells.

The NAWS project will also investigate the feasibility of alternative disposal sites within the Missouri River Basin. Annual monitoring and operational and maintenance information concerning sludge handling and disposal will be included in the annual report to the GJTC.

**Disinfection at the Minot WTP**

The City of Minot will implement and install ultraviolet (UV) disinfection facilities at the water treatment plant as an element of the overall disinfection strategy. UV disinfection has potential for increased inactivation of *cryptosporidium* and other protozoans. Minot will retain the current chloramine residual disinfection for the distribution system.

Implementation of UV disinfection will involve placement of UV reactors on the finished water piping leaving the water treatment plant, after filtration.

Because of space and access limitations and the configuration of the Minot facility, UV systems are planned for multiple locations. These include the existing high service pump station room, a vault to be constructed on one of the finished water distribution pipelines leaving the water treatment plant and a facility on the future NAWS finished water pump station.

**Design Criteria.** The total design capacity of each UV disinfection station will be 9 mgd each. Each station will consist of two duty reactors and one standby reactor, with each reactor having a capacity of 4.5 mgd. The design criteria for the UV system is presented in Table 7.

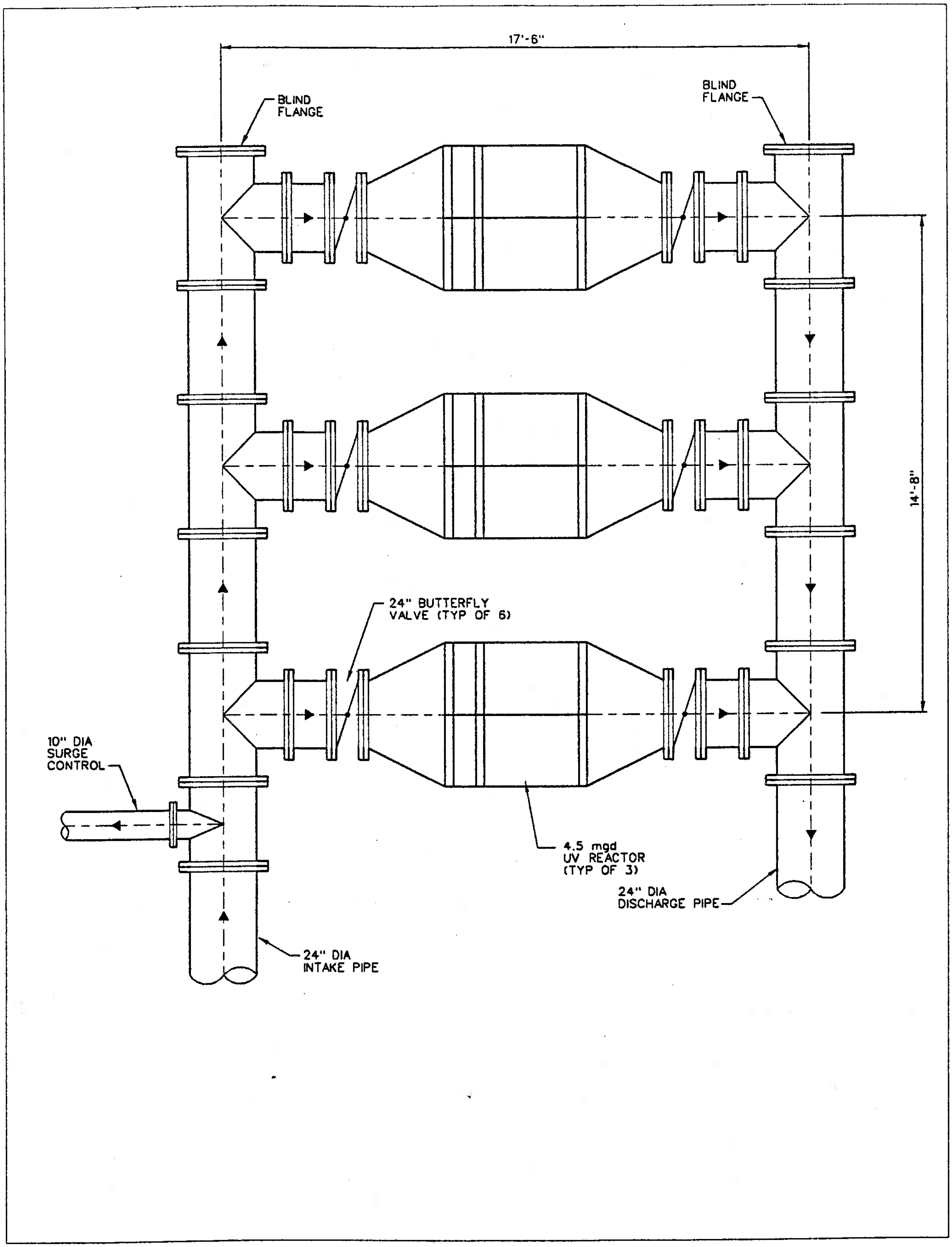
**TABLE 7**

**UV SYSTEM DESIGN CRITERIA FOR POST TREATMENT DISINFECTION AT THE MINOT WTP**

| Description | Units | Criteria |
|---|---|---|
| System Flow Rates | | |
| Maximum day flow | mgd | 26 |
| Average day flow | mgd | 10.4 |
| Minimum day flow | mgd | 5.2 |
| No. of UV disinfection stations | No. | 3 |
| Station capacity | Each, mgd | 9 |
| Reactors (low pressure, high intensity) | | |
| No. per station (2 duty, 1 standby) | No. | 3 |
| Reactor capacity | mgd | 4.5 |
| Transmittance | % | 90 to 95 |
| *Cryptosporidium* inactivation | No. | 2 log |
| UV dose | $mJ/cm^2$ | 20 to 30 |
| Variable power | % | 50 to 100 |

**Equipment Layout.** The equipment layout will consist of three reactors operated in parallel, with one of the units serving in standby. A typical UV station facility layout is shown in Figure 3. This configuration can be placed in the existing high service pump station subbasement area or in vaults constructed on the existing distribution supply line from the plant or at the new NAWS wetwell/pump station.

Each reactor will be isolated by valves and each UV station will be equipped with a surge control device to reduce potential for water hammer. Each unit will be equipped with a UV sensor. Dosing requirements will be maintained by a control system using flowrate and sensor data. Each reactor will be equipped with a UV lamp cleaning system.






Typical Layout of
NAWS 9 mgd UV Disinfection Station
Figure 3

MONTGOMERY WATSON