HDR

Junction City

Water Treatment Plant Preliminary Engineering Analysis and Pre-Design Summary

Final

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WATER TREATMENT PLANT PRELIMINARY ENGINEERING ANALYSIS AND PRE-DESIGN SUMMARY

PREPARED FOR:
CITY OF JUNCTION CITY, KANSAS

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EXECUTIVE SUMMARY

For a number of years capital improvements and maintenance at the water treatment plant have been delayed due to the financial position of the City. At this time, there are several infrastructure needs at the water treatment plant that need to be addressed. The purpose of this report is to evaluate the water treatment plant and provide recommended capital projects to provide quality water that meets or exceeds regulatory limits, enables customer demand to be met, and provides for improved future maintenance of the water supply and treatment system. Projects that are identified as a result of this evaluation will be prioritized based on criticality and phased for design and construction over the next several years as funds allow. The water system phasing will be completed in combination with phased projects at the East and Southwest Wastewater Treatment Plants.

The scope of the engineering analysis includes evaluation of capacity needs and water rights for current and future demands; evaluation of the existing supply and treatment facilities at the water treatment plant; determination and prioritization of projects needed to address safety, reliability, and other factors. Projects are identified in a Capital Improvement Plant (CIP) and divided into Phase I, Phase II, and Phase III projects based on criticality need of the project.

In February, 2007 Burns & McDonnell completed the "Water Master Plan," which included hydraulic modeling of the water distribution system and development of a capital improvements plan to address identified issues in the water distribution system, including piping, pumping, and storage. Therefore, this report will not assess the water distribution system beyond the water treatment plant, except where the City has identified specific capital improvement projects, those projects will be included in the CIP where known.

Demand Projections

Annual municipal water use reports submitted by the City to the Kansas Department of Agriculture Division of Water Resources (DWR) from 2002 to 2012 were used to estimate historical water use. From these reports, a historical water use of and average of 150 gallons per capita per day (gpcd) was determined, in conjunction with population projections, to project future water use on an average basis. City water usage in 2045 is projected to increase to a total of 1,973 millon gallons (Mgal) per year (5.4 MGD on an average basis).

Maximum day demands were projected using a peaking factor of 1.85; this factor is multiplied by the average day demand to provide the maximum day demand. Without considering conservation, the projected maximum day demand in 2015 is 10.0 MGD.

Considering conservation and a reduction in water loss, additional average day and maximum day projections were calculated using a goal of 134 gpcd on an average basis. With this reduced water use,

the City's projected water demand in 2045 is 1,799 Mgal per year (4.9 MGD on an average basis) with a maximum demand of 9.1 MGD.

Water Rights

The City holds three water right certificates for groundwater in the Republican River basin. Vested right GE 002 is the City's most senior water right. Most recently, the City obtained appropriated right 23804 which combined all of the City's municipal water rights into one combined annual quantity and maximum diversion rate for all ten of the City's wells. The maximum annual quantity under the water rights is 1,530 Mgal per year and a maximum diversion rate of 10 MGD.

The City has exceeded their annual water use limit of 1,530 Mgal in both 2011 and 2012, with a total volume pumped by the City of 1,644 and 1,682 MG, respectively. Therefore, additional water rights are required to meet both current and future water rights. Junction City is a member of the Kansas River Water Assurance District No. 1 (Assurance District), which as storage space in Milford, Tuttle Creek, and Perry Reservoirs. As a member of the Assurance District, there is an opportunity to obtain water rights from the Assurance District to supplement the existing water rights. The additional water rights would be added to the existing water rights; the existing groundwater wells can be used to access these water rights. An application to obtain additional water rights is being completed.

Water Supply

The existing water supply generally consists of ten water supply wells that draw from the Republic River alluvium east of the water treatment plant. Recently, the casing of Well #16 collapsed, leaving the City with nine active wells. The estimated capacity of the remaining nine wells is 6.2 MGD, with a firm capacity of 5.2 MGD with the largest well out of service. This capacity is based on operating the wells to keep the water level 3 feet above the top of the screen in order to minimize well fouling and other maintenance issues that can result from drawing the water level down into the screen. Based on the current maximum day demand of 8.3 MGD and the 2045 projected demand of 10.0 MGD, additional well capacity is required in order to meet current and future demands.

Two primary alternatives were reviewed to increase the well field capacity. The first alternative is to rehabilitate or offset certain existing wells to increase their capacity and replace pumps in select other wells to better match the pumping rate with what the well is capable of supplying. The total estimated capital cost of this alternative is $2,362,000. The second alternative is to construct a 7 MGD horizontal collector well. A horizontal collector well would be advantageous because it would simplify well field operations, would decrease the level of maintenance required in the well field, and would increase drought resistance. The estimated capital cost of this alternative is $3,762,000. Although the second alternative is more expensive in terms of capital costs than the first, the horizontal collector well is recommended due to the previously-stated advantages.

Water Treatment

The wells supply water to the water treatment plant. The original plant facilities were constructed in 1976 and have a nominal capacity of 10 MGD. In general, the following treatment is provided:

- Aeration by forced updraft aerators
- Primary lime softening
- Rapid mix with chlorine addition
- Secondary settling
- Filtration followed by additional chlorine injection

The following summarizes issues associated with the water treatment processes and infrastructure:

- Inaccurate plant flow meters, including raw water and high and low service
- Biological growth inside the aerators
- Lack of chemical stabilization following softening allows for deposition of calcium carbonate on the weirs and in the pipelines throughout the plant and the water distribution system and limits flow rates
- Lime sludge lines experience plugging, preventing proper operation of the softening basins and withdrawal of lime sludge
- Decant water from the lime sludge lagoons is recycled to the process, returning organics that can cause taste and odor issues
- Ferric sulfate and polymer feed equipment (for coagulation) is non-operational and the high turbidity loading to the filters necessitates the need for a coagulant feed
- Equipment inside the softening basins and the secondary basins is approaching the end of its useful life and requires replacement
- Filtration capacity is less than the nominal capacity of the plant and of the projected 2045 maximum day capacity of 10 MGD; the capacity may be adequate at higher filtration rates provided that turbidity breakthroughs do not occur
- The existing filter media will reach the end of its useful life in 2020
- Plant staff are unable to replace the lime storage bin dust collector media due to inaccessibility to the media; the inability to replace the media causes dust issues during offloading of dry lime
- The fluoride system is antiquated and overfeeds fluoride
- None of the existing chemical storage and feed systems have secondary containment, which is required for all chemical systems under current regulatory requirements
- There have been high disinfection by-product samples on an individual basis; under the Stage 2 Disinfection By-Product Rule, for which compliance began October 1, 2013, there will be a greater potential for violations to occur
- The existing pressure feed chlorine system poses a safety risk – there is no means to close the valves on the ton cylinders, the cylinders must be manually switched, and the nature of the pressure feed system would result in a large chlorine leak if it were to occur.

Storage and Pumping

Water from the filters collects in two small clearwells below the filters. Transfer pumps pump the water from these clearwells to an above ground clearwell on the water treatment plant site. High and low service pumps pump water from the above ground clearwell to the high pressure zone and the low pressure zone, respectively.

The following are issues associated with plant storage and pumping:

- The transfer pumps will reach the end of their useful life in 2020
- The high and low service pumps require additional pressure head to meet minimum water distribution system pressures
- Water hammer and associated water main breaks have been an issue in the past
- The existing 2400V motor control center for the high and low service pumps is approximately 30 years old and doesn't operate reliably; medium voltage motor control centers and pump motors are more expensive than low voltage (480V) motor control centers and pump motors.
- Additional and redundant storage capacity will be needed in the high service pressure zone in approximately 2015
- The existing ground storage tank at the water treatment plant is in need of painting
- A redundant ground storage tank is needed to facilitate future tank maintenance
- Water inside the plant ground storage tank is not well mixed and can exacerbate taste and odor issues

Plant Power

The water treatment plant is fed from a single Westar Energy Utility line which feeds the main 15kV switchgear. The main switchgear feeds transformer T-1, which powers the 2400V Motor Control Line-up serving the high and low service pumps, and transformer T-2, which powers the 480V Motor Control Center, which feeds the remainder of the plant loads.

The following are issues associated with plant power:

- The main 15kV switchgear is approximately 30 years old and has reached the end of its useful life
- Transformer T-1 is leaking oil; Transformer T-2 is also leaking oil, but is not as critical as T-1
- If the single utility feed experiences a power failure, the wells cannot pump water and the plant cannot treat or distribute water

Two alternatives were reviewed to provide emergency power during a power utility failure: 1) a stand-by generator, and 2) a second Westar utility feed from a separate substation than the existing feed. The stand-by generator is estimated to cost $310,000. The secondary utility feed is estimated to cost between $150,000 to $210,000, depending on the installed voltage; if the high and low service pumps and motor control center are replaced at 480V, which is recommended, the feed would cost $210,000. Doing so would also eliminate the need for the existing transformers T-1 and T-2.

SCADA/Instrumentation

Control and monitoring of processes and equipment is limited at the existing plant due to lack of a Supervisory Control and Data Acquisition (SCADA) system. This means, generally, that wells are turned on and off manually and well flow and water level is read locally at the well requiring plant staff to go out to the wells to read information. In addition, all chemical dosing is done manually rather than being flow-paced. There is a phone line signal that transmits water distribution tank levels to the plant for operation of the high and low service pumps; however, this has been unreliable at times. Addition of a SCADA system at the plant would improve the productivity of the plant staff and increase the reliability of the treatment and pumping processes.

Ancillary Facilities

Other issues at the water treatment plant include:

- Wells, piping, and equipment are in need of cleaning and painting
- Plant piping downstream of the softening basins need cleaning of the calcium carbonate deposits to restore hydraulics and maximize the water that can be treated
- The roof of the building, particularly in the filter gallery, is leaking and is in need of replacement
- The building HVAC system is antiquated and in need of an upgrade
- The well access road needs a new gravel surface to improve accessibility to the well sites

Recommended Projects and Phasing

The following is a summary of the recommended projects by phase:

Immediate Needs

- Submit an application to DWR for Water Assurance District storage to be withdrawn through existing wells
- Install automatic shut off valves on the existing chlorine ton cylinders
- Convert the exiting chlorine gas pressure feed system to a vacuum system with automatic switchover

Phase I Projects

- Install a horizontal collector well (or do improvements within the existing well field as an alternative option)
- Install carbon dioxide feed to the softening basin effluent
- Improve the lime sludge piping from the Sludge Control Buildings to the Lime Sludge Lagoons and replace the solids contact equipment in the softening basins
- Install individual and combined filter effluent turbidimeters; add sonar level indication for the transfer pumps

- Construct improvements to the lime feed system, including improved access to the lime storage bin dust collector and replacement of the pneumatic conveyance piping
- Install secondary containment for all existing chemical systems
- Convert secondary disinfection to chloramines with an ammonia feed prior to clearwell storage
- Retrofit the existing high and low service pump station with new high and low service pumps and replacement of the 2400V motor control line-up with a new 480V motor control line-up
- Install soft starts for the low and high service pumps
- Sandblast and paint the inside and outside of the ground storage tank clearwell
- Install a mixing system in the ground storage tank clearwell
- Replace the 15 kV switchgear (abandon transformers T-1 and T-2)
- Install a second power utility feed to the plant and well field (automatic transfer for the well field is optional)
- Replace well controls to be compatible with SCADA (replace Wells #6, 11, and 17 initially with replacement of the remaining controls in the future)
- Clean interior of plant piping of calcium carbonate deposits downstream of lime addition
- Replace the building roof and skylights
- Replace existing AHU-1 and existing water cooled condensing unit
- Replace existing AHU-2 with new heating and cooling heating and cooling unit with hot water heating and air cooled DX cooling
- Replace existing AHU-3 with new HW heated air cooled DX unit that has dehumidification of existing spaces incorporated into the unit.
- Replace existing AHU-4 with new DX cooled hot water heated unit and roof-top condensing unit.
- Gravel surface the access road to the wells.
- Replace customer meters (Phase I of 3)
- Contract for distribution system storage inspection and maintenance
- Construct bulk water station

<u>Phase II Projects</u>

- Replace influent raw water meter
- Replace high and low service meters
- Implement conservation water rates
- Install a chlorine feed in the raw water meter vault prior to the aerators
- Install ferric and polymer feeds to the softening basin effluent (pending verification by jar-testing) and replace the equipment in the secondary basins
- Install a new fluoride chemical feed system
- Install surge relief valves on the high service transmission main leaving the plant
- Install a system-wide SCADA system
- Paint exposed piping and equipment, plant-wide

- Remove all existing controls and install new DDC controls on all HVAC equipment.
- Replace existing gas fired boilers with high efficiency condensing gas fired boiler systems.
- Install a new dedicated air handling unit for the laboratory area.
- Replace customer meters (Phase 2 of 3)
- Overhaul Spruce Street Booster Station

Phase III Projects

- Construct a 0.5 MG tank in the high service pressure zone
- Replace recovery pumps (if required)
- Replace filter media (if required)
- Replace transfer pumps (if required)
- Repave plant access road
- Replace customer meters (Phase 3 of 3)
- Install distribution sample stations

The table below shows the recommended projects, phasing of the projects, and capital cost estimate.

PROJECT		PHASE 1 (2014 - 2015)	PHASE 2 (2016 - 2017)	PHASE 3 (2019 - 2021)
Plant Raw Water Meter			$ 73,000	
High and Low Service Pipe Painting/Meters/Surge Valves			$ 110,000	
Horizontal Collector Well/Repair Well Controls (#6, 11, 17)		$ 3,762,000		
Recarbonation (Carbon Dioxide Feed)		$ 755,000		
Lime Sludge Improvements		$ 714,000		
Lime Sludge Decant to Sanitary Sewer			$ 20,000	
Liquid Ferric Sulfate Feed System			$ 812,000	
Liquid Polymer Feed System			$ 67,000	
Lime System Improvements		$ 77,000		
Fluoride Feed System		$ 67,000		
Chemical Containment		$ 18,000		
Filter Effluent Turbidimeters		$ 19,000		
Replace Filter Media				$ 164,000
Chloramines Conversion (Ammonia Feed)		$ 137,000		
Chlorine Gas Feed System Improvements		$ 63,000		
High and Low Service Pump Upgrades/Electrical		$ 763,000		
Replace Transfer Pumps				$ 173,000
Elevated Water Storage Tank in High Pressure Zone				$ 1,304,000
Ground Clearwell Improvements (Painting and Mixing)		$ 542,000		
Additional Ground Storage Clearwell				$ 1,344,000
Plant/Well Emergency Power		$ 210,000		
SCADA/Well Controls			$ 483,000	
Clean Piping and Basin Weirs of Deposition		$ 55,000		
Paint Plant Piping and Equipment			$ 60,000	
Replace Building Roof and Skylights		$ 271,000		
HVAC Improvements		$ 112,000	$ 91,000	
Re-Pave Plant Roadway				$ 208,000
Gravel Surface Well Field Roadway				$ 116,000
Bulk Water Station		$ 75,000		
SUBTOTAL		$ 7,640,000	$ 1,716,000	$ 3,309,000
Mobilization, Bonding and General Requirements	5.0%	$ 382,000	$ 86,000	$ 165,000
Overhead and Profit	10.0%	$ 764,000	$ 172,000	$ 331,000
SUBTOTAL		$ 8,786,000	$ 1,974,000	$ 3,805,000
Contingency	25.0%	$ 2,197,000	$ 494,000	$ 951,000
SUBTOTAL		$ 10,983,000	$ 2,468,000	$ 4,756,000
Engineering, Legal, Administrative	20.0%	$ 2,197,000	$ 494,000	$ 951,000
SUBTOTAL		$ 13,180,000	$ 2,962,000	$ 5,707,000
Additional Projects (Not Subject to Markups)				
Water Conservation Rates			$ 50,000	
Customer Meter Replacements		$ 600,000	$ 1,200,000	
Water Distribution System Sample Stations				$ 108,000
Distribution System Tank Inspections		$ 80,000		
Spruce Street Booster Pump Station Overhaul			$ 521,000	
TOTAL		$ 13,860,000	$ 4,733,000	$ 5,815,000
TOTAL (ALL PHASES)				$ 24,408,000

1 INTRODUCTION

The City of Junction City (City) is located in Geary County, Kansas along Interstate 70 at the confluence of the Smoky Hill and Republican Rivers. The City has ten water supply wells that supply a 10 MGD water treatment plant (WTP), to serve drinking water to approximately 25,000 people in Junction City and surrounding areas. The water supply and treatment system is operated under contract by Veolia Water North America (Veolia Water). HDR was retained by the City to evaluate the water supply and treatment system and provide recommended capital improvements.

1.1 PURPOSE

For a number of years capital improvements and maintenance have been delayed due to the financial position of the City. At this time, the financial position of the City is improving and there are several infrastructure needs at the water treatment plant that need to be addressed. The purpose of this report is to evaluate the water treatment plant and provide recommended capital projects to provide quality water that meets or exceeds regulatory limits, enables customer demand to be met, and provides for improved future maintenance of the water supply and treatment system. Projects that are identified as a result of this evaluation will be prioritized based on criticality and phased for design and construction over the next several years as funds allow. The water system phasing will be completed in combination with phased projects at the East and Southwest Wastewater Treatment Plants.

1.2 SCOPE

The scope of this engineering analysis includes evaluation of capacity needs and water rights for current and future demands; evaluation of the existing supply and treatment facilities at the water treatment plant; determination and prioritization of projects needed to address safety, reliability, and other factors. Projects are identified in a Capital Improvements Plan (CIP) and divided into Phase I, Phase II, and Phase III projects based on criticality need of the project.

In February, 2007 Burns & McDonnell completed the "Water Master Plan," which included hydraulic modeling of the water distribution system and development of a capital improvements plan to address identified issues in the water distribution system, including piping, pumping, and storage. Therefore, this report will not assess the water distribution system beyond the water treatment plant, except where the City has identified specific capital improvement projects, those projects will be included in the CIP where known.

2 DEMAND PROJECTIONS

2.1 POPULATION PROJECTIONS

The historical population of Junction City has been heavily influenced by activities at the near-by United States Army base, Fort Riley. Notable periods of population shift include the period between 1940 and 1960, when the Fort developed into a primary training base and also began to see a large influx of troops for the 1st Infantry Division; and a decrease in population for the 2000 Census that succeeded the transition of the 1st Infantry Division from Fort Riley to Germany. Junction City and surrounding areas have seen a dramatic increase in population since 2006 due to the return of the 1st Infantry Division known as the Base Realignment and Closure and Grow the Army initiatives. The October 2006 report entitled *Strategic Action Plan and Growth Impact Assessment for the Flint Hills Region* identified the likely increase in the regional population by 2012 to be 28,700 including military personnel, civilian workers, and military dependents. The historical Census population of Junction City is shown in Figure 2-1.

