Miller Road Treatment Facility
Evaluation Report

Prepared on behalf of:
Motorola
and
North Indian Bend Wash Participating Companies

Prepared by:
ENVIRON International Corporation
Brentwood, Tennessee

Date:
April 17, 2008

Project Number:
#20-20209A

C. SCOTT REECE
REGISTERED ENGINEER
AGRICULTURE
No. 12281
STATE OF TENNESSEE

C Scott Reece
18 Apr 2008

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Summary

ENVIRON International Corporation (ENVIRON) was retained by Arnold & Porter, Counsel, on behalf of Motorola, who represents the North Indian Bend Wash Participating Companies (NIBWPC) to evaluate the design and operation of the Miller Road Treatment Facility in Scottsdale, Arizona. This request was precipitated by two occurrences of inadequately treated water during October 2007 and January 2008.

At the request of Counsel, ENVIRON reviewed documents describing the facility and conducted two site visits to evaluate the treatment equipment and control system. During the site visits of February 25-29, 2008 and March 17-20, 2008, ENVIRON assessed the condition of the facility and tested alarms and interlocks. Various process conditions were simulated to allow ENVIRON personnel to understand and recreate the conditions during the treatment malfunctions. Arizona American Water Company (AAWC) operation personnel were interviewed at the end of the second visit. A former AAWC operator and the Bristol Babcock programmer, subcontractor for the control system program, were also interviewed by telephone subsequent to the second visit.

The facility is adequately designed to remove the concentrations and types of volatile organic compounds (VOCs) of concern found in the groundwater. Sufficient control logic, interlocks and safeguards are provided to ensure satisfactory performance of the treatment system.

<u>First Occurrence – October 2007</u>

In October 2007, the PCX1 well was directed to Tower 2 for nine days. During the start up of Tower 2, measured air flow rates from Blower 2 were below the required minimum of 5000 cfm. The AAWC operator assumed that the flow measurement was incorrect and manually set the flow value to 8500 cfm in the control logic, so that the system could operate in automatic mode and allow the control logic to function. Routine weekly samples were taken during Tower 2 operation; however, results received after the nine day run of Tower 2 indicated the presence of trichloroethylene (TCE) in the tower bottoms and clearwell.

As a result the investigation, ENVIRON determined that

- the low air flow rate of the blower was the result of the blower rotating backwards, which was caused by improper wiring of the blower motor; and,
- the lack of sufficient air flow resulted in inadequately treated water during the October 2007 incident.

<u>Second Occurrence – January 2008</u>

During the January 15-16, 2008 incident, well PCX-1 was pumped to Tower 3 without Blower 3 operating, which resulted in inadequate treatment. ENVIRON was asked to determine why or how Blower 3 could shutdown and the system not generate a train failure or alarm condition. ENVIRON personnel spent a considerable amount of time studying the program code and simulating various scenarios. When the system was tested in the automatic mode, all interlocks worked properly and caused a train failure and shutdown. However, when the system was taken out of the automatic mode, a train failure would not occur. The train failure logic only works when all the conditions for automatic mode are met. When a blower is manually turned off, the

automatic mode is turned off in the control logic, and no failure sequence is generated. During the day of January 15, 2008, a new PV-15 well pump was being flushed through Tower 1. At the end of the day, the AAWC operator reported that only Train 1 (well PV-15 and Blower 1) was shutdown. However, historical computer data show that Blower 3 was also manually turned off between the shut down of well PV-15 and Blower 1.

In addition to the train failure logic, the control program generates a well stop command when the associated blower is turned off. This logic only works when a well is assigned to a treatment train. Since well PCX-1 did not stop upon blower shutdown, either the radio communication between MRTF and PCX-1 well site was absent or the well was not assigned to Train 3. Since no communication failure occurred during the incident, well PCX-1 must not have been assigned to Tower 3, and the program logic would not command the well to stop.

As more fully discussed in this report, ENVIRON draws the following conclusions concerning the January incident:

- The air stripping system is adequate to remove the VOCs of concern.
- Sufficient control logic is provided to cause a system shutdown during equipment failure.
- The shut down of PV-15, Blower 3 and Blower 1 occurred in a four minute span, indicating that the system was shut down manually.
- No train failure was generated because the blowers were manually turned off.
- The AAWC operator was present during the shutdown of Blower 3.
- PCX-1 was not assigned to Tower 3 control logic and would not receive a stop command when Blower 3 was turned off.
- The AAWC operator did not manually shut down well PCX-1 nor confirm that it stopped after turning off the blower.
- The inadequate treatment of water from well PCX-1 was the result of AAWC operator error.

Introduction

In the mid-1990s, the North Indian Bend Wash Participating Companies (NIBW PCs) designed and constructed the Miller Road Treatment Facility (MRTF) to remove volatile organic compounds from contaminated groundwater in Scottsdale, Arizona. The facility was brought online in March 1997, and ownership was transferred to Arizona-American Water Company (AAWC). AAWC now owns and operates the facility. Costs associated with the remediation of the NIBW groundwater are reimbursed by the NIBW PCs.

Per the request of Arnold and Porter, LLP, counsel for Motorola and the North Indian Bend Wash Participating Companies, ENVIRON International Corporation (ENVIRON) was retained to provide an engineering evaluation and control system review of the Miller Road Treatment Facility. This request for evaluation came as a result of two incidents in the operation of the MRTF: one in October 2007 and one in January 2008. Since the second incident, the treatment facility has been shut down, awaiting a thorough investigation into the cause of the mishaps and subsequent corrective action.

During the October 2007 incident, well PCX-1 was diverted to the Train 2 air stripping tower from October 9 to October 17 while the Train 3 air stripper tower was being inspected. During the time well PCX-1 was pumping to Train 2, routine samples were taken from the tower sump and clearwell. The concentration of trichloroethylene (TCE) in the samples measured 14 ppb and 9 ppb, respectively. These results were received in November after Tower 2 was shutdown and water from well PCX-1 transferred back to Tower 3.

During the January 2008 incident, Blower 3 shut down on the afternoon of January 15 without triggering an alarm or train failure sequence. As a result, well PCX-1 continued to pump into Tower 3 until the morning of January 16 when the blower was restarted. For approximately 16 hours, inadequately treated well water was pumped to the Paradise Valley Arsenic Removal Facility (PVARF). This action caused TCE concentrations above 5 ppb to be delivered to the public drinking water supply during this period.

As part of the investigation to determine the root causes of the two incidences, ENVIRON was requested to perform the following tasks:

- Review the design of the facility;
- Review existing data, including the daily AAWC operator logs, alarm logs, preventative maintenance logs, operations and maintenance manuals, and other available information necessary to understand the situation and malfunction(s) that occurred;
- Review the control system software and programming implementation;
- Conduct a site investigation;
- Test alarms and interlocks and validated portions of 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 operating personnel.

Discussion

Site Visit

ENVIRON personnel arrived at the office of Errol L. Montgomery and Associates, Inc. on Monday, February 25, 2008 to attend an orientation meeting with representatives, subcontractors, and legal counsel for Motorola or the PCs. ENVIRON was provided with an overview of the Miller River Treatment Facility (MRTF) and a summary of the October 2007 and January 2008 incidents.

On Monday afternoon, a tour of the MRTF was conducted. Along with ENVIRON and Motorola representatives, personnel and legal counsel from the Environmental Protection Agency (EPA), Arizona Department of Environmental Quality (ADEQ), Maricopa County, and Arizona American Water (AAWC) were present. The plant tour was led by James (Jim) Lutton, a consultant for NIBW PCs. The plant tour served as an introduction to the facility, outlining each area of the facility and identifying pertinent pieces of equipment and instrumentation. Brief descriptions of the October 2007 and January 2008 incidents were provided, allowing all those present to ask questions and gain a better understanding of the tasks at hand.

From Tuesday, February 26 until Friday, February 29, 2008, ENVIRON performed a site investigation of the MRTF that included the inspection and evaluation of the process control system, major equipment, accessory equipment, and instrumentation. A second site visit was conducted on March 17-20, 2008. During this follow-up visit, the control logic was tested more thoroughly and key operating personnel were interviewed. The following sections provide a summary of activities and findings of the site investigation. Equipment and instrumentation associated with the clearwell were not evaluated.

Process Equipment and Instrumentation

The Piping and Instrumentation Diagrams (P&IDs) for the facility were “walked down” to verify as-built conditions. Marked up P&ID’s are provided as Attachment 1 to show revised conditions. The MRTF consists of three packed towers that strip volatile organic compounds (VOC’s) from contaminated well water using air. Typically, well PCX-1 is directed to Tower 3, and well PV-15 is directed to Tower 1. Tower 2 serves as a spare for either well. Well PV-14 formerly discharged to the MRTF clearwell but is currently pumped directly to the Paradise Valley Arsenic Removal Facility (PVARF).

Well PCX-1 enters the facility on the east side and passes through a motor operated valve (MOV) into a distribution header. Manual valves and two other MOV’s allow the water to be directed into any of the three towers. Outside of the building, through both MOV’s and manual valves, the PCX-1 water can be directed to either well PV-14 or well PV-15 discharge piping. At the time of this investigation, the water was directed inside the building to Tower 3.

Water flows through a venturi type flow meter and a motorized flow control valve prior to discharge to the top of the tower. Discharge from the tower is directed to either the clearwell or Arizona Canal based on the position of MOV’s on the piping to each of these locations.

Each stripping tower has a dedicated blower to provide air for the process. Atmospheric air passes through a roof mounted intake screen and is piped into the intake of the blower. The

blower discharges air into the bottom of the packed tower that passes upward, counter current to the water flow. The air is discharged out the top and is ducted to granular activated carbon (GAC) units for VOC adsorption. Manual dampers are provided to allow the air flow to be directed to one of three GAC units. Air instrumentation includes an inlet air differential pressure (dP) switch, blower discharge pressure switch, flow transmitter, and local dP flow indicator.

Blowers

The blower inlet screens were inspected and found to be in need of cleaning. One of the screen panels in Blower 3 intake was damaged. Apparently, the restriction of air through the plugged screen created sufficient pressure to cause the filter element to be pulled into the filter housing. The damaged screen was secured into the filter housing. AAWC personnel were notified of the filter condition. Pictures 1 through 4 show the condition of the blower inlets. Dirty or clogged screens will reduce air flow. No maintenance records were located or provided by AAWC personnel to indicate the frequency of filter maintenance. The last documented cleaning of the blower intakes was April 6, 2006. This event was documented in the AAWC operator's daily log notes. Information in the Operations and Maintenance Manual recommended monthly inspection of the intake screens.

> *Synopsis: The blower inlet screens are not routinely inspected and cleaned which can lead to reduced air flow.*

Blowers 1, 2, and 3 were operated to determine the air flow. A manometer was placed on each blower discharge to determine the blower discharge pressure, so the value could be compared to the expected flow based on the blower discharge curve provided by the manufacturer. Blower discharge flow is monitored using an annubar flow sensor and dP transmitter and local indicator. Based on the flow sensors characterization, the SCADA system coverts the dP measurement to flow in cfm. This flow is indicated and trended in the SCADA system. Documentation provided indicated that the flow is properly calculated. The transmitters were factory calibrated and installed by AAWC in December 2007.

When Blower 2 was first operated, the blower produced low flow and only 2.5 inches of discharge pressure as compared to a normal pressure of 17 to 24 inches. After inspecting the blower, ENVIRON personnel identified that the blower was rotating in a reversed direction. At ENVIRON's request, AAWC arranged for an electrician to rewire the motor. Subsequently, the blower was operated with the correct rotation, and anticipated pressure and flow were achieved.

> *Synopsis: Blower 2 was found to be rotating in the reverse direction resulting in inadequate air flow. This condition accounts for the inadequate treatment of PCX-1 well water during the October 2007 incident.*

The tables below present the results of measurements for each blower operating without water flow and after Blower 2 rotation was corrected. The second table presents additional testing of the blowers required to evaluate anomalies in the first evaluation.

Initial Blower Performance Evaluation			
Parameter	**Blower 1**	**Blower 2**	**Blower 3**
Discharge pressure, inch of water	24	17.25	17.875
Flow transmitter dP, inch of water	1.04	1.46	0.48
dP gauge, inches of water	1.0	1.50	0.50
Blower flow at HMI, cfm	15,000	17,800	10,260

Initial Blower Performance Evaluation			
Parameter	**Blower 1**	**Blower 2**	**Blower 3**
Expected flow based curve, cfm	16,500	22,000	20,500
Blower motor vibration, mils/s	1.5	2.7	1.8
Blower shaft vibration, mils/s	5.9	3.0	2.5
Motor amps from MCC monitor Phase A	94.5	2.40	89.8
Motor amps from MCC monitor Phase B	85.8	2.33	91.8
Motor amps from MCC monitor Phase C	79.0	2.18	86.5

Second Blower Performance Evaluation			
Parameter	**Blower 1**	**Blower 2**	**Blower 3**
Motor, rpm	1787	1785	1790
Blower, rpm	1949	1930	1962
Motor amps at motor Phase A	102	110	86
Motor amps at motor Phase B	105	110	88
Motor amps at motor Phase C	102	106	85

The measured flow from Blower 3 is less than what would be expected based on the manufacturer's performance curve. The inlet screens are very dirty and can have an impact on blower performance, but the reduced flow is much greater than would be expected. On the second site visit, the intake screens were cleaned, the discharge damper was checked, and an electrician was obtained to check the rpm of each blower. The bushings that hold the damper blades were extremely worn and allowed some modulation of the damper blades. This modulation resulted in some drifting of the air flow rate. The electrician verified that the motor and blower rpm were correct. After further evaluation, a rattling noise was heard emanating from the duct work at the sensor location. A damaged, plugged or corroded sensor would result in a low air flow rate. The condition of the flow sensor should be evaluated and replaced if not repairable. The actual air flow from Blower 3 is probably higher than the values recorded.

Synopsis: Blower 3 air flow sensor appears to be damaged or corroded. The discharge dampers were worn and unstable.

Towers

Towers 1 and 3 had significant calcium carbonate deposits within the tower. Tower 2 had relatively clean packing. Water was pumped from well PV-15 to Towers 3 and 2 to observe water distribution. Samples were collected from both towers for VOC analysis. Water distribution in Tower 3 was poor, but distribution in Tower 2 was very good. A small water leak was noticed in the inlet piping or nozzle to Tower 2. ENVIRON was told that a major overhaul of each tower is scheduled this spring; therefore, a detailed inspection of the towers was not conducted. The towers are rated for 2100 gpm. When the MOV on Tower 3 was manually placed in the full opened position, the flow rate was over 2300 gpm. The tower water flow should be limited to the rated capacity of 2100 gpm, unless field testing is performed to ensure a higher capacity rating.

Synopsis: Tower performance can be reduced when the packing is plugged or when the flow rate exceeds design.

Off Gas Control

The original MRTF design provided an air drying system on each tower air discharge prior to entering the granular activated carbon (GAC) columns. Originally, high temperature and low air flow interlocks were provided to initiate a system failure and subsequent shutdown. ENVIRON was informed by Jim Lutton that the drying system was deemed to be unreliable and not necessary for the low concentration of VOCs in the off gas. The dryers were deactivated in 1999.

Originally, four GAC units were provided to remove VOC from the off gas, three units on-line and one standby. Currently, GAC Unit 3 originally designated for Tower 3 has been removed, and the flow from Tower 3 is routed to the former standby unit, GAC Unit 4. Some of the dampers that control the flow have corroded and are either difficult to operate or appeared inoperable. Some on the dampers are relatively new and work well. If dampers are not fully open, the rate of air flow through a tower will be reduced.

Synopsis: Some dampers need replacement.

Field Instrumentation

Field instruments were identified on the piping and instrumentation diagrams, visually inspected where accessible, and verified as to whether or not they were integrated into the current process. If an instrument was verified to be integrated, output data were collected to verify operation. No verification of the correct calibration of the instruments occurred during the site investigation. A summary of the findings are below.

Tower in Inlet Water Flow

1-T1-FIT-16, 1-T2-FIT-16, 1-T3-FIT-16

The inlet water flow is calculated by measuring the pressure loss through a venturi type flow meter. A differential pressure sensor transmits a signal to the SCADA system, which coverts the flow into gallons per minute (gpm). All the dP transmitters were powered. The transmitter on Tower 1 was not connected to the flow meter; therefore, it would not produce a reading if water was flowing. Both flow measuring devices on Towers 2 and 3 generated a flow signal when water was pumped to the respective tower. The preferred location of a dP transmitter in a liquid application is below the sensor to prevent the entrapment of air in the process connections. When mounted above, care should be taken to ensure no air is entrapped in the process connections. Additionally, all the transmitters generated signals when there was no water flow; subsequently, the computer screen or human-machine interface (HMI) read a false flow (e.g. 350 gpm) and did not force a zero flow reading.

Synopsis: The location of the transmitters allows for the collection of air in the process connections piping that can produce inaccurate measurements. The meters did not read zero when there is no flow.

Motor Operated Valves

AAWC personnel indicated the three motor operated valves (MOV's) used to direct the water flow from well PCX-1 was not part of the SCADA system. Documentation shows that the control and status of these valves are connected to Remote I/O panel 5, which provide status

(opened/closed) position of these valves. During the investigation of the Remote I/O panel 5, the Bristol processor was not programmed. The controller is no longer functioning and must be reloaded with the program if any of these I/O's are to interface with the HMI. Upon analysis, no impacts on the automatic mode of operation have been identified. On the second site visit, the MOV's on Well PV-15 were investigated after they did not respond to a start command. Upon investigation, the electronics from both valves had been totally removed. These valves can only be operated manually.

Synopsis: The MOV's upstream from the tower scan only be operated manually.

The MOV's at each tower are provided to control well flow to the tower. Currently, the valve on Tower 3 is operated manually in a full open or closed position. The open and closed status signals were confirmed. At the time of the inspection, the MOV on Tower 3 could not be operated automatically. An AAWC operator reported that the motor was inoperable, and the valve was operated manually for system startup and shutdown. Therefore, this valve, which should automatically close on system failure, could not. The design and program logic uses these valves to control the flow rate at 2100 gpm to the towers. According to August 2007 AAWC operator logs, the valve on Tower 3 was closing, causing the flow to decrease and initiate a tower shut down. The MOV was mechanically blocked open by the operator, so the Tower would not fail and water could be pumped. If the measured flow rate is above 2100 gpm, the program will send a signal to close the valve until the flow is restricted to 2100 gpm. If the valve is prevented from closing, the flow will not be regulated, and the motor will continue to try to close the valve, resulting in a damaged motor. Since the flow from well PCX-1 pumps more than 2100 gpm, the program would command the valve to close to reduce the flow. The current inoperable condition of this MOV is likely the result of manually circumventing the control system.

