# Engineering Evaluation
# Central Groundwater Treatment Facility
# Scottsdale, Arizona

Prepared for:

**Scottsdale, Arizona**

Prepared by:

**ENVIRON International Corporation**
**Nashville, Tennessee**

Date:

**January 2009**

Project Number:

**2021115A**

ENVIRON

# Contents

Page

**1.0 Summary ..... 1**
**2.0 Introduction ..... 2**
**3.0 Background ..... 2**
**4.0 Central Groundwater Treatment Facility ..... 3**
4.1 General Process Description ..... 3
4.2 Modifications to Existing System ..... 3
**5.0 Discussion ..... 6**
5.1 Site Visit ..... 6
5.2 Process Equipment and Instrumentation ..... 6
5.2.1 P&IDs ..... 6
5.2.2 Preventative Maintenance Records ..... 6
5.2.3 Daily Operations ..... 8
5.3 Control System Description ..... 9
5.4 Control System Evaluation and Testing ..... 11
**6.0 Conclusions And Recommendations ..... 13**

List of Tables
Table 1: Major Process Equipment List
Table 2: Preventative Maintenance During a Carbon Change Out Event
Table 3: CGTF: Control System I/O Test Results
Table 4: Recommended SCADA Enhancements
Table 5: Stripping Tower Alarm Set Points

List of Figures
Figure 1: Graphical Representation of CGTF

List of Attachments
Attachment A: Photographs of CGTF Components
Attachment B: Revised P&IDs
Attachment C: Example Work Order
Attachment D: Instrumentation Preventative Maintenance for 2008
Attachment E: Instrumentation Corrective Maintenance Work Orders
Attachment F: Example of Daily Log Sheets
Attachment G: Control Logic Diagrams

# 1.0 Summary

ENVIRON International Corporation (ENVIRON) was retained by Motorola, the representing company for the North Indian Bend Wash Participating Companies (NIBW PCs), to perform an engineering evaluation of the Central Groundwater Treatment Facility (CGTF) located in Scottsdale, AZ. The objective of the evaluation was to provide an independent review of the facility and make recommendations as necessary to ensure the safe and confident operation of the treatment facility.

A site investigation of the facility was conducted by ENVIRON the week of August 4, 2008. The evaluation included a design review, inspection of equipment, review of operating procedures, assessment and testing of the control system, and review of operation and maintenance logs.

The CGTF is in good condition and well maintained. Personnel were very knowledgeable of the system, and safeguards to ensure water quality are being implemented. This evaluation identified some aspects of operation and design that can provide further enhancements to the overall success of the facility.

# 2.0 Introduction

ENVIRON presents these findings on behalf of Motorola and the NIBW PCs. This engineering evaluation is in response to the USEPA Region 9's request for all groundwater facilities that discharge to a potable water system to conduct an independent engineering evaluation to verify the reliability of the facility; providing recommendations if necessary.

# 3.0 Background

The NIBW PCs in conjunction with the City of Scottsdale designed and constructed the Central Groundwater Treatment Facility to address the 1988 Record of Decision and in accordance with the 1991 Consent Decree (CIV-91-1835-PHX-WPC) and the 2003 Amended Consent Decree (CIV-91-1835-PHX-JFM). The facility was designed to remove North Indian Bend Wash (NIBW) and target volatile organic compounds (VOCs) from contaminated groundwater in Scottsdale, Arizona. The facility was brought online in late 1993, and ownership was transferred from the NIBW PCs to the City of Scottsdale, AZ (City) on March 18, 1994.

ENVIRON International Corporation (ENVIRON) was retained by Motorola, the representing company for the NIBW PCs, to perform an engineering evaluation of the CGTF located at 8650 E. Thomas Road, Scottsdale, AZ. The objective of the evaluation was to provide an independent review of the facility with respect to operation, maintenance and the existing control system instrument, alarms and interlocks and to recommend additional operating procedures/protocols and/or control features, as necessary, for the safe and confident operation of the treatment facility. The evaluation, which included data review and a site visit, included the following tasks, as requested by Motorola:

- Review the existing design of the facility;
- Review existing data including the daily operator logs, alarm logs, preventative maintenance logs, operations and maintenance manuals, and other available information;
- Conduct a site investigation;
- Review the control system software and programming implementation;
- Test alarms and interlocks for a treatment column and validate the existing control program;
- Conduct a review of the mechanical, electrical, instrument, and control systems as compared to the original design of the facility; and
- Interview key operation personnel.

This report includes an assessment of the design and control of the processes at the CGTF, including drawings, program software, instrumentation and equipment. This report also includes a review of the Operation and Maintenance Plan and operation and maintenance protocol; as well as recommendations for software, hardware controls, protocol or equipment necessary to ensure the continued reliability of the facility.