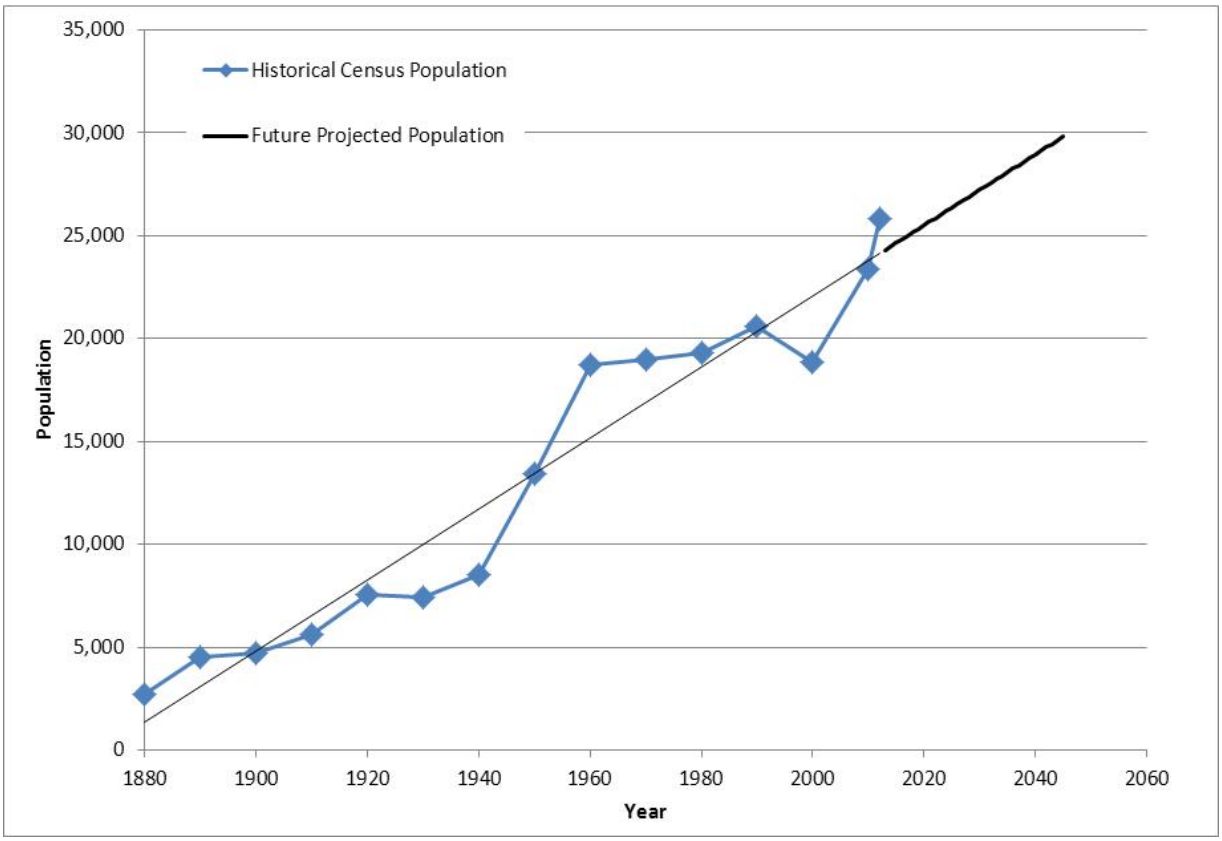


Table 2-1: Historical and Projected Population

The *Economic Impact Summary (1 Oct 11 – 30 Sep 12)* prepared by Fort Riley indicates the following qualitative population forecast for 2013 through 2015:

- The solider population assigned to Fort Riley will remain steady for the foreseeable future, but longer dwell times between deployments will result in an increase in soldiers residing on the base.
- There is expected to be a slight increase in the number of families accompanying soldiers.
- Civilian employee numbers are expected to decrease as a result of the current fiscal environment.
- Contractor numbers are expected to decline drastically as major infrastructure projects are wrapping up.

This report indicates that the major population growth in the area has passed and that future population growth may be more average.

As a result of the completion of the growth initiatives at Fort Riley, future growth is assumed to be similar to past growth. A linear projection of the population based on historical census data since 1880 was projected into the future to a planning horizon of 2045. Table 2-1 presents the projected population for this engineering analysis.

Table 2-2: Population Projections

Year	Population
2010	23,353
2015	24,644
2020	25,506
2025	26,369
2030	27,232
2035	28,094
2040	28,957
2045	29,819

2.2 ANNUAL AVERAGE DEMAND PROJECTIONS

Annual municipal water use reports submitted by the City to the Kansas Department of Agriculture Division of Water Resources (DWR) from 2002 to 2012 were used to estimate historical water use and project future water demands. Historical water use is presented in Table 2-2. Reports were not available for 2004, 2005, and 2010. The total water use reported to DWR includes water sold to public suppliers, industry, stock, and bulk customers, residential and commercial, water provided for free (that is metered), and unaccounted for water. Service populations were also provided in the annual reports to DWR. This water use and population were used to determine historical annual average per capita water use. The average annual per capita water use for the 10-year period based on water sold to residential and commercial customers, including unbilled metered water provided for free (for City buildings, flushing, etc.) and water unaccounted for, was an estimated 150 gallons per capita per day (gpcd). In recent years, the annual amount of raw

water diverted exceeds the total water metered by the City. Estimated water loss has steadily increased from 13.7% in 2003 to 25.5% in 2012.

For each year 2011 and 2012, the City reported annual raw water diversion exceeding its allotted annual water right of 1,530 million gallons (Mgal). Projected water use is estimated based on the annual average water use per capita and the projected population discussed in Section 2.1. In addition, the projected annual average water use is estimated to include projected wholesale, industrial, and residential and commercial water use based on 10-year historical trends. City water usage in 2045 is projected to increase a total of 1,973 Mgal. This projected use is 11.8% greater than 2012 water use and 22.9% greater than the City's appropriated diversions.

As shown in Table 2-2, between 2002 and 2012, the City has experienced considerable water losses (discussed further in Section 2.4). The City has recently completed a Water Conservation Plan and adopted a target goal to reduce per capita water use to 134 gpcd. Projected target water use is estimated based on the reduced rates for water use. If the City can take steps to reduce water loss which will lead to a reduction in per capita water use, the target water usage in 2045 is projected to be 1,800 Mgal. Additional water conservation could be realized with implementation of an inclining block water rate structure. Under these water rates, as a customer uses more water, they are charged a higher rate, which sends a price signal to the customer to conserve water.

Table 2-3: Historical Annual Water Use

		Year							
Description[1]	**Unit**	**2002**	**2003**	**2006**	**2007**	**2008**	**2009**	**2011**	**2012**
Raw Water Diverted	Mgal	1,280	1,280	1,430	1,412	1,374	1,280	1,644	1,682
Water Sold to Other Public Water Suppliers	Mgal	48	52	51	45	44	48	51	52
Water Sold to Industrial, Stock, and Bulk Customers	Mgal	223	225	261	270	219	223	264	228
Water Sold to Residential and Commercial Customers	Mgal	680	677	806	749	709	680	782	817
Metered Water Provided Free	Mgal	143	152	70	56	64	143	167	157
Unaccounted For Water	Mgal	185	175	243	292	338	185	381	429
Annual Percentage Water Loss	%	14.5%	13.7%	17.0%	20.7%	24.6%	14.5%	23.2%	25.5%
Residential + Water Loss		865	852	1049	1041	1048	865	1163	1245
City Population [1]	cap.	18,880	18,886	19,500	20,000	20,059	20,671	23,353	25,817
Estimated Water Use per Capita [2]	gpcd	146	146	157	150	152	134	156	149

Notes:
[1] Historical data provided in Municipal Water Use Report; data not available for 2004, 2005, and 2010.
[2] Estimates based on population and water sold to residential and commercial customers, metered water provided for free, and unaccounted for water

Table 2-4: Projected Annual Water Use

Description	Unit	Year 2013	2015	2020	2025	2030	2035	2040	2045
City Population	cap.	24,299	24,644	25,506	26,369	27,232	28,094	28,957	29,819
Projected Wholesale Water Use	Mgal	53	53	54	54	54	55	55	56
Projected Industrial Water Use	Mgal	246	248	254	260	266	272	278	284
Projected Residential and Commercial Water Use[1]	Mgal	1,330	1,349	1,396	1,444	1,491	1,538	1,585	1,633
Per Capita		150	150	150	150	150	150	150	150
Projected Annual Water Usage[1]	Mgal	1,629	1,651	1,704	1,758	1,812	1,865	1,919	1,973
Projected Annual Water Usage with Conservation[2]	Mgal	1,487	1,507	1,555	1,604	1,653	1,701	1,750	1,799

Notes:

[1] Projected water usage based on population projections presented in Section 3.2

[2] Projected water usage based on the City target per capita usage of 134 gpcd

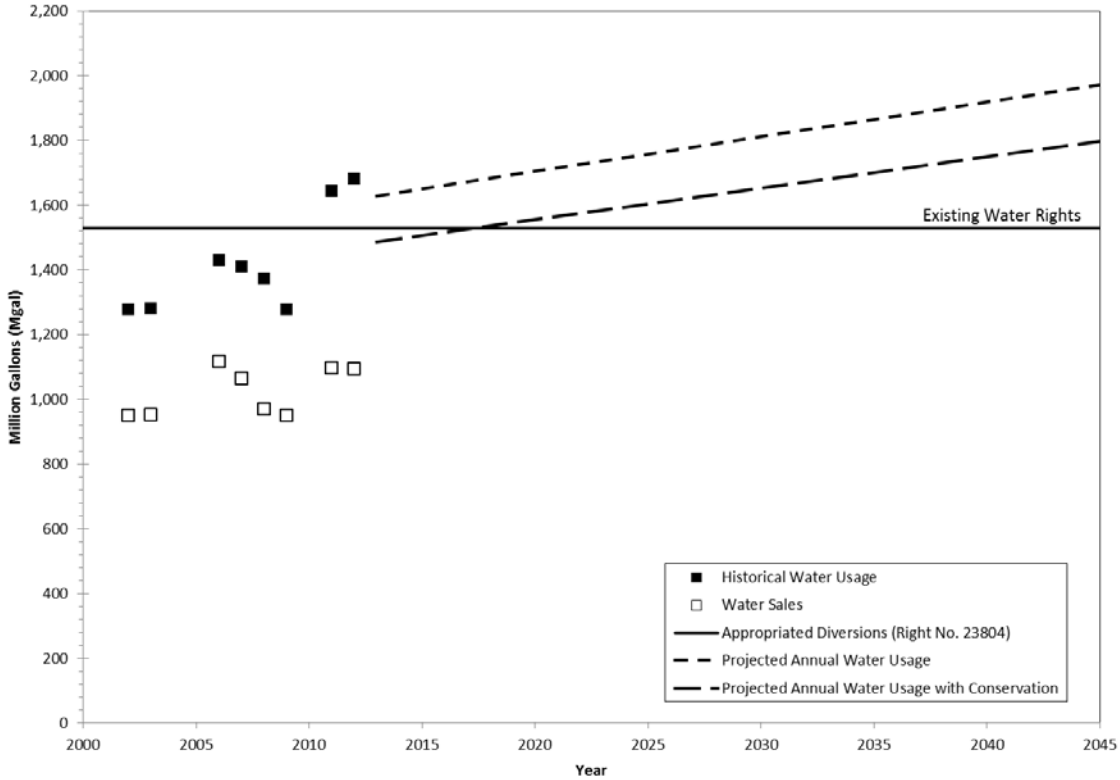


Table 2-5: Historical and Projected Water Use

2.3 MAXIMUM DAY DEMAND PROJECTIONS

The size of water supply and treatment infrastructure is generally based on the maximum single day demand including water lost in the treatment process and water distribution system. The maximum water pumped by City wells between 2002 and 2012 ranged from 5.3 to 8.4 MGD. The amount of water pumped and treated at the WTP in this time period, including low service and high service pumping, ranged between 4.3 and 6.2 MGD. Compared to the average annual demand based on historical water usage data previously presented, the peaking factor for maximum day demand has ranged from 1.55 to 1.84. The projection for future maximum day demand is based on a peaking factor of 1.85; additionally, this maximum day demand could be reduced if the per capital use rate is decreased to 134 gpcd as previously discussed. Not including conservation, the projected maximum day demand in 2015 is 10.0 MGD.

Table 2-6: Historical Maximum Day Water Diversion

		Year										
Description	**Unit**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Annual Volume Raw Water	Mgal	1279.6	1280.5	N/A	N/A	1430.3	1411.6	1374.2	1279.6	N/A	1644.3	1682.2
Annual Average Raw Water	mgd	3.51	3.51	N/A	N/A	3.92	3.87	3.76	3.51	N/A	4.50	4.61
Max Day Raw Water Diverted	mgd	5.88	5.43	5.26	5.71	6.31	6.44	5.83	5.99	7.52	8.29	8.43
Peaking Factor	-	1.68	1.55	N/A	N/A	1.61	1.67	1.55	1.71	N/A	1.84	1.83
Average Peaking Factor	-											1.68
Maximum Peaking Factor	-											1.84

Table 2-7: Projected Maximum Day Water Diversion

		Year							
Description	**Unit**	**2013**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**
Projected Max Day									
Annual Average Volume	Mgal	1629.2	1650.7	1704.4	1758.0	1811.7	1865.4	1919.1	1972.7
Annual Average	mgd	4.5	4.5	4.7	4.8	5.0	5.1	5.3	5.4
Max Raw Water Diverted	mgd	8.3	8.4	8.6	8.9	9.2	9.5	9.7	10.0
Projected Max Day with Conservation									
Annual Average Volume	Mgal	1487.3	1506.8	1555.4	1604.0	1652.7	1701.3	1750.0	1798.6
Annual Average	mgd	4.1	4.1	4.3	4.4	4.5	4.7	4.8	4.9
Max Raw Water Diverted	mgd	7.5	7.6	7.9	8.1	8.4	8.6	8.9	9.1

Notes:
Projected water diversions based on a historical Peaking Factor of 1.85 between 2002 and 2012.

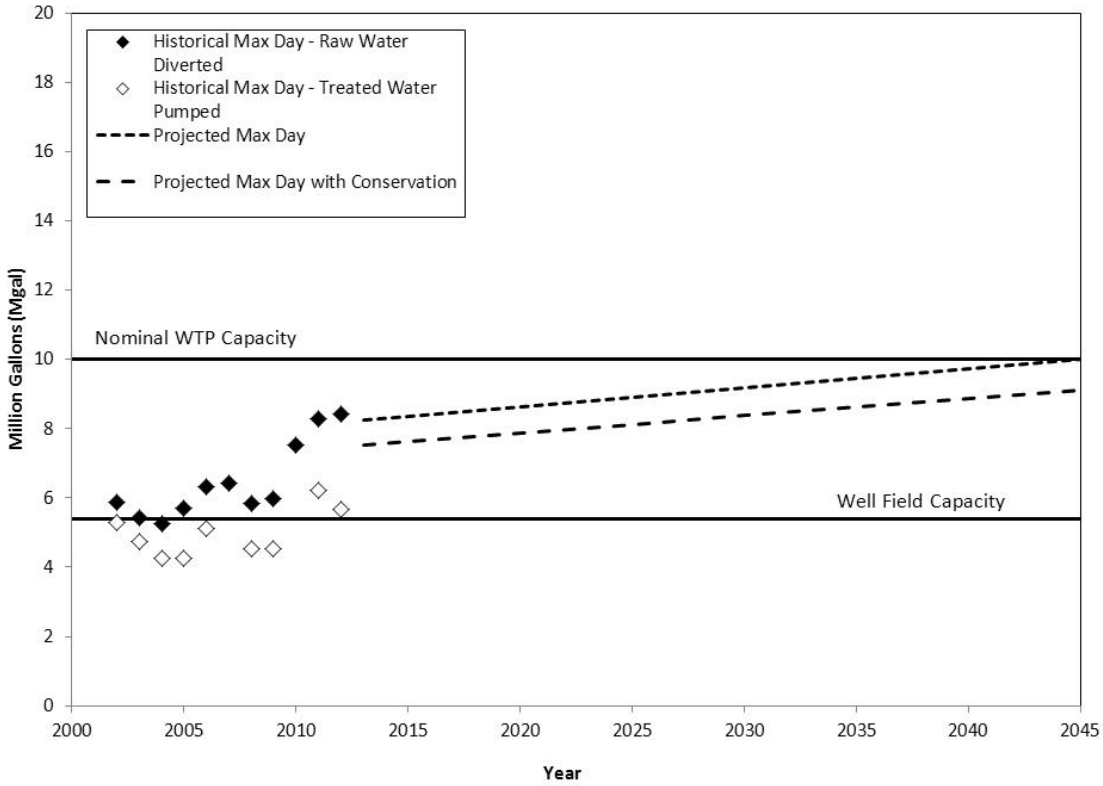


Table 2-8: Projected Maximum Day Water Use

2.4 UNACCOUNTED-FOR WATER

As shown in Table 2-2, between 2002 and 2012, the amount of water that is unaccounted for has been increasing. The terms 'water loss' and 'unaccounted for water' are used somewhat interchangeably. For the purposes of this study and per the Kansas Water Office and Division of Water Resources, unaccounted for water is defined as the amount of water that is diverted minus: 1) metered amount of water that is sold to customers (residential, commercial, and industrial); 2) metered water sold to other public water suppliers; and 3) water metered but unbilled for City buildings, flushing, and other uses determined by the City.

Unaccounted for water consists of two basic components: water physically lost from the distribution system (real losses) and water used but not documented or paid for (apparent losses). In most municipal water distribution systems the following are the main potential sources of unaccounted for water:

- Water main breaks and leakage - The largest portion of unaccounted for water is typically lost through water main leaks because they often go undetected for long periods of time. Water main breaks and leaks can be attributed to a number of factors including poor design, improper installation, poor thrust restraints, joint failure or aged pipe.
- System pressure - Water pressure within the distribution system can affect unaccounted for water in many ways. High pressure can lead to higher break rates. High pressure can also lead to higher leakage rates once a leak or break has occurred. Once the distribution system has been laid out and pressure zones have been established, it is difficult to reduce pressure in an area.
- Fire fighting - Water used for fire fighting is typically over short periods of time and usually accounts for less than 1 or 2 percent of total production. Water used for occasional fire-hydrant flow testing also does not account for a significant portion of unaccounted for water.
- Water main flushing - Water main flushing through fire hydrants results in a significant volume of water because virtually all water mains in the distribution system are flushed.
- Meter under registration - Most water meters tend to register less water than is actually used as they become older.
- Theft of water - Water can be stolen from hydrants. Water can also be stolen at services by removing the meter or tapping into a service line upstream of the meter.

Raw water diverted and water sold should be reviewed monthly to assess water loss; reviewing data more frequently may lead to discovery of patterns in the data, such as certain months where the water loss is excessive. The following typical practices are recommended in order to reduce unaccounted-for water, both real losses and apparent losses:

- Scheduled replacement of aged or deteriorated water mains – The City should be proactive and replace aged and deteriorated water mains annually via capital improvement projects.
- Improved system pressure management – The City should continue to monitor and manage system pressure in order to decrease the amount of pressure-related water main breaks that occur. Based upon the City's water distribution hydraulic model, the City could determine which areas have the highest probability of excessive pressure due to the location of storage tanks, pumping

stations, and changes in elevation. If the pressure at these locations cannot be reduced without adversely affecting other areas of the distribution system, then the age and condition of those water mains should be noted and evaluated to determine if water main replacement is necessary. The City should also try to eliminate any excessive water hammer conditions.

- Directional water main flushing – Traditional flushing consists of opening of a fire hydrant until the water clears up or disinfectant residuals increase. Directional flushing consists of closing valves within the distribution system and then opening a fire hydrant to maximize the velocity in the pipes being flushed. This type of water main flushing does require additional labor hours to close/open valves but it uses approximately 40% less water than traditional flushing methods by creating higher velocities for more efficient pipe cleaning thereby decreasing amount of time necessary to flush the mains. Other benefits of directional water main flushing include: immediate water quality improvement, allowing for simultaneous preventative maintenance activities such as valve and hydrant exercise, and minimal rusty water disturbance to surrounding areas.
- Implement meter maintenance program – The City should improve their existing meter maintenance program. To reduce the amount of meter under registration, it is recommended that the City implement a meter replacement program so that all service meters are replaced based on their age approximately every 15 to 20 years.
- Implement a leak detection program, particularly in older parts of town to identify and repair leaks.

The City is currently implementing a program to replace service meters in the water distribution system and to ensure continued calibration of the meters going forward as well as converting meters to read water usage remotely remotely (AMR or automatic meter reading). This year the City is replacing approximately half of the meters that are greater than 2". Over the next four years, all residential meters will be replaced. Maintenance of the meters will be as outlined in the Water Conservation Plan, which is as follows:

- 3" and larger meters (<20 meters currently) will be tested every year and repaired/replaced if test measurements are not within industry standards
- 2" to <3" meters (~100 meters currently) will be tested every other year and repaired/replaced if test measurements are not within industry standards
- 5/8" and 1" meters – test a random sample once per year and repaired/replaced if test measurements are not within industry standards

Based on conversations with City staff in September, 2013, all of the 3" meters and some of the 2" meters have been replaced with new meters to date. As a result of this, the City has seen an increase in the flow measured at the meters, indicating that many of the existing meters across the water distribution system may be under-reporting water use. Therefore, the unaccounted-for water is expected to decrease as a result of water sold increasing (due to increased accuracy of meters). Additionally, the increase in water sales will bring additional water sales revenue to the City to fund needed capital improvements.