Synopsis: The inoperability of the Tower 3 MOV eliminated one of the Tower Failure interlocks. Valve repair is required before automatic running of Train 3.

<u>Blower Discharge Pressure High/Low Switch</u>

1-BL1-PSL/PSH-12, 1-BL2-PSL/PSH-12, 1-BL3-PSL/PSH-12

Pressure switches to indicate both low and high pressure conditions were originally provided on the air flow duct from Blowers 1, 2, and 3. Low or high pressure conditions are provided to cause a system failure and automatic shutdown of the train. In the fall of 2004, digital pressure gauges were purchased to replace the switches. This new type gauge was a pressure transmitter that provided a continuous pressure reading and two switched outputs. Although program changes were made to receive the new pressure signal, neither the new signal nor the switches were ever hooked up by AAWC; therefore, no low pressure signal could be received when a blower fails. All computer programming commands associated with the pressure switches were inhibited or disabled by the AAWC operators. Pictures of each pressure transmitter with disconnected wires can be found in Pictures 5, 6, and 7. The addition of blower pressure output is desirable because it helps to analyze the performance of the blowers. With this new signal, additional alarm set points can be programmed to alarm the operator when the blower is not functioning as expected. This alarm would be separate and independent of a train failure alarm.

Synopsis: The pressure switches and transmitters were not connected, which eliminated one of the tower shutdown interlocks.

Blower Flow dP Indicator/Transmitter

1-BL1-FE/FIT-11, 1-BL2-FE/FIT-11, 1-BL3-FE/FIT-11

An air flow dP transmitter and an air flow local dP indicator for each blower were connected to an air sensor in the air ducts from Blowers 1, 2, and 3. For each blower, the local dP indicator reading generally corresponded to the dP transmitter indicator reading when the blowers were operated.

The dP local indicator and the dP transmitter were mounted below the dP element. Generally, in an air or gas application, the instruments should be mounted above the sensing element to prevent liquid from collecting in the connection lines. A drain line was provided on the high pressure connection line; however, on Blowers 1 and 3 the drain was not at the low point of the line, which can allow water to collect. Since the process measurements are only in the 0 to 2 inches of water range, the presence of water in the collection lines can have a significant effect on the output reading. Pictures of local dP indicator and dP transmitter of Towers 2, 3, and 1 can be seen in Pictures 8, 9 & 10.

Synopsis: The dP connection lines allow for collection of water that can affect blower flow reading.

Blower Vibration Element/Indicating Transmitter

1-BL1-VE/VIT-13A/B, 1-BL2-VE/VIT-13A/B, 1-BL3-VE/VIT-13A/B

A vibration element was located for each blower motor and blower impeller shaft. High vibration is provided to cause blower shutdown and system failure and shutdown. The system appeared to be correctly wired, and the HMI was receiving signals from the transmitter. High vibration is set in the SCADA system, and blower shutdown must be initiated through the system program. The vibration measurements were acceptable and did not cause the recent blower shut down or train failure.

Synopsis: Blower vibration equipment was operating properly and was not the recent cause of blower shut down.

Tower Air Flow Switch

1-T1-FSL-10, 1-T2-FSL-10, 1-T3-FSL-10

Documentation shows that an air flow switch is located in the process air dryer to provide a signal on low air flow. These switches were originally designed to alarm and initiate a train failure sequence to prevent well water flow during low air flow conditions. As a result of removing the air dryer from the process, each of these switches had been disabled. The flow switch wiring had been disconnected at the control panel and a jumper installed at the terminals to simulate a closed switch, i.e. flow condition met. The condition of the local dryer panel for Tower 3 is shown in Pictures 10 and 11. The dryer panels for Tower 1 and 2 were in similar condition.

Synopsis: The air flow switch was disabled, which eliminates one of the tower shutdown interlocks.

GAC Relative Humidity and Temperature Transmitters

1-GC1-AIT/TIT-19, 1-GC2-AIT/TIT-19, 1-GC3-AIT/TIT-19, 1-GC4-AIT/TIT-19

A relative humidity/temperature transmitter and element were located on each GAC unit. GAC Absorption Unit 3 has been removed. Water was found in each of the sensor housings. Each element and transmitter was inoperable. Pictures of the instruments were taken, and the typical condition of the sensing element and transmitter are shown as Pictures 13 and 14. For vapor phase carbon system relative humidity, less than 50 percent is desired to prevent the carbon from saturating with water. When water is adsorbed into the carbon, the capacity removal efficiency for vapor phase organics is reduced. Excess water can increase headloss and reduce air flow. Because the vapors are saturated with moisture, the GAC units are operated with the drain valve open to prevent the units from filling with water. The VOC loading rate is very low, so the impact of operating in this mode should be minimal.

Each GAC Units was originally equipped with a manometer on the side of the GAC tank to measure the dP across the GAC Unit. High dP will indicate a plugging of the unit, which can lead to lower tower air flow and less effective VOC adsorption. The manometers are inoperable as can be seen in photographs 15 and 16.

Synopsis: The headloss manometers were missing on the carbon units; therefore, the impact of any plugging on blower flow cannot be ascertained.

Process Control and Data Analysis

Before data analysis began, ENVIRON personnel, with the assistance of an AAWC employee collected electronic data backups of the following information:

- Wonderware Applications:
  - History Directory;
  - Miller Road OPC Directory;
- Accol program loads for the Data Concentrator and PCX1 remote;
- Trend bitmap snapshots from the October incident;
- Trend bitmap snapshots from the January incident;
- Dataview snapshot of all signals current settings, control inhibited and manual inhibited signals;
- SCADA Alarm Setup and Configuration files;
- Raco Autodialer alarm logs from March 20, 2007 through January 25, 2008; and
- Access database configuration.

The locations of instrumentation and associated Input/Output (I/O) control panels were identified. Primary focus was given to air stripper Tower 3 and Well PCX-1 control programming and I/O points. To verify that the Supervisory Control and Data Acquisition (SCADA) system was receiving signals from the blowers, the running contact status of each blower was tested. Blowers 1 and 2 operated as expected in both Wonderware and Bristol Netview. When Blower 3 running contact status was tested, Bristol Netview indicated proper status change, but the Wonderware graphics associated with the change did not accurately indicate the change. Further investigation indicated that the OPC server was not updating the live I/O associated with Blower 3 running status. The OPC server was placed in "monitor" mode, and the I/O updated and operated as expected. When Blower 3 running contact status was tested after the OPC change, both Wonderware and Bristol Netview accurately indicated the Blower 3 status change. This anomaly only affects the graphic screen. It does not affect the control logic.

Since no functional control description was provided nor was the program code written with explanatory comments, the intent of the program code was not easily identified. During the first site visit, time did not permit a line by line analysis of the code to determine the impact of all I/O status points; therefore, Blower 3/Train 3 was investigated by running the program in automatic mode and identifying any fault conditions. AAWC personnel assisted in operating the blowers as needed. Blower 3/Train 3 start-up was initiated by the HMI (auto operation), but would not shutdown upon the shutdown command from the HMI. After evaluating the code to identify system permissives and shut down initiation, we found that many of the I/O status points within the program were control-inhibited or disabled. In other words, the I/O in the program was manually set by AAWC operators to give a desired condition regardless to the actual condition in the field.

Several attempts were made to simulate normal run conditions on the first visit. Because many of the I/O points were disabled and their interrelationship with the required permissives to operate in automatic mode was unclear, additional normal run conditions were postponed until the program logic could be studied to determine program intent and deficiencies. Since no historical record of I/O status is logged, there is no way to determine the status of the I/O at the time of train failure. Some of the I/O may have been inhibited during the system shut down to prevent inadvertent startup.

Due to the presence of shutdown commands from the HMI, Blower1/Train 1 and Blower 2/Train 2 were never tested in "auto" mode to simulate normal run conditions. Both trains were run in "manual" mode to verify run status and check field instrumentation.

The ACCOL program has more than 7000 lines of code. Much of the program involves equipment that is no longer working and many of the permissives are interdependent. A logic diagram for the operation of the towers was developed and is provide in Attachment 2.

> *Synopsis: Inhibition of many I/O points prevented the program from responding properly.*

Remote I/O panels 1, 2 and 3 that are associated with Towers 1, 2, and 3, respectively were examined. All relays were in working order and all wiring appeared to be properly terminated. When specific field instrument were tested, the I/O circuits were functioning properly.

After receiving permission to operate well PV-14, the control logic was to be evaluated with water flowing through the system. During the test, a train failure sequence was initiated and well

PV-14 pump shutdown as a result of safety features within the process control logic. An investigation of the ACCOL program determined that the process control coding was not designed to allow well PV-14 to pump to any of the towers while the system was in "auto" mode. Well PV-14 and tower commands were placed in "manual" mode to force water into Towers 2 and 3. Samples were taken by AAWC for TCE analysis from both towers while operating with well PV-14 water flow. Because the system could only operate with well PV-14 water while in "manual" mode, the process control program sequencing and interlocks were not evaluated on the first site visit. Subsequently permission to operate well PV-15 was obtained from the regulatory agencies. On the second visit, the control interlock strategy was successfully tested using well PV-15 and Trains 3 and 2.

The trendline for Blower 3 flow rate was examined from November 2007 through the current period. On December 6, when new transmitters were reportedly installed, the air flow read zero in the HMI when the blower was not operating. After the start of Blower 3 on December 14 until January 3, the flow rate began to drop off from above 4500 cfm to around 3800 cfm. Since the flow had been consistently below 5000 cfm, the low flow set point was reported to have been reset from the default of 5000 to a value of 2000. On January 3, 2008, the transmitter was recalibrated by AAWC instrument personnel to correctly generate an output based on a square root function rather than a linear function. After recalibration, flow indication remained at ~8000 cfm. On January 15, 2008 at 2:25 pm, the blower flow trendline dropped rapidly from ~8000 cfm to a flatline of ~2500 cfm. The AAWC operator reported that water had collected in the transmitter connection piping and generated a false reading of 2500 cfm at the time of the incident. The observed HMI low flow set points were 2000 cfm, 2000 cfm, and 5000 cfm for Blowers 1, 2 and 3, respectively. ENVIRON had been told that the Blower 3 set point was 2000 cfm and that lower setpoint was the reason that the low flow alarm was not triggered after blower shutdown. During AAWC operator interviews, ENVIRON was told by AAWC that the set point for Blower 3 had been changed from 2000 to 5000 after the shut down of the facility on January 16, 2008.

> *Synopsis: The low flow set points for the Blowers have been manually set by the AAWC operators at values less than the recommended minimum value.*

Further review of the trendlines show that the measured values of blower air flow or tower water flow are often inhibited to fixed values. Fixed water flow will inaccurately represent the amount of water treated, and fixed blower flow will circumvent shutdown logic on low flow conditions. Discussions with AAWC operator indicated that program inputs/outputs are often inhibited or disabled to operate the facility. A review of documents generated by the Bristol service representative and confirmed during an interview indicated that control inhibition was not necessary to operate the facility.

> *Synopsis: The program is often and unnecessarily inhibited or disabled by the AAWC operator, resulting in an inaccurate operational data and a potential loss of safety features.*

A review of the event logs showed that the Bristol system made no Train 3 alarm call outs to the Raco autodialer on January 15, 2008. Numerous Train 1 and well PV-15 alarms were sent during the morning, which were the result of start-up activities on well PV-15. These alarms occurred on both the Raco autodialer and the redundant WIN911 software alarm package. The only autodialer alarms generated during the afternoon were a "Train 1 Failure – normal" and "Well 15 Lockout alarm – normal" at 16:40. There appears to be a similar Train 1 Failure alarm

reset at 11:58 in the WIN 911 log. However, the Raco generated a lost carrier signal at 11:54 and may have been offline. If these are the same signal, then there was a 4:40 hour delay in the log, whereas other alarms are noted within 2-3 minutes of each other. This period of concern was during the time of Tower 3 Failure. Even if the Raco was offline during this period, a WIN911 call out should have been made in the event of a train failure.

Synopsis: The software did not show a Train 3 system failure on January 15, 2008.

During the first site investigation, analysis of the as-found condition for the January 2008 incident was investigated. The January incident condition included a "red" screen for Blower 3 on the morning of January 16. Red indicates that Blower 3 was in an "off" condition. A yellow screen indicates a lockout – alarm condition. No alarms or lockouts were noted. After simulating a number of scenarios with the system in the auto mode, no shut down could be generated through the program that did not generate a fault condition and resultant call out on the Raco Autodialer and WIN911. After the first visit and considerable evaluation of the program and simulation of various scenarios on the second visit, the only scenario found that replicated the as-found condition of the January 2008 incident required human intervention.

A new well pump had recently been installed at Well PV-15 and on January 15, 2008 was being flushed by the AAWC operator. Water from well PV-15 was routed through Tower 1 for treatment. The AAWC operator reported that he ran the Stripper from about 11 am to 2 pm, after which he shut down well PV-15 and shut down Blower 1. He stated that when he left around 2 pm, Blower 3 was running. This account is inconsistent with the computer historical data. A review of the SCADA trendlines, as depicted in the HMI screen images shown in Figures 1 and 2, show the following sequence of events:

08:00 to 10:45 – operate Blower 1 and attempt to start Train 1
10:45 to 15:23 – Train 1 operating with well PV-15 and Blower 1
14:24:18 – Well PV-15 turned off
14:25:30 – Blower 3 turned off
14:28:30 – Blower 1 turned off

If a train initiates a shut down either as a "train failure" or operator command, the blower is programmed to run for ten minutes to ensure that any residual water in the tower is treated. On January 15, 2008, Blower 1 only ran for approximately four minutes after the well PV-15 was shutdown, which indicates that the AAWC operator shut the blower down prior to the control system shutdown command. Prior to Blower 1 shutting down, Blower 3 was turned off. If Blower 3 was turned off at the MCC or local panel, an alarm condition or train failure would not have occurred; thus, no alarm was generated or train lockout reported. However, the control program will issue a well shutdown command when the associated blower is not operating to prevent water from entering the tower without the blower operating. This command is predicated on the well being assigned to the train through the HMI. A tower control screen is provided in the HMI graphics to start up each train. On this screen a specific well is assigned to a specific tower, e.g. PCX-1 assigned to Tower 3. Figure 3 shows the screen settings when Trains 1 and 3 are operating in auto mode. The selection of a well is required to start a specific train, but once the train is operating, the well can be deselected on the screen and not affect the operation of the well or tower. Figures 4 and 5 show the screen with PCX-1 selected and not selected, respectively, when Tower 3 is in auto mode.

If the well is deselected on the tower control screen, it is removed from the program logic and will not receive a command to stop when the blower is stopped either manually or during a train failure sequence. Since the well did not receive a stop command, well PCX-1 was not associated with Tower 3 logic in the HMI. The deselection of the well from the control logic could have occurred anytime after the December 14, 2007 start-up; however, during the day of the January 15, the AAWC operator was using the setup screen to operate well PV-15 to Tower 1. During this time or previously, well PCX-1 was deselected from the Train 3 logic. As a result of the well being deselected by the AAWC operator, well PCX-1 continued to operate when Blower 3 was turned off. The AAWC operator did not confirm that the well had stopped pumping prior to his departure from the facility.

> *Synopsis: Blower 3 was manually turned off during Train 1 shutdown. Well PCX-1 was not turned off manually or via the program logic and contaminated water entered Tower 3 without the blower operating.*

System Process Design

The system as designed appears to be sufficient to remove the concentrations of VOC to acceptable concentrations. We performed air stripping calculations for TCE and found that the stripping tower is adequate to remove a TCE concentration of 200 ppb to treatment standards in 2100 gpm of water with at an air flow 11,300 cfm. During our investigation, the blowers were not delivering the design air flow, probably because of severe tower plugging. The current level of TCE is around 80 ppb from PCX-1 and will require less flow. The minimum default air flow is now 5000 cfm. After the proposed rehab of Tower 3 and the replacement of the flow sensor, a sampling program should be conducted to determine stripper efficiency at various air flow rates and temperatures. The minimum air flow requirement set in the control system should be based on this test work.

The SCADA system, although not well documented, did provide adequate control and a number of control safeguards. All of the interlocks are via the SCADA system. No hardwired interlocks are provided. Control system or software interlocks are often used, because they allow a sequence of events to occur in response to abnormal conditions. Specifically, during a Train Failure, the control logic allows the blowers to operate an additional ten minutes to ensure that any water remaining in the tower is properly treated. Unfortunately, many of the shutdown interlocks have been removed from the system as indicated in this report. At the time of inspection only low air flow and blower status were operable. When low air flow triggers a Train Failure, a signal is sent to stop the well, close the tower inlet MOV, open both the clearwell and canal valves and stop the blower after a 600 second run time. Blower status monitors the on-off condition of the blower. If the blower shuts down, when the system is calling for it to run, a Train Failure is initiated. Whenever a Train Failure is initiated, the control system must be reset before placing a train back into the automatic mode. The SCADA system also provides an interlock to close the inlet MOV on train failure, but unless the control system commands the MOV to close, the MOV stays in its current position. Two conditions prevented this interlock from working: (1) when the system was taken out of auto mode by manually turning the blower off, the command logic was disengaged, and (2) the MOV was opened in the manual mode and would not have closed if a command had been given.

Operation and Maintenance

None of the AAWC employees questioned seemed to have a complete understanding of the control logic. Numerous conditions prompted the AAWC operator to circumvent the control logic to run the stripper system. Many of these conditions were a result of equipment not being properly maintained. In October 2007, the Bristol service technician disabled well level and air dryer signals within the program at the request of AAWC, because these devices were out of service. After this reprogramming the Bristol technician stated that no interlocks needed to be inhibited, i.e. to input false values into the program logic, to operate the facility. However, key instruments used to safeguard the tower operation were either out of service or inhibited by the AAWC operator. Whenever a process variable did not meet the process requirements, the AAWC operator inputted an acceptable fixed value into the logic. This action overrode the automatic control of the particular item. Examples were inputting an air flow value or manually opening and closing the tower influent motor operated valve. Both of these items are key components in the train failure sequence.

Pressure transmitters/switches for the blower discharge were purchased in Fall 2004 and mounted, but never hooked up The tower effluent air flow switch was part of the air dryer system, but it was also part of the train failure logic. When the dryer system was deemed to be unnecessary, no alternative air flow switch was provided. Both of these actions eliminated system safeguards.