# 4.0 Central Groundwater Treatment Facility

## 4.1 General Process Description

The CGTF utilizes the process of air stripping to remove VOCs from contaminated groundwater. The CGTF is comprised of three treatment trains; each train consisting of a packed column, a process air fan, and an off-gas vapor treatment system. Each column was designed to decrease the inlet TCE concentration from 1500 µg/L to less than 5 µg/L at a flow rate of 3150 gallons per minute (gpm). Each train can be operated independently so that only the required numbers of columns need to operate to meet water demand. One or more columns can be out of service without disrupting the entire system. A list of major equipment is provided in Table 1 and a graphical representation of the treatment facility is provided as Figure 1 Photographs of various components of the treatment system that are described below can be viewed in Attachment A.

The CGTF is supplied by Well 71, Well 72, Well 75A, and Well 31. All wells, except Well 31, are owned by the City. Well 31 is owned by the Salt River Project (SRP). All four wells currently produce groundwater with concentrations above the Safe Drinking Water Act Maximum Contaminant Level (MCL) for at least one of the NIBW VOCs.

During operation, water from the four wells is collected in a common raw water header where it is distributed to each available column. Motor operated valves (MOVs) and manual throttling valves allow operations personnel to evenly distribute the flow to the active columns. Flow meters are located on the inlet piping to each column to monitor the amount of water entering each column. Water flows from top to bottom within the column, while air is pulled through by the fan in a counter current direction.

Each column has a dedicated fan for the process. Atmospheric air passes through an intake screen located outside the building and is piped into the bottom of the column. The fan pulls the air upward, countercurrent to the water within the column. The air flow is measured to verify that adequate air is being provided to the column.

The fan discharges to an off-gas treatment system. This system has three trains, each consisting of a heating unit to reduce relative humidity, and a granular activated carbon (GAC) contactor to adsorb VOCs transferred from the groundwater to the air. Each fan normally discharges to its assigned train, however, dampers are provided in a common duct to allow cross over during maintenance. Each GAC contactor is split into two parallel beds, a top bed and a bottom bed within each GAC vessel. Differential pressure (DP) gauges located on the top and bottom of the GAC contactor monitor the DP across each bed.

All treated water from the CGTF is either distributed to the City's potable drinking water system or is discharged to the Salt River Project (SRP) irrigation system via recycle pumps located at the common wetwell.

## 4.2 Modifications to Existing System

In April of 1995, maldistribution of water was identified as a potential cause for inefficient VOC removal from all three columns at the CGTF. The water distributor in each column was leveled to improve column efficiency. Additionally, all original packing (Jaeger #2 Tri-Pack [3 1/2-inch diameter]) was replaced with smaller diameter packing (Jaeger #1 Tri-Pack [2-inch diameter]) to increase the available surface area for water and air contact.

The April 1995 modifications were not as effective as desired, and the water maldistribution continued at the CGTF into 1995. In July and August of 1995, additional modifications were completed for all three columns. Samples were collected from the influent and the effluent over a 3 month sampling period to assess the performance of the CGTF. By November 1995, the EPA allowed the CGTF treated water to be used by the City for its municipal water supply.

In April 1998 and May of 2000, rehabilitation efforts were made at the CGTF to improve the facility, specifically the performance of the packed columns, focusing on the optimization of the air and water distribution. These modifications also allowed for greater operational flexibility. In April 1998, rehabilitation efforts focused on Packed Column 1.

The following upgrades were completed on Column 1:

- Packed Column 1:
    - A new tower distribution section was added to the top of the column;
    - An improved inlet header and water distributor was installed at a three-foot higher elevation;
    - Three feet of new packing was added to the column;
    - A new column cleaning system was installed, and,
    - A new air distributor was installed.
- Magnetic flow meters were installed on each water inlet line to replace annubars;
- A drain system was installed on the column inlet pipe as a safeguard to ensure that no untreated water enters the column when shut down. A flow meter is located on each drain line to monitor the amount of water leaving the column at shutdown; and,
- The Safe-T-Climb ladder system was replaced with ladder cages.

The successful 1998 rehabilitation on Packed Column 1, led to the rehabilitation of Packed Column 2 and Packed Column 3 in May 2000.

In 2007, a rehabilitation project took place at the CGTF. The following tasks were completed:

- A well water surge protection system including a 20,000 gallon ASME-rated hydropneumatic tank was installed;
- Column packing in all three columns was removed and replaced;
- The column interior walls were prepared and recoated with a chemical resistant coating;
- The raw water inlet pipe was re-routed around the finished water common sump rather than through it;
- The raw water inlet valves (MOVs) at each column were replaced;

- The access to the existing water distribution trays and mist eliminators was upgraded;
- The cleaning solution pumping, handling, and distribution system in each column were upgraded;
- New air fans were installed;
- New variable frequency drives for the new fans were installed; and,
- A discharge isolation system between CGTF and Reservoir (Site) 80 was designed and installed.