The existing well meters are calibrated every three years; therefore, it is believed that the well meters accurately indicate the amount of water is diverting. The well meters are propeller meters, with the

exception of Well 18, which is a mag meter. The calibration process includes pulling the meter and sending it to the manufacturer to be factory calibrated, which results in an accuracy of +/-2% per the manufacturer. With regular calibration, the propeller meters are sufficient for metering of the wells; as wells are replaced or meters fail, new meters should be installed as mag meters.

Flow from all wells combines into a 30-inch line, which is metered with a venturi meter ahead of the aerators. Veolia Water staff report that this meter reads below the totalized flow of the individual well meters as much as 0.5 MGD; it has not been calibrated since it was installed. It is recommended that the existing venturi flow meter be replaced with a mag meter. Costs for replacement of the meter are presented in Appendix A. After the new meter is installed and operating, the reading on the flow meter can be compared with the totalized flow of the individual wells to assess the accuracy of the individual well propeller flow meters and determine whether replacement of those meters is required.

Additionally, as shown in Figure 2-3, the difference between the raw water diverted and the treated water being pumped from the plant (both high and low service) has been increasing, indicating water is being lost in the plant, either by physical water loss or meter inaccuracy. Similar to the water loss of the whole system, as discussed previously, the problem is getting worse over time. The high and low service pump venturi meters are thought to be inaccurate and replacement with mag meters is recommended. Costs for replacement of the flow meters are presented in Appendix A.

2.5 RECOMMENDATIONS

The following are recommended improvements related to water conservation and unaccounted for water:

- Implement water conservation rates to promote water conservation
- Replace customer meters with more accurate meters and implement a program to replace the meters in the future to maintain accuracy
- Replace the plant raw water flow meter
- Replace the high and low service pump discharge meters

Costs for the above improvements are detailed in Appendix A. Phasing of these improvements will be discussed in Section 11.

3 WATER RIGHTS

3.1 EXISTING WATER RIGHTS

The City holds three water right certificates for groundwater in the Republic River basin. Vested right GE 002 is the City's most senior water right. Most recently, the City obtained appropriated right 23804 which combined all of the City's municipal water rights into one combined annual quantity and maximum diversion rate limitation for all ten of the City's wells. A total of twelve (12) wells are permitted under the three combined water rights. Table 3-1 summarizes the water rights available to the City.

Table 3-1: Existing Water Right Summary

File No.	Priority Date	Use Made of Water	# of Active Points of Diversion	Permitted Annual Quantity (ac-ft)	Permitted Annual Quantity (MG)	Maximum Diversion Rate (gpm)
GE 002	7/30/1954	Municipal	4	1,765	575	2,850
9658	12/30/1963	Municipal	5	2,513	819	3,800
23804	3/19/1975	Municipal	10	4,480	1,460	6,250
23804 [1]	3/19/1975	Municipal	10	4,695	1,530	6,945 [2]

Notes:

[1] Limiting condition that combines GE 002, 9658, and 23804 for a maximum annual quantity and maximum diversion rate for all three water rights together.

[2] 6,945 gpm = 10 MGD

Table 3-1 summarizes the limitations placed by the DWR on usage of water for municipal purpose by the City. Those limitations are a total pumping volume of 4,695 ac-ft (1,530 MG) and a maximum instantaneous pumping rate of 6,945 gpm. Annual water use data provided by the City to HDR indicate that the annual water use limit was exceeded in both 2011 and 2012, with a total volume pumped by the City of 1,644 and 1,682 MG, respectively. City water use data shows that the maximum daily pumping volume diverted was 8.24 MG (5,722 gpm) on June 27 2012, which indicates that the maximum diversion rate is sufficient to accommodate the current water demands.

3.2 WATER ASSURANCE DISTRICT STORAGE

Junction City is a member of the Kansas River Water Assurance District No. 1 (Assurance District). The Assurance District has storage space in Milford, Tuttle Creek and Perry Reservoirs. Members of the assurance district are allowed to access "assurance water" which is defined as water in storage within a reservoir held under a water reservation right. Assurance water can be provided as supplemental water to eligible water right holders (a municipal or industrial entity with an existing water right). Water right holders are therefore assured to receive enhanced flow during times of drought. Eligible water right holders include any permitted surface water diversions or any permitted groundwater diversions located with a ¼ mile of the stream.

HDR contacted the regional water commissioner for the DWR to determine how much water in storage Junction City has access to through the Kansas River Water Assurance District. The DWR has indicated the City has 1,520 MG (4,665 ac-ft) of water in storage through the Assurance District.

3.3 ALTERNATIVES

As described in Section 2.2, the City's current annual water right appropriation is not sufficient to meet current demands, unless water conservation is implemented. Additionally, a deficit of 443 MG (1,357 ac-ft) was identified between the projected annual water in 2045 use and the annual water available for diversion by water right. Therefore, adding additional water rights to increase the annual volume available for diversion is an immediate need. Existing water rights are sufficient to meet the project maximum demand of 6,945 gpm (10 MGD).

The availability of water for new water right permits is assessed by the Kansas Division of Water Resources (DWR). The first check performed by the DWR is to evaluate the safe yield of the aquifer within a 2 mile radial circle of a proposed diversion location, using the procedure described in KAR 5-3-11. A check of the safe yield calculation near the City wells indicates that the area within 2 miles of the wells is over-appropriated and no new water supply wells can be installed within this area (Figure 3-1), unless supplemental water from the Assurance District is added to the existing water right. The only exception to this rule is the installation of replacement well, which could be drilled if an existing well fails or no longer produces water in an economical manner. However, the addition of a replacement well will not increase the annual water quantity available for diversion.

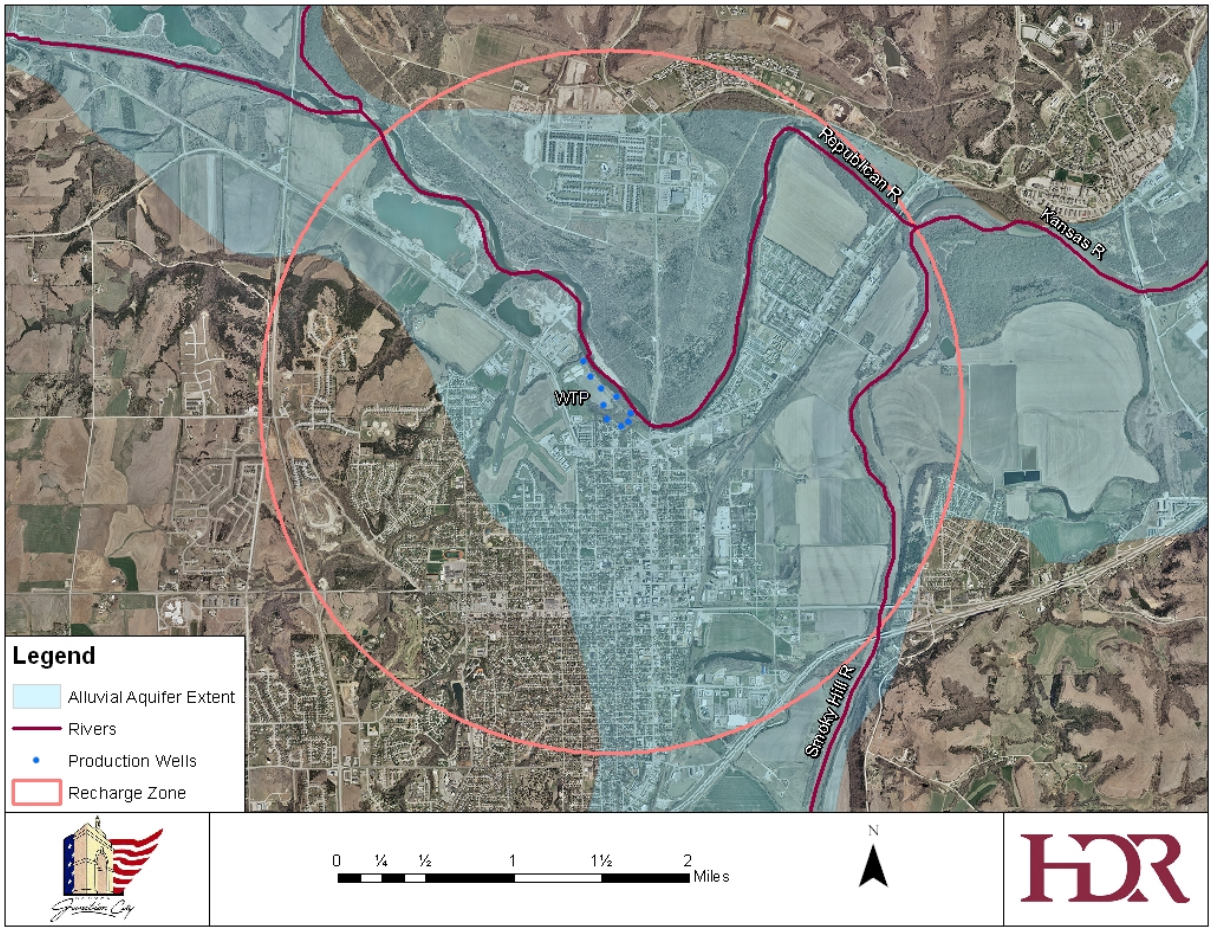


Figure 3-1: City Well Field Yield Determination

The option of developing new water rights for the City was discussed with the regional water commissioner for the DWR. DWR has indicated that they would not approve any new water rights within a 2 mile radius of any existing City supply wells, unless supplemental water from the Assurance District is added to the water right. They have also indicated that any new water rights outside of that buffer would be approved on a case by case basis. As a result of this discussion with the DWR, HDR has identified the following options are available to increase the quantity of water available for diversion, and are listed in order of recommendation:

1. Submit an application to divert water to the DWR to increase the annual quantity of water available for diversion from the well field. The request would rely on using a portion of the 4,665 ac-ft the City has in storage as assurance water to supplement (and increase) the permitted annual volume available for diversion from the City's existing water rights. This water could be withdrawn using the existing well field infrastructure, or by new wells that could be installed within the general proximity of the existing wells. The request should be made in the amount of 1,360 ac-ft to ensure sufficient annual volume to meet the projected 2045 demand for water. A review of the water

assurance contract provided by the City indicates that there would be no additional cost to use the storage beyond the membership costs the City already pays annually.

2. Install new wells outside of the 2 mile radial circle shown on Figure 3-1. These new wells would be outside of the area of influence of the existing wells, in areas where the aquifer safe yield is not exceeded. The volume of water available for appropriation will vary by location, but it appears that up to 1,588 ac-ft (1.4 MGD) is available from each 2 mile radial circle outside of the shown on Figure 3-1. However, the availability of water will vary given the number of wells that are registered within the 2 mile radial circle, therefore water availability must be evaluated on a case by case basis.
3. Purchase existing water rights from large registered water users located near the well field.

3.4 RECOMMENDATIONS

3.4.1 Immediate Needs

It is recommended that the City proceed with application to the DWR for additional water rights through the Kansas River Water Assurance District. This is an immediate need to avoid additional over-pumpage of water rights.

3.4.2 Phased Needs

There are no other recommendations related to water rights.

4 WATER SUPPLY

4.1 EXISTING FACILITIES

The water supply generally consists of ten water supply wells that draw from the Republic River alluvium east of the water treatment plant. Recently, the casing of Well #16 collapsed, leaving the City with nine active wells. Recently there have also been capacity issues with Well #18; these issues are not evaluated as a part of this engineering analysis but are being evaluated separately. All the wells combine into a 30-inch water main into the water treatment plant. Figure 4-1 shows the layout of the existing well field.

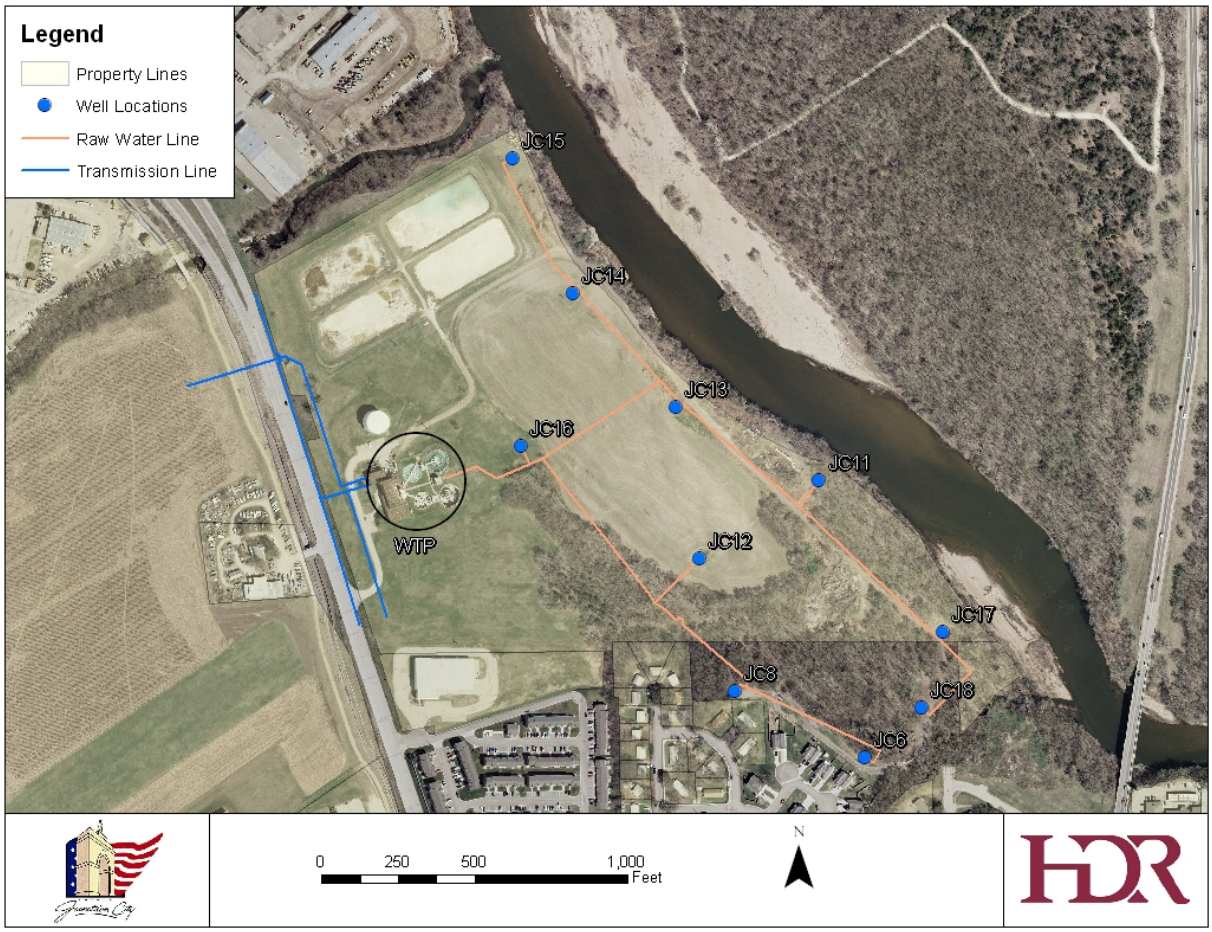


Figure 4-1: Existing Well Field Layout

4.1.1 Hydrogeology

Near the City well field, the Republican River alluvial aquifer is an unconfined (water table) aquifer that consists of relatively thin deposits of medium to coarse grained sand. These sand deposits which comprise the aquifer extend vertically to the bedrock surface. In the vicinity of the well field, bedrock consists of

limestone or shale and is typically encountered between 53 feet and 72 feet below ground surface (bgs). Depth to water near the well field ranges between 25 to 40 feet bgs. Well pumping rates are limited by the relatively thin saturated thickness of the aquifer.

4.1.2 Well Field Capacity

Well operational data provided by Veolia Water were used to estimate the current maximum pumping rate for each well. Measurements of static water level, pumping water level, and flow rate were used to estimate the current specific capacity (SC), in gallons per minute per foot of drawdown, at each pumping well. The current SC estimates were in turn used to develop an estimate of the instantaneous pumping capacity of each well.

The first step in developing an estimate of the maximum flow rate for each well was to calculate the available drawdown in each well. To do this, the depth to the static water level was subtracted from the depth of the pumping water level. The pumping water level within each well was set 3 feet above the top of the screen interval. Three (3) feet was selected because that represents approximately 10 percent of the saturated thickness of the aquifer. It is a recommended design practice to maintain the pumping water level above the top of the screen interval of the well (Recommended Standards for Water Works, 2012 Edition) in order to increase the design life of the well. Maintaining the pumping water level above the top of the well screen reduces the rate at which well performance deteriorates due to mechanical plugging (from silts and clays), chemical plugging (from the precipitation of minerals), or biological plugging (from microbial growth) of the well screen (Driscoll 1986).

The maximum well flow rate was then calculated by multiplying the available drawdown in the well by the SC. Maximum pumping rates for each well are presented below in Table 4-1. The firm pumping capacity of the well field is 9.0 MGD but the firm capacity of the wells (using the recommended operating procedures described above) and pumps is 5.2 MGD. Firm capacity is the well field capacity with the highest producing well, Well 18, out of service.

Table 4-1: Summary of Existing Well Field

Well	Typical Pumping Rate [1]	Pump Capacity [2]	Well Capacity [3]	Actual Capacity [4]
6	375	425	605	425
8[5]	400	425	1361	425
11	900	1250	585	585
12	625	750	260	260
13	850	900	336	336
14	850	950	240	240
15	875	1100	667	667
17	850	950	657	657
18	700	723	980	723
Total (MGD)		10.8	8.2	6.2
Firm (MGD)		9.0	7.4	5.2

Notes:
1 Pumping rate that appears most frequently in data provided by Veolia Water.
2 Assumed installed pump capacity (based on maximum pumping rate that appears in data provided by Veolia Water).
3 Maximum pumping rate to keep the water table 3 feet above the top of the well screen. Three (3) feet was selected as the operating level of for the pumping water level because it is approximately 10 percent of the average aquifer thickness.
4 The minumum of 2 and 3.
5. Well capacity based on available data. Should be field verified.

Based on Table 4-1, when comparing the well capacity to the pump capacity, it appears that the capacity of the well has likely declined over time. Most likely, the wells were capable of producing between 700 and 1250 gpm when they were installed, indicating that rehabilitation of the well, by cleaning or other methods, may restore the capacity.

A method to provide a short term, incremental increase in well field capacity could be to better match pump capacity to well capacity in wells where field data indicate that the well could pump water at a capacity higher than what the pump is rated for (see Table 4-1). In these wells (6, 8, and 18) it may be possible to replace the existing pump with a pump of a higher capacity. However, since the well flow analysis is based on limited pumping data, field testing of these wells should be performed to verify that the wells can sustain a flow rate that is higher than the current pump capacity.

Well capacity could be increased from what is presented in Table 4-1 if the pumping water level is allowed to enter the screen interval of the well. However, allowing the pumping water level to enter the well is not a recommended operating practice and could result in a decline in well performance.

4.2 ALTERNATIVES

The firm capacity of the well field was estimated at 5.2 MGD, as previously described. Therefore, additional well field capacity is required to meet the projected maximum water demand of 10 MGD in 2045. Water from the Assurance District could be used to increase the annual quantity of water available for diversion near the well field as described in Section 3, however additional well capacity is needed to meet the projected 2045 maximum day demands. It is assumed that new/offset wells will be capable of producing approximately 750 gpm.