Requests were made for records of equipment maintenance, but no maintenance records have been received to date. Although daily operator logs were kept that referenced some outside service activities, no maintenance records were found at the facility. A good maintenance management practice retains a file on each piece of mechanical equipment and instrumentation. These files should include equipment description, supplier, preventive maintenance schedule and lubricants, and record of service performed. When investigating Blower 2 motor wiring issue, no record was found at the facility to indicate when the motor was replaced or last serviced. Equipment maintenance records appear to be deficient.

Recommendations

The following recommendations are made to improve reliability and improve fail-safe operation:

1. Repair the motor operated valve on Tower 3 and add to all trains a pneumatically operated on-off valve to fail close on train failure. Alternatively, replace the motorized tower inlet control valves with pneumatic operated control valves. Pneumatic operators are more reliable than motor operated valves and can be set to fail closed.

2. Provide a tower air flow switch to ensure the air is flowing and hardwire the switch to close the tower inlet valve and initiate a train shut down when air flow is not detected. Wire this switch in a manner that the run condition causes a contact closure so that a system cannot operate when an instrument fails.

3. Repair or replace the air sensor on Blower 3.

4. Relocate the blower flow transmitters and pressure transmitters above the flow sensor and route pipe connections up to transmitters with no low points. Wire the

blower pressure transmitter and switch contacts to the I/O panel. Include blower discharge pressure in the SCADA system and trend the data. High and low pressure conditions should be included in the alarms list. Pressure will help monitor the blower's performance.

5. Inhibition of certain control logic should be available only to supervisory personnel. Minimum and maximum process variables should be programmed such the operator cannot enter a setpoint above or below these limits. For instance, when treating PCX-1 well water, the minimum blower low flow alarm cannot be set below 10,000 cfm. This minimum flow should be determined by experimentation.

6. The logic associated with the tower setup screen should be rewritten to alarm if the selected well is deselected from the control logic. If the alarm is not removed within a specific time, a train failure will be initiated.

7. Replace dP manometers on GAC adsorbers to allow the operator to access the condition of a GAC unit and its impact on air flow rate through the tower.

8. Proceed with an overhaul of the stripping towers.

9. Replace or repair GAC inlet damper valves as need.

10. Develop an equipment management file system and implement a preventative maintenance system. Routine inspection of instrument, UPS, and SCADA hardware should be included.

11. Provide a manometer, 0-2 inches water vacuum, connected on the inlet duct to the blower to monitor the condition of intake screen condition. Since the intake is served by a screen rather than a filter that can plug relatively quickly, a dP switch is not necessary as long as the manometer is routinely checked and recorded.

The following additional improvements to the facility are provided for consideration:

12. Relocate the tower inlet flow transmitters to a position beside or below the flow element and route connection pipe with no high spots that can trap air. Calibrate or program flow readings to zero when there is no flow.

13. Repair the blower power meters and include blower motor amps in the trend data to monitor the blower's performance.

14. Provide hardwire interlock for high-high vibration on the blowers and motors. The signals can be taken directly from contacts on the vibration monitoring system.

15. Adjust MOV limit switches as needed to ensure valves fully open or fully closed.

16. Expand the alarm logs to include non critical actions. Alarms are typically classified as Class 1, 2, or 3. Class 1 alarms are critical and require immediate action; Class 2 alarms require action in a reasonable amount of time; and Class 3 alarms are for general information. Examples of each are:

a. Class 1 – blower stops or low-low air flow
b. Class 2 – blower low air flow or low discharge pressure
c. Class 3 – canal valve status change (open/close)

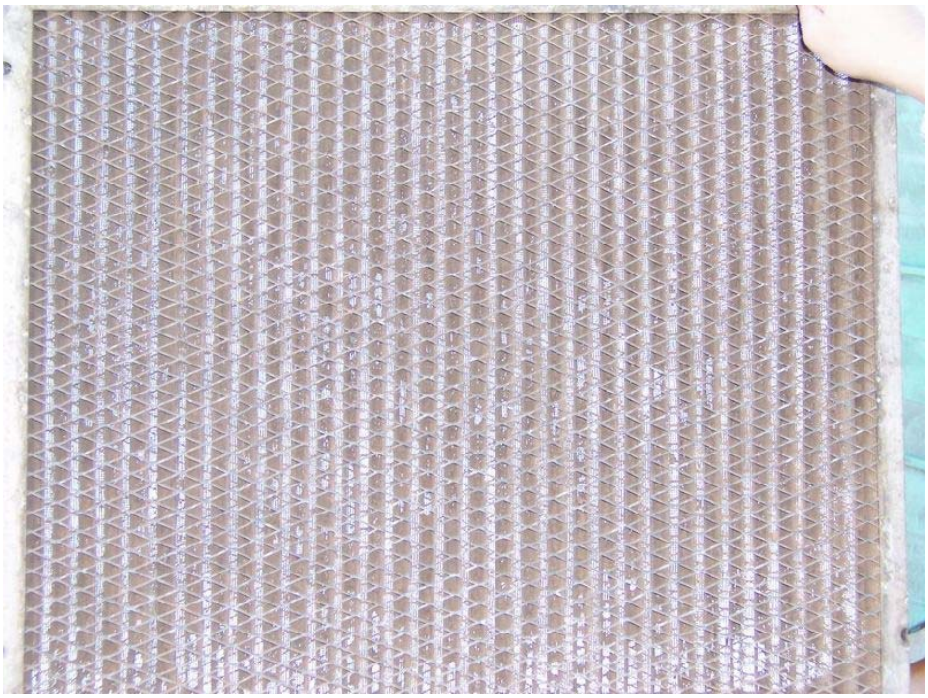
17. Reprogram ACCOL logic to remove all abandoned I/O and prepare a logic diagram. The position of the outside MOV's may need to be brought back in the logic, depending on how the facility will be operated in the future.

18. Continue to evaluate methods to minimize scaling in the air strippers.

19. Conduct a sampling program to verify stripper efficiency at various air flows and temperatures.

Photographs:

Picture 1: Blower Intake Unit

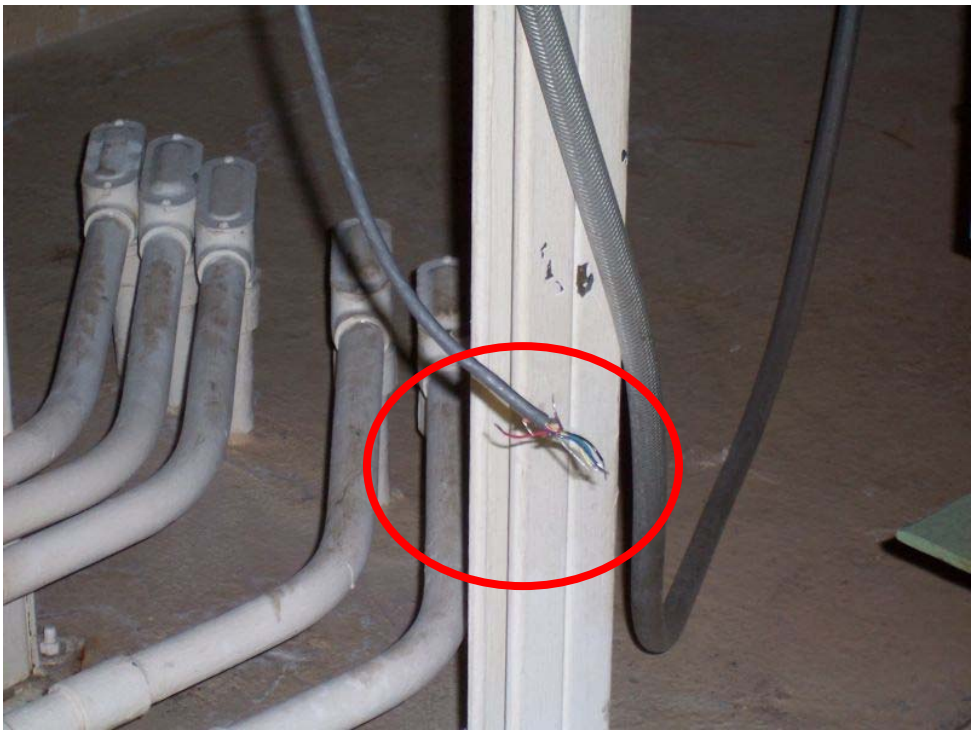


Picture 2: Typical Dirty Screen

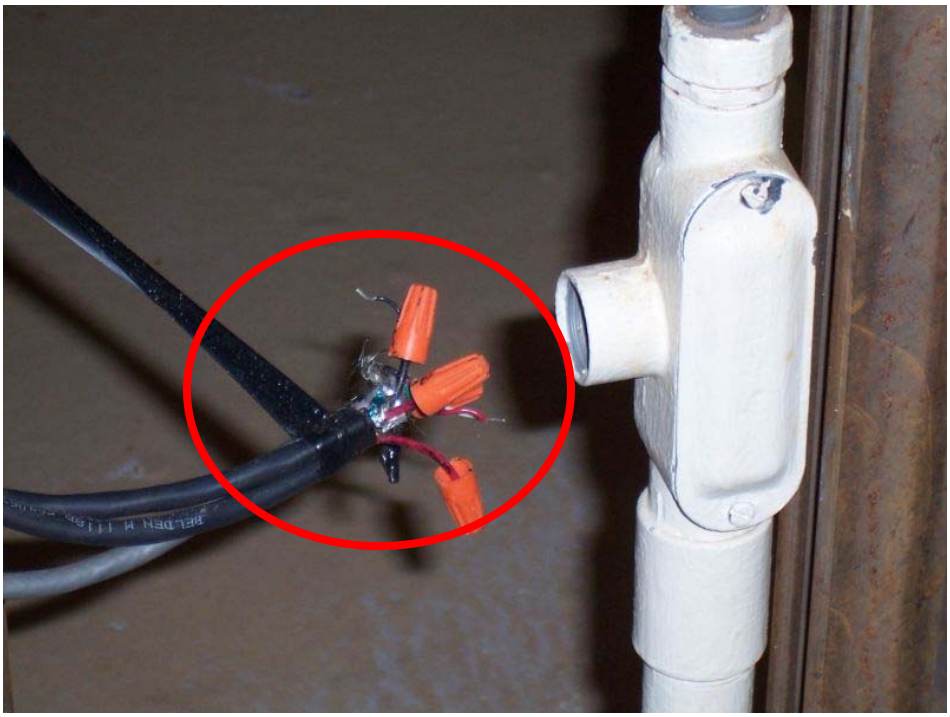
Picture 3: Blower 3 Damaged Screen

Picture 4: Blower 3 Damaged Screen Removed

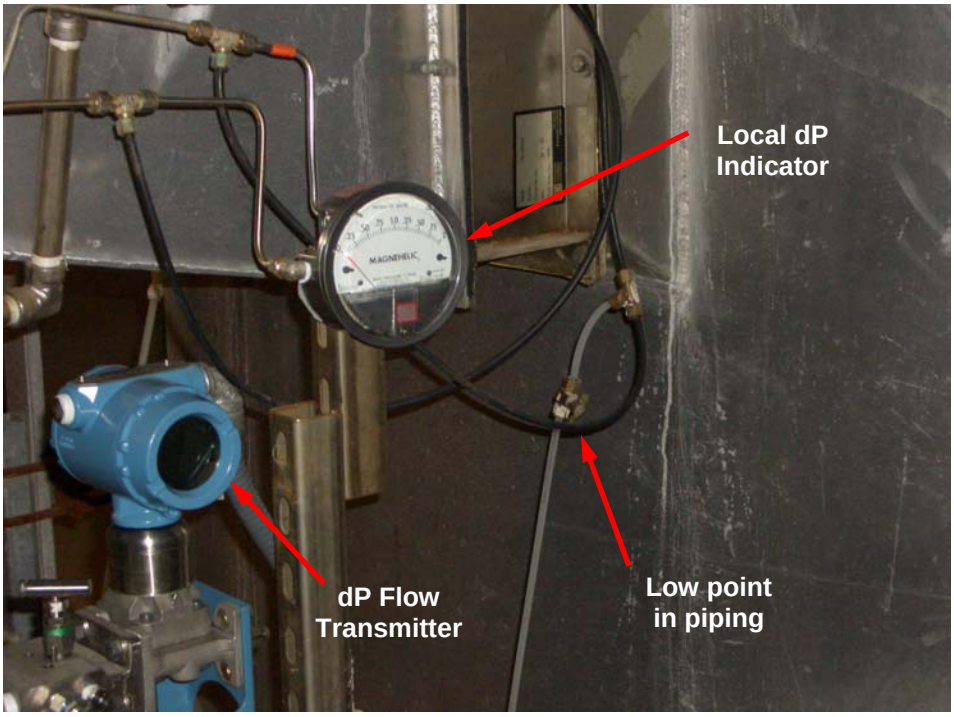
Picture 5: Tower 1 Disconnected Pressure Switch



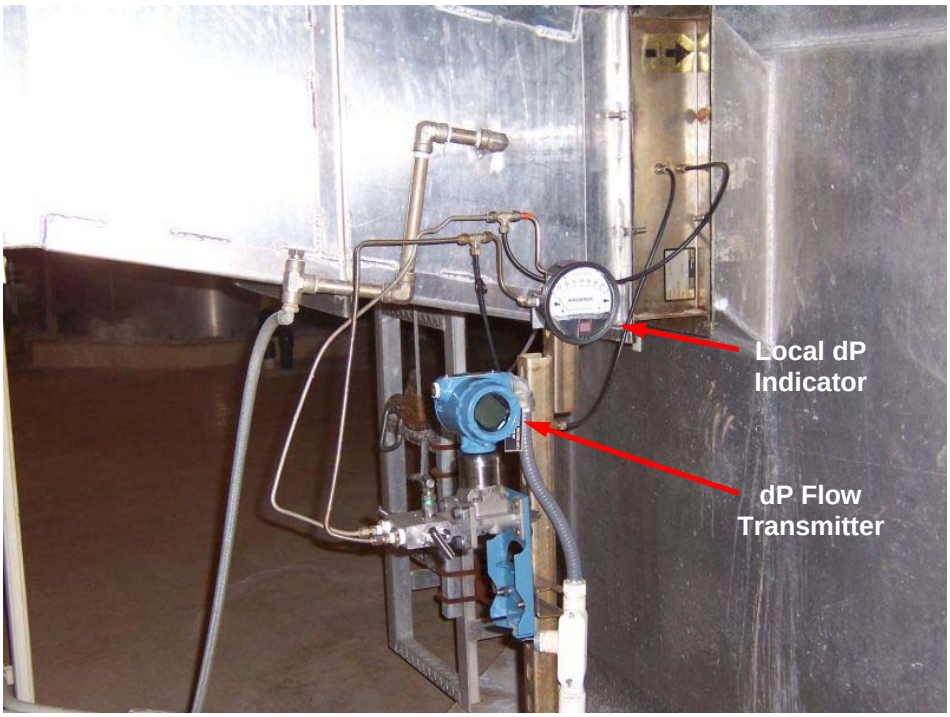
Picture 6: Tower 2 Disconnected Pressure Switch



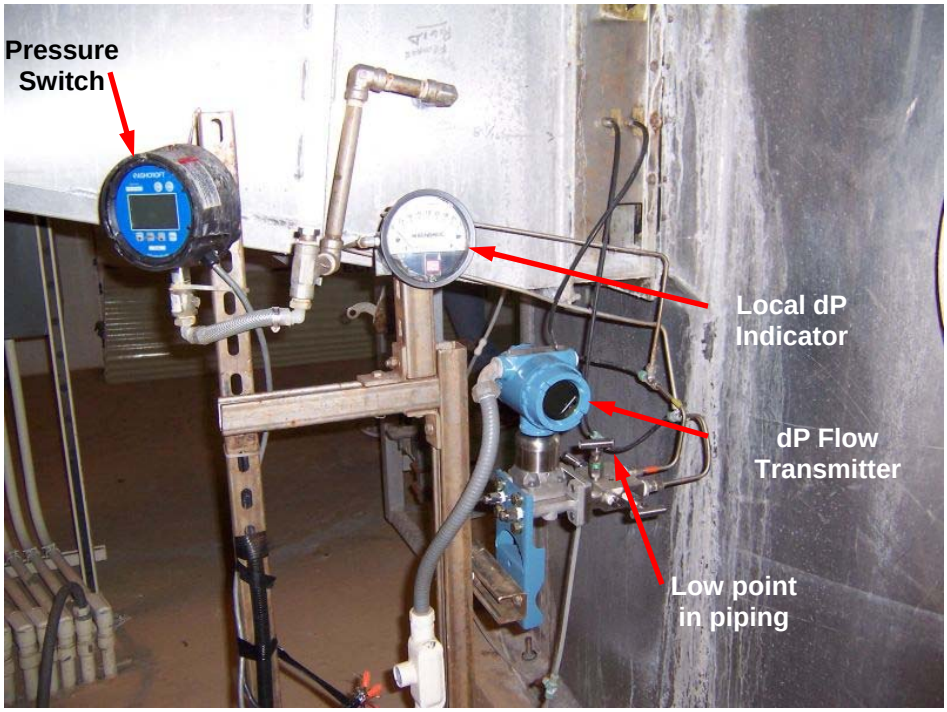
Picture 7: Tower 3 Disconnected Pressure Switch



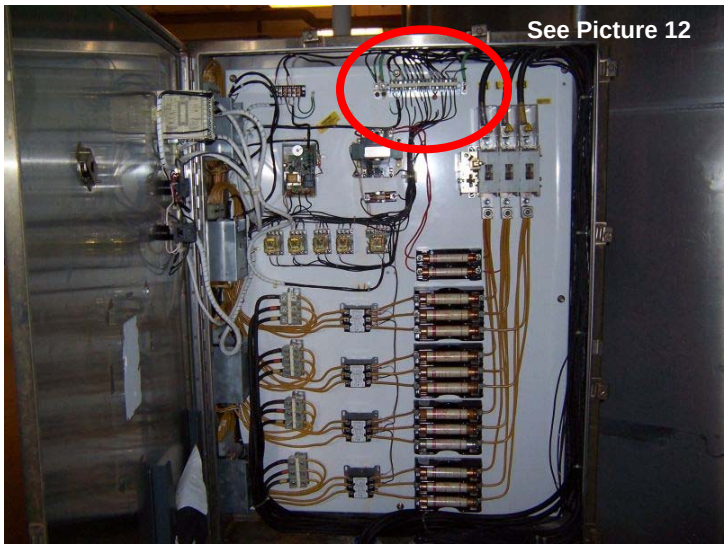
Picture 8: Tower 1 dP Flow Transmitter and Local dP Indicator