During the evaluation of the facility, all three packed columns were in operation, allowing for a thorough engineering evaluation**.**

# 5.0 Discussion

## 5.1 Site Visit

ENVIRON personnel arrived at the City of Scottsdale Water Campus on Monday, August 4, 2008, to attend an orientation meeting. Representatives from the City of Scottsdale, ENVIRON, and Motorola were present at this meeting. All the tasks necessary to perform the engineering evaluation were reviewed and Scottsdale personnel made arrangements for ENVIRON to obtain access to documents and key personnel. On Monday evening, a brief tour of the CGTF was conducted.

From Tuesday, August 5 until Thursday, August 7, 2008, ENVIRON performed an evaluation of the CGTF, which included the inspection and evaluation of the process control system, major equipment, accessory equipment, instrumentation, and maintenance protocol. Control logic was tested and operating personnel were interviewed. The following sections provide a summary of activities and findings during the engineering evaluation.

## 5.2 Process Equipment and Instrumentation

### 5.2.1 P&IDs

During the evaluation, the Piping and Instrumentation Diagrams (P&IDs) for the facility were evaluated to identify any discrepancies between the as-built drawings and the current piping, equipment, and instrumentation within the facility. The available, original P&ID's did not reflect the rehabilitation projects of 1998, 2000 and 2007. Many of the field instruments and equipment did not have name tags that related to the P&ID tags. This condition most likely occurred because new equipment was not furnished with name tags. Marked up P&IDs are provided as Attachment B to show revised conditions.

### 5.2.2 Preventative Maintenance Records

ENVIRON reviewed all available preventative and corrective maintenance records for 2004-2008 to verify that all instrumentation and equipment were properly maintained according to manufacturer specifications. Instrumentation and equipment at the CGTF are maintained by two different personnel groups within the facility, but all work orders and maintenance records are recorded in a common web-based database provided by Hansen Information Technologies (Hansen). As preventative maintenance or corrective maintenance tasks arise, work orders are initiated by the responsible party, either the appropriate division or operations, and remain open until the task is complete. An example of a work order for both equipment and instrumentation through Hansen can be found in Attachment C.

The CGTF electrical division is responsible for all instrumentation maintenance, while the maintenance division is responsible for all equipment maintenance. During the review, it was determined that instrumentation records for preventative and corrective maintenance were available and complete. The maintenance records and work orders for equipment preventative and corrective maintenance were difficult to locate due to a current transition between work order databases.

Due to the transition, the Hansen database does not have one unique identification tag number within Hansen. It is possible that one piece of equipment may be stored within the database

under numerous identification tag numbers or names. This ambiguity prevents a complete historical search when reviewing data for one piece of equipment or instrument. The Hansen system is new, and the City of Scottsdale has previously identified issues with the system; corrective actions are currently in progress.

#### 5.2.2.1 Instrumentation

In order to properly maintain all instrumentation within the CGTF, the electrical division performs routine inspections, calibrations and preventative maintenance on all instruments within the facility, as well as corrective maintenance on any instrumentation that fails between inspections. The preventative maintenance inspections and calibrations occur twice a year, usually in April and October, to provide consistency. Each instrument is tested to verify that the output values are within acceptable range of the target values. Any deviation from the target output will lead to the recalibration of the instrument. If calibration does not correct the issue or if the instrument can not be recalibrated, then the instrument or parts to the instrument will be replaced. All instrument preventative maintenance documentation for 2008 can be found in Attachment D. This serves as an example of all instrument test or calibration documentation that CGTF has on record for previous years.

When instrumentation fails, corrective maintenance is performed and documented through the Hansen database. This database records the date, the problem, and any corrective action necessary to return the instrument to working order. This may require repair, changing parts, or replacing the entire instrument. A summary of all instrumentation corrective maintenance work orders for 2004 to 2008 can be found in Attachment E. An example of a complete work order can be found in Attachment C.

#### 5.2.2.2 Equipment

In order to consistently maintain all equipment within the CGTF, the maintenance division conducts preventative maintenance inspections during scheduled shut downs of a treatment train. Train shutdown occurs routinely for carbon replacement in the GAC off-gas adsorbers and usually annually for column cleaning.

The City has set up GAC unit carbon replacement on a rotational basis so that only one of the three units is changed out at time. During a carbon change out, the maintenance staff also performs the preventative maintenance tasks found in Table 2. While performing the tasks, the maintenance staff visually inspect all of the attached piping, valves and other items. Unscheduled maintenance or repairs may also occur during a carbon service event based upon what is discovered during the visual inspection. During the site evaluation, Fan No. 1 appeared to pass a metallic object through the ductwork. Consensus was that the noise could have been generated from debris resulting from corrosion of the steel ductwork. During the next column cleaning the ductwork should be thoroughly inspected for integrity.