4.2.1 Alternative 1: Rehabilitate or Offset Existing Wells and Replace Pumps

Alternative 1 for increasing well field capacity is to rehabilitate or offset the existing wells (including offset of Well #16) and replace pumps to match well capacity. Additionally, one new well would be needed to bring the well up to capacity and could be installed within the 12 wells that are permitted under the existing water rights (the new total of wells would be 11). The following capacities could be realized:

- Replacement of pumps in Wells 6, 8, and 18 – brings firm capacity to 4,330 gpm (6.2 MGD)
- Offset (or Rehab) Wells 12, 13, and 14 – brings firm capacity to 6,580 gpm (9.5 MGD)
- Offset Well 16 – brings firm capacity to 7,330 gpm (10.5 MGD)

For cost estimation purposes, it will be assumed that Wells 12, 13, and 14 will be offset rather than rehabilitated. Rehabilitation may be possible; however, there is uncertainty in how much additional capacity rehabilitation will provide. Wells 12, 13, and 14 were chosen because they appear to provide the most additional capacity. Under this alternative, approximately 1,000 linear feed of well field piping between Well #8 and the 24" line to the plant will need to be upsized to 20 inches. Table 4-2 summarizes the costs of this alternative.

Table 4-2: Summary of Costs for Water Supply Alternative 1, Rehabilitate or Offset Existing Wells and Replace Pumps

Item	Quantity	Unit	Unit Cost	Total Cost
Well, 50-70' deep, Complete with Well House, Installed	4	LS	$325,000	$1,300,000
Mag Meters (12")	4	EA	$12,000	$48,000
Meter Vault	4	EA	$15,000	$60,000
20" Piping	1000	LF	$200	$200,000
8" Piping	1500	LF	$80	$120,000
Piping Tie-Ins	6	LS	$5,000	$30,000
Abandon Existing Wells Being Offset	4	EA	$3,000	$12,000
Remove Existing Well Pumps	3	EA	$1,500	$5,000
Replace Well Pumps, Installed	3	EA	$69,000	$207,000
Replace Well Controls #6, 11, 17 (Remote On/Off)	3	EA	$25,000	$75,000
Electrical & Instrumentation (20% of System)	1	LS	$305,000	$305,000
Construction Total				$2,362,000

4.2.2 Alternative 2: Replace Pumps and Install New Wells

Alternative 2 for increasing well field capacity is to replace pumps to match well capacity and install new wells to bring the firm capacity of the well field to 10 MGD.

- Replacement of pumps in Wells 6, 8, and 18 – brings firm capacity to 4,330 gpm (6.2 MGD)
- Offset Well 16 – brings firm capacity to 5,080 gpm (7.3 MGD)

At 750 gpm per new well, an additional 3 wells would be needed to bring the well field capacity to a minimum of 10 MGD. Two additional wells can be installed within the existing water rights to bring the total permitted wells to 12. These wells may be subject to DWR's minimum well spacing of ¼ mile, which would require these wells to be either across the Republican River or on the airport property. Additionally, the remaining additional well would be subject to DWR's 2-mile radius safe yield rule, which would require this well to be installed a minimum of 2 miles away from the existing well field, most likely close to the confluence of the Republican and Smoky Hill Rivers. Because of these constraints, costs for this alternative were not estimate and this alternative is eliminated.

4.2.3 Alternative 3: Install Horizontal Collector Well

An alternative could be the installation of one (1) horizontal collector well (HCW). Based on the geology in the well field, construction of a HCW appears feasible. In alluvial environments similar to Junction City's well field, a HCW can be expected to produce between four (4) to seven (7) times the flow rate of a traditional vertical well, indicating the plausible range of flow rates for a HCW is between 4 to 7 MGD. A HCW, when operated with the other existing vertical wells, would likely produce sufficient water to meet the projected maximum water demand. One horizontal collector well, at a capacity of 7 MGD with four pumps, could be installed under the existing water rights bringing the total wells to 10. The firm capacity of the well field as a whole would be 10.5 MGD, with one 1200 gpm well pump in the HCW out of service. A horizontal collector well would be advantageous for the City because it would simplify well field operations by reducing the number of wells and it would decrease the level of maintenance needed. If this option is selected, detailed hydrogeologic testing is recommended to further evaluate the potential yield of a horizontal collector well.

Table 4-3: Summary of Costs for Water Supply Alternative 3, Rehabilitate or Offset Existing Wells and Replace Pumps

Item	Quantity	Unit	Unit Cost	Total Cost
Horizontal Collector Well - 5 MGD - with Pumps and House, Installed	1	LS	$3,000,000	$3,000,000
20" Piping	200	LF	$200	$40,000
Piping Tie In	1	LS	$7,000	$7,000
20" Mag Meter	1	EA	$20,000	$20,000
Meter Vault	1	LS	$20,000	$20,000
Replace Well Controls #6, 11, 17 (Remote On/Off)	3	EA	$25,000	$75,000
Electrical & Instrumentation (20% of System)	1	LS	$600,000	$600,000
Construction Total				$3,762,000

4.3 RECOMMENDATIONS

Installation of a 7 MGD horizontal collector well is recommended to bring the total firm capacity of the well field to 10.5 MGD.

Given the variability of alluvial environments, an evaluation of subsurface conditions at potential well sites should be performed prior to the installation of any new wells. This is especially true for the construction of a HCW. A preliminary review of available data indicates that the construction of a HCW is feasible near the City well field. However, detailed hydrogeologic testing should be performed to evaluate the site specific geologic conditions at any potential HCW site.

Additionally, due to the significant increase in water withdrawal from a relatively concentrated cluster of wells, it is recommended that a groundwater model be developed to evaluate the sustainability of withdrawing up to 10 MGD from the well field.

The recommendations of the water supply system are summarized as follows:

- Install a 7 MGD horizontal collector well
- Conduct hydrogeologic testing during the design phase
- Develop a groundwater model during the design phase

The phasing of these improvements will be discussed in Section 11.

5 CONVENTIONAL WATER TREATMENT

5.1 GENERAL TREATMENT PROCESS

The wells supply water to the WTP. The original WTP facilities were constructed in 1976 and the plant has a nominal design treatment capacity of 10.0 MGD. In general, the following treatment is provided:

- Aeration by forced updraft aerators
- Primary lime softening
- Rapid mix with chlorine addition
- Secondary settling
- Filtration followed by additional chlorine injection

Figure 5-1 shows the layout of the WTP. A schematic of the treatment process is provided in Figure 5-2.

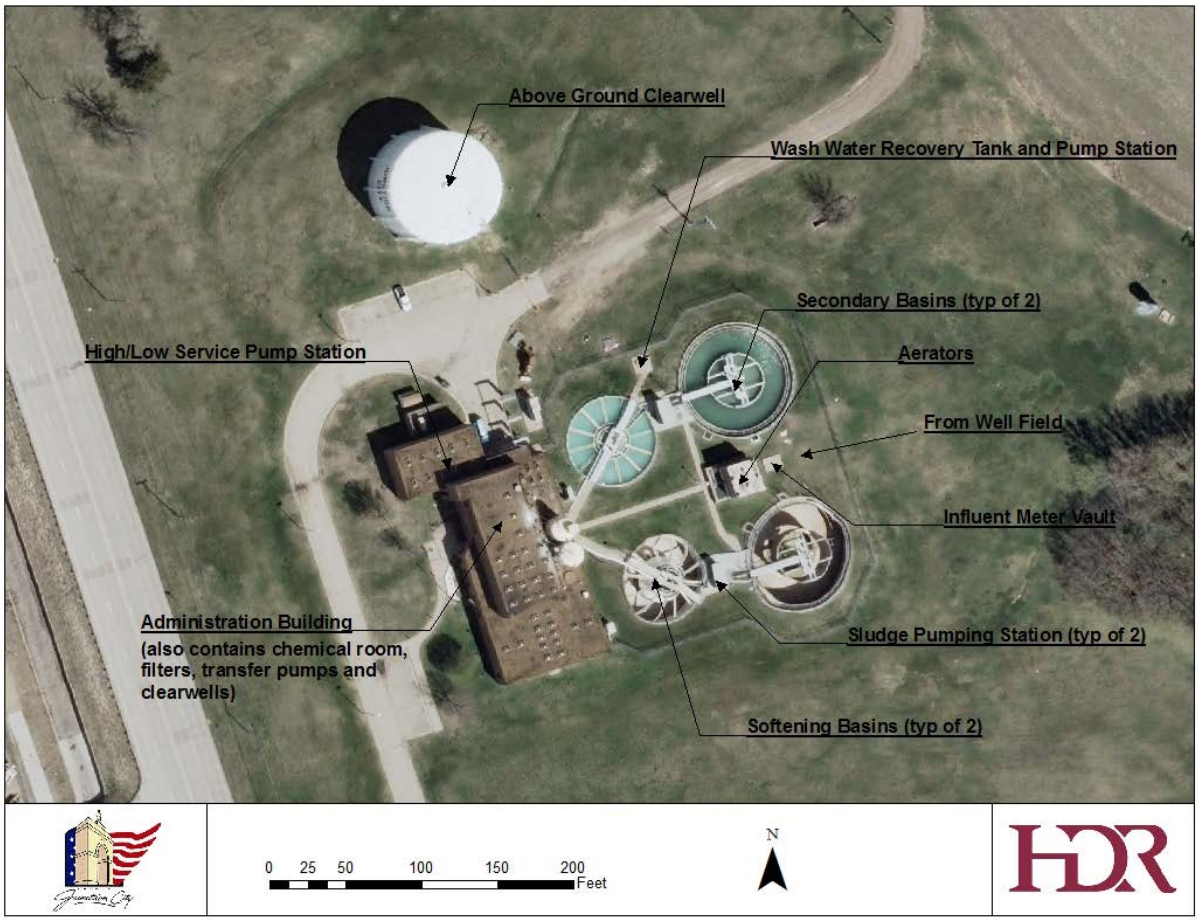
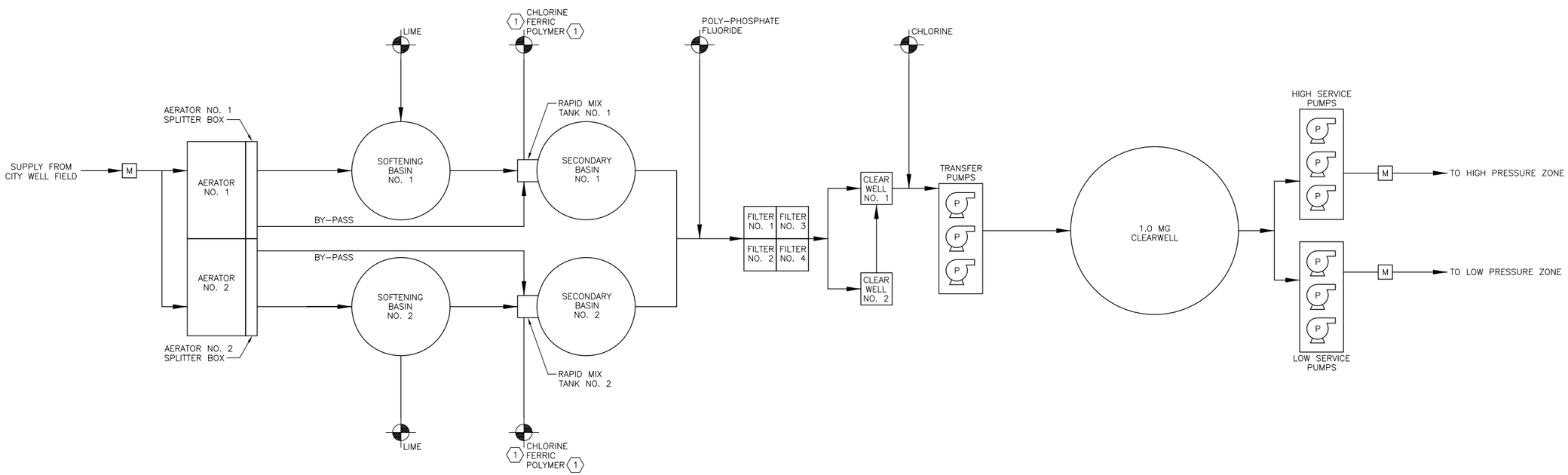


Figure 5-1: Layout of Water Treatment Plant

KEY NOTES:

(1) NOT CURRENTLY IN USE.



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City of Junction City, Kansas

Water Treatment Plant Engineering Report

TREATMENT PROCESS SCHEMATIC

FIGURE 5-2

DRAWING: FIGURE 5-1.dwg DATE: Dec 19, 2013 - 2:20PM

5.2 WATER QUALITY

Veolia Water staff collected data at each stage of the water treatment process on July 18, 2013; the data collected is presented in Table 5-1.

Table 5-1: Summary of Water Quality Data - July 18, 2013

Parameter	Unit	Raw Water	Softened Water	Settled Water	Filtered Water
Alkalinity	mg/L as $CaCO_3$	254	92	108	113
Total Hardness	mg/L as $CaCO_4$	305	183	172	164
Carbonate Hardness	mg/L as $CaCO_5$	254	92	108	113
Non-Carbonate Hardness	mg/L as $CaCO_6$	51	91	64	51
Magnesium Hardness	mg/L as $CaCO_7$	79	72	70	72
Calcium Hardness	mg/L as $CaCO_8$	226	112	102	92
Langelier Index	-	0.18	1.37	1.13	1.16
Ryznar Index	-	7.03	6.57	6.78	6.78
TDS	mg/L	508	344	370	372
Specific Conductance	umhos/cm	830	523	577	581
pH	-	7.39	9.31	9.04	9.10

The following are conclusions about the data:

- The water is high in magnesium hardness and also has some non-carbonate hardness.
- The pH was not raised high enough on this day for magnesium hardness removal.
- There is some hardness precipitating in the settling basins and filters.
- The high Langelier Index of the filtered water indicates the water is scale forming.

5.3 AERATION

Aeration is used to remove carbon dioxide and oxidize iron in the raw water. Two forced draft aerators are installed in parallel. There is no true flow splitting to the process other than hydraulically with a tee after the raw water meter. Once the flow is split at this location, it remains split until after secondary clarification. There is no chemical feed ahead of the aerators; the presence of oxygen in the aerators can result in biological growth within the aerators. Plant staff have confirmed that this occurs inside the aerators. It is recommended that Veolia Water periodically (one day a month) chlorinate the raw water ahead of the aerators; this would require a chlorine feed line to the head of the aerators. Excessive chlorination at this location can lead to increased disinfection by-products; however a minimal amount of chlorine feed would keep the growth down while minimizing disinfection by-product formation.

5.3.1 Recommendations

The following are recommendations for the aerators:

- Install chlorine piping from an existing spare rotometer to the raw water meter vault with a chemical injector
- Periodically feed chlorine to limit biological growth inside aerators

To maximize efficiency, this improvement should be done in conjunction with the raw water meter replacement. Costs for this improvement are included with replacement of the raw water meter (see Appendix A).

5.4 LIME SOFTENING

5.4.1 Current Practices

A single-stage lime softening process is employed for removal of calcium hardness. Two primary clarifiers operate as the softeners, with lime addition in the rapid mix/flocculation well in the center of the tank. The softening process is followed by secondary clarifiers that serve to settle out any remaining particulates prior to the filters. Veolia Water staff target a pH of 10.5 to 10.6 in the softening basins. There is currently no means of chemical stabilization to bring down the pH prior to distribution; however, at low plant flow rates up to 40% of the treated water flows can be bypassed around the softening process and blended with the treated water to bring down pH. When treated flows get above 4.5 MGD, the ability to raise the pH in the softening basins is limited by the lack of stabilization. The goal finished water hardness is currently 170 – 180 mg/L.

The softening basins are solids contact units; the units are not operated with a sludge blanket, primarily due to concerns about being able to withdraw solids coupled with on-going plugging issues with the lime sludge piping. As a result, there is a significant build-up of calcium carbonate on the v-notch weirs of the softening basins. The secondary clarification basins are conventional clarifiers with sludge draw-off.

The waste sludge produced by the lime softening process is drawn off of the primary and secondary clarifiers and discharged by gravity through 8” lines. The lines from each set of primaries/secondaries combines in the yard and flow to four lagoons located on the west side of the site. The lagoons settle the sludge. The settled lime sludge is dried and then land applied, while the decant water is recycled to the aerator outfall boxes. Plugging of the 8” gravity sludge line has been an issue. Plugging is caused by lime solids settling out and coating the interior of the pipe, eventually causing plugging. Veolia Water has hired pipe cleaning companies in the past to clear the blockages; however, a lack of cleanout points and a number of bends have prevented a full cleaning.

5.4.2 Recarbonation Analysis

The pH of the water after lime softening must be reduced to provide a stable water quality that is just slightly depositing instead of highly depositing as currently exists. Since split treatment bypassing cannot be counted on to provide adequate lime softening and stabilization as described above, chemical addition to reduce the pH must be provided. This process is typically accomplished through recarbonation using carbon dioxide. With the addition of a carbon dioxide feed system, the existing by-pass around the primaries would be abandoned.

A carbon dioxide dose of approximately 100 pounds per day per MGD per pH unit is typically required. From a maximum pH of 11.0 in the primary softening basins to a pH between 8.5 and 9.0 for a stable water quality after softening, a pH reduction of up to 2.5 pH units would be required. At the plant capacity of 10 MGD, a maximum carbon dioxide dose of 2,500 pounds per day or 104 pounds per hour would be required. An average day in a peak month at design capacity would be about 8 MGD. At an average day demand (of the peak month) of 8 MGD, thirty days of storage would require a carbon dioxide storage vessel of 30 tons capacity. The 30-ton storage tank would allow for full tanker truckload delivery (20 tons) of carbon dioxide, which would result in the lowest possible delivered cost per pound of carbon dioxide. The storage tank would be located outdoors on the plant site in a location suitable for truck access for chemical delivery.

A Pressurized Solution Feed (PSF) carbon dioxide system was evaluated. PSF utilizes conversion of carbon dioxide gas into carbonic acid solution, which can be injected into pipelines as well as basins and tanks. This process improves efficiency and reduces reaction time, reducing or eliminating the need for tankage for detention time for full pH reduction. The PSF solution is recommended to be injected into the effluent piping immediately after each primary softening basin. The PSF solution feed would be automatically adjusted to provide the setpoint pH based on feedback from a pH probe located downstream of the PSF feed point. The pH probe could be located near the end of the secondary basin influent piping, utilizing the detention time of the primary softening basin effluent piping, secondary basin rapid mix chamber, and secondary basin influent piping. With this process, the pH of the water would be reduced in the secondary basin, enhancing the performance of the ferric sulfate coagulant for clarification and turbidity removal through the secondary basin. The secondary basin volume would provide ample detention time for full pH stabilization before filtration.

Three PSF feed panels would be provided: one each dedicated to each primary/secondary basin train and one spare for redundancy. The carbon dioxide and feed water piping to the panels and the solution feed water piping from the panels would be manifolded such that any panel could be directed to feed either basin train. Each PSF panel would have a carbon dioxide feed capacity of at least 52 pounds per hour. The panels would be located on the second floor of the building, where sufficient floor space should be available for the panels and necessary access; Appendix A shows a potential layout of the panels on this level. The panel area should be walled in to create a separate room with ventilation provided to contain and control a carbon dioxide release. An existing plant service water line that previously served filter surface wash could be tapped and used for feed water to the PSF panels. Piping for approximately 100

gpm feed water capacity would be required to the panels, and two lines of solution feed piping for approximately 50 gpm capacity each would be required from the panels to each primary softening basin effluent. A carbon dioxide gas line for approximately 104 pounds per hour capacity would be required from the storage tank to the panels. The panels, pH probes, and storage tank would require electrical service and integration with the plant control system.