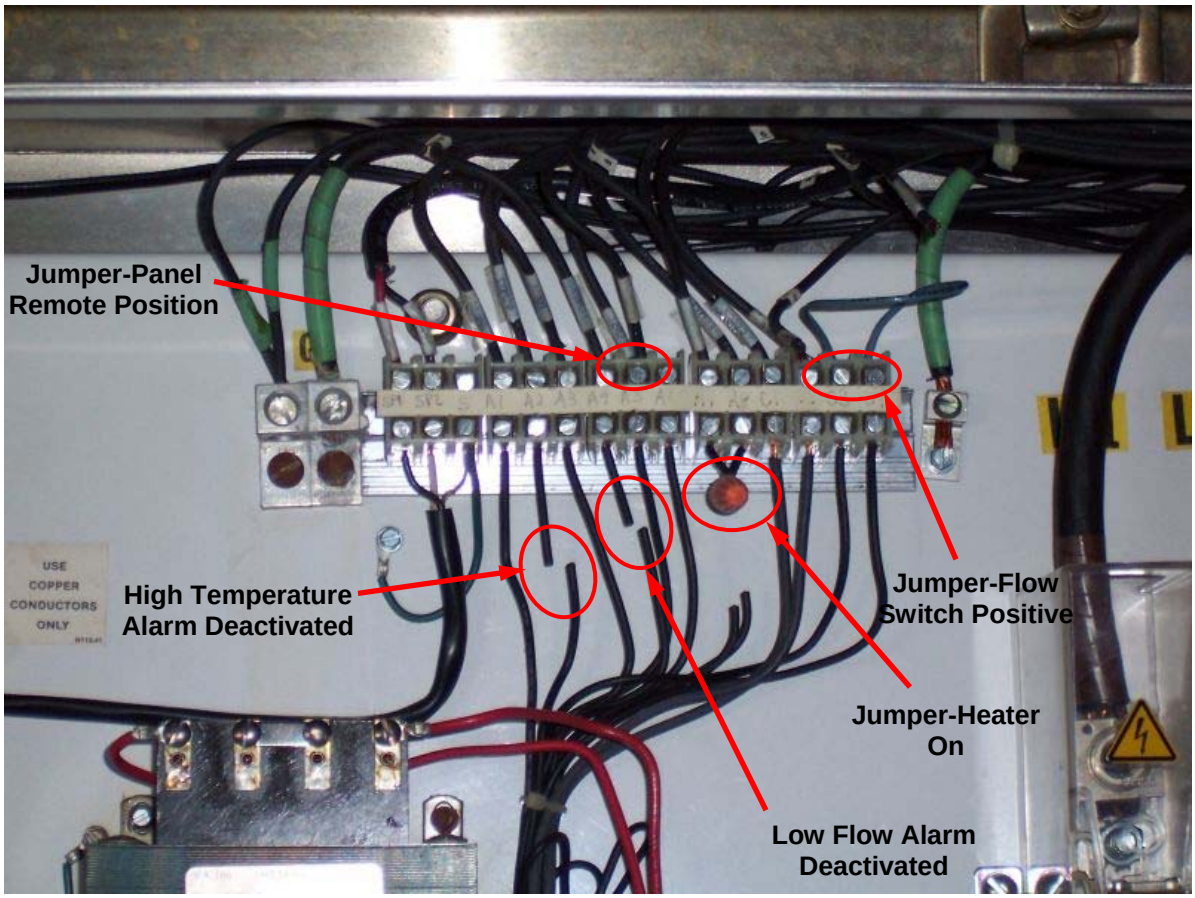
Picture 8: Tower 2 dP Flow Transmitter and Local dP Indicator



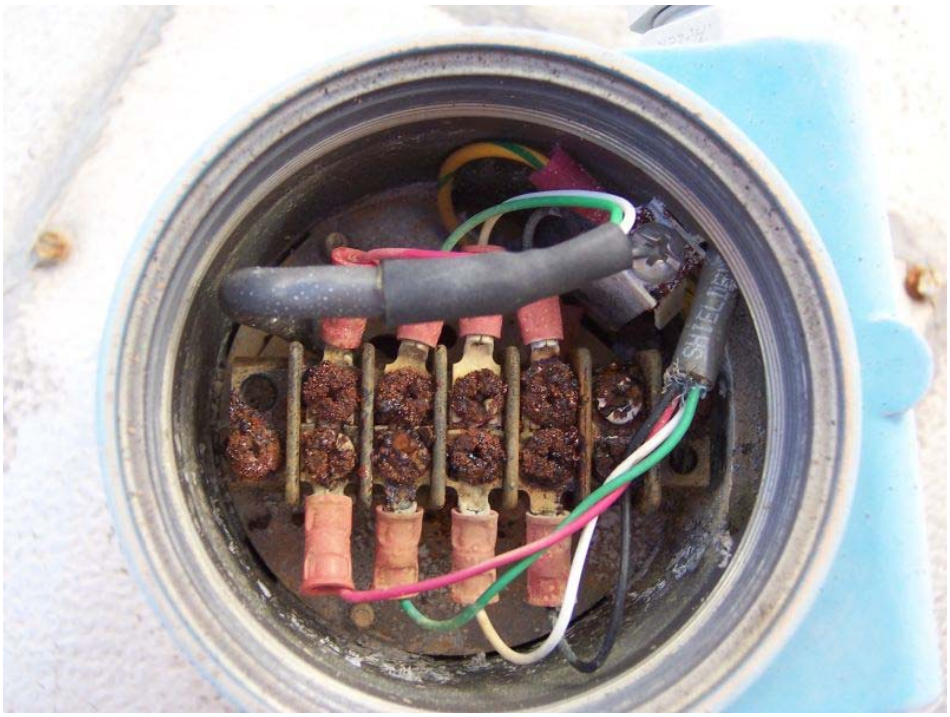
Picture 9: Tower 3 dP Flow Transmitter and Local dP Indicator



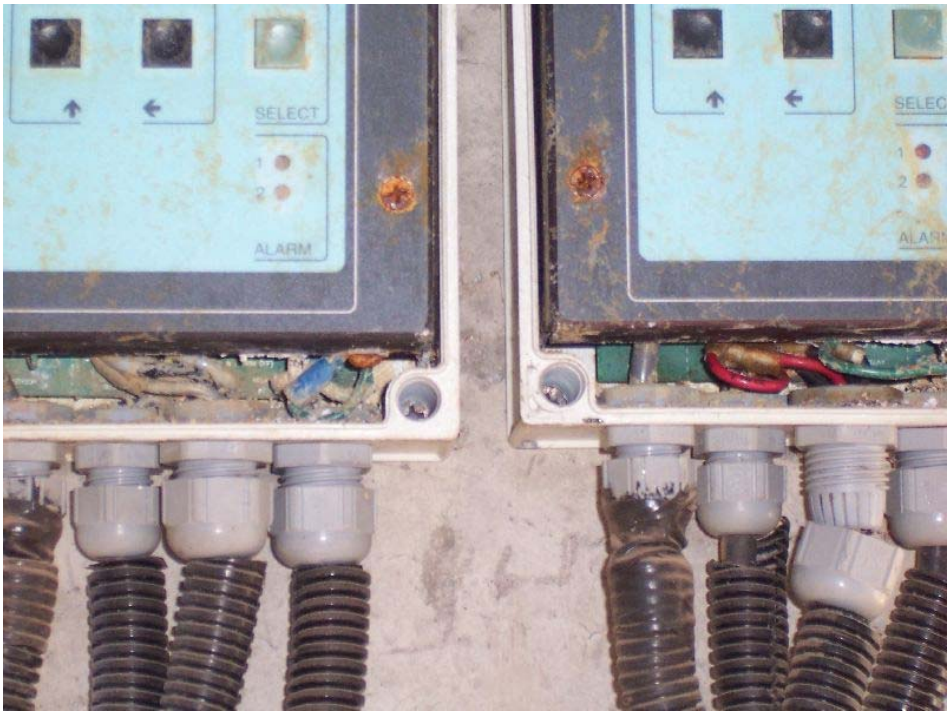
Picture 11: Tower 3 Dryer Panel



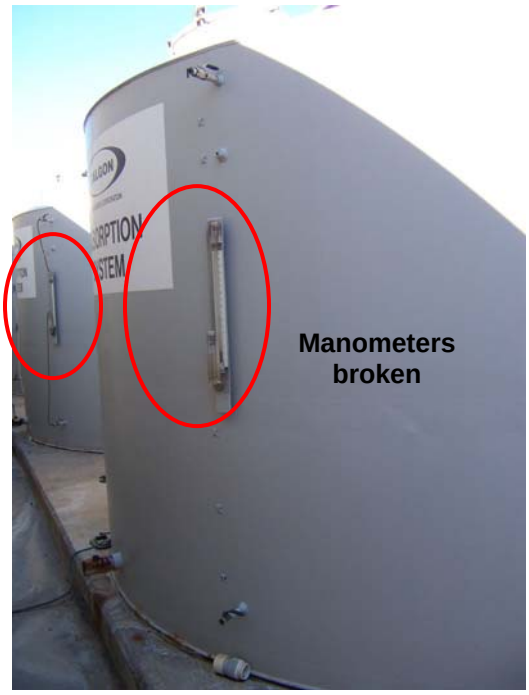
Picture 12: Tower 3 Dryer Panel I/O Terminal Block



Picture 13: GAC Unit 1 Relative Humidity Element



Picture 14: GAC Unit 1 & 4 Relative Humidity Transmitters



Picture 15: GAC Unit 1 & 2

Picture 16: GAC Unit 4

Figures:

FIGURE 1. MRTF JANUARY 15, 2008 (0800 – 1600)

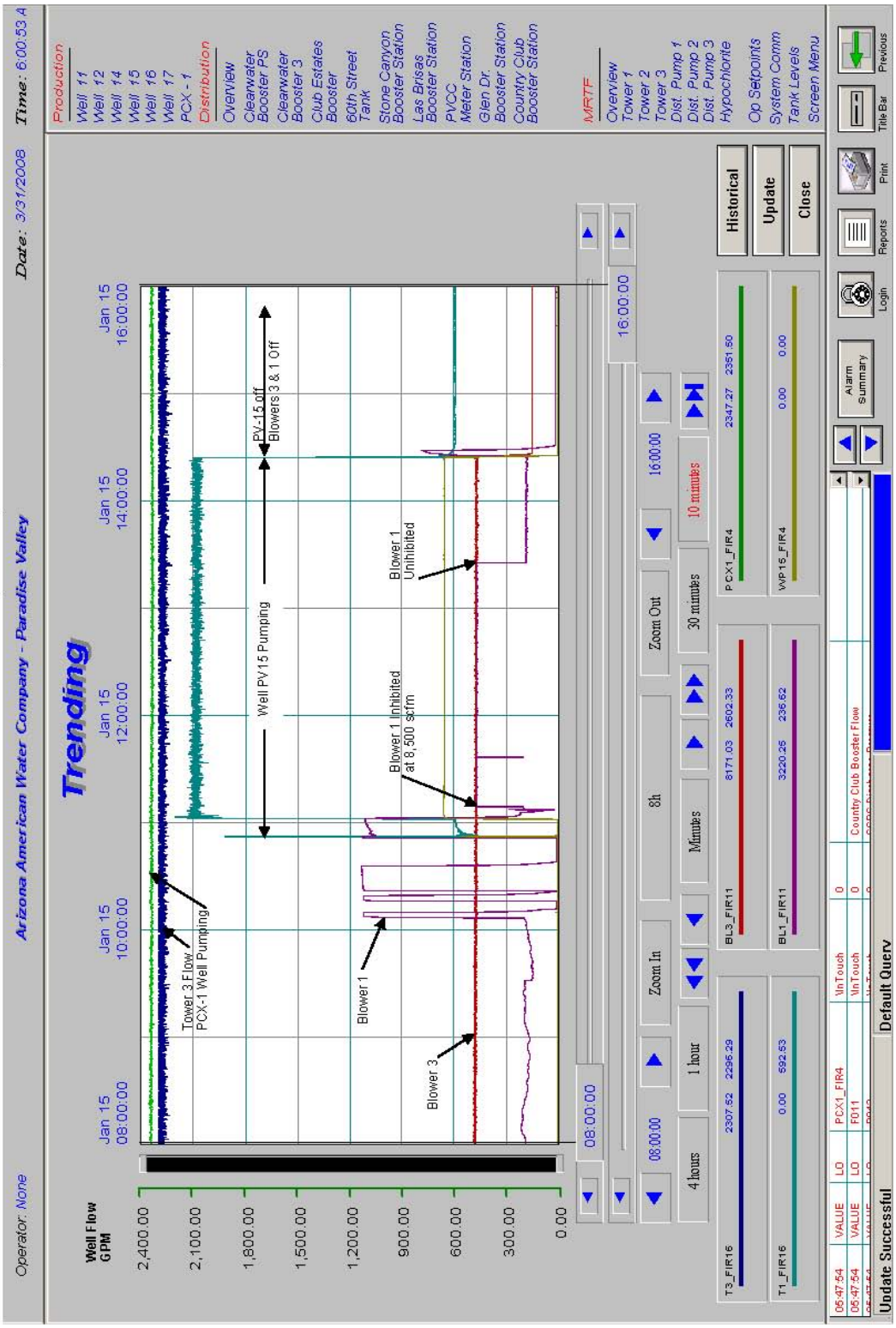


FIGURE 2. MRTF JANUARY 15, 2008 (14:23 – 14:31)