Column cleaning is usually scheduled during the winter when area water demand is low. A cleaning was not performed in 2006 or 2007, because of the planned tower and equipment upgrades in 2007. A tower inspection and cleaning occurred in 2008. During column cleaning, all three packed columns are taken out of service to prevent any cross contamination between the cleaning solution and the treated wastewater. A cleaning solution consisting of hydrochloric acid is flushed through each packed column until all calcium carbonate scaling is removed from the packing. The cleaning solution is recycled through the columns using a cleaning pump. The

solution is changed out as needed until the column is free of calcium carbonate. Once the cleaning is complete, the solution is then neutralized with caustic and discharged to the sanitary sewer. The column air intake is “blinded” off on three sides and a flexible duct recovers the exhaust. During a column clean out the following tasks are performed by the maintenance division according to the City of Scottsdale preventative maintenance schedule:

- Acid wash for each column, distributed through cleaning solution piping manifold;
- All column sumps will be drained and inspected for any signs of failure;
- All column sumps will be inspected for sand. If a considerable amount of sand is present, a contractor will remove the sand prior to column cleaning;
- Column influent distribution trays will be inspected for sand and cracking of tray welds;
- Cleaning pump suction will be inspected;
- The interior of the columns will be inspected; and,
- The visible packing will be inspected.

ENVIRON has determined through the evaluation of records and through interviews with operations personnel that instrumentation and equipment are maintained according to manufacturers specification.

### 5.2.3 Daily Operations

In addition to maintaining trends and events on the control system as described below, operators inspect the condition of the facility and record a number of parameters on a daily log sheet. These daily log sheets were reviewed to verify consistent record keeping. Examples of Daily Log Sheets can be found in Attachment F. On a daily basis, the following parameters are monitored:

- Ambient Air temperature;
- Ambient Relative Humidity;
- Chlorine residual;
- Column water flow;
- Column DP;
- Fan air flow;
- Fan filter DP;
- Inner and Outer bearing temperature;
- GAC DP for top and bottom bed;
- Heater humidity;
- Heater temperature; and,
- Any unusual events are recorded and work orders are initiated if necessary.

ENVIRON has determined through the evaluation of records and interviews with operations personnel that the current daily log protocol is sufficient for continued reliable operation of the CGTF.

As part of the evaluation, ENVIRON verified that the operator in charge of the CGTF is certified under the AZ Department of Environmental Quality (AZDEQ) as a Grade 4 Water Treatment Facility Operator. Since the CGTF is classified as a Grade 2 water treatment facility, the City of Scottsdale is in compliance with the requirements of the AZDEQ.

## 5.3 Control System Description

The CGTF is controlled through a system-wide supervisory control and data acquisition system (SCADA) with main system hardware located at the Scottsdale Water Campus. The CGTF can be monitored by personnel using the Scottsdale Web-based system. Additionally, the CGTF and the wells have remote terminal units (RTU) that allow for local control. The SCADA software is composed of Bristol Babcock "ACCOL" programming and Open Enterprise human-machine interface (HMI).

Well and tower operation is automatically controlled based on the level of water in the Pima Park Reservoirs. As the water level falls, the control system will send a startup sequence command to one of the wells. The well and tower sequence of operation is predetermined by the operator. The operator will assign to each well a start sequence as lead, lag 1, lag 2 and lag 3, by entering in the HMI numbers 1 through 4 to each well. No two wells can be assigned the same number.

Similarly, the towers are assigned a start sequence as either lead, lag 1 or lag 2 by entering numbers 1, 2 or 3 for each well. No two towers can be assigned the same number.

When the level in the reservoirs initiates a call for a well to start, the system confirms that an adequate number of towers are operating. If inadequate, a call to start the next tower will be initiated. A sequence of events and a number of checks are required before the command to start the well is given. When a call for a tower to start is initiated, the following events commence:

- Confirm tower is ready
- Confirm air duct heater is ready
- Confirm air duct dampers are in correct position
- Start blowers
- Confirm air flow rate
- Start heater
- Open and confirm inlet water valve is open
- Enable air duct heater controller

At this position in the sequence, the program confirms that the tower is running and will issue a start command to the designated well. Each well has its own logic for operation and includes low well water level, low water flow, and high water discharge pressure as interlocks for shutdown.

Personnel stated that since the first of the year, the system has been operated with all towers running. Therefore, the sequence discussed above only affected the turning on and off of the groundwater wells. This policy ensures that no water can enter the distribution system without passing through an operating tower.