The carbon dioxide storage and feed system would include the following:

- Liquid carbon dioxide storage tank (30 tons capacity)
- Concrete foundation pad for tank
- Three PSF feed panels (52 pounds per hour each)
- Two solution injectors/diffusers
- Two pH probes
- Carbon dioxide gas piping, fittings, valves
- Feed water piping, fittings, valves
- Solution piping, fittings, valves
- Masonry room construction for PSF panel area
- HVAC for PSF panel room
- Electrical for PSF panel room, storage tank, and pH probes
- Integration with plant control system

5.4.3 Lime Sludge Withdrawal Evaluation

As previously discussed, the sludge discharge piping from the basins to the lagoons has experienced ongoing plugging problems. The sludge blowdown piping from the primary and secondary basins is 8" diameter ductile iron piping that interconnects in the common sludge control buildings between each set of primary and secondary basins. The piping exits the building as 8" ductile iron gravity piping to the lagoons with several bends, tees, and valves. The main issue is that the 8" gravity piping is over-sized and does not provide adequate flow velocity to keep solids scoured from the piping. Therefore, solids are deposited and form hard scale that plugs the piping. The addition of flushing water and continuous sludge blowdown have been used to minimize the scaling and plugging, but periodic cleaning is still required. These issues have also prevented the primary softening basins from being operated in a more efficient solids-contact, suspended-sludge-blanket mode due to greater piping plugging potential.

Replacement of the 8" gravity piping with smaller diameter piping, and pumping of the lime sludge at a rate to provide a consistently adequate flow velocity to scour the pipe clean of solids would minimize these plugging issues. A 4" diameter pipe flowing at 200 gpm would provide a flow velocity of approximately 5 feet per second, which would keep the piping scoured clean of solids. Using a smooth-walled pipe material such as PVC or HDPE instead of cement-lined ductile iron would also provide less scaling potential and be easier to keep scoured clean. Fusion welded HDPE or PVC piping would provide a continuous pipeline with few joints or flow restrictions, further reducing the scaling potential.

The existing sludge recirculation pump in each process train's sludge control building could provide a flow rate near 200 gpm for sludge blowdown to the lagoons. The existing pumps have some useful life remaining, and should be used until they need replacement. When ferric addition is implemented (to be discussed in Section 5.5), an additional pump could be used to recycle sludge to the rapid mix and for better performance of flocculation and sedimentation; the piping is currently set up in the pump station to recycle sludge to the rapid mix basin. The existing pump suction piping in the building would be removed and replaced with new 4" suction piping, fittings, valves, and cleanouts. New 4" sludge blowdown piping would be installed from the sludge control building to the sludge hoppers in the bottom center of the primary and secondary basins. The new 4" sludge blowdown piping could be installed using jointless cured-in-place-piping (CIPP) inserted through the existing 8" ductile iron piping, with the 4" ends sealed inside the 8" pipe ends in the basins and the building. The existing 8" piping may need to be cleaned of any accumulated scale before the new 4" CIPP would be inserted. The existing pump discharge piping would be removed and replaced with new 4" discharge piping, fittings, valves, and cleanouts as indicated in Figure 5-3. The existing 3" flushing water line into the sludge control building would be extended to the pump suction to allow for flushing of the new piping system. The flushing water could be either flowed through the discharge piping to the lagoons or flowed backwards through the pump suction piping and sludge blowdown piping into the basins. Automatic operation of the sludge blowdown sequence would require the pump to run for a setpoint minutes' duration at a setpoint frequency throughout the day, with an automatic flushing water valve actuated to open for a setpoint minutes' duration following each sludge blowdown operation to flush the volume of the line to the lagoon with clean water. Flushing of the pump suction piping and sludge blowdown piping backwards into the basins would be done manually as a scheduled maintenance activity.

New 4" piping would be installed from each train's sludge control building to an interconnecting point in the yard, with one common 4" pipe continuing to the lagoons. New 4" piping, fittings, valves, and cleanouts would be installed at the lagoon to provide the multiple lagoon influents as existing. The yard piping improvements are indicated in Figure 5-4. The new 4" piping exiting each sludge control building could be installed using jointless cured-in-place-piping (CIPP) inserted through the existing 8" ductile iron piping to a fitting beyond the secondary basin as indicated in Figure 5-4. The existing 8" piping may need to be cleaned of any accumulated scale before the new 4" CIPP would be inserted. This would minimize excavation in close proximity to the existing structures, resulting in less risk of collateral damage and likely less cost. The 4" piping would be installed by direct bury excavation from those points on to the lagoon. The direct bury piping would be either HDPE or PVC jointless fusion welded pipe. The use of fittings would be minimized, with pipe deflection sweeps used instead of bends where possible. Cleanouts would be provided at ends of pipe runs and other intermediate points along the lines. Valves would be eccentric plug valves, which are suitable for high-solids applications and full-ported to facilitate any pipeline cleaning methods.

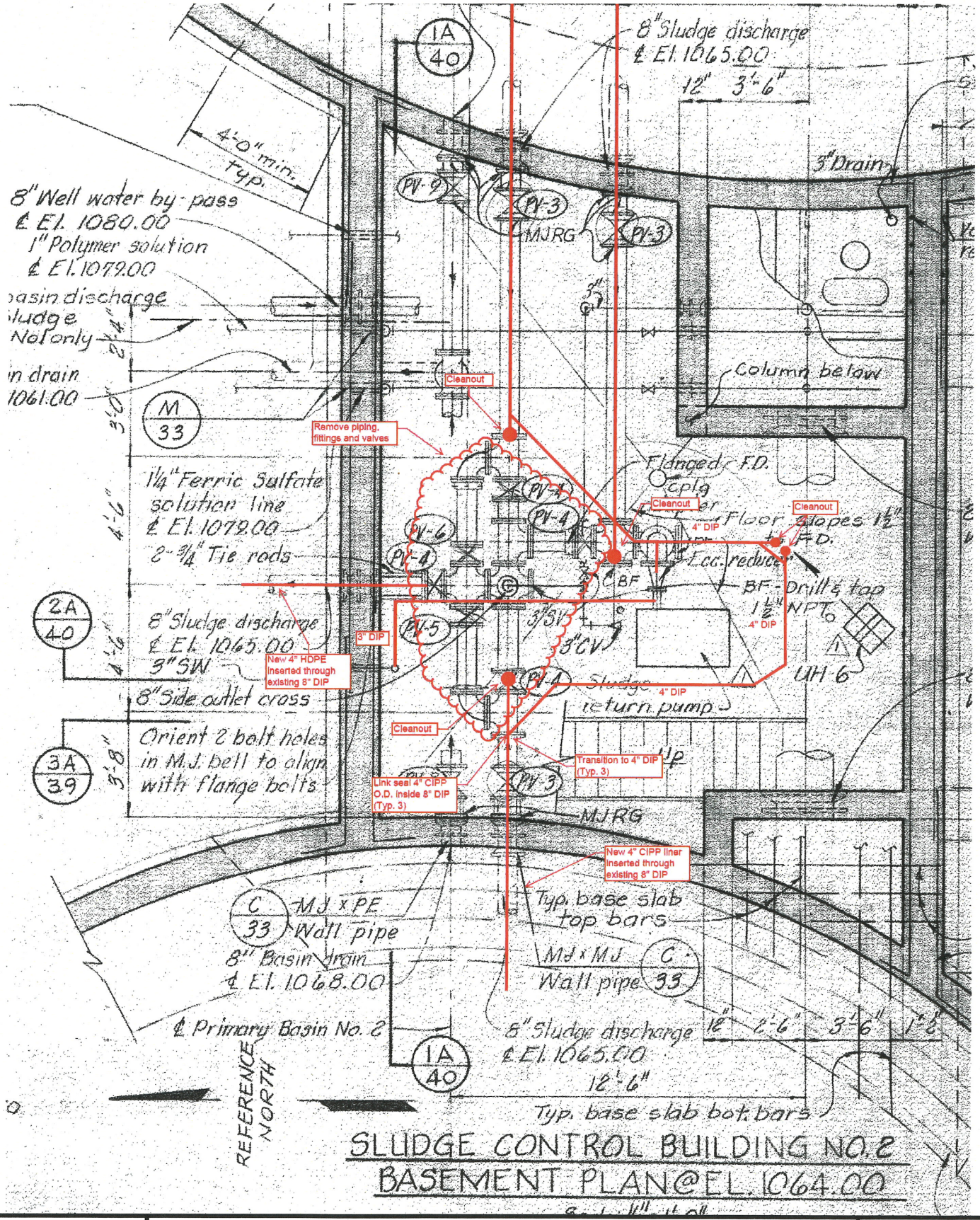

FIGURE 5.3
PROPOSED LAYOUT FOR SLUDGE CONTROL BUILDING IMPROVEMENTS

N

NOT TO SCALE

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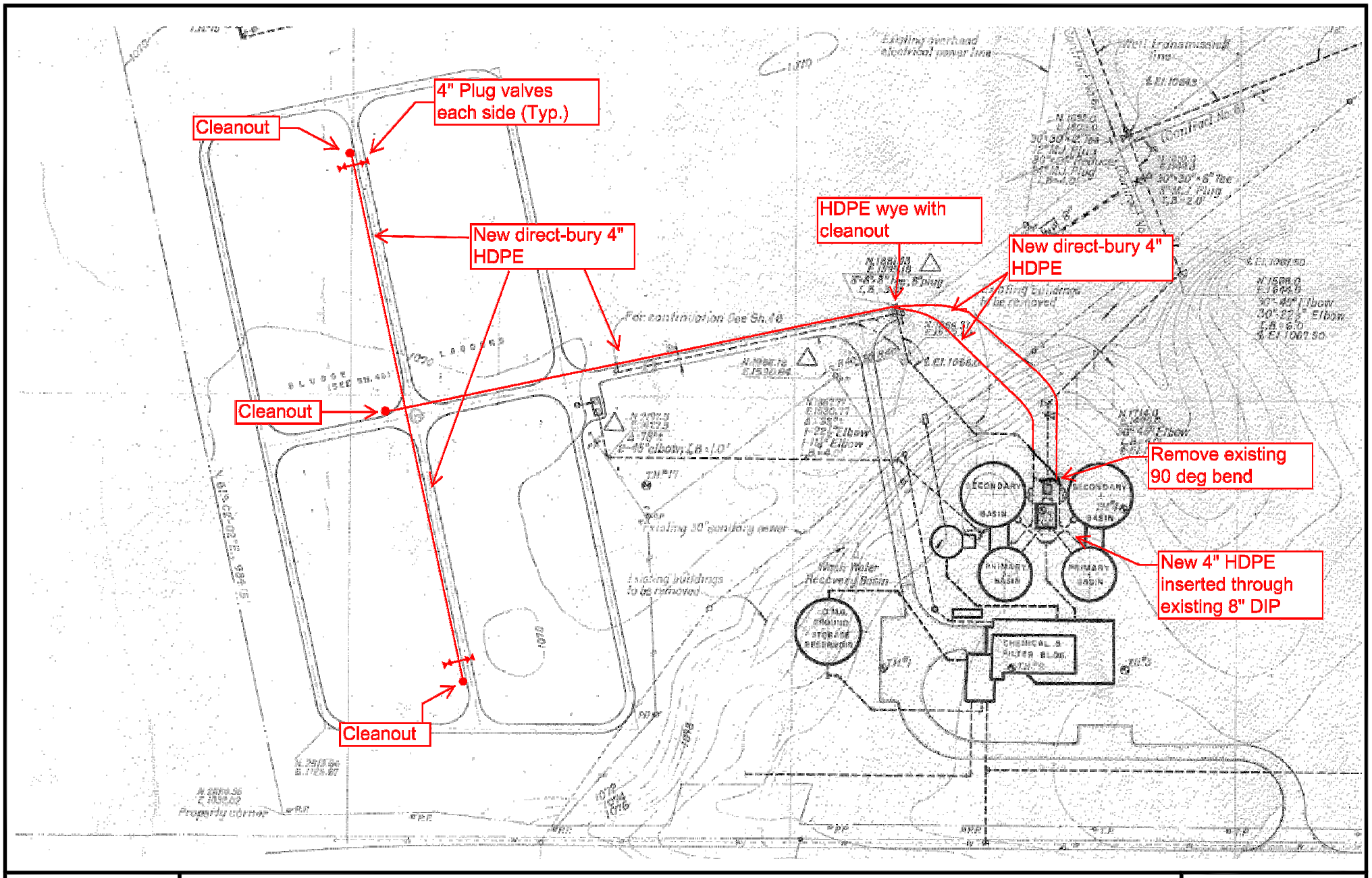


FIGURE 5.4
PROPOSED LAYOUT FOR
LIME SLUDGE DISCHARGE LINE

N

NOT TO SCALE

Construction of these improvements would require phasing to keep one basin train in service while the improvements are completed for the other basin train. Train 1 would remain in service while train 2 is taken out of service for construction. When the train 2 improvements are complete, train 2 would be put back in service and train 1 would be taken out of service for construction. Construction of each train's improvements must be scheduled to occur during the fall/winter/spring so that both trains are in service during the summer peak demand season.

In order to operate the softening basins with a sludge blanket for optimum harness removal and sludge withdrawal as described above, it will be necessary to replace the solids contact equipment inside the basin. The equipment is approaching 30 years old and the end of its useful life.

In addition to the above improvements, it is recommended that the practice of recycling the decant water from the lagoons back to the process be discontinued. Recycling this flow stream returns organics to the process and can cause taste and odor issues. It is recommended that this flow stream be discharged to sanitary sewer, or if possible, to the river. There is a 30" sanitary sewer on the plant site that the flow could be discharged to. Discharge of this flow stream to the river would require a permit from KDHE.

5.4.4 Recommendations

The following is a summary of the recommendations for the lime softening system:

- Install a carbon dioxide feed system including storage tank, feed panels, piping, and all related items
- Construct new lime sludge piping utilizing the existing lime sludge pumps to the existing lagoons with appropriate valves and cleanouts
- Replace the solids contact equipment in both softening basins
- Re-route lagoon decant water to the on-site sanitary sewer

Costs for these improvements are detailed in Appendix A. The phasing of these improvements will be discussed in Section 11.

5.5 COAGULATION

5.5.1 Current Practices and Need for Coagulant Feed

There is currently no coagulant being fed. Several years ago, granular ferric sulfate and liquid polymer were fed into the rapid mix box prior to the secondary basins; however, the equipment for both systems malfunctioned and has not been repaired or replaced. Additionally, plant staff report that the ferric sulfate feed lines are collapsed outside of the secondary basins.

The secondary basins are intended to be used for clarification, settling and removal of the lime softening floc particles that are carried over from the primary softening basins. Even with optimized operation of the primary softening basins for turbidity removal, it is likely that significant particulates will be carried over to

the secondary basins. Without the addition of a coagulant or polymer, very little settling and removal of these particulates will occur through the secondary basins. It is important to operate the secondary basins for good turbidity removal to reduce the particulate loading to the filters to ensure adequate filter run times and low filter effluent turbidity. Optimized plant performance with a secondary basin effluent turbidity goal of less than 3 NTU average and less than 5 NTU maximum is the current standard of practice. Based on three days of testing turbidities at the primary and secondary basins, the turbidity coming off these basins is highly variable and generally above the stated standard of practice. Therefore, the addition of a coagulant or polymer is necessary for this level of performance.

5.5.2 Coagulation Feed Options

Options for coagulant chemicals include alum (aluminum sulfate), ferric sulfate, and polymer. These chemicals are discussed further in Appendix B.

5.5.3 Recommendations

Jar testing is a method of evaluating different coagulants, polymers, and combinations of both to determine the optimum performance and/or cost among the options. A jar testing apparatus consists of a series of glass beakers with a stirring mechanism in each beaker. Water from the plant process to be tested, in this case the primary softening effluent/secondary influent, is collected and added to each jar. Varying dosages of a coagulant or polymer or combination are added to each beaker, rapidly mixed, slow mixed, and allowed to settle in a prescribed manner and sequence. Upon completion of settling, water samples are collected from the top of each jar and measured for turbidity, and the lower the turbidity the better the performance of the coagulant/polymer/combination. The optimum dose of each coagulant/polymer/combination can be determined and the cost of each calculated. In this way, a coagulant or polymer or combination of both can be selected for full-scale use in the plant.

Since this application involves lime softening and recarbonation with pH of 8.5 to 9.0, alum is not likely to perform well. However, ferric sulfate and many polymers will likely perform well. It is recommended that jar testing be performed using ferric sulfate, a variety of polymers, and combinations of both ferric sulfate and polymers. This jar testing should be performed before final coagulant and polymer storage and feed systems are designed and implemented. For this study, both ferric sulfate and polymer storage and feed systems will be evaluated and costs estimated.

<u>Ferric Sulfate Storage and Feed System</u>

An average ferric sulfate dose of about 20 mg/L is assumed, pending verification by jar testing. At the plant capacity of 10 MGD, a maximum of about 300 gallons per day or 12.5 gallons per hour would be required. An average day in a peak month at design capacity would be about 8 MGD. At an average day demand of 8 MGD, thirty days of storage would require about 6,000 gallons capacity. The 6,000 gallons of storage would allow for full tanker truckload delivery (4,000 gallons) of ferric sulfate, which would result in the lowest possible delivered cost per gallon of ferric sulfate.

A 6,000-gallon storage tank would be installed on the plant site in a location suitable for truck access for chemical delivery. The tank would be provided with dual-wall containment with interstitial leak detection and alarming, with transfer pumps located inside the building to deliver ferric sulfate to a day tank to be located on the second floor.

A 300-gallon day tank serving the chemical feed pumps would be located on the second floor of the building; Appendix A shows a potential layout of the day tank and feed pumps. The day tank would have either weight or level measurement capability to determine the amount of chemical used each day. The tank would have a sealed cover, vented to the outdoors. Spill containment would be provided around the day tank.

Three ferric sulfate chemical feed pumps of at least 6.25 gallons per hour capacity each would be provided: one each dedicated to each secondary basin and one spare for redundancy. The chemical feed piping from the pumps would be manifolded such that any pump could be directed to feed either secondary basin.

Piping for transfer of ferric sulfate from the bulk storage tank to the day tank, and two lines of chemical feed piping from the day tank and feed pumps to each secondary basin influent rapid mix chamber would be required. The bulk storage tank and transfer pumps, day tank and chemical feed pumps would require electrical service and integration with the plant control system.

The ferric sulfate storage and feed system would include the following:

- Liquid ferric sulfate storage tank (6,000 gallons capacity)
- Transfer pump station with two transfer pumps
- Day tank (300 gallons capacity)
- Containment around day tank and feed pumps
- Three chemical feed pumps (6.25 gallons per hour capacity each)
- Chemical transfer piping, fittings, valves
- Chemical feed piping, fittings, valves
- Electrical for storage tank, transfer pumps, day tank, and feed pumps
- Integration with plant control system

<u>Polymer Storage and Feed System</u>

An average polymer dose of about 1.0 mg/L is assumed, pending verification by jar testing. At the plant capacity of 10 MGD, a maximum of about 10 gallons per day or 0.4 gallons per hour would be required. An average day in a peak month at design capacity would be about 8 MGD. At an average day (of the peak month) demand of 8 MGD, thirty days of storage would require about 240 gallons capacity. One full pallet of five 55-gallon drums would provide 275 gallons or one tote tank would provide 275 gallons; either option would provide more than 30 days' storage. The pallet or tote storage area would be located in the existing chemical feed room.

A 10-gallon day tank serving the chemical feed pumps would be located in the existing chemical feed room. A transfer pump inserted in a drum or tote tank would be used to transfer polymer to the day tank. The day tank would have either weight or level measurement capability to determine the amount of chemical used each day. Spill containment would be provided around the day tank.

Three polymer chemical feed pumps of at least 0.2 gallons per hour capacity each would be provided: one each dedicated to each secondary basin and one spare for redundancy. The chemical feed piping from the pumps would be manifolded such that any pump could be directed to feed either secondary basin. Appendix A shows a potential layout of the chemical system.

Piping for transfer of polymer from the drum/tote to the day tank, and two lines of chemical feed piping from the day tank and feed pumps to each secondary basin influent rapid mix chamber would be required. The transfer pump, day tank and chemical feed pumps would require electrical service and integration with the plant control system.