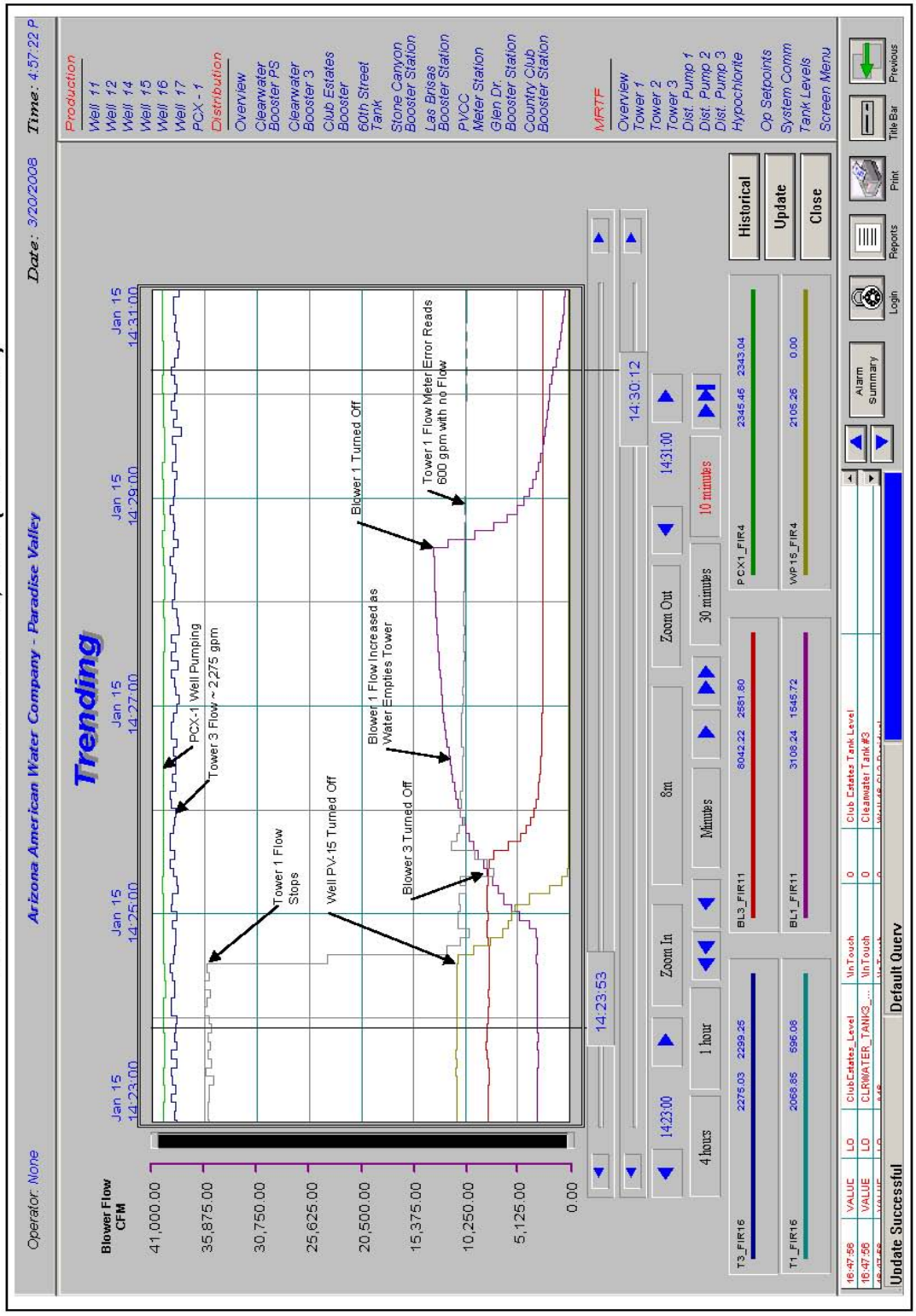


FIGURE 3. MRTF TOWER SCREEN WITH TOWER 1 & 3 IN AUTO OPERATION

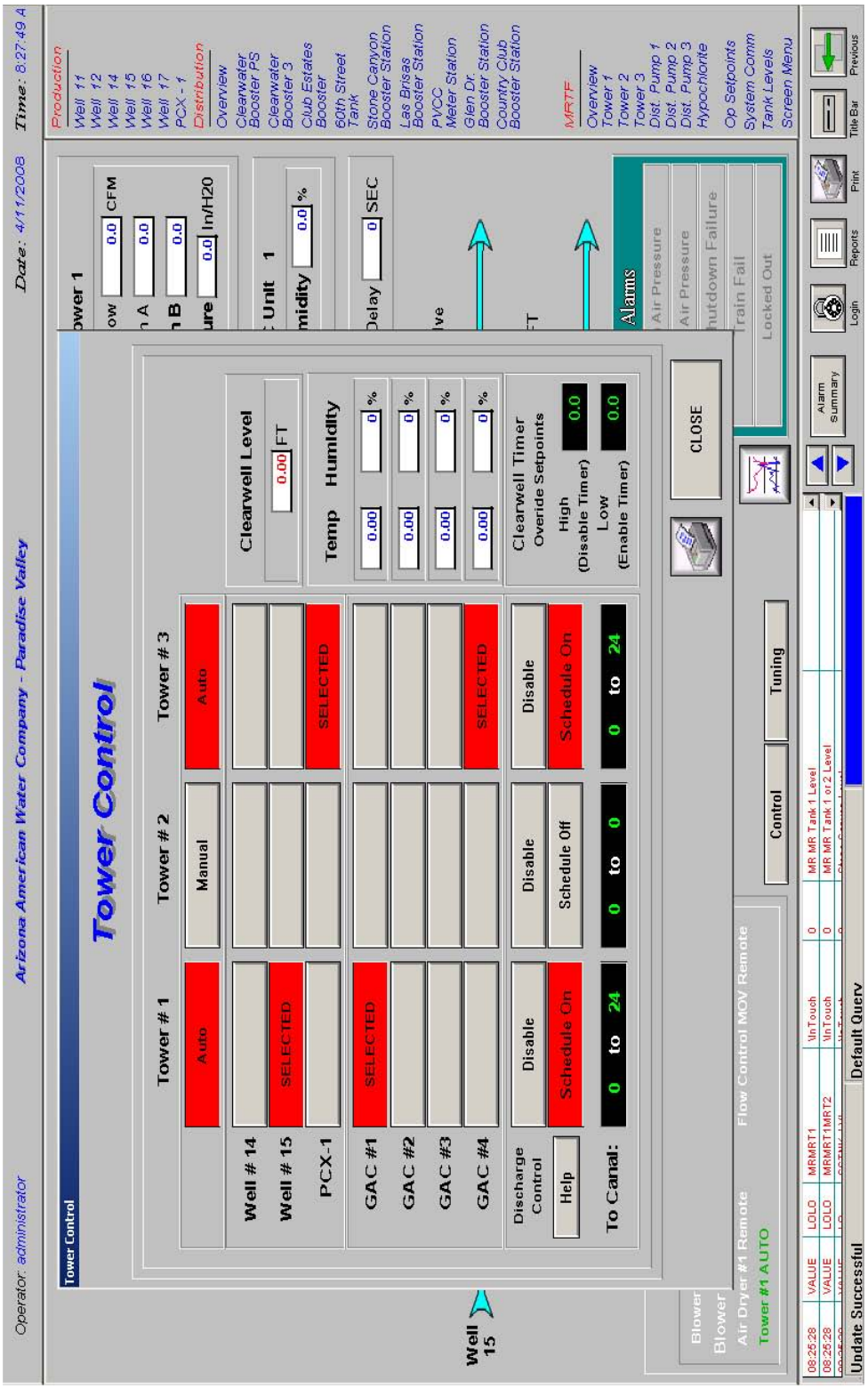


FIGURE 4. MRTF TOWER SCREEN WITH TOWER 3 IN AUTO OPERATION WITH PCX-1 SELECTED

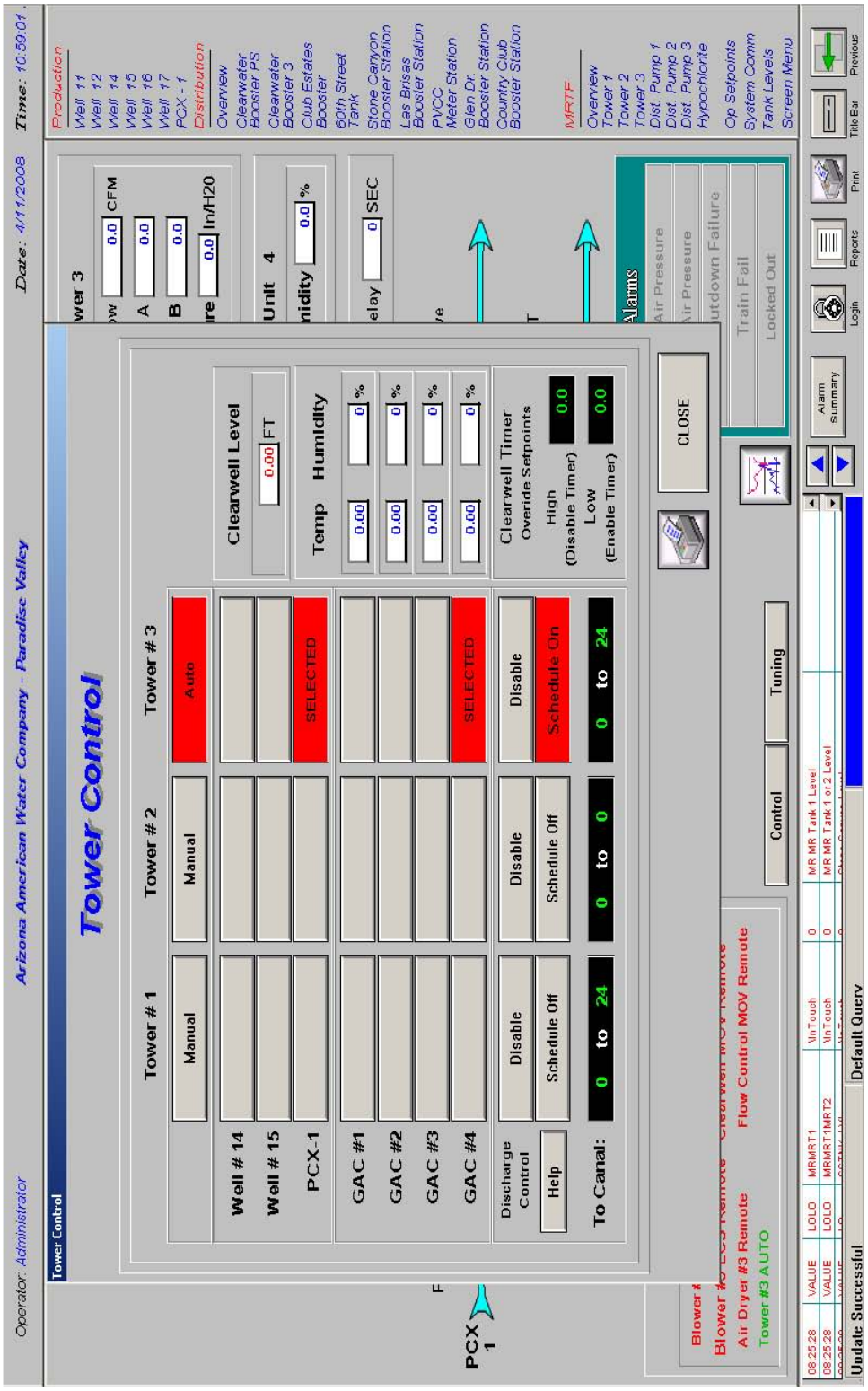
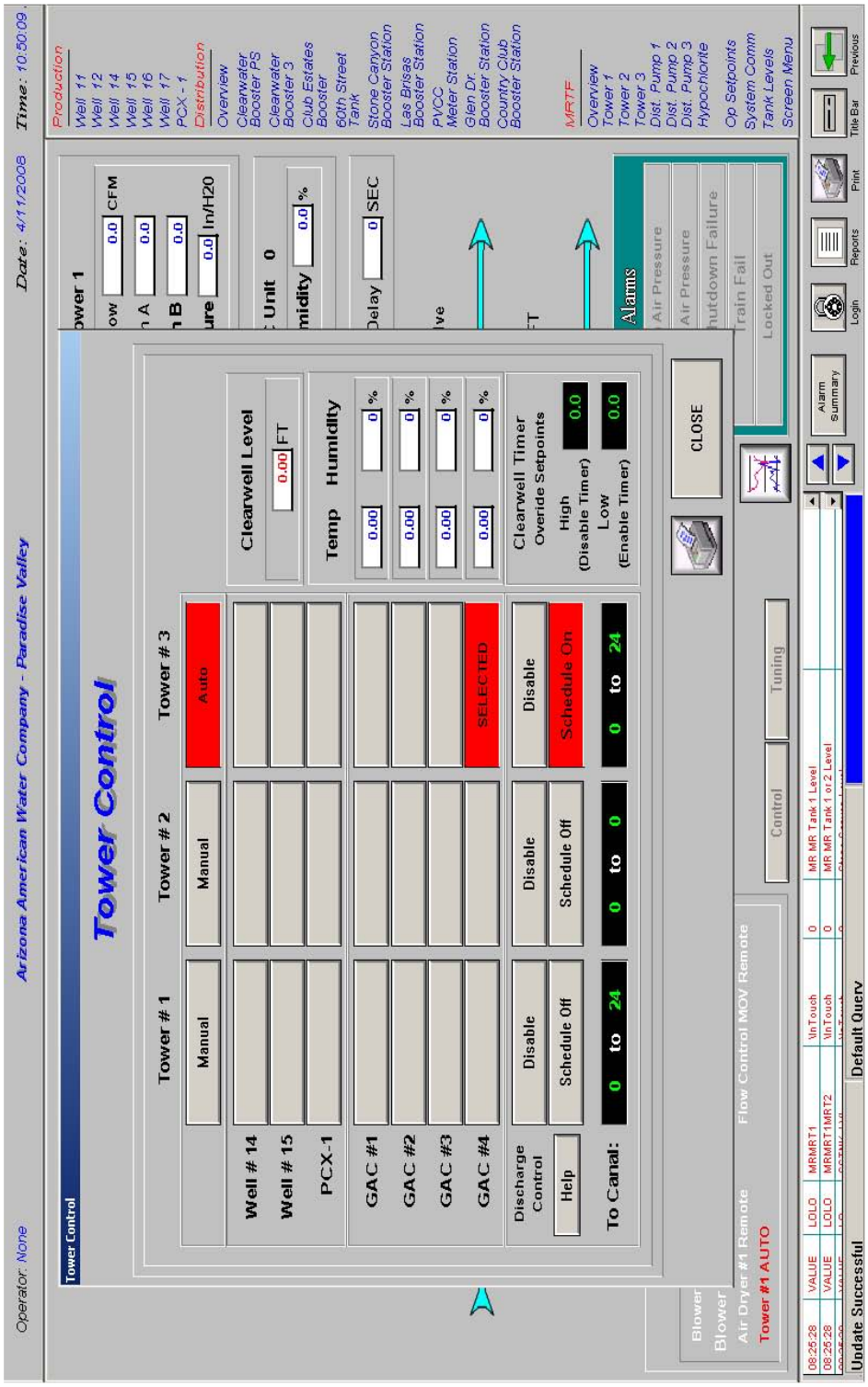
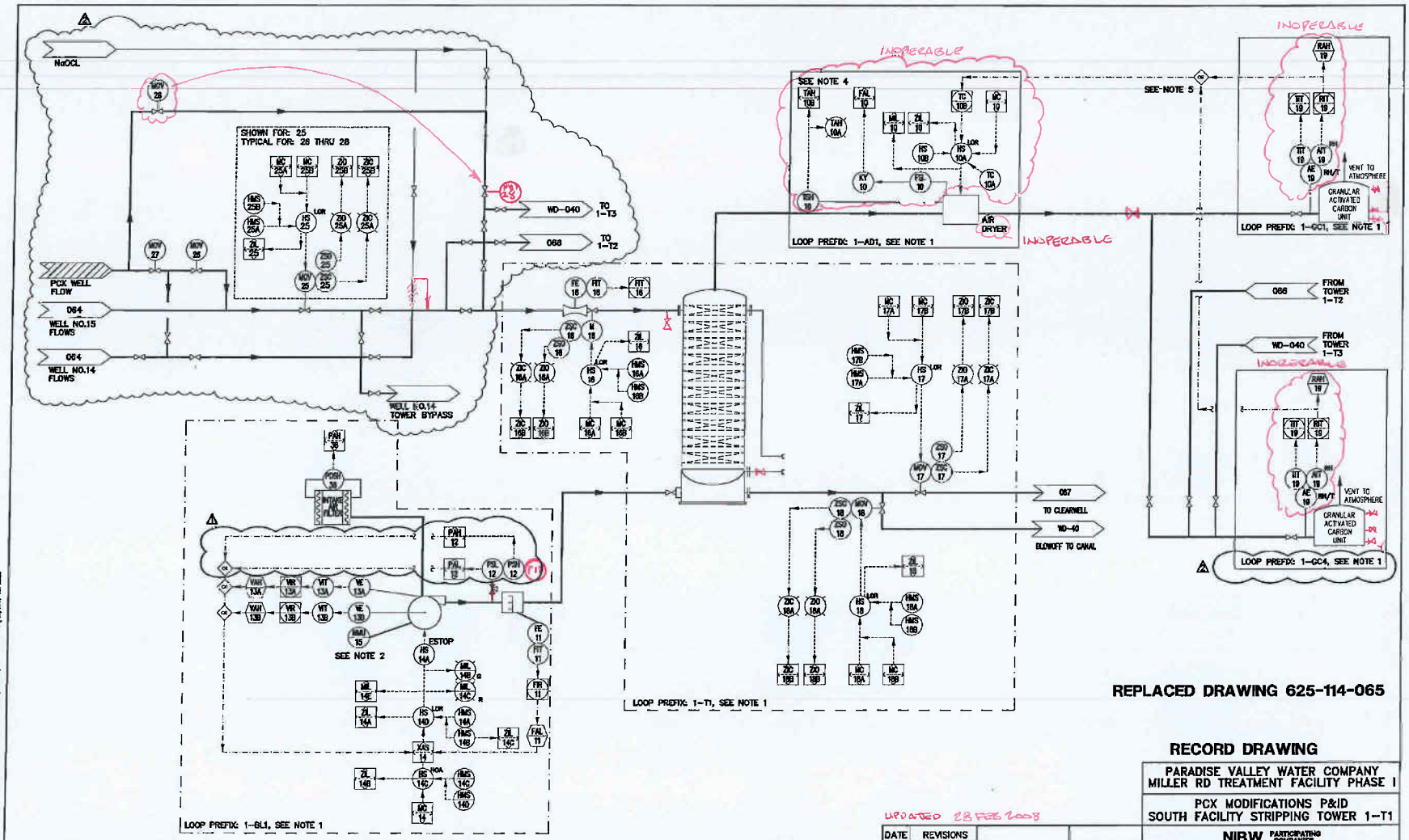


FIGURE 5. MRTF TOWER SCREEN WITH TOWER 3 IN AUTO OPERATION WITHOUT PCX-1 SELECTED



Attachment 1:
Piping and Instrumentation Diagrams



REPLACED DRAWING 625-114-065

RECORD DRAWING

NOTES:

1. THE COMPLETE DEVICE TAG CONSISTS OF THE LOOP PREFIX, THE DEVICE TYPE AND THE LOOP NUMBER. FOR EXAMPLE 1-BL1-FIT-11.
2. SEE DRAWING 062 FOR MMU COMMUNICATIONS.
3. STOP AIR DRYER AND CLOSE TOWER INFLUENT RATE OF FLOW CONTROLLER ON BLOWER FAILURE
4. STOP AIR BLOWER AND CLOSE TOWER INFLUENT RATE OF FLOW CONTROLLER ON AIR DRYER FAILURE
5. RTU CALCULATES TEMPERATURE SETPOINT USING RELATIVE HUMIDITY FROM 1-GC1-AIT-19 OR 1-GC-AIT-19 BASED ON OPERATOR ASSIGNMENT AND OPERATOR ENTERED RELATIVE HUMIDITY SETPOINT.

UPDATED 28 FEB 2008

DATE	REVISIONS
1/17/95	1 REVISED BY ADDENDUM
8/23/96	2 PCX MODIFICATION

WARNING 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1 THEN DRAWING IS NOT TO SCALE.

PARADISE VALLEY WATER COMPANY
MILLER RD TREATMENT FACILITY PHASE I

PCX MODIFICATIONS P&ID
SOUTH FACILITY STRIPPING TOWER 1-T1

NIBW PARTICIPATING COMPANIES

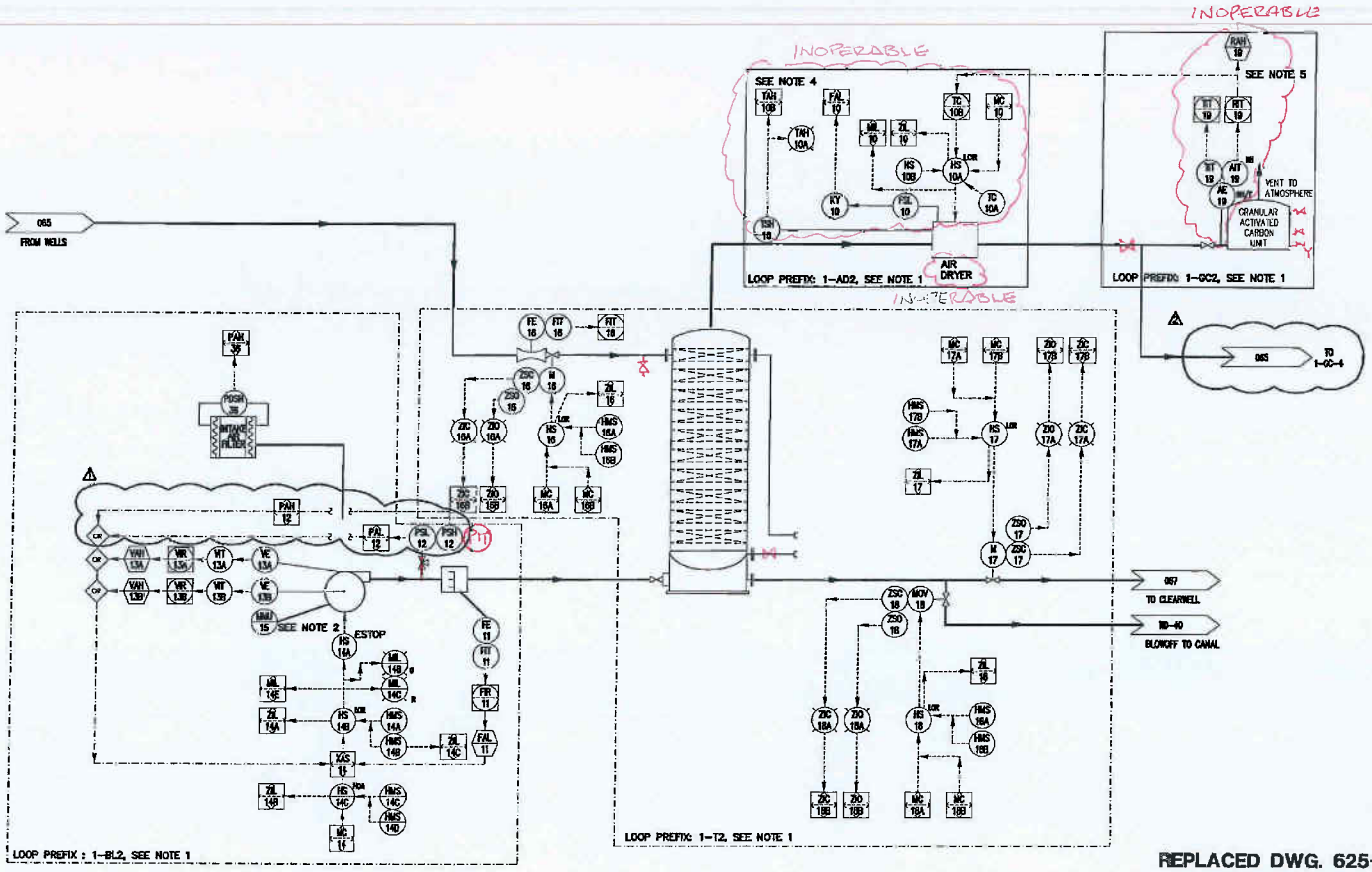
MONTGOMERY WATSON

DRAWN BY: SDG
PROJECT ENGR: GLC
APPROVED: SS
DATE: 6-23-95

USE DIMENSIONS ONLY
SCALE AS SHOWN

USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES

WD-038



REPLACED DWG. 625-114-066

RECORD DRAWING

NOTES:

1. THE COMPLETE DEVICE TAG CONSISTS OF THE LOOP PREFIX, THE DEVICE TYPE AND THE LOOP NUMBER. FOR EXAMPLE 1-BL2-FIT-11
2. SEE DRAWING 062 FOR MMU COMMUNICATIONS.
3. STOP AIR DRYER AND CLOSE TOWER INFLUENT RATE OF FLOW CONTROLLER ON BLOWER FAILURE
4. STOP AIR BLOWER AND CLOSE TOWER INFLUENT RATE OF FLOW CONTROLLER ON AIR DRYER FAILURE
5. R1U CALCULATES TEMPERATURE SETPOINT USING RELATIVE HUMIDITY FROM 1-GC2-AIT-19 OR 1-GC*-AIT-19 BASED ON OPERATOR ASSIGNMENT AND ASSIGNMENT OPERATOR ENTERED RELATIVE HUMIDITY SETPOINT.