A tower will shut down either by a normal sequenced shutdown or by an alarm trip. A normal sequenced shutdown occurs when the water in the reservoir rises to a specific level and the call for a well is cancelled. During this tower shutdown sequence, the following steps take place:

- Close and confirm position of tower Inlet water valve
- Close and confirm position of tower inlet water line drain valve
- Stop blower
- Stop air duct heater

Several parameters are monitored during the operation of the towers. Some parameters will issue a warning alarm, while others will initiate a tower shutdown or alarm trip. In addition to local alarms, alarms are issued via an autodialer to operators. The following list summarizes most of the alarm conditions:

| Process | Condition | Response |
|---|---|---|
| Process air inlet screen | High differential pressure | Alarm |
| Tower | High differential pressure | Alarm |
| Well water flow | High water flow | Alarm trip |
| Process air | Low air flow | Alarm |
| Process air | Low-Low air flow | Alarm trip |
| Process air | Low air/water ratio | Alarm trip |
| Process air | High relative humidity | Alarm trip |
| Process air blower | High bearing temp | Alarm |
| Process air blower | High-High bearing temp | Alarm trip |
| Process air blower | High vibration | Alarm trip |
| Well RTU | Loss of communication | Alarm |

A number of improvements from the original design have been made to the control system, either as new field instrumentation or program changes.

Field changes include new water flow meters, new water inlet motor operated valves (MOV), new process air flow meters, variable frequency device on blowers, tower inlet pipe drain valve and flow meter, new water flow meter for recycle pumps, and a new VFD for one of the recycle pumps. Control changes include inlet MOV monitoring, blower motor monitoring and blower speed control, process air flow, air to water ratio monitoring, well water flow to tower water flow deviation, and other system checking.

## 5.4 Control System Evaluation and Testing

The Bristol ACCOL Program was reviewed to gain an understanding of the specific control actions. Many of the input/output tags do not include a text description of the tag. This lack of description increases the time required for someone unfamiliar with the program to identify the function of a particular I/O. The ACCOL tag list should include a description of each tag. Attachment G provides logic diagrams depicting the control logic associated with various aspects of operating the wells and stripping towers.

Field devices were tested to ensure that they were operable and that their signals were being received by the SCADA system. Table 3 provides a summary of the items tested and the results. Generally the field devices were working and the SCADA system received the proper responses. Highlights from the test plan are as follows:

- Some of the limit switches on air pipe dampers needed adjusting to more accurately reflect a full open or full closed position. The adjustments were made and verified.

- The air low flow switches were inoperable, but had been replaced with flow transmitters; however, no low flow set point had been programmed to replace the low air flow switch. The low flow input should be restored either by a new switch or programmed from the flow transmitter. Additionally, a low blower amp set point can be established to indicate low blower air flow. When the blower output is down to 9000 cfm the blower amperage should be around 45 amps. This value can be field verified and programmed into the alarm logic.

- The low level and high level switches for the clearwell recycle pumps had been disabled. The low level switch will cause the recycle pumps to shut down. The high level switch will shut down the towers. Neither of the switches is needed during normal operation of discharging to the Pima Park reservoirs. However, if the recycle pumps are used to pump to the canal, both input points should be restored either by level switches or programmed inputs from the sump level transmitter.

In addition to checking the control logic of the programming, several scenarios were created to evaluate the responses of the control system; such as, valve position, low air flow, tower sequence, tower failure, I/O card communication error, well flow / tower flow deviation, and clearwell level. Generally the program logic and responses were adequate to properly treat the water. However, as with any system, enhancements and more fail-safe actions can be made. Table 4 lists all the recommended enhancements that have resulted from the system evaluation.

Some of the more significant items are listed below:

- During a tower shutdown sequence, the blower continues to operate until the program confirms that the motor operated valve on the water inlet is closed; however, if the cause of tower shutdown is associated with low air flow and the MOV fails to close, water from other operating wells can pass through the tower with insufficient air flow. Therefore, during a shutdown sequence, if the inlet MOV does not close within an appropriate time (30 seconds), all wells should receive a shutdown command. During the evaluation, the program was reconfigured to implement this desired action.

- A low process air flow switch or low flow set point from the flow transmitter should be assigned to the low flow input in the program. During the evaluation, a low flow input from the transmitter was added to the program.

- The program maintains the last input value for analog inputs when a signal is lost. I/O cards should be monitored for “healthy state”. If a card is analyzed to be “unhealthy” the I/O values should be driven to a fail safe value, which may initiate a tower or system shutdown.

- A number of I/O’s required for system start-up or shut down are not recorded in the event log, such as inlet air valve – “open”. A change of status of these I/O’s should be logged so that the cause for system shutdown or reset can be determined by reviewing the event log.

- The air flow measured from fan number 1 was approximately 85 percent of the other two fans. Scottsdale personnel are in the process of replacing the existing flow meter to determine if the lower reading is a result of an inaccurate meter or if the output from the fan is below expectations.

The process parameter set points and time delays have been changed from the original configuration. The inlet flow rate and process air flow rates have been adjusted based on lower VOC in the groundwater than the original design. The revised minimum air flow rates where not evaluated, but current operating data demonstrates effective treatment using the current parameters. Table 5 lists alarm values and response time based on the original design, current settings and recommended settings. Quicker response times to trigger alarms are recommend to minimize the chance for less than best performance and because current control hardware can easily produce quicker response.