The polymer storage and feed system would include the following:

- Floor area for one pallet storage of drums or tote tank
- Transfer pump
- Day tank (10 gallons capacity)
- Containment around day tank and feed pumps
- Three chemical feed pumps (0.2 gallons per hour capacity each)
- Chemical transfer piping, fittings, valves
- Chemical feed piping, fittings, valves
- Electrical for transfer pump, day tank, and feed pumps
- Integration with plant control system

In addition, it is recommended that the mechanism equipment in both secondary basins be replaced. They are approaching 30 years old and the end of their useful life.

The following is a summary of the recommendations for coagulation:

- Conduct jar testing to identify optimum coagulant and dosages
- Install a ferric feed system including storage, chemical pumping, piping, and all other related appurtenances
- Install a polymer feed system including storage, chemical pumping, piping, and all other related appurtenances.
- Replace the mechanisms in the secondary basins with solids contact equipment.

Costs for these improvements are detailed in Appendix A. Appendix C shows a potential layout of the chemical feed systems. These improvements will be phased in Section 11.

5.6 FILTRATION

Filtration is provided by four dual media filters. Each filter is 21'-0" square with approximately 4'-6" of media depth. The filter media was replaced in 2000; at that time the original surface wash system was removed and an air scour system was installed. Veolia Water staff report that they generally use two filters and rotate them. Filters are backwashed based on a loss of head gauge, but generally are backwashed approximately every three days. Sodium hexametaphosphate is fed upstream of the filters.

At the nominal plant capacity of 10 MGD, the filtration rate is 5.25 gpm/ft^2. This is above typical operating practices and the current KDHE standard of 4 gpm/ft^2 for gravity filters. At a filtration rate of 4 gpm/ft^2, the flow rate is limited to 7.6 MGD. Operating filters at a higher filtration rate can have the following outcomes that result from driving the floc deeper into the filter media:

- Turbidity breakthroughs may occur before the terminal head loss signaling backwash is needed occurs
- Reduced filter run times based on having to backwash more frequently

Presumably, the plant was originally approved and therefore rated at the stated filtration rate. Being a groundwater source, the plant is not required to monitor turbidity of the filter effluent; therefore, the plant operators would not know if turbidity breakthroughs are occurring. If the combined filter effluent is higher than 1 NTU it may begin to become an aesthetic water quality issue. The plant has not reached a maximum flow rate of 10 MGD, at least in the last 10 years. As the maximum day pumpage from the plant approaches 10 MGD, the issues stated above may start to gradually occur. It is recommended that combined and individual filter effluent turbidimeters be installed to monitor the effect the higher filtration rate has on filter effluent turbidity. As effluent turbidity increases and filter run times are reduced, it may be necessary to add filtration capacity in the future. For the purposes of this report, the installation of the turbidimeters will be assumed to be required from a capital cost perspective; additional filtration capacity will not be assumed to be required at this time, and would only be required if turbidity monitoring indicates a water quality issue or if filter run times are unacceptably reduced at increasing filtration rates approaching the 10 MGD capacity of the plant. Costs for installation of the turbidimeters are given in Appendix A.

Filtration of unstable, high pH water, similar to current operations at the plant, can cause encrustation of filter media due to deposition of calcium carbonate. Encrustation can be determined by collecting samples of the filter media and having a sieve analysis completed to determine the existing effective size and uniformity coefficient of the media versus what was originally supplied. The application of sodium hexametaphosphate ahead of the filters serves to prevent calcium carbonate deposition on the media; the addition of the air scour system should have also helped to keep the media clean. Therefore, the existing filter media is likely adequate until it is 20 years old, in 2020, or beyond. Upon implementation of the recarbonation project, the filters could be cleaned with an acid solution (sulfuric acid, citric acid, and glacial

acetic acid are examples). The cleaning process consists of backwashing, draining the filter to within 6 inches of the media, addition of acid over the entire surface of the filter bed, air-scour application, followed by backwashing.

Following backwash, water that is filtered to waste is stored in the recovery basin on the north side of the plant. The water is then pumped to the head of the lime softening process along with the decant water from the lime sludge lagoons. Based on conversations with Veolia Water staff, the recovery pumps are still in working order. The pumps are submersible and operate based mechanical floats with a readout bubbler system in the storage tank; occasionally, the controls fail to operate properly. At this time, replacement of the pumps is not necessary.

The following is a summary of the recommendations for filtration:

- Install turbidimeters for each filter effluent line
- Monitor effluent turbidities and backwash intervals in consideration of future filtration capacity
- Replace filter media at end of service life (2020)

Costs for these improvements are detailed in Appendix A. Phasing of installation of the turbidimeters is discussed in Section 11.

5.7 CHEMICAL SYSTEMS

Existing chemical systems not discussed above include lime, fluoride, and sodium hexametaphosphate. Chlorine will be discussed in the next section. The existing chemical systems do not have containment. Containment is typically required to hold 110% of the volume of a storage tank of liquid chemical. As a result of improvements to the chemical systems at the water treatment plant, all existing chemical systems should be upgraded to include containment. Containment can be by a modular unit, a double-walled storage tank, or by concrete curbing. Costs for installing containment for each existing chemical system are detailed in Appendix A. Phasing of these improvements is discussed in Section 11.

5.7.1 Lime

Lime is fed at the center of the primary softening basins to facilitate lime softening. The existing lime feed system consists of lime storage bins with pneumatic conveyance piping, and lime slakers to form lime slurry for feeding. Plant staff cannot adequately access the lime storage bin dust collector to change the filters and therefore have issues with dust generated during offloading. The access to the dust collector is only on one side. Additionally, the pneumatic conveyance piping has experienced numerous areas where cracking has occurred; holes have worn through the bends. The piping has been temporarily repaired for use, however, it is in need of replacement. It is recommended that additional walkway be installed, the filter media in the dust collector be replaced, and the pneumatic conveyance piping for the dry lime be replaced.

Costs for these improvements are detailed in Appendix A. Phasing of installation of the lime system improvements is discussed in Section 11.

5.7.2 Fluoride

Fluoride is currently fed upstream of the filters. The existing fluoride feed system consists of dry sodium silicofluoride stored in a feed hopper and a volumetric feeder. The volumetric feeder has become unreliable and overfeeds fluoride. The feeder is sized to provde 1 mg/L; however, plant staff have reduced the dosage to 0.3 to 0.4 mg/L. It is recommended that this feed system be replaced. A liquid fluoride such as fluosilicic acid could be fed with diaphragm metering pumps and totes/drums, although the liquid chemical will be more expensive than the existing dry chemical.

<u>Fluoride Storage and Feed System</u>

The fluoride storage and feed system would include the following:

- Floor area for one pallet storage of drums or tote tank
- Transfer pump
- Day tank (10 gallons capacity)
- Containment around day tank and feed pumps
- Two chemical feed pumps (0.3 gallons per hour capacity each)
- Chemical transfer piping, fittings, valves
- Chemical feed piping, fittings, valves
- Electrical for transfer pump, day tank, and feed pumps
- Integration with plant control system

Costs for these improvements are detailed in Appendix A. Phasing of installation of the fluoride feed system is discussed in Section 11.

5.7.3 Sodium Hexametaphosphate

Sodium hexametaphosphate is currently fed upstream of the filters to control calcium carbonate encrustation on the filter media. There are no known issues with this chemical system, and therefore no improvements to this chemical system are required.

6 DISINFECTION

6.1 CURRENT PRACTICES

Groundwater systems are not required to disinfect; however, if a system has a positive sample during its Total Coliform Rule monitoring, providing 4-log disinfection of viruses would preclude the City from extensive source water monitoring that can be required under the Groundwater Rule. Disinfection is currently implemented at the plant; however there are currently no compliance requirements that are necessary for the plant. Disinfection is currently achieved by the injection of chlorine solution into the process water at two locations: the rapid mix basins ahead of the secondary clarifiers and the filter influent. The target free chlorine residual leaving the plant is 1.7 mg/L. The chlorine feed system consists of the following:

- Chlorine Storage Room
    - Two ton cylinders mounted on a scale
    - Pipe manifold for gas withdrawal under pressure
    - Pressure reducing valve with pressure gage
    - Trunnions to hold two spare chlorine cylinders plus spare trunnions for the future
- Chlorine Feed Room
    - Two eductors/feeders
    - Distribution panel consisting of two rotameters for metering to each of the secondary basin rapid mix locations, one rotameter for metering to the filter influent, and one spare rotameter.

6.2 DISINFECTION BY-PRODUCTS

The City is currently required to comply with the Stage 1 Disinfection By-Product Rule (D/DBPR), which has established MCLs of TTHM and HAA5s as 80 ug/L and 60 ug/L, respectively. Under this rule, the City samples for TTHMs and HAA5s at one location in the distribution system, and compliance is based on a running annual average (RAA) of the results at that location. Under Stage 2 D/DBPR, for which the City began compliance on October 1, 2013, the City samples for TTHMs and HAA5s quarterly at four (4) additional sampling locations; based on Figure 6-1, the permanent Stage 2 sampling sites are the existing Stage 1 site (meaning the results at this site will be used for both Stage 1 and Stage 2 compliance) as well as Site No. 2 (located at the Municipal Building), Site No. 3 (located on East Chestnut) and Site No. 5 (located at Fire Station No. 2).

The sampling locations for both the Stage 1 D/DBPR and the Stage 2 D/DBPR are shown in Figure 6-1. The MCLs for the Stage 2 DBPR will not change; however, compliance under Stage 2 will be based on a RAA of the quarterly samples at each location, termed a locational running annual average (LRAA).

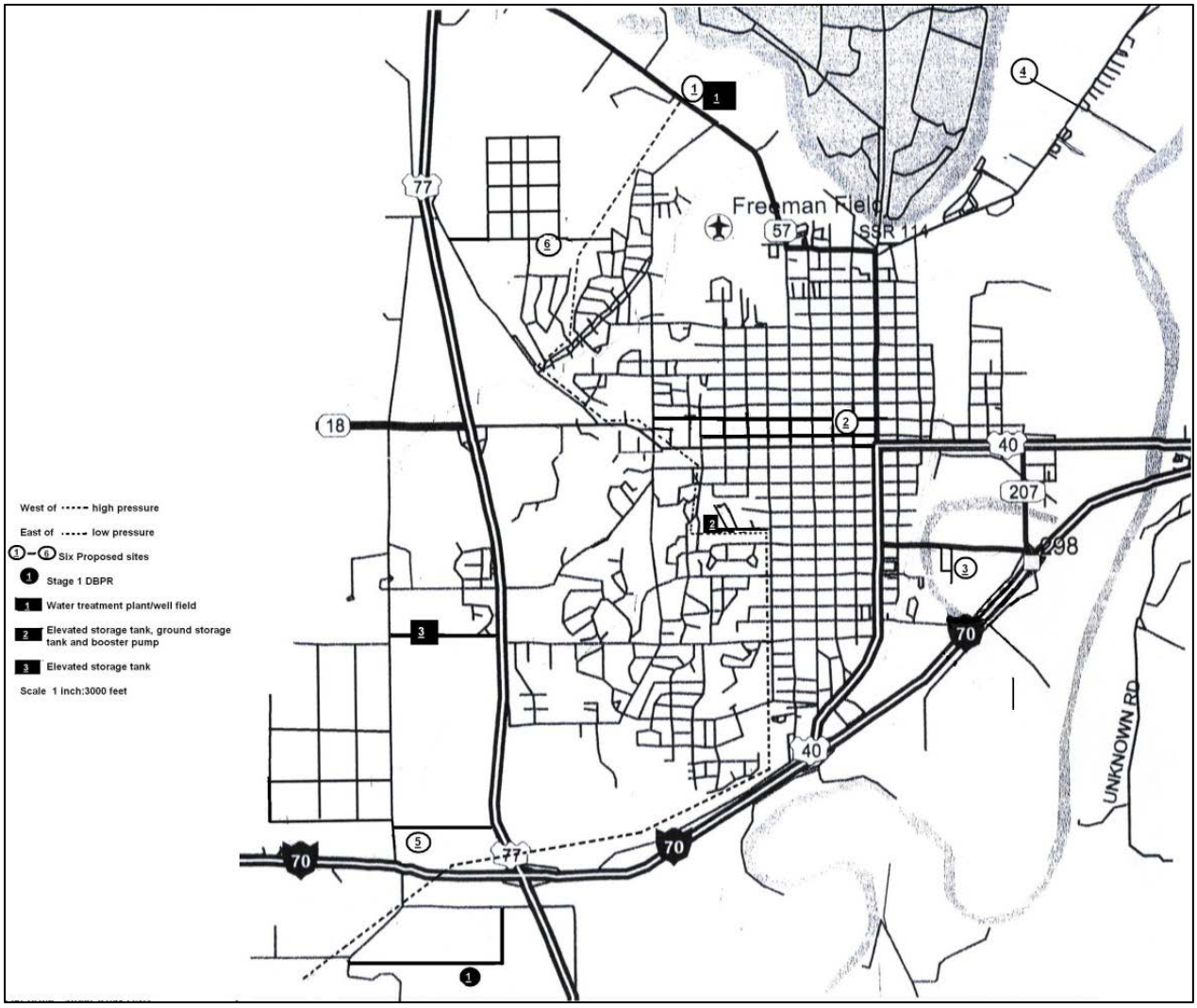


Figure 6-1: D/DBP Sampling Locations - Stage 1 and Stage 2 IDSE

Veolia Water provided sampling data of DBPs within the plant to evaluate the formation of DBPs prior to the discharge of finish water into the distribution system by testing for DBPs at five sample locations within the WTP. Disinfection by-product concentrations are expected to be increasingly higher further downstream and into the distribution system due to the extended reaction time. The analysis within the WTP will then be used to compare to the formation of DBPs in the distribution system.

6.2.1 Historical Disinfection By-Product Formation

Samples at the locations within the WTP were collected between July 25, 2013 and August 8, 2013 and analyzed for DBP development within the plant. The results of the analysis are provided in Table 6-1. The purpose of this analysis was to determine whether the majority of the DBPs are formed in the plant and to what extent formation continues in the distribution system. The results show that nearly half of the DBPs are formed within the plant prior to distribution. The other half are developed from extended contact time in the distribution system.

Table 6-1: DBP Sampling Data of WTP and Distribution System

Date	Primary Basin Effluent		Secondary Basin Effluent		Filter Effluent		Clear Well Effluent		Plant Tap		Distribution System[1]	
	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)
7/25/2013	ND	ND	6.1	18.2	19.5	6.4	23.8	9.7	34.8	11.8		
8/1/2013	ND	ND	9.1	6.2	10.3	6.3	16.6	9.3	27.7	12.1	64.0	11.0
8/8/2013	5.4	3.4	15.7	6.4	17.6	6.8	19.6	8.3	28.6	9.5		

ND = non-detectable

RAA = running annual average

Notes:

(1) Sample concentrations provided for the distribution system were reported in Quarter 2 of 2013.

As previously discussed, the City currently tests the water for TTHMs and HAA5s at one point in the water distribution system for compliance with the Stage 1 DBPR. Distribution system sample results for the Stage 1 D/DBPR between 2004 and present are provided in Table 6-2. Based on the historical data, the City has never been out of compliance with the Stage 1 D/DBPR.

Development of a plan to reduce DBPs is recommended when RAA exceed 80% of the MCL. In 2006/2007 and 2010/2011, there were extended periods of time where the RAA for TTHMs exceeded 80% of the MCL. The average sample concentrations were 60.4 µg/L for TTHMs and 16.0 µg/L for HAA5s; TTHMs were on average greater than 80% of regulatory limits for approximately 28.9% of the samples between 2004 and present.

Table 6-2: Distribution System RAAs for Compliance with Stage 1 DBPR

Year	Qtr	Total THM (ug/L)	Total HAA5 (ug/L)	Total THM RAA (ug/L)	Total HAA5 RAA (ug/L)
2004	1	66	15	66.0	15.0
2004	2	40	15	53.0	15.0
2004	3	63	12	56.3	14.0
2004	4	77	19	61.5	15.3
2005	1	35	14	53.8	15.0
2005	2	54	12	57.3	14.3
2005	3	65	21	57.8	16.5
2005	4	38	19	48.0	16.5
2006	1	55	18	53.0	17.5
2006	2	64	14	55.5	18.0
2006	3	91	23	62.0	18.5
2006	4	60	31	67.5	21.5
2007	1	57	20	68.0	22.0
2007	2	69	15	69.2	22.3
2007	3	60	19	61.5	21.3
2007	4	56	19	60.5	18.3
2008	1	58	13	60.8	16.5
2008	2	51	12	56.3	15.8
2008	3	61	15	56.5	14.8
2008	4	87	24	64.3	16.0
2009	1	36	12	58.8	15.8
2009	2	50	13	58.5	16.0
2009	3	73	18	61.5	16.8
2009	4	75	13	58.5	14.0
2010	1	57	14	63.8	14.5
2010	2	49	13	63.5	14.5
2010	3	88	22	67.3	15.5
2010	4	83	20	69.3	17.3
2011	1	49	12	67.3	16.8
2011	2	53	12	68.3	16.5
2011	3	55	8	60.0	13.0
2011	4	57	14	53.5	11.5
2012	1	56	15	55.3	12.3
2012	2	61	15	57.3	13.0
2012	3	61	9	58.8	13.3
2012	4	77	22	63.8	15.3
2013	1	44	13	60.8	14.8
2013	2	64	11	61.5	13.8

RAA = running annual average

Individual values in red denote samples above the MCL (not out of compliance for RAA).

RAA values in red denote samples above 80% of the MCL.

6.2.2 Future Regulations

Compliance with the Stage 2 D/DBPR will be required by the City beginning October 1, 2013. The Stage 2 D/DBPR will be based on locational running annual averages (LRAA) rather than system-wide averages, using the same MCLs as the Stage 1 DBPR (80 µg/L for TTHMs and 60 µg/L for HAA5s). This means that the results from DBP sampling will no longer be averaged across the entire distribution system. Instead, the results of sampling will be averaged each quarter individually at each sampling site, and the running annual average of the results at each location must meet the MCLs.

The Stage 2 DBPR contains a requirement for every utility (regardless of water source) to complete an Initial Distribution System Evaluation (IDSE). The purpose of the IDSE is to locate new sampling points for DBP sampling in the distribution system. The City will be required to sample at four (4) sites. The City completed four (4) quarters of monitoring at six locations proposed under the IDSE in 2008 and 2009. The results of this sampling are provided in Table 6-3. The results show that the City experiences an overall trend with higher TTHM concentrations during the spring and summer at the six sampling points. The data collected shows that the City would have been close to a violation at one sampling location, SMP#5, if the Stage 2 D/DBPR had been in effect. Review of the individual sample data shows high TTHMs. SMP #5 is located furthest away from the plant.