UPDATED 28 FEB 2008

DATE	REVISIONS
1/17/96	REVISED BY ADDISON
4/23/96	PCX MODIFICATION

WARNING 0 1/2 1
IF THIS BAR DOES NOT MEASURE 1 THEN DRAWING IS NOT TO SCALE.

PARADISE VALLEY WATER COMPANY
MILLER RD TREATMENT FACILITY PHASE I

PCX MODIFICATIONS P&ID
SOUTH FACILITY STRIPPING TOWER 1-T2

NIBW PARTICIPATING COMPANIES

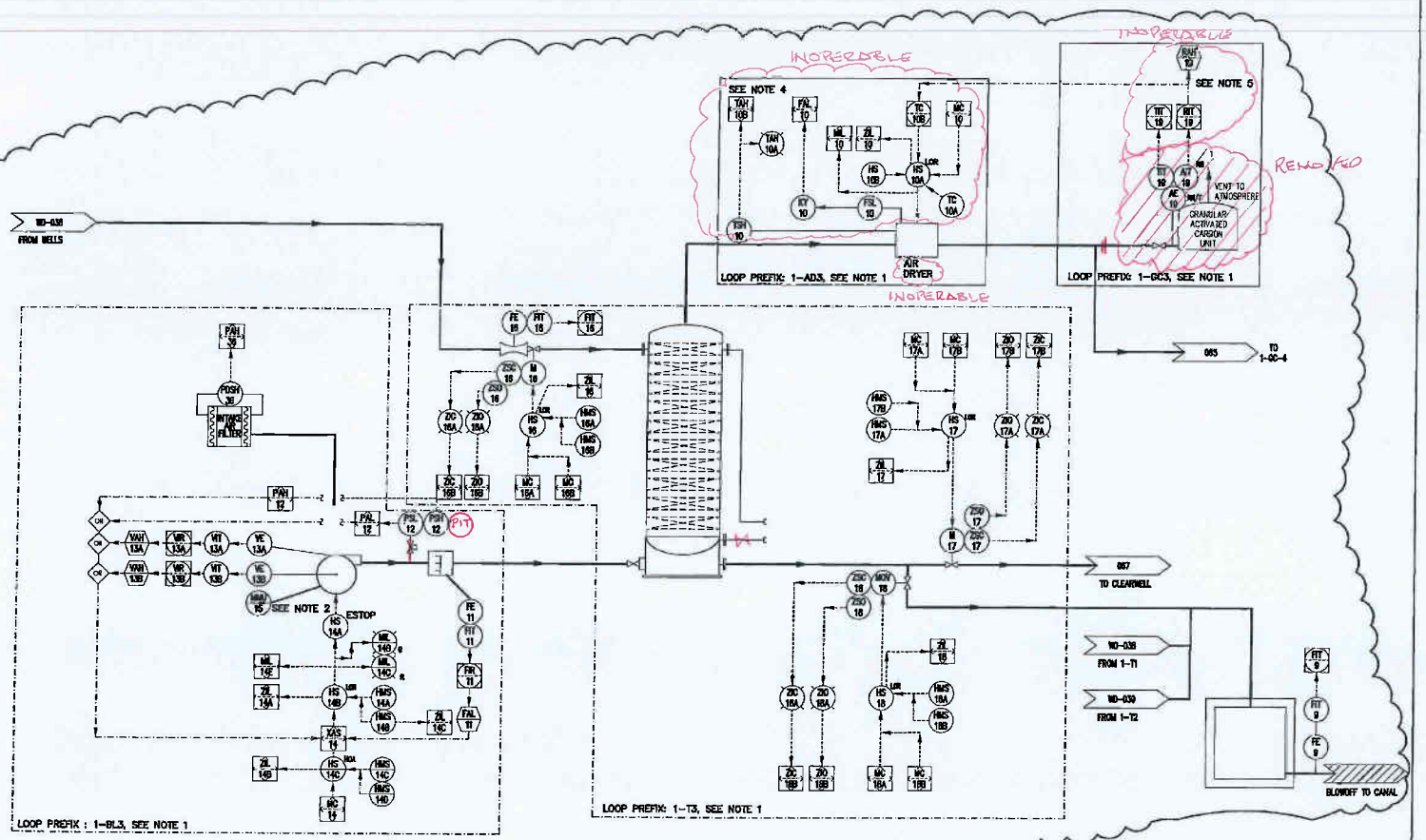
MONTGOMERY WATSON

DRAWN BY: SDB
PROJECT ENG'R: CAC
APPROVED: BS
DATE: 8-22-96

USE DIMENSIONS ONLY
SCALE AS SHOWN

USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES

WD-039



NOTES:

1. THE COMPLETE DEVICE TAG CONSISTS OF THE LOOP PREFIX, THE DEVICE TYPE AND THE LOOP NUMBER. FOR EXAMPLE 1-BL3-FIT-11
2. SEE DRAWING 062 FOR MMU COMMUNICATIONS.
3. STOP AIR DRYER AND CLOSE TOWER INFLUENT RATE OF FLOW CONTROLLER ON BLOWER FAILURE
4. STOP AIR BLOWER AND CLOSE TOWER INFLUENT RATE OF FLOW CONTROLLER ON AIR DRYER FAILURE
5. RTU CALCULATES TEMPERATURE SETPOINT USING RELATIVE HUMIDITY FROM 1-GC3-AIT-19 OR 1-GC*-AIT-19 BASED ON OPERATOR ASSIGNMENT AND ASSIGNMENT OPERATOR ENTERED RELATIVE HUMIDITY SETPOINT.

UPDATED 28 FEB 2008

DATE	REVISIONS
8/23/06	1 PCX MODIFICATION

WARNING 0 1/2 1
IF THIS BAR DOES NOT MEASURE THREE INCHES, THIS DRAWING IS NOT TO SCALE.

RECORD DRAWING

PARADISE VALLEY WATER COMPANY
MILLER RD TREATMENT FACILITY PHASE I

PCX MODIFICATIONS P&ID
SOUTH FACILITY STRIPPING TOWER 1-T3

NIBW PARTICIPATING COMPANIES

MONTGOMERY WATSON

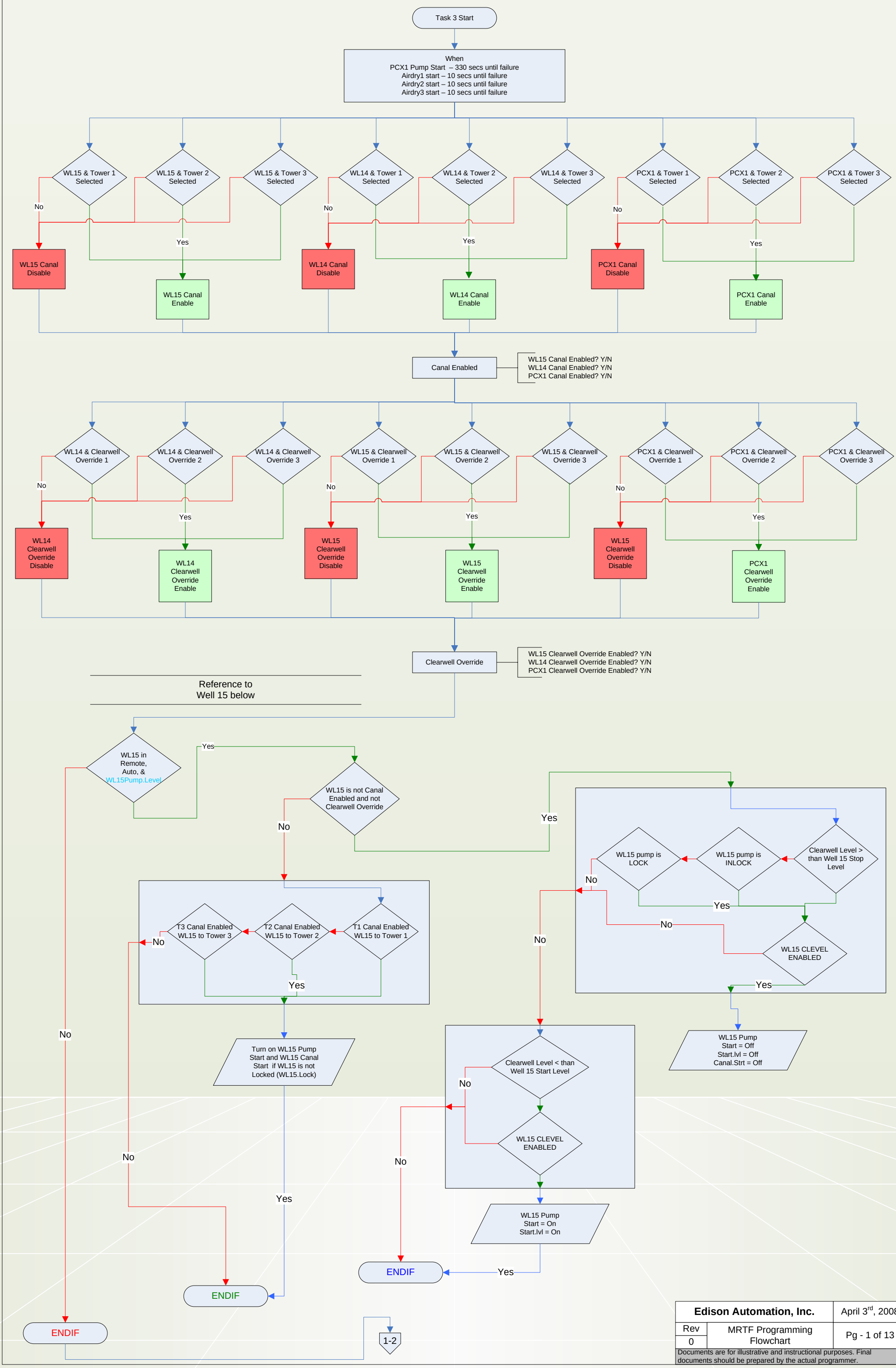
DRAWN BY: SDB
PROJECT ENG'R: CAC
APPROVED: SE
DATE: 8-25-06
USE DIMENSIONS ONLY
SCALE AS SHOWN

USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES

WD-040

Attachment 2:
Control System Logic Diagram

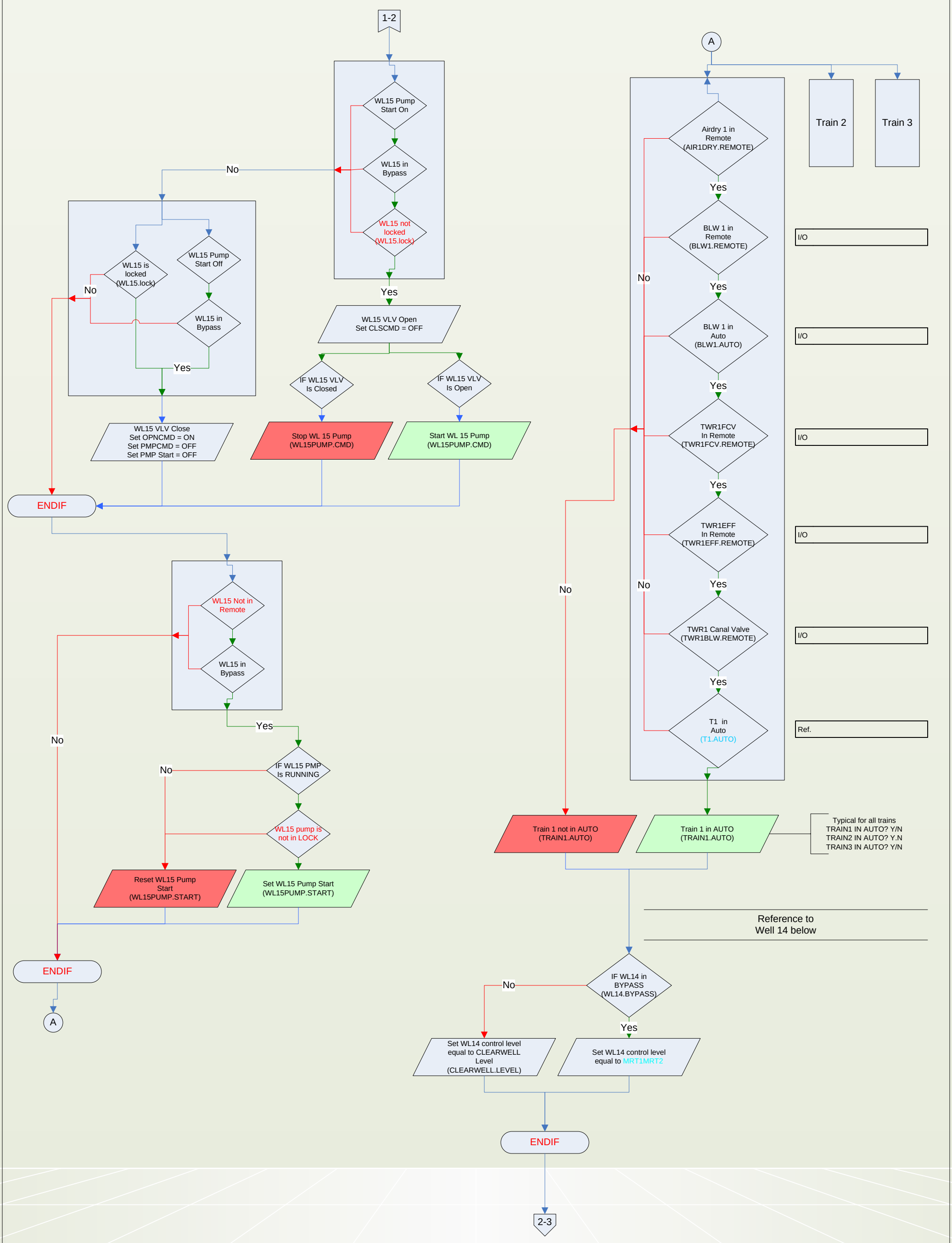
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 1 of 13

Documents are for illustrative and instructional purposes. Final documents should be prepared by the actual programmer.

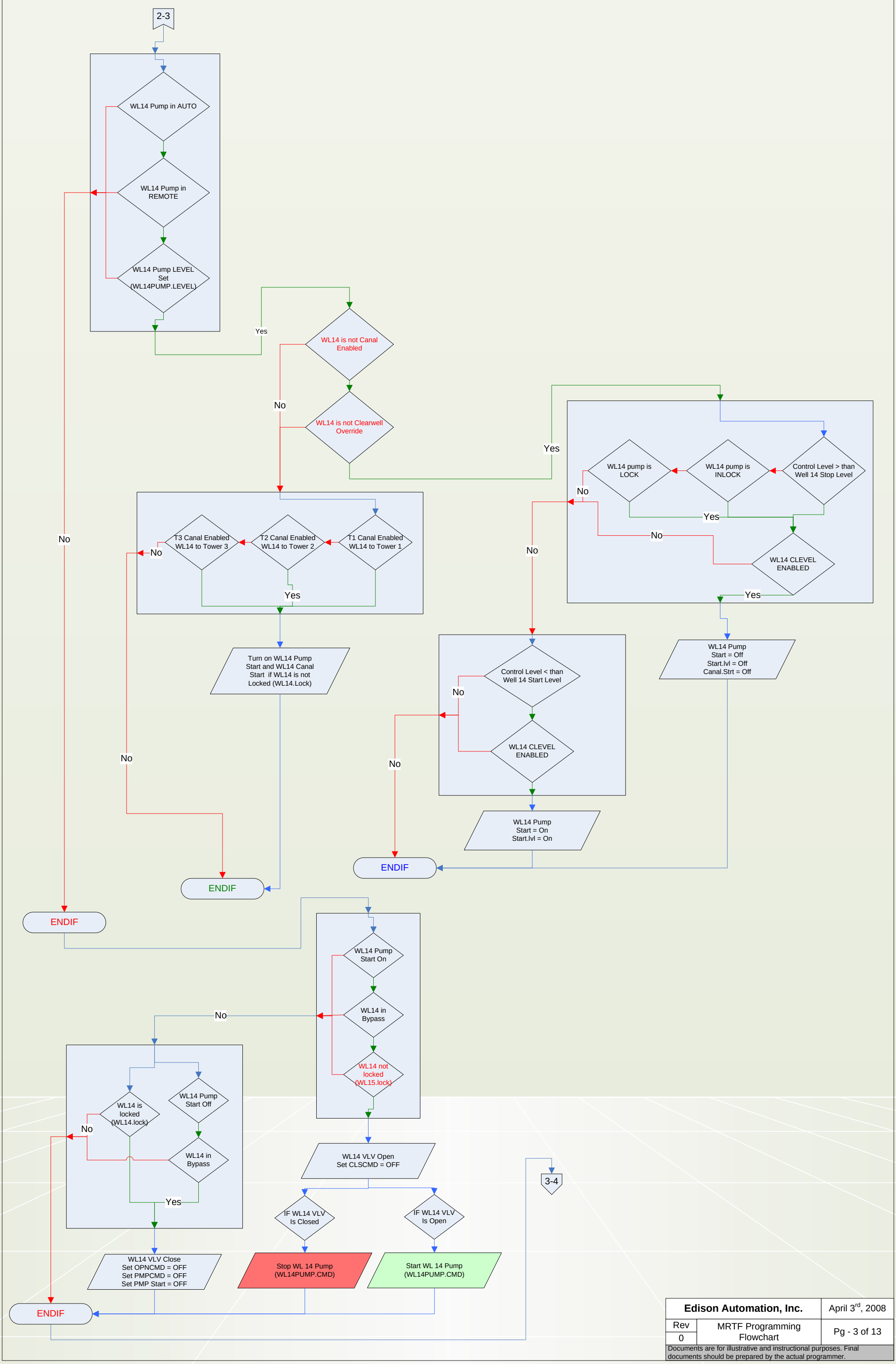
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 2 of 13

Documents are for illustrative and instructional purposes. Final documents should be prepared by the actual programmer.