We were informed by Scottsdale personnel that a new control system was planned to be installed later this year. Therefore, some of the less critical recommendations could be postponed and incorporated into the new control system. One additional consideration for the new system is to group process I/O from each train on the same group of I/O cards. For example, inlet water flow, fan air flow, and relative humidity for train one should all be on the same analog card rather than connecting all the inlet water flows on the same card as is now the case. If a card malfunctions, then only one train will be affected rather than losing process variables for every train.

# 6.0 Conclusions And Recommendations

The CGTF is in good condition and well maintained. Personnel were very knowledgeable of the system. Safeguards to ensure water quality have been and continue to be implemented. This evaluation has identified some aspects of operation and design that can provide further enhancements to the overall success of the facility.

The following recommendations are made to enhance reliability and improve documentation of plant changes or maintenance activity:

1. P&IDs should be updated to reflect any change, addition, or deletion to piping, equipment, or instrumentation. The P&IDs are the active record of the system and should be reviewed before any change to the facility is contemplated. This procedure helps identify inadvertent consequences when changes are contemplated. It also provides the operators an invaluable tool.

2. All equipment and instrumentation within the facility should be properly tagged with the corresponding number on the P&ID.

3. Within the Hansen maintenance database, each piece of equipment or instrument should be given a unique tag number. All work orders pertaining to the individual piece of equipment or instrument should be available in one location. The database should also be completed to include a preventative maintenance schedule.

4. During the next tower cleaning, thoroughly inspect the off gas ductwork for corrosion.

5. Any changes made to the SCADA system and control logic should be documented. Numerous changes and enhancements have been made to the original computer programming. This documentation will allow those unfamiliar with the facility to more quickly evaluate control problems and troubleshoot the system when current control personnel are unavailable.

6. A number of recommendations were made to enhance the operation of the control system. These recommendations were presented in Tables 4 and 5.

# Tables

**Table 1: Major Process Equipment List**

**Table 2: Preventative Maintenance During a Carbon Change Out Event**

**Table 3: CGTF: Control System I/O Test Results**

**Table 4: Recommended SCADA Enhancements**

**Table 5: Stripping Tower Alarm Set Points**

**Table 1: CGTF - Major Process Equipment**

| Line No. | Equipment Name | Type | Design flow / Capacity | Design Pressure | HP | Electric (V/Hz/Ph) | Manufacturer | Model Number | Remark |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Well 31 | Vertical Line Shaft | 2,500 gpm | SRP Well | 300 | 460-60/3 | Ingersol Rand/Dresser | 9537 | SRP Well |
| 2 | Well 71 | Submersible | 1,000 gpm | 350' | 300 | 2300-60/3 | Worthington | 14M160 | Submersible |
| 3 | Well 72 | Submersible | 2,100 gpm | 465' | 300 | 2300-60/3 | Centrilift | WNE1600 | Submersible |
| 4 | Well 75A | Submersible | 1,800 gpm | 430' | 300 | 2300-60/3 | Centrilift | | Submersible |
| 5 | Packed Column No. 1 | Induced Draft Counter-current | 3100 cu.ft packing | | N/A | N/A | Jaeger (packing) | 2-inch polyethylene Tripack | |
| 6 | Packed Column No. 2 | Induced Draft Counter-current | 3100 cu.ft packing | | N/A | N/A | Jaeger (packing) | 2-inch polyethylene Tripack | |
| 7 | Packed Column No. 3 | Induced Draft Counter-current | 3100 cu.ft packing | | N/A | N/A | Jaeger (packing) | 2-inch polyethylene Tripack | |
| 8 | Process Fan No. 1 | Backward Inclined Centrifugal | 13,900 cfm @ 2442 rpm | 17.2 in H2O | 60 | 230-460/60/3 | New York Blower | Class IV Size 305 AcF | w/VFD |
| 9 | Process Fan No. 2 | Backward Inclined Centrifugal | 13,900 cfm @ 2442 rpm | 17.2 in H2O | 60 | 230-460/60/3 | New York Blower | Class IV Size 305 AcF | w/VFD |
| 10 | Process Fan No. 3 | Backward Inclined Centrifugal | 13,900 cfm @ 2442 rpm | 17.2 in H2O | 60 | 230-460/60/3 | New York Blower | Class IV Size 305 AcF | w/VFD |
| 11 | Duct Heater 1 | Natural Gas Fired | 7630-14,000 cfm | 15.0 in H2O | N/A | 115-1-60 | Powrmatic | DH-70 | 500,000 BTU |
| 12 | Duct Heater 2 | Natural Gas Fired | 7630-14,000 cfm | 15.0 in H2O | N/A | 115-1-60 | Powrmatic | DH-70 | 500,000 BTU |
| 13 | Duct Heater 3 | Natural Gas Fired | 7630-14,000 cfm | 15.0 in H2O | N/A | 115-1-60 | Powrmatic | DH-70 | 500,000 BTU |
| 14 | GAC 1 | Vapor Phase Granular Activated Carbon | 20,000 lb | 5.0 in H2O | N/A | N/A | Wheelabrator Clean Air Systems Inc., Westates Carbon Division | Submersible | contactors are dual bed, 10,000 lb each |
| 15 | GAC 2 | Vapor Phase Granular Activated Carbon | 20,000 lb | 5.0 in H2O | N/A | N/A | Wheelabrator Clean Air Systems Inc., Westates Carbon Division | WOCS-12D | contactors are dual bed, 10,000 lb each |
| 16 | GAC 3 | Vapor Phase Granular Activated Carbon | 20,000 lb | 5.0 in H2O | N/A | N/A | Wheelabrator Clean Air Systems Inc., Westates Carbon Division | WOCS-12D | contactors are dual bed, 10,000 lb each |
| 17 | Recycle Pump 1 | Vertical Turbine | 2750 gpm | | 50 | 460 | Ingersol Rand | 0693-9029 | w/VFD |
| 18 | Recycle Pump 2 | Vertical Turbine | 2750 gpm | | 50 | 460 | Ingersol Rand | 0693-9030 | |
| 19 | CIP Pump | Centrifugal | 1100 gpm | 125 psi | 50 | 460 | Metpro/Fybroc | 1500 | |