Table 6-3: IDSE Standard Sampling DBP Data

Date	SMP#1		SMP#2		SMP#3		SMP#4		SMP#5		SMP#6	
	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)	TTHM (ug/L)	HAA5 (ug/L)
10/15/2008	19.7	9.6	56.2	11.6	66.0	12.8	41.3	7.7	84.7	15.5	36.4	7.6
1/13/2009	18.3	4.9	44.8	7.3	37.8	7.2	27.0	6.5	61.0	10.0	34.8	8.8
4/15/2009	12.5	8.2	50.5	9.9	50.2	9.2	47.3	9.2	67.8	11.8	40.6	7.9
7/8/2009	22.9	8.4	62.9	9.2	53.9	9.6	45.3	8.8	94.0	16.0	33.5	7.6
LRAA	18.4	7.8	53.6	9.5	52.0	9.7	40.2	8.1	76.9	13.3	36.3	8.0

LRAA = locational running annual average

6.3 OPTIONS FOR CONTROL OF DISINFECTION BY-PRODUCTS

6.3.1 Chloramination

One of the least expensive options for reduction of disinfection by-product formation is conversion of secondary disinfection from free chlorine to chloramines. Chloramines are formed by the reaction of ammonia with aqueous chlorine. Monochloramine is the preferred chloramines species for use in disinfection of drinking water as other species can cause taste and odor problems. The following are advantages of using chloramines for secondary disinfection:

- Chloramines are not as reactive with NOM in forming DBPs as free chlorine is and therefore retard the formation of disinfection by-products.
- The residual is more stable and longer lasting than free chlorine, providing better protection against bacterial regrowth in the distribution system.
- Inexpensive and easy to make

6.3.1.1 Chlorine Contact Requirements

The City has a history of positive coliform samples under Total Coliform Rule monitoring. The Groundwater Rule provides the opportunity for 4-log virus inactivation to avoid targeted source water monitoring when upon a positive source coliform sample. Based on the City's history of positive coliform tests, it would be in the best interest to provide 4-log virus inactivation in lie of doing targeted source water monitoring to comply with the Groundwater Rule if additional positive coliform samples are detected. There are two options for providing 4-log inactivation of viruses: 1) provide the full 4-log inactivation through disinfection only; or 2) obtain 2-log credit for conventional treatment and filtration and provide the additional 2-log inactivation through disinfection. The second option would require extensive instrumentation to monitor for individual filter effluent turbidity and combined filter effluent turbidity, and compliance with portions of the Long-Term 2 Enhanced Surface Water Treatment Rule. Since full 4-log inactivation can be easily provided with free chlorine contact through the existing piping and clearwells, this option is recommended.

Obtaining adequate concentration and contact time (CT) to meet EPA's Surface Water Treatment Rule is more difficult with chloramines as the contact time requirements are substantially longer than that of free chlorine. Therefore, it is recommended that free chlorine continue to be used as the primary disinfectant and ammonia be added for secondary disinfection after CT is achieved with free chlorine. The CT requirement of 5.6 mg/L*min was chosen based on the following:

- Chlorine residual 3.0 mg/L
- pH of 8.5 – 9 (per Section 5.4.3).
- Minimum temperature of 11 deg C (based on review of the last 3 years of raw water data)

A total CT of greater than 5.6 mg/L*min can be provided though the sub-filter clearwells and transfer pump discharge piping to a recommended ammonia application point downstream of the transfer pumps. Therefore, adequate CT can be provided to keep the ammonia feed location inside the building, avoiding installation of exterior buried piping and chemical feed manhole.

6.3.1.2 Ammonia Chemical Options

At water treatment facilities, ammonia is normally purchased in one of the following three forms:

- Anhydrous ammonia (Gas) (NH_3)
- Aqueous ammonia (NH_4OH)
- Liquid ammonium sulfate $(NH_4)_2SO_4$

The above chemicals are described further in Appendix B. The ammonia dosage is based on the concentration of chloramine residual desired in the distribution system. Theoretically, one mole of ammonia reacts with one mole of chlorine to form one mole of monochloramine. Restated, one milligram per liter of ammonia reacts with approximately four milligrams per liter free chlorine to get an equivalent amount of monochloramine. However, this ratio can vary at each plant and should be established at the time of use. The minimum chloramine residual recommended at the entrance to the distribution system is 3 mg/L and the maximum allowable chloramine residual entering the distribution system is 4 mg/L. It is estimated that ammonia dosages of 0.5 mg/L to 1 mg/L are needed.

6.3.2 Other DBP Control Options

The City maintains compliance with Stage 1 D/DBPR based on the data presented in Section 5.2.1. The Stage 2 D/DBPR IDSE data provided in Table 4-4 of Section 5.2.2 indicates compliance is most difficult to achieve at Sample Point #5 (SMP#5) based on TTHM concentrations. This sample point is located in the high pressure zone at the Fire Station No. 2 near Lacy Drive and Spring Valley Road. The Stage 2 D/DBPR samples at this site were collected in 2008 and 2009, at which time SMP#5 was located on the end of an 8-inch water main. Improvements have since been made to the City distribution system and expanded service beyond SMP#5; these improvements include the construction of a 12-inch water main on Spring Valley Road, from Lacy Drive north to Ash Street, which eliminated the dead end at SMP #5. In the current improved distribution system, SMP#5 is located on a complete service loop. This type of improvement subsequent to the Stage 2 D/DBPR IDSE sampling may have the effect of decreasing DBP concentrations at SMP #5. It is recommended that additional sampling be conducted at SMP #5 to evaluate whether there has been a reduction in DBP concentration as a result of the water distribution system improvements.

6.3.3 Recommendations

It is recommended to continue monitoring for TTHMs and HAA5s according to the requirements of the Stage 2 D/DBPR to determine the level of compliance. If compliance can be maintained using free chlorine as the primary and residual disinfectant, then no further improvements may be necessary under the current regulatory framework. Additional operational changes in the water treatment process may further reduce DBPs. Discontinuing chlorine application to the secondary basin influent and applying chlorine only to the filter influent would eliminate the fraction of DBPs formed through the secondary basins. Raising the pH to 11.0 in the primary softening basins would remove some of the magnesium hardness, and the magnesium hydroxide precipitate that is formed should remove a fraction of the NOM DBP precursors by adsorption. This would also provide the benefit of lower total hardness of the finished water. If compliance cannot be

maintained at all times even with these enhancements, then it is recommended to proceed with implementation of chloramination improvements using liquid ammonium sulfate, as described below.

Ammonia Sulfate Storage and Feed System

An average residual chlorine of 3.0 mg/L is assumed, with a Chlorine to Ammonia-Nitrogen mass ratio equal to four (4). At the plant capacity of 10 MGD, a maximum feed rate of approximately 63 gallons per day or 2.6 gallons per hour of ammonia sulfate would be required. At an average day demand (of the peak month) of 8 MGD, thirty days of storage would require approximately 1500 gallons capacity. A total of six (6) 275-gallon tote tanks would provide 1650 gallons of ammonia sulfate, adequate for 30 days' storage. The tote storage area would be located in the existing chemical feed room.

A 70-gallon day tank serving the chemical feed pumps would be located in the existing chemical feed room. A transfer pump inserted in a tote tank would be used to transfer ammonium sulfate to the day tank. The day tank would have either weight or level measurement capability to determine the amount of chemical used each day. Spill containment would be provided around the day tank. Appendix C shows a potential layout of the chemical feed system.

Two (2) ammonium sulfate chemical feed pumps operating with a range of 0.4 to 3.0 gallons per hour capacity each would be provided: one duty pump and one spare for redundancy. Piping for transfer of aluminum sulfate from the tote to the day tank, and lines of chemical feed piping from the day tank and feed pumps to an injector located on the 24-inch diameter transfer pump discharge pipe would be required. The transfer pump, day tank and chemical feed pumps would require electrical service and integration with the plant control system.

The ammonium sulfate storage and feed system would include the following:

- Floor area for six (6) tote tanks
- Transfer pump
- Day tank (70 gallons capacity)
- Containment around day tank and feed pumps
- Two chemical feed pumps (3.0 gallons per hour capacity each)
- Chemical transfer piping, fittings, valves
- Chemical feed piping, fittings, valves
- Electrical for transfer pump, day tank, and feed pumps
- Integration with plant control system.

The following is a summary of recommendations:

- Evaluate Stage 2 DBP sample data obtained near Fire Station No. 2 to assess whether DBP levels have decreased since the IDSE sampling
- Install a liquid ammonium sulfate feed system with storage, chemical feed pumps, piping, and all other related appurtenances

Costs for the ammonium sulfate feed system are detailed in Appendix A. Phasing of these improvements will be discussed in Section 11.

6.4 CHLORINE FEED SYSTEM

6.4.1 Improvements to Existing System

There are concerns with the safety of the existing chlorine feed system. The concerns are as follows:

- OSHA cited concern regarding the chlorine gas piping, which is Schedule 80 steel, and possible leakage. Veolia Water had a 3rd party inspection of the piping completed in May 2013. The testing concluded that the piping was adequate and did not need to be tested for another 5 to 8 years.
- Currently, if a leak were to occur, there is not a means to close the valves on the ton cylinders remotely. In other words, a Veolia Water staff member would have to enter the room to close the valve.
- Of the two cylinders that reside on the scale, when one is empty, Veolia staff manually switch the system over to the full cylinder. This increases the amount of time staff spend in the room, increasing the potential for exposure to a chlorine leak, and also interrupts chlorine supply to the feed points while the cylinders are being switched.

In order to improve the safety of the chlorine feed system, it is recommended that the existing pressure feed system be converted to a vacuum feed system. With the existing pressure system, if there is a leak in the pressure piping from the ton cylinder to the feeder, chlorine gas will leak out until the ton cylinder nearly empties and the pressure inside the cylinder is the same as atmospheric pressure; this corresponds to a large chlorine gas release. With a vacuum system, if there is a leak in the vacuum piping, the pressure goes to atmospheric pressure right away and the gas withdrawal from the ton cylinder stops; the only gas released is the small amount of gas contained within the vacuum piping. The conversion would be accomplished by installing a vacuum regulator on the cylinder outlet and replacing the existing pipe (both the tubing and the steel pipe) to the feeders with black polyethylene pipe for vacuum service.

Additionally, the installation of an automatic valve actuator is recommended to provide an additional level of safety to the chlorine gas feed system. The Uniform Fire Code (UFC) requires automatic shutoff valves, scrubbers, or other safety measures to protect firemen and other responders to a plant emergency. The City has adopted the 1997 version of the UFC; however, regardless of whether a municipality has adopted the UFC, any water utility using ton cylinder gas chlorine should have one of the above gas safety features. The 2006 version of the UFC allowed automatic shutoff valves to be considered as equivalent safety

protection to scrubbers, and they are much less costly in capital and O&M. An actuator would attach to the existing outlet valve on each cylinder. One controller would be needed for both actuators and would be mounted on the wall next to the door to the room along with a remote kill button for manual override of the controller to close the valves. The controller would be connected to the existing gas detector, which is relatively new, and upon alarm by the gas detector signaling a chlorine leak, send a signal to the actuators to close the valves. The vacuum regulator described above would then be mounted to the actuator.

In order to reduce the amount of time workers have to spend in the chlorine storage room, thereby reducing the potential exposure of workers to chlorine gas, it is recommended that an automatic switchover device be installed. The controller contains switches that detect when the cylinder is running low in order to automatically switch the supply to the full cylinder.

6.4.2 Alternative Sodium Hypochlorite Feed System

An additional option to improve the safety of the chlorine feed system would be to replace the entire gas feed system with a sodium hypochlorite feed system. Sodium hypochlorite has become increasingly employed in water treatment systems as the primary means of disinfection. Risk management is reported to be the number one driver of converting reliable gas chlorine systems to generally more expensive to operate and maintain "liquid bleach" systems. Sodium hypochlorite is commercially available in a liquid form as a 12.5% to 15% available chlorine solution. Alternatively, dilute hypochlorite solutions can be electrochemically generated on-site from a salt brine solution.

Advantages

- Chlorine scrubbing or gas containment systems required for chlorine gas are not required with sodium hypochlorite.
- Sodium hypochlorite is safer and easier to use than chlorine gas.
- Equipment for liquid sodium hypochlorite systems is inexpensive as compared with other disinfectants.
- Overall, life-cycle costs of on-site generation is generally less expensive than bulk sodium hypochlorite or chlorine gas.

Disadvantages

- Higher concentrations of sodium hypochlorite are unstable to some degree and degrades over time and with exposure to light and elevated temperatures. Therefore, it must be stored away from heat and sunlight.
- Liquid sodium hypochlorite is more expensive to purchase in bulk than chlorine gas.
- Off gassing requires careful layout of suction and discharge lines to the metering pumps.
- Additional storage and equipment required to maintain system reliability.

<u>On-Site Generation</u>

Generating sodium hypochlorite on-site is a relatively simple process using salt, water and electricity. Salt (NaCl) is first dissolved to create a saturated brine solution, which is diluted with water to form a 32% brine

solution. Diluted brine solution, which is a good conductor of electricity, is then electrolyzed to produce chlorine gas at the positive electrode (anode) and sodium hydroxide and hydrogen at the negative electrode (cathode). The chlorine gas further reacts with sodium hydroxide to form a 0.8% strength hypochlorite solution.

This process generates small quantities of hydrogen gas as a by-product. As a result, forced ventilation of the reaction vessel and storage tank to evacuate the gas will be necessary. The on-site generation of hypochlorite requires very pure salt (99.7%) to protect the electrodes from contamination. To produce one pound of chlorine equivalent, typically 3.5 pounds of salt, 15 gallons of water, and 2.5 kWh of electricity are required. Salt is typically delivered in 50-pound bags, 2,500 pound "super-sacks" or via tankers. With a finished product of 0.8% sodium hypochlorite, degradation of the solution is not an issue unlike the 15% solution strength.

Bulk Storage

As indicated previously, sodium hypochlorite is available in bulk at strengths between 12.5% to 15% available chlorine. The oxidizing nature of this substance means it should be handled with extreme care. Contact with acids will rapidly liberate chlorine gas and, as already stated, it will react with many chemicals such as iron, copper and nickel on contact. Following are some of the important items that need to be addressed to store sodium hypochlorite in bulk.

- Higher strength solutions will degrade the fastest. The solution strength should be matched to the application.
- Storage at higher temperatures results in faster degradation. Generally the ambient temperature should not exceed 86º F and during summer months it is recommended that storage is limited to one month maximum as it begins to degrade in 14 days.
- Its high reactivity does reduce its stability and storage of bulk solutions has to be handled carefully as a reduction in available chorine will mean a greater volume of solution (higher dosage) has to be used to ensure satisfactory disinfection.

6.4.3 Recommendations

It is recommended that the City proceed with conversion of the pressure feed system to a vacuum feed system, installation of automatic closing actuators, and installation of an automatic switchover. These improvements will considerably improve the safety of the existing chlorine gas feed system for a relatively low cost. While a sodium hypochlorite system would be a safer alternative, there is still service life within the existing chlorine gas system and chlorine gas is typically lower cost over the life-cycle of the equipment. When the existing chlorine feeders are nearing the end of their service life, the City could consider sodium hypochlorite at that time.

6.4.3.1 Immediate Needs

The following is a summary of the recommended improvements that are considered immediate needs related to the chlorine feed system:

- Convert pressure feed system to a vacuum feed system
- Install automatic closing actuators
- Install automatic switchover

Costs for these improvements are detailed in Appendix A.

6.4.3.2 Phased Needs

There are no phased improvements associated with the chlorine feed system.

7 STORAGE AND PUMPING

7.1 EXISTING FACILITIES

Filtered water from Filters No. 1 and 3 flows to the west clearwell and water from Filters No. 2 and 4 flows to the east clearwell. Both clearwells are located under their respective filters. The total clearwell volume is approximately 227,000 gallons; there is a 30" pipe between the two clearwells, with an isolation valve, that allows the west clearwell to flow to the east clearwell. Three vertical turbine transfer pumps, each rated for 3,500 gpm at 46 feet of head, are located above the east clearwell and pump to the above-grade clearwell on the site. The firm capacity of the transfer pumping is 7,000 gpm, or 10 MGD. The on-site clearwell is welded steel and is 74 feet in diameter.

Water is pumped to the water distribution system by the High and Low Service Pump Stations that are located inside the water treatment plant building. Both pump stations draw from the same 24-inch suction header from the 1 million gallon above-ground clearwell. There is a bypass line that allows the transfer pumps to pump directly to the high and low service suction header. The low service pumps deliver water through a 20-inch transmission main directly into the low pressure zone, which comprises the east and southern parts of the city. The high service pumps feed the high pressure zone through a separate 20-inch transmission main that extends from the plant to the west side of the city.

There are three low service pumps each rated for 2,200 gpm. Currently, one of the pumps is out of service. Similarly, there are three high service pumps, each rated for 1,800 gpm. All pumps are constant speed horizontal split case pumps. Table 7-1 presents the total distributive pumping capacity at the water treatment plant.

Table 7-1: Distributive Pumping Capacity

Description	Quantity	Rating		Horsepower (hp)	Total Capacity (gpm)	Firm Capacity (gpm)	Firm Capacity (MGD)
		Flow (gpm)	Head (ft)				
Low Service Pumps	3	2,200	185	150	6,600	4,400	6.34
High Service Pumps	3	1,800	350	250	5,400	3,600	5.18
Total					12,000	8,000	11.52

7.2 PUMPING EVALUATION

7.2.1 Transfer Pumping

Based on conversations with Veolia Water staff, the transfer pumps are in good working order, except for the controls of pump #2 are currently being worked on. The pumps operate off of a bubbler system that indicates level in the post-filter clearwells. At this time, replacement of the pumps is not necessary; however they should be replaced at the end of their service life (estimated to be 2020). It is proposed to add a sonar level transmitter as backup to the bubbler system to add reliability to the operation.

7.2.2 Low and High Service Pumping

As discussed previously, the low service pumps have never been replaced and one pump is currently out of service. The high service pumps have been replaced once since the plant was built and there are no known issues with them.

The low and high service pumps appear to have adequate capacity to meet the projected maximum day demand in 2045 of 10 MGD. The 2007 Water Master Plan indicated that the high and low service pumps are required to deliver more flow and pressure to both pressure zones for the years 2011, 2016, and 2026. The Master Plan indicated that additional pressure is required to overcome system head loss that prevents the ground and elevated storage from replenishing during minimum hour demands. The design conditions at that time were as follows, which are dependent upon the improvements made within the distribution system which were recommended as part of the Master Plan:

- Low service pumps: 2,300 gpm at 210 feet of head
- High service pumps: 2,300 gpm at 380 feet of head
- Total firm capacity: 13.25 MGD

The Master Plan indicates the total water pumped in excess of the 10 MGD maximum demand projected for this study; the Master Plan also projected population and water demands higher than this study. At this time, the design conditions of the pumps cannot be verified; the hydraulic model must be updated and calibrated for current and project demands based upon this study as well as any water distribution system improvements that have been completed since the model was originally calibrated. The flow rate may not need to increase to the values stated in the Master Plan; however, the pressures delivered by the pumps are likely needed to be greater than the existing pumps are capable of due to probable deposition of calcium carbonate (due to lack of recarbonation) and associated decreased hydraulic capacities in the water distribution system as indicated in the Master Plan, particularly in the low service zone.

For the purposes of this study, it will be assumed that new pumps will be required at the above design conditions. Space for larger pumps and motors will be a concern within the existing pump station; the suction and discharge piping of each pump does not lend itself to much flexibility in pump size. However, there is space for an additional low service pump and an additional high service pump; therefore, four

pumps of a smaller capacity for each low and high service could be provided to meet the total firm capacity of approximately 10 MGD if space is a concern during final design.

Veolia Water staff report that the water transmission mains leaving the plant have had a high occurrence of main breaks; this indicates there may be a water hammer issue with the pumps turning off. Most of the breaks are occurring on the high pressure zone side at the following known locations:

- In the high pressure zone along Spring Valley Road south of Rucker Drive (this location is approximately 5,000 feet north of where the high service transmission line ties into the high pressure zone, near the periphery of the system)
- In the high pressure zone along Rucker Drive south of Westwood Boulevard (this is essentially the location where the high service transmission line ties into the high service pressure zone)

The locations of the main breaks indicate that when the pumps stop, a pressure surge is occurring in the high service transmission line. The pressure wave propagates along the long length of the line (approximately 10,000 feet); the whole water transmission main and likely much of the lines in the high pressure zone are subject to collapsing pressures. Each pump discharge line has a pneumatic cylinder-operated butterfly valve that are set for 5 minute open and close times.