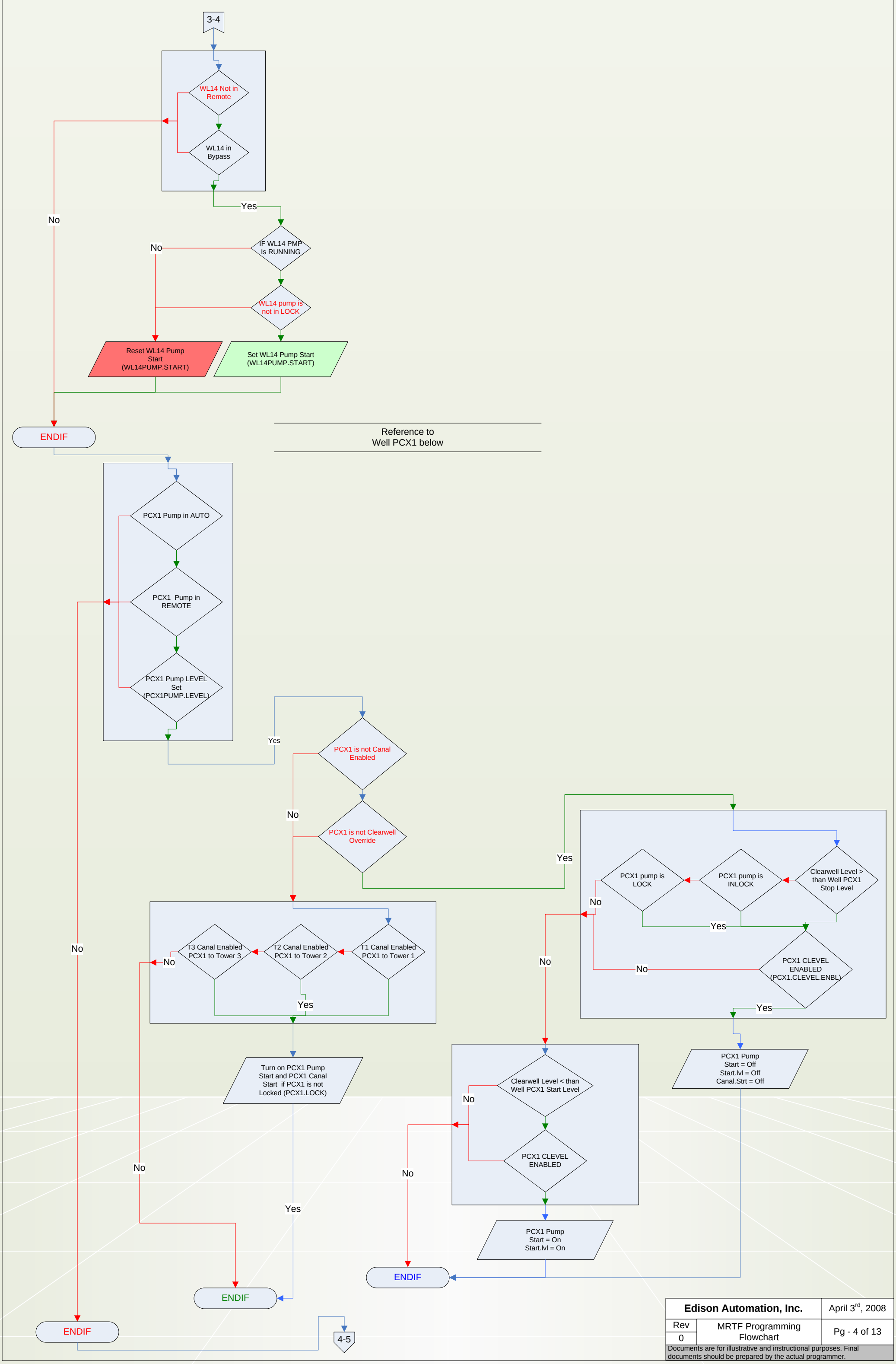
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 3 of 13

Documents are for illustrative and instructional purposes. Final documents should be prepared by the actual programmer.

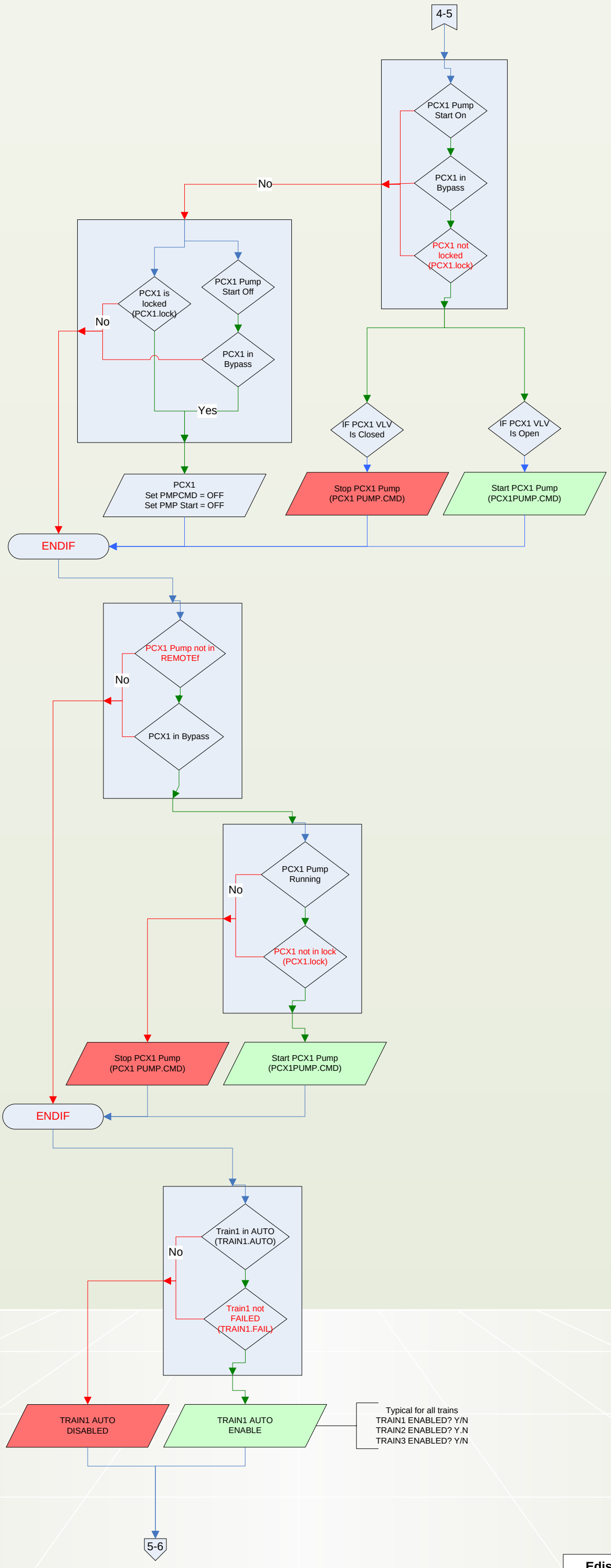
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 4 of 13

Documents are for illustrative and instructional purposes. Final documents should be prepared by the actual programmer.

MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 5 of 13

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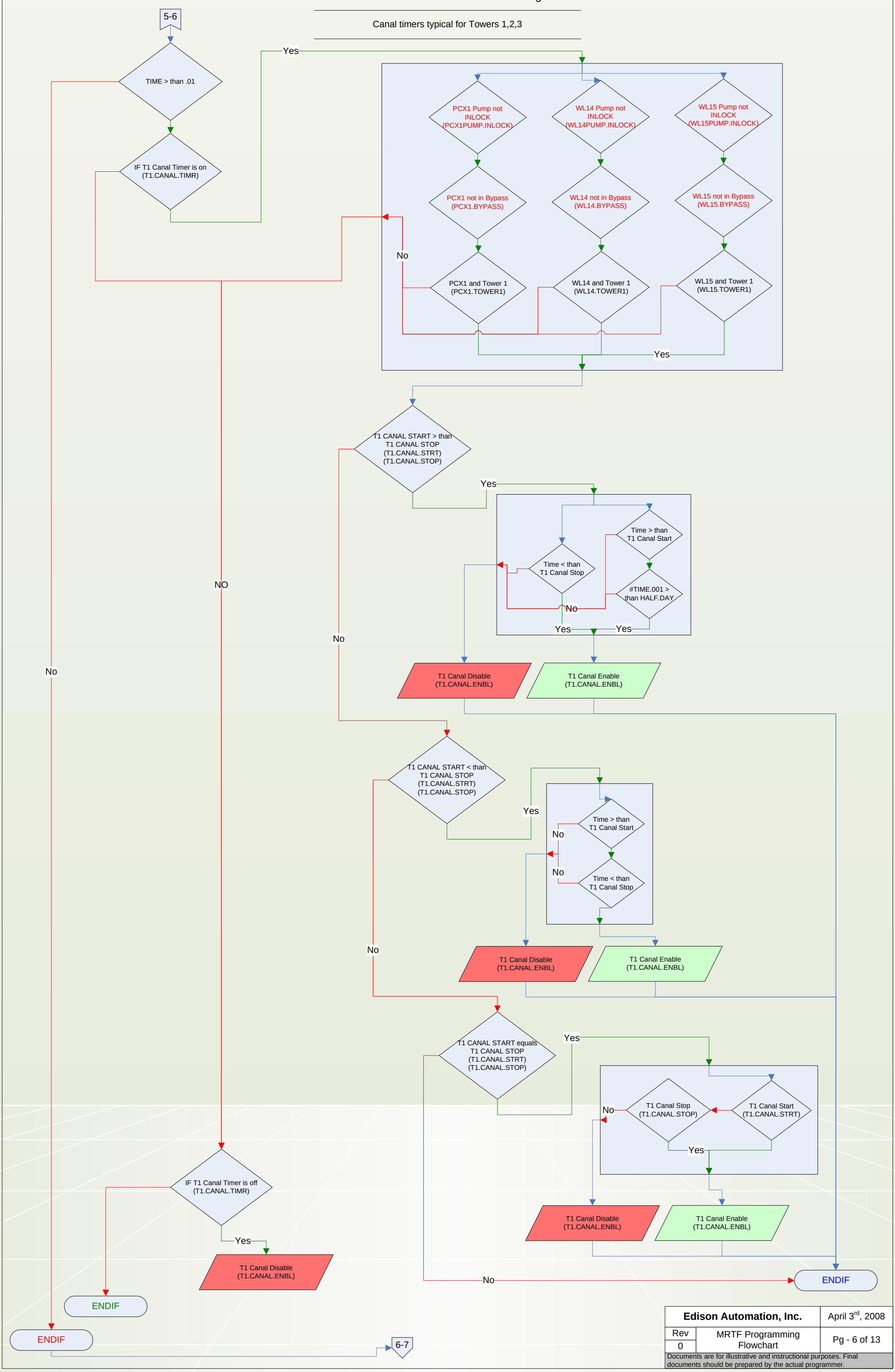
MRTF – Task 3 – Flow Chart Work In Progress

Canal timers typical for Towers 1,2,3



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Rev 0	MRTF Programming Flowchart	Pg - 6 of 13

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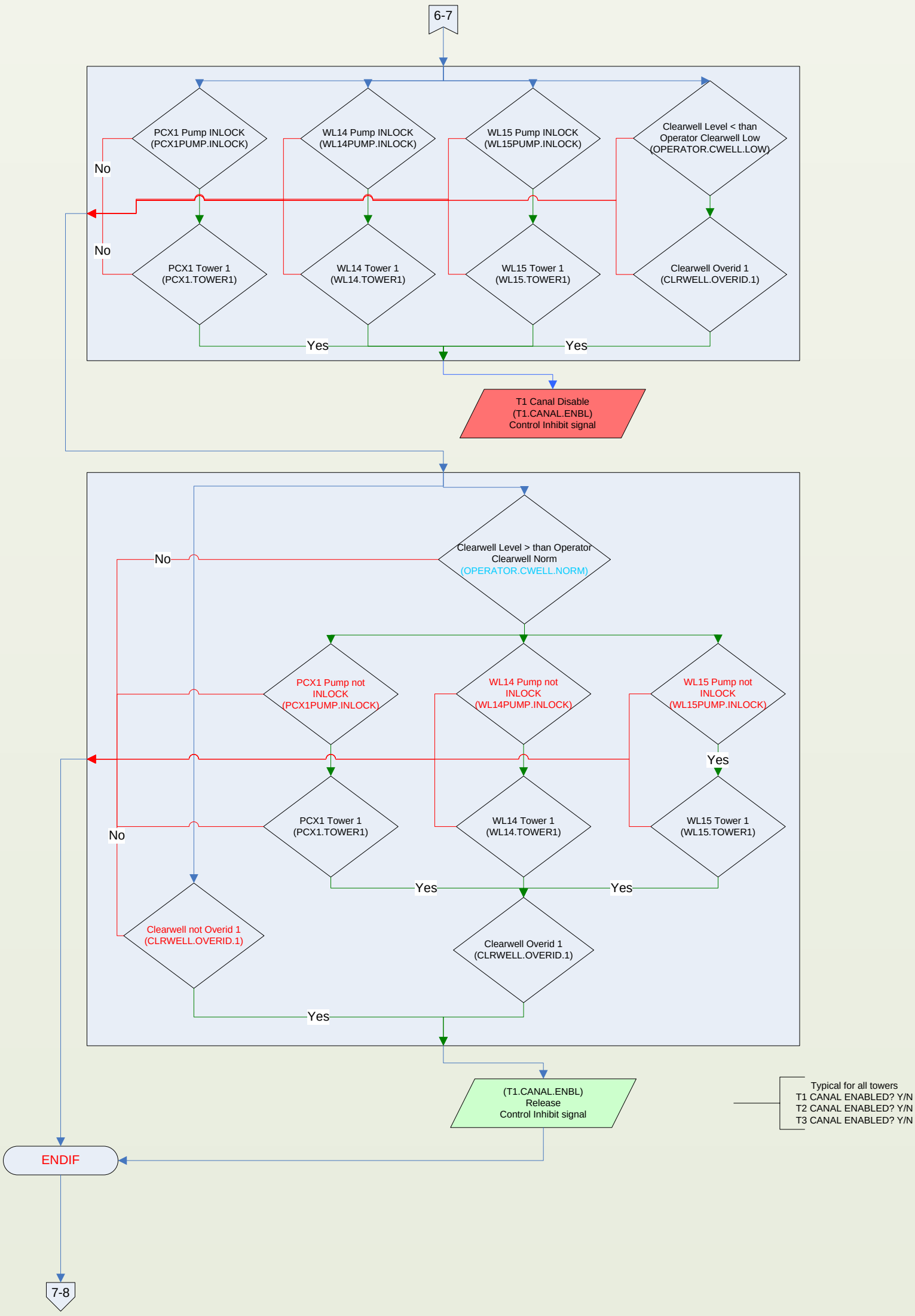
Canal Enabled Code typical for Towers 1,2,3