## Table 2: Preventative Maintenance During a Carbon Change Out Event

| Equipment | Description |
|---|---|
| Heater | Inspect unit through inspection port. |
| | Inspect associated gauges and instruments for damage, moisture, correct zero setting and range. |
| | Inspect for loose flanges, screws, ripped or torn insulation, and burn marks. |
| Blowers | Inspect for correct operation. |
| | Inspect for loose bolts, cracks, excess water, ripped or torn rubber coupling. |
| | Clean the inside cavity of the outer and inner bearings to remove old grease. |
| | Inspect all bearings for excess wear, temperature related issues, or debris. |
| | Properly repack bearing with synthetic bearing grease. |
| | Replace top bearing cap and tighten to required torque. |
| | Check the motor belts for tension and check the condition of the motor belts and sheaves. Replace if necessary. |
| | Perform a walk around of all blowers and motors to identify any unusual noise, vibrations, temperatures, or smells. |
| Air Intake | Remove and rise air intake filters to remove any debris. |
| | Inspect housing for any damage or loose bolts. |
| | Verify that the DP gauge is correctly zeroed and there is no moisture or damage present. |
| Miscellaneous | Perform a walk around of the facility to identify anything unusual. |

## Table 3: CGTF - Control System I/O Test Results

| Line | Description | Tag type | Number | I/O Confirm | Remarks |
|---|---|---|---|---|---|
| | *Discrete Signals* | | | | |
| 1 | Water inlet valve Tower 1 | ZSC | 250 | Y | |
| 2 | Water inlet valve Tower 1 | ZSO | 250 | Y | |
| 3 | Water inlet valve Tower 2 | ZSC | 250.2 | Y | |
| 4 | Water inlet valve Tower 2 | ZSO | 250.2 | Y | |
| 5 | Water inlet valve Tower 3 | ZSC | 250.3 | Y | |
| 6 | Water inlet valve Tower 3 | ZSO | 250.3 | Y | |
| 7 | Fan 1 throttling valve | ZSC | 400 | Y | Not closed at 95% open |
| 8 | Fan 2 throttling valve | ZSC | 400.2 | Y | Not closed at 50% open, will change to >95% |
| 9 | Fan 3 throttling valve | ZSC | 400.3 | Y | Not closed at 50% open, will change to >95% |
| 10 | Fan 1-2 interconnect valve | ZSC | 450 | Y | Not closed at 100% open |
| 11 | Fan 2-3 interconnect valve | ZSC | 450.2 | Y | Not closed at 100% open |
| 12 | Air valve to atmosphere | ZSC | 460 | Y | |
| 13 | GAC 1 inlet damper valve | ZSC | 510 | Y | |
| 14 | GAC 2 inlet damper valve | ZSC | 510.2 | Y | |
| 15 | GAC 3 inlet damper valve | ZSC | 510.3 | Y | Originally no input, but adjusted set point and verified input. |
| 16 | GAC 1 outlet damper valve | ZSC | 520 | Y | |
| 17 | GAC 1 outlet damper valve | ZSC | 520.2 | Y | |
| 18 | GAC 2 outlet damper valve | ZSC | 520.3 | Y | |
| 19 | GAC 2 outlet damper valve | ZSC | 530 | Y | |
| 20 | GAC 3 outlet damper valve | ZSC | 530.2 | Y | |
| 21 | GAC 3 outlet damper valve | ZSC | 530.3 | Y | |
| 22 | Recycle pumps to tower valve | ZSC | 600 | N | not connected, normally not used |
| 23 | Recycle pumps to SRP valve | ZSC | 601 | Y | |
| 24 | Inlet filter 1 high dP | PDIS | 400 | Y | |
| 25 | Inlet filter 2 high dP | PDIS | 400.2 | Y | |
| 26 | Inlet filter 3 high dP | PDIS | 400.3 | Y | |
| 27 | Tower 1 high dP | PDIS | 401 | Y | |
| 28 | Tower 2 high dP | PDIS | 401.2 | Y | |
| 29 | Tower 3 high dP | PDIS | 401.3 | Y | |

## Table 3 (con't) : CGTF - Control System I/O Test Results

| Line | Description | Tag type | Number | I/O Confirm | Remarks |
|---|---|---|---|---|---|
| 30 | Clearwell low level | LSLL | 620 | N | control relay (CR 214) removed in I/O panel; inhibits manual operation of Recycle Pumps |
| 31 | Clearwell high level | LSHH | 620 | N | control relay (CR 216) removed in I/O panel; program reconfigured to generate HH form LIT620 |
| 32 | Recycle pump air gap box high water level | LSHH | 600 | N | Level alarm not used since VFD added to Recycle Pump, switch was to prevent box overflow. |
| 33 | Air flow low switch | FSL | 400 | N | Switches are no longer used. Air flow transmitters FIT |
| 34 | Air flow low switch | FSL | 400.2 | N | 400/400.2/400.3 added; however low flow alarm from analog |
| 35 | Air flow low switch | FSL | 400.3 | N | signal needs to be generated in place of switch or add new |
| | *Control functions* | | | | |
| 36 | Fan 2 low flow alarm | FAL | 400.2 | Y | generated tower failure and shutdown |
| 37 | Tower 3 - remove requirement to run (high reservoir level) | | | Y | Generated normal shutdown sequence |
| 38 | Fan 1 throttling valve closed alarm | ZSC | 400 | Y | generated tower failure and shutdown |
| 39 | Tower 1 inlet pipe drain valve | | | Y | valve opens on tower shutdown |
| 40 | Tower 2 inlet pipe drain valve | | | Y | valve opens on tower shutdown |
| 41 | Tower 3 inlet pipe drain valve | | | Y | valve opens on tower shutdown |
| 42 | Analog card: loss of communication | | | N | Loss of communication did not generate an alarm |

## Table 4: Recommended SCADA Enhancements

| Item No. | Comment |
|---|---|
| 1 | Include all of the MODBUS failure alarms into the system lockout. This will initiate the shutdown procedure for all wells and towers upon a MODBUS communication failure or any column inlet valve. (Completed while on-site) |
| 2 | Generate and include into the system lock out an inlet valve failed to close alarm. This will prevent contamination of the wet wells if an inlet valve failed to close during a shutdown and other wells are operating. (Completed while on-site) |
| 3 | Timer 58 was duplicated within the system, the duplicate should be reassigned a new identification number. (Completed while on-site) |
| 4 | Reset the damping on the air line flow indicating transmitter to obtain quicker process response. |
| 5 | Cause process variable go to fail-safe values upon analog I/O card communication failure so that a shutdown procedure will be initiated if key process signals are lost. |
| 6 | Modify program to initiate the shutdown procedure for any train should the associated fan indicate low amps. |
| 7 | All valve limit switches will be set as logical event alarms and will be included in SCADA for event troubleshooting. |
| 8 | Add flow check of column inlet pipe drain valve upon column shutdown. If the flow within the drain valve does not go to zero with set time after shutdown (indicating that water is still entering the train), an alarm should be generated and operations should be notified. |
| 9 | Add restriction to well/tower for lead/lag assignment. Assignments should be limited to the number of items, since the program logic does not recognize other values, e.g. number 5 can not be assigned. |
| 10 | Reassign an output from flow transmitter FIT620 to LSHH620. The low air flow switch was used to confirm the blower start up. This flow switch no longer works and should be replaced with the low flow transmitter check. |
| 11 | Reset the default delay timer per Table 4. |
| 12 | Add tag descriptions in the ACCOL program. |
| 13 | When installing new I/O panels, group parameters by trains rather by common process variables. |

## Table 5: Stripping Tower Alarm Set Points

| Parameter | Units | Design | | Current | | Recommendation | |
|---|---|---|---|---|---|---|---|
| | | Value | Delay (sec.) | Value | Delay (sec.) | Value | Delay (sec.) |
| Tower high water flow | gpm | 3,250[a] | - | 3,350 | 1,200 | [b] | 120 |
| Tower low air flow | cfm | 11,200 | - | 9,200 | 120 | [b] | 60 |
| Tower low-low air flow | cfm | - | 60 | 9,000 | 120 | [b] | 60 |
| Tower air/water ratio | - | 29 | - | 28 | 120 | [b] | 60 |
| Tower effluent air high relative humidity | % | 70 | 600 | 80 | 2,700 | 60 | 300 |

Notes
(a) value increased to better match multiple well flow.
(b) no change from current settings anticipated, but tower efficiency not verified for these conditions during this evaluation.

# Figures

## Figure 1: Graphical Representation of CGTF