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 7 of 13

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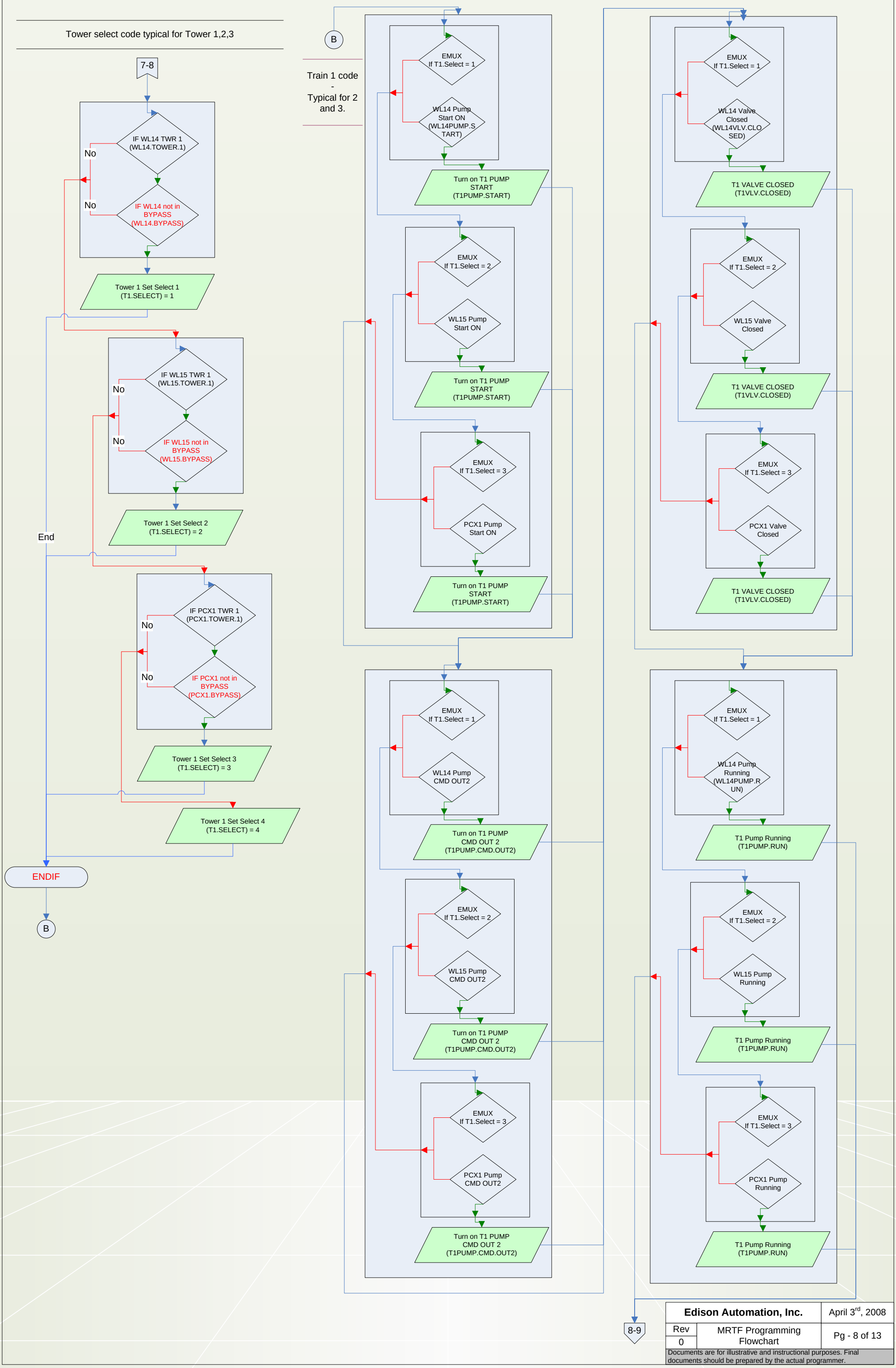
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 8 of 13

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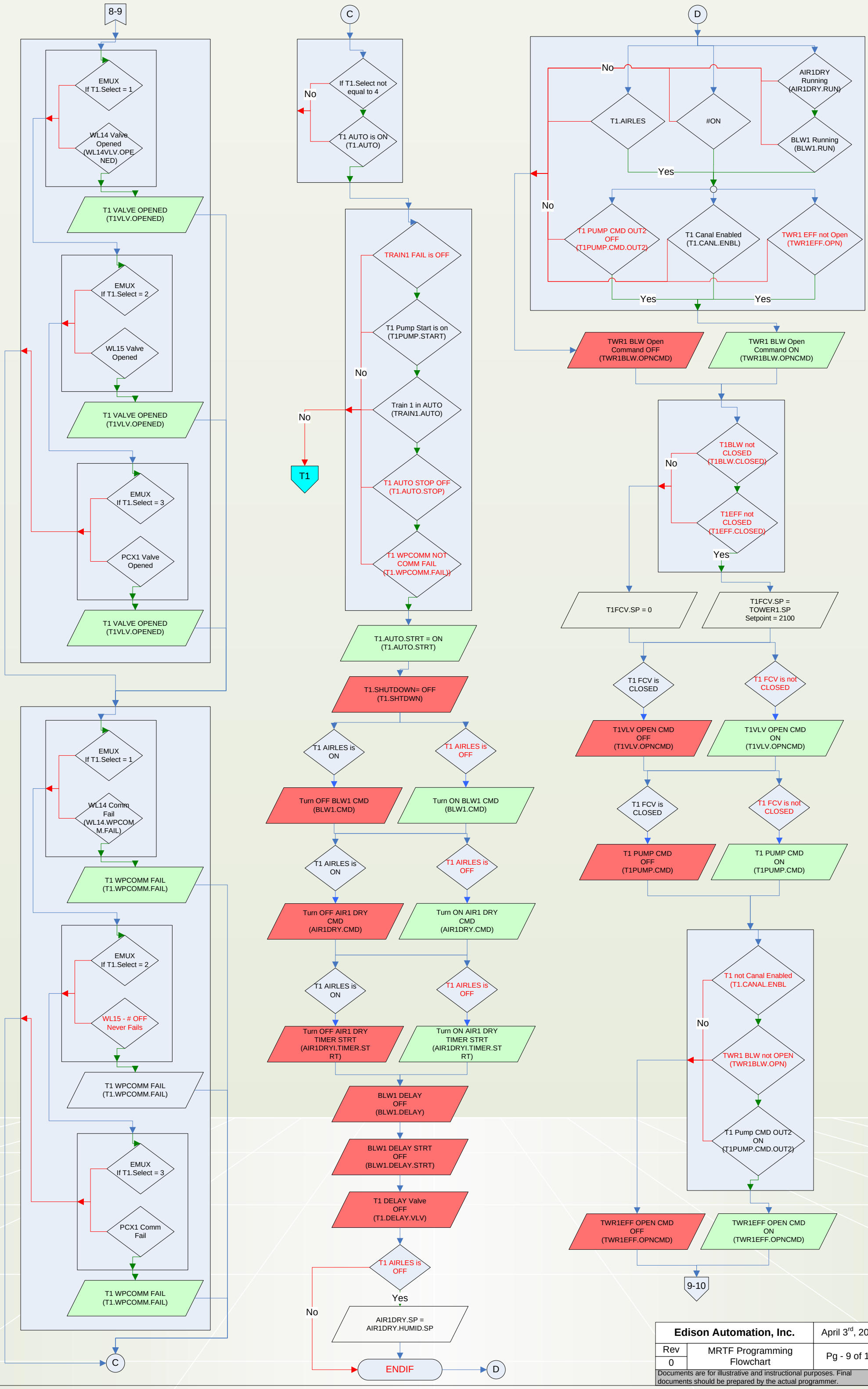
MRTF – Task 3 – Flow Chart Work In Progress



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Rev 0	MRTF Programming Flowchart	Pg - 9 of 13

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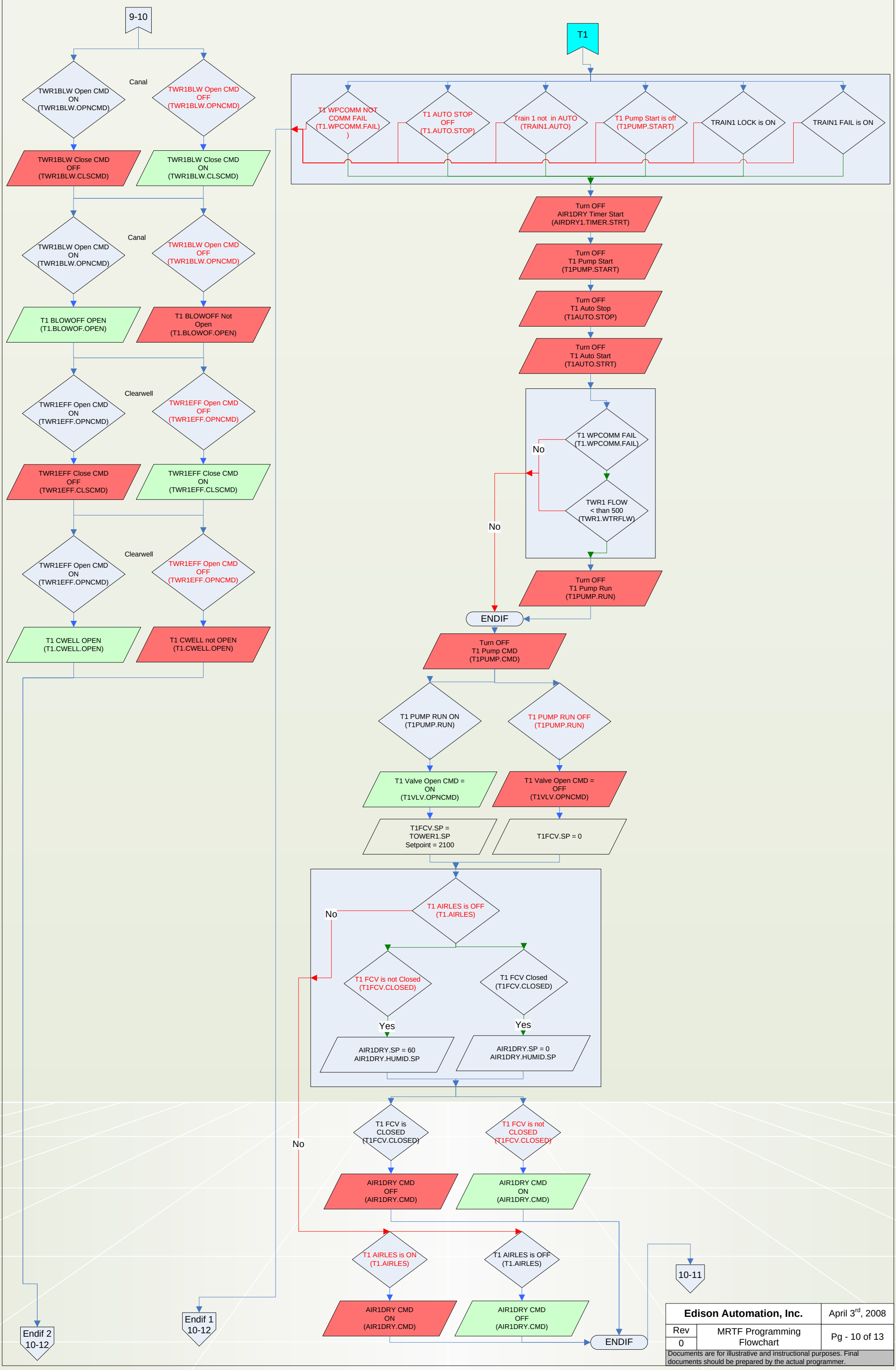
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 10 of 13

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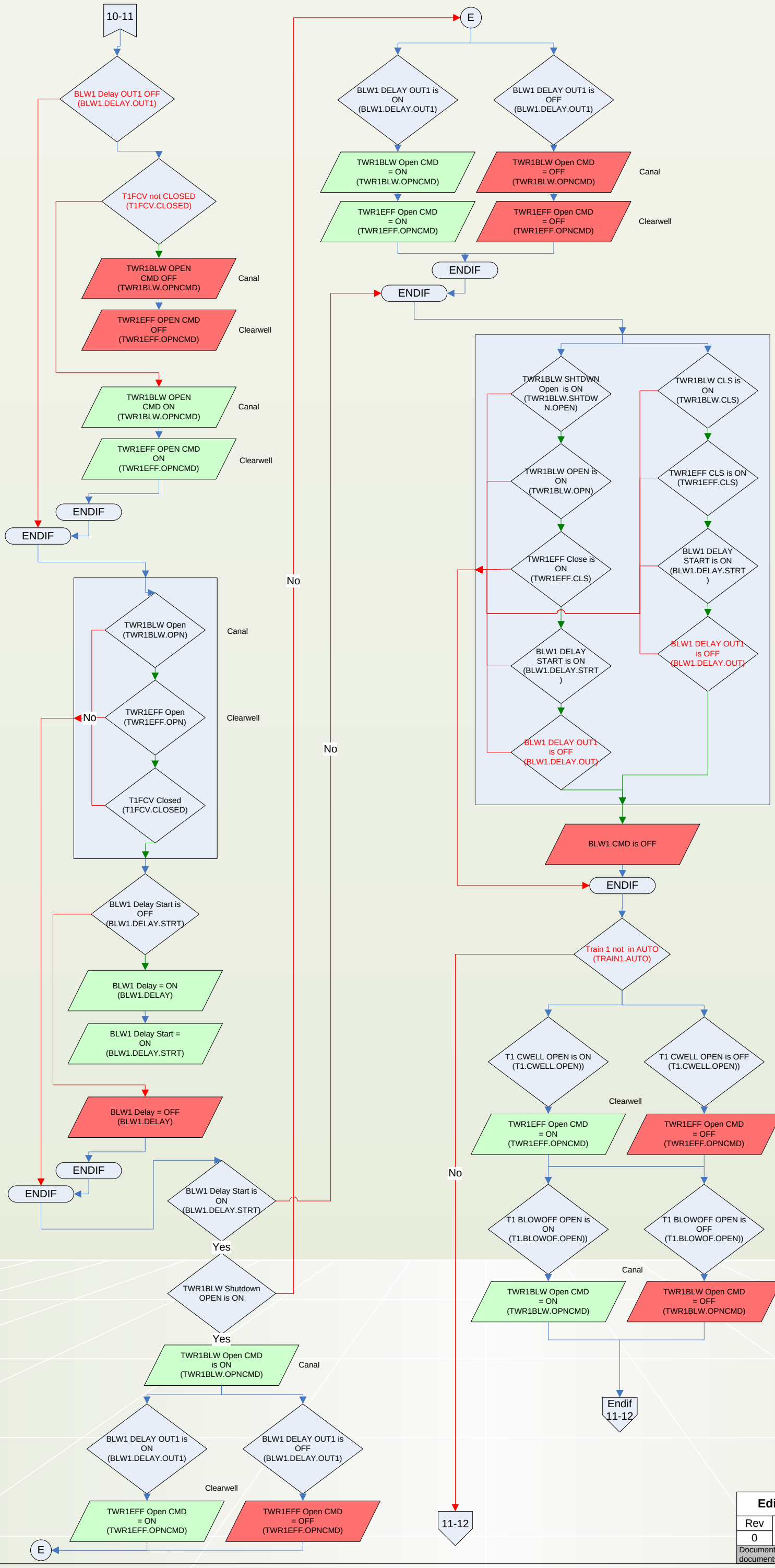
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 11 of 13

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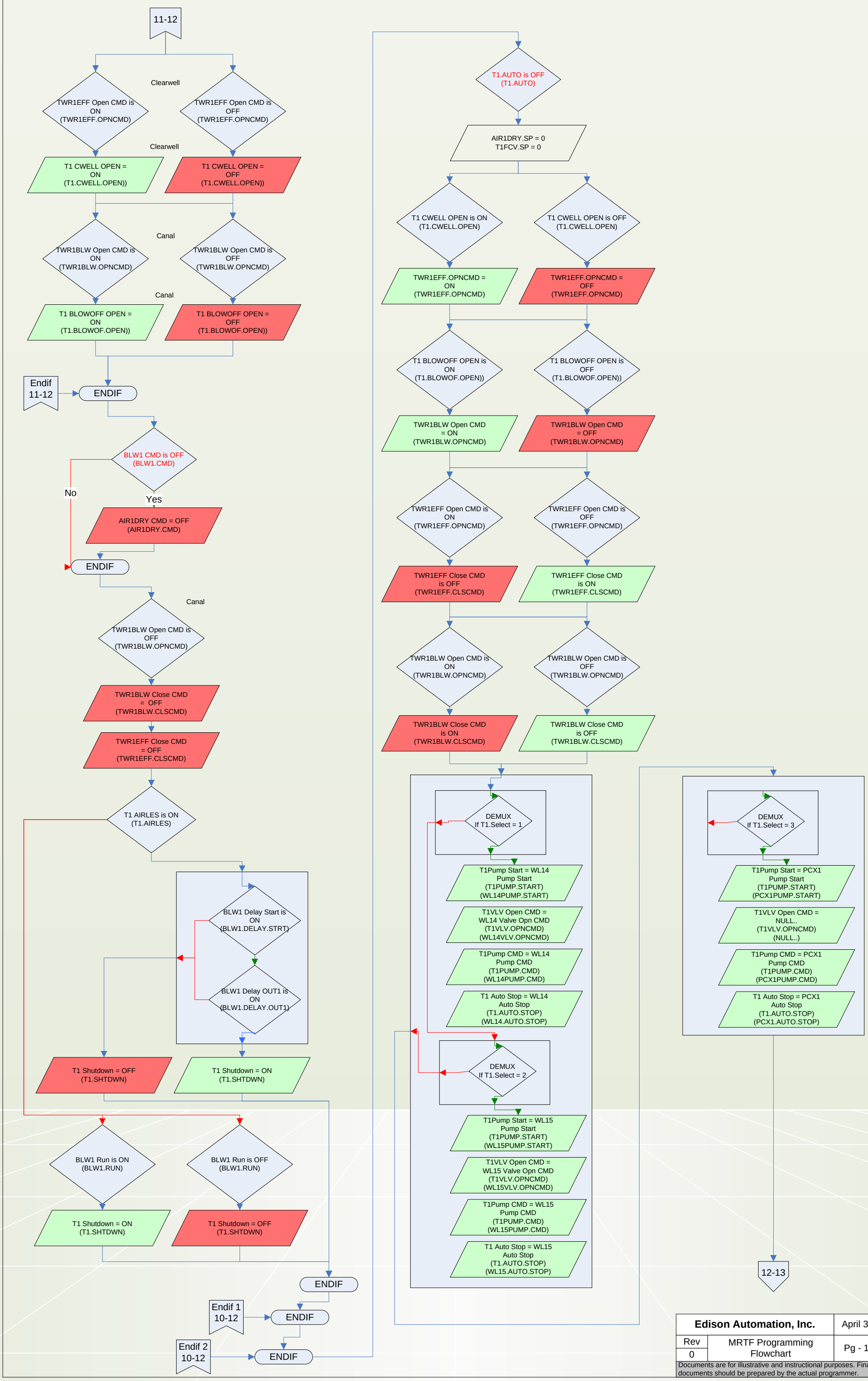
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 12 of 13

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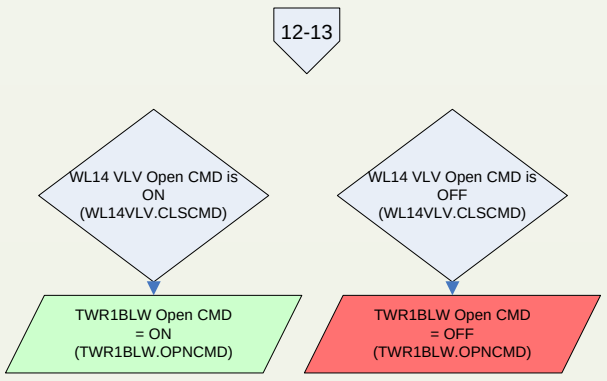
MRTF – Task 3 – Flow Chart Work In Progress



Edison Automation, Inc.		April 3rd, 2008
Rev 0	MRTF Programming Flowchart	Pg - 13 of 13

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