The options for reducing water hammer in the transmission main are as follows:

- Install a surge suppressor valve. This type of valve senses the pressure surge and first opens to dissipate the surge, then slowly closes to minimize surge. This valve could be installed on the pump discharge header in the room below the pump room.
- Install a slow-closing ball valve on the pump discharge. A ball valve with an operator that can adjust the opening and closing speeds can act as a slow-closing check valve for the pump. There does not appear to be space to install these valves on the pump discharge; therefore this option is eliminated.
- Install “soft” motor starters for the existing pumps. Soft starts would be beneficial to slow the start and stop of the pump speed by reducing the inrush of current that occurs when a pump starts or shuts down. Soft starts gradually increase the voltage to the motor upon startup; they also perform the same function when stopping the equipment as they gradually decrease the voltage supplied, which reduces the surge potential.
- Install VFDs for the existing pumps. VFDs vary the speed of the motor upon startup and stopping by changing the output frequency. By regulating the speed of the motor, they can also better match pump demand with system demand. VFDs commonly require a filter to reduce the harmonics generated. Additionally, they will require air conditioning of the pump room as heat reduces the life of the VFD equipment.

It is recommended that soft starts be installed for each low and high service pump to reduce the potential for water hammer. Soft starts have the benefit of reducing water hammer and do not require air conditioning to operate. Additionally, it is recommended to install surge suppressor valves on the high

service pump discharge at a minimum; installation of the valves on both the high and low discharge lines would be preferable.

One issue that will need to be addressed concurrently with the pump replacement is replacement of the existing 2400V motor control line-up. The existing 2400V motor control line-up is fed from transformer T-1; it feeds the three high service pumps and the three low service pumps. It is approximately 30 years old and does not operate reliably. Veolia Water staff report that the disconnect switch for one of the pump motor starters does not operate; it is indicated to be off, however the pump is still capable of running. When the pumps are replaced, the motor control line-up should also be replaced. Upon replacement, it is recommended that the motor control line-up be replaced at 480V, which is low voltage compared to the existing medium voltage 2400V motor control lineup. Replacement at 480V will result in reduced capital costs of the motor control line-up, pumps, and soft starters; Table 7-2 outlines the costs for replacement at 480V versus 2400V. Additionally, the main incoming switchgear to the plant could be changed out to 480V, reducing the cost of replacing this equipment, as well as eliminating the need for the transformers T-1 and T-2.

Table 7-2: Comparison of Pump Station Costs at 480V versus 2400V

Option 1: High and Low Service Pump Station Upgrades - Replace at 480V				
Low Service Pumps	3	EA	$40,000	$120,000
High Service Pumps	3	EA	$60,000	$180,000
Motor Control Lineup (480V) / Soft Starters	6	EA	$10,000	$60,000
480V Switchgear	1	LS	$125,000	$125,000
Installation (25% of System)	1	LS	$121,000	$121,000
Piping Allowance (20%)	1	LS	$60,000	$60,000
Electrical & Instrumentation (20% of System)	1	LS	$97,000	$97,000
Construction Total				$763,000
Option 2: High and Low Service Pump Station Upgrades - Replace at 2400V				
Low Service Pumps	3	EA	$50,000	$150,000
High Service Pumps	3	EA	$70,000	$210,000
Motor Control Lineup (2400V) / Soft Starters	6	EA	$45,000	$270,000
15KV Switchgear	1	LS	$250,000	$250,000
Installation (25% of System)	1	LS	$220,000	$220,000
Piping Allowance (20%)	1	LS	$60,000	$60,000
Electrical & Instrumentation (20% of System)	1	LS	$176,000	$176,000
2400v Transformer Refurbishment	2	LS	$25,000	$50,000
Construction Total				$1,386,000

7.2.3 Recommendations

The following are the recommendations for the high and low service pump station:

- Replace the switchgear at 480v
- Replace the motor control line-up with soft start motors at 480v
- Replace the high and low service pumps at 480v
- Install surge protection valves (costs included with replacement of the high and low service flow meters)

Phasing of these improvements is discussed in Section 11.

7.3 STORAGE EVALUATION

7.3.1 Storage Capacity

In addition to the 1 million gallon clearwell at the water treatment plant, there is also water tank storage in the water distribution system. The total storage available to the City is 3.7 million gallons. Table 7-3 presents the amount of storage within the water distribution system.

Table 7-3: Water Distribution System Storage Capacity

Tank Name	Pressure Zone	Type	Nominal Volume (MG)
WTP Clearwell [1]	Both	Ground	1.0
Spruce Street North Reservoir	Low	Below-Grade	0.6
Spruce Street South Reservoir	Low	Below-Grade	0.6
Spruce Street Elevated	Low	Elevated	0.5
Ash Street Elevated	High	Elevated	1.0
Total - Low Service [2]			2.25
Total - High Service [3]			1.45
Total Storage Capacity			3.7

Notes:
[1] Assumes back-up power will be installed at the plant so that the WTP clearwell can be counted as storage.
[2] Includes 55% of the clearwell volume based on ratio of low service pumping to total pumping out of clearwell.
[2] Includes 45% of the clearwell volume based on ratio of high service pumping to total pumping out of the clearwell.

Typical practice in highly residential communities is to provide 22 percent of the maximum day demand. Additionally, storage for emergency events such as fires must be provided; typically 3,500 gpm is provided for commercial areas for a minimum of 3 hours.

Based on the current maximum demand of 8.3 MGD, the following storage analysis was completed:

Low Service Pressure Zone

- Low service storage required to meet 22% of maximum day demand (55% of total maximum day demand: 1.00 MG
- Low service fire storage required to meet 3,500 gpm for 3 hours: 0.63 MG
- Total storage required in the low service pressure zone: 1.63 MG

High Service Pressure Zone

- High service storage required to meet 22% of maximum day demand (45% of total maximum day demand): 0.82 MG
- High service fire storage required to meet 3,500 gpm for 3 hours: 0.63 MG
- Total storage required in the high service pressure zone: 1.45 MG

This analysis indicates that both pressure zones currently have enough storage to meet distribution system storage requirements.

Based on the 2045 maximum demand of 10.0 MGD, the following storage analysis was completed:

Low Service Pressure Zone

- Low service storage required to meet 22% of maximum day demand (55% of total maximum day demand: 1.21 MG
- Low service fire storage required to meet 3,500 gpm for 3 hours: 0.63 MG
- Total storage required in the low service pressure zone: 1.84 MG

High Service Pressure Zone

- High service storage required to meet 22% of maximum day demand (45% of total maximum day demand): 1.00 MG
- High service fire storage required to meet 3,500 gpm for 3 hours: 0.63 MG
- Total storage required in the high service pressure zone: 1.63 MG

This analysis indicates that by 2015, additional storage will be required in the high service pressure zone. In 2014, the City should look at the addition of 0.5 MG in the high pressure zone. If conservation is implemented to reduce the projected maximum day demand, this addition of storage could be delayed until 2030.

7.3.2 Storage Maintenance

There has been minimal maintenance performed on the above-grade clearwell at the plant. Veolia Water staff report that they have periodically power-washed the outside of the tank and touched up with paint. Currently, the outside of the tank has mildew or mold as a result of condensation on the exterior of the tank; see Figure 7-1. Additionally, the paint on the bottom half of the tank appears to be peeling, exposing previous paint coatings of differing color.

Figure 7-1: Existing Plant Clearwell

The tank needs to be cleaned and repainted to preserve the service life of the steel as well as improve the aesthetics for the community. HDR has contacted Tnemec to visit the site and do an evaluation of the paint on the exterior of the tank. The short- and long-term solutions for maintenance of the tank areas follows:

- Short-term cosmetic solution: The tank can be pressure washed. Pressure washing may expose more of the old tank paint; however, the tank can be temporarily coated with paint.
- Long-term solution: The tank will need to be taken out of service to be painted both on the inside and the outside. Tnemec recommends, based on their site evaluation, that the tank be sandblasted to bare steel and then painted.

The specification provided by Veolia Water for the original tank construction in 1976 indicate that the paint primer used was lead-based. Lead paint was commonly used prior to 1980. Based on the probable existence of lead paint, containment during sandblasting of the painted steel will be required with disposal of the hazardous material. A lead paint test should be completed for both the interior and exterior to confirm the existence of lead paint.

One of the challenges of painting the tank will be taking it out of service, since it is the only tank at the water plant for finished water storage. The options for taking the tank out of service are as follows:

- Match water supply flow rates from the wells to the transfer pumping and high and low service pumping in order to utilize the smaller clearwells under the filters as the only means of plant storage
- Bring in temporary storage tanks to provide additional storage volume
- Construct an additional above-ground clearwell in parallel with the existing clearwell

At this time, it is recommended that temporary storage tanks be brought in to paint the existing clearwell; the option of matching the transfer pump rates to the high and low service pumping should be evaluated during design to determine if there might be a cost savings. To promote on-going maintenance and provide redundancy to clearwell storage, it is recommended that an additional 1 million gallon clearwell be installed in the future. This clearwell is recommended to be a pre-stressed concrete tank that does not require periodic painting.

7.3.3 Clearwell Mixing

A review of the plant record drawings indicates that the inlet pipe to the tank terminates at the tank floor; additionally, the outlet pipe drains from the floor of the basin, 180 degrees from the inlet pipe. This does not provide for good mixing and allows for short-circuiting; therefore, it is recommended that mixing of the tank contents be improved.

Mixing in water storage tanks is a practice that circulates the water in the storage tank. Storage tanks that are not well mixed may result in stagnation of the potable water which causes loss of disinfectant residual, inconsistent water age, taste and odors, and nitrification (for chloraminated systems). Well-mixed storage tanks provide the following benefits:

- Prevents stagnation, thermal stratification, and short-circuiting
- Prevents nitrification in chloraminated systems, which can be energy- and chemical-intensive to correct
- Maintains disinfectant residual and reduces formation of disinfection by-products
- Reduces or eliminates the need for flushing and forced turnover (reduces energy costs and waste of water)

Tank mixing can be passive, which includes incorporating mixing into the design of the tank inlet and outlet, or by an active mechanical system, which requires an energy source to operate.

<u>Passive Mixing Systems</u>

Passive mixing requires minimal maintenance and uses the energy of the fill and draw cycles to eliminate short-circuiting and achieve mixing. An example of a passive mixing system is the Tideflex Mixing System which incorporates check valves on risers to facilitate filling and draining from various levels of a tank; see Figure 7-2.

Figure 7-2: Example of Tideflex Vertical Mixing Manifold
(Source: New England Environmental Equipment)

Active Mixing Systems

Active mechanical mixing requires equipment to be installed in the tank to physically mix the water and require a power source to operate the equipment. Examples include the SolarBee mixer and the PAX mixer, which are described below.

The SolarBee mixer is a mixer that is powered from solar panels installed on the roof of the tank; the electricity is also used to charge a battery that is used to power the mixer during the night. The mixer floats on the water and moves up and down with the tank level. The mixer is collapsible and can be installed through a hatch in the roof of the water tank. Figure 7-3, from SolarBee's website, describes the SolarBee mixer further.

The PAX mixer is a submersible mixer with an impeller that mixes the contents of the tank (see Figure 7-4). The mixer is stationary on the bottom of the tank and installs through a conventional hatch. A solar-powered option is available for the PAX mixer as well.

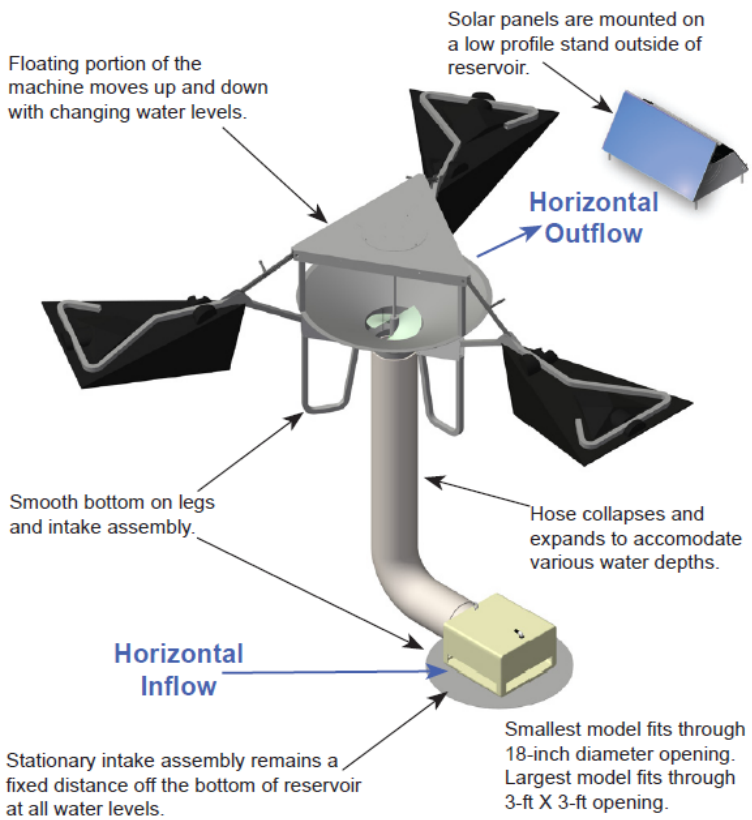


Figure 7-3: SolarBee Mixer

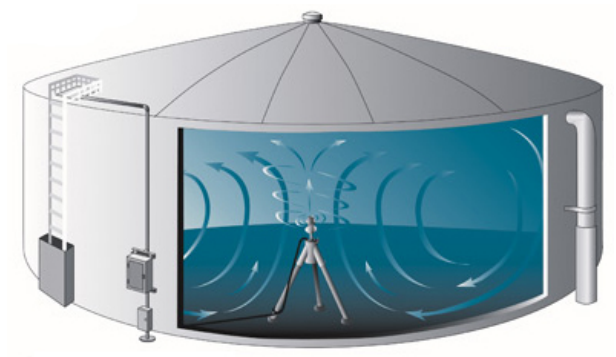


Figure 7-4: PAX Water Mixer

It is recommended that the inlet pipe be extended vertically in the tank and equipped with Tideflex inlet nozzles. Additionally, the outlet pipe should be extended vertically in the tank and equipped with Tideflex outlet valves. Such a system would promote more mixing and turnover in the tank, minimizing stratification and short-circuiting. This retrofit would be a passive type of mixing system in that electricity and on-going maintenance are not required. In order to maintain the ability to drain the tank, a new drainage fire hydrant will need to be installed on the outlet line.

7.3.4 Recommendations

The following are the recommendations for system storage:

- Install a 0.5 MG elevated water storage tank in the high pressure zone in 2014
- In the short-term, pressure wash and touch-up the exterior paint of the tank
- In the long-term, take the tank out of service and sand-blast and paint the interior and exterior including containment for the existing lead paint
- Install a passive mixing system such as the Tideflex mixing system for adequate mixing and turnover of the tank volume
- Construct an additional 1 MG above-ground clearwell at the plant site

Costs for these improvements, except for short-term pressure washing, are detailed in Appendix A. Phasing of these improvements will be discussed in Section 11.

8 PLANT POWER

8.1 EXISTING FACILITIES

The water treatment plant is fed from a single Westar Energy Utility source which feeds the main 15kV switchgear. The main switchgear feeds transformer T-1, which powers the 2400V Motor Control Line-up serving the high and low service pumps, and transformer T-2, which powers the 480V Motor Control Center, which feeds the remainder of the plant loads. Appendix D depicts the existing plant overall one line diagram.

8.1 15KV SWITCHGEAR

The existing main 15kV switchgear to the plant is approximately 30 years old and is in need of replacement. The switchgear is fed from a single utility feed, with provisions for a future second utility feed and an auto throw-over (ATO) system. Based on discussions with Veolia Water staff, the main utility switch to the plant is not operable and cannot be opened; therefore, the main power feed to the plant cannot be turned off. Since the second utility feed was never installed, the ATO system has never been in use and has not been exercised since installment. This equipment has reached the end of its useful life and replacement is recommended. Replacement of this gear at 15kV would be approximately $250,000. If the high service and low service pumps are replaced with motors that are 480V as discussed in Section 7.2, this incoming switchgear could be changed to 480V, which would reduce the equipment cost to approximately $125,000, resulting in a cost savings of $125,000. This would also remove the need for the transformer T-1, eliminating the refurbishment cost as discussed in Section 8.2 below.

8.2 TRANSFORMERS

One of the critical concerns of the plant is the oil leaking from transformer T-1, as shown in Figure 8-1. This transformer feeds the high and low service pumps, and is considered a high priority for repair. It was evaluated whether to refurbish or replace the transformer. The transformer is over 30 years old; both refurbishment and replacement of the transformer were evaluated. Transformers are usually very reliable with a typical 20-35 year design life, but can last as long as 60 years. The challenge with replacement of this transformer is the length of installation time. It would be difficult to find a transformer that is built with the same dimensions as the existing one, such that the existing transformer could be removed and the new transformer installed in its exact place so that down time to the high and low service pumps is minimized. A transformer with different dimensions could possibly require a new concrete equipment pad, and new cables on the primary and secondary sides. The cost of a new transformer alone would be approximately $50,000. Adding in the cost of replacing the concrete pad and cables, the total would be about $75,000.

Figure 8-1: Existing Transformer T-1

The other option that was considered was refurbishment of the existing transformer. Refurbishment would be very similar to installing a new transformer; it would include repairing the source of the leak, re-gasketing, refilling with oil, testing, and painting. A scope and fee was obtained from Lynn Electric for refurbishment of the transformer; Appendix E includes the proposed tests and items for repair. The cost of refurbishment would be approximately $25,000, which includes removing the existing transformer, and putting a temporary transformer in its place during the repair, resulting in very little down time to the plant.

Transformer T-2 is also leaking oil although not as badly as T-1, see Figure 8-2. This transformer is critical in that it feeds the remainder of the plant loads, which are also necessary for a functioning plant. The issues are similar to transformer T-1, therefore this transformer is recommended for refurbishment as well.

Figure 8-2: Existing Transformer T-2

If the high and low service pumps are replaced with 480V motors instead of 2400V motors, transformers T-1 and T-2 would no longer be needed and the cost of refurbishment would be eliminated.

8.3 EMERGENCY POWER

8.3.1 Water Treatment Plant

Currently there is only a single utility feed to the plant from the power utility, Westar Energy. A reliable alternate power supply is recommended to keep the plant operable during a power utility failure. The options that were considered were installation of an emergency diesel-fueled standby generator or a second utility feed from Westar Energy.

The loads that require standby power was discussed with Veolia Water staff and a load sequence was developed, which is presented in Appendix F. Some of these loads may not be in service currently, however, upgrades may occur at the plant in the future that will take the place of these loads. The loads are started in a step sequence so that the generator is not overloaded upon starting the loads. Current operations are for the loads to be started manually during an outage, so essentially all of the loads are started individually. However, a generator load sequence was established to mimic the starting sequencing if the loads are automated to start by plant SCADA in the future. Generator manufacturers were consulted and it was determined that a 1000kW generator would be of sufficient size to accommodate the generator loads. The primary voltage at the plant main switchgear is 12,470V; 1000kW is smaller than the typical size for a medium voltage generator, and therefore is not considered cost effective. The alternative to a medium voltage generator would be a 480V generator with a transformer to step the voltage up to 12,470V. The cost for installation of a new generator and a step up transformer would be approximately $310,000.

Monthly costs for the generator would include preventive maintenance and the usage of diesel fuel for exercising the generator.

Westar Energy was consulted with regard to the installation of a second utility feed to the plant. A second 12.47kV feed would be from a separate substation than the existing feed to provide reliability in the power supply. The two substations are fed by separate transmission lines, providing redundancy in power supply. Under this option, Westar Energy proposes to upgrade the overhead primary line, rebuild poles and install a new manual switches. Because Westar is including manual switches in their price, the cost of the new 15kV switchgear discussed in Section 8.1 would be decreased. The base cost of building a second 12.47kV utility feed would be $150,000. To guarantee that the secondary line always has capability in the substation in the future, the cost would be $250,000, with a monthly charge of $262.

Switching of the plant to backup power would be manual by Westar, switching within 20 minutes of an outage on primary power. An additional cost would be incurred if automatic switching is preferred; at the time of this draft report, Westar has not provided the cost, but indicated that automatic switching would be expensive and that they can be out to the plant to switch the feed within 20 minutes. Therefore, at this time, the optional cost of automatic switching is not included.

If the high and low service pumps are replaced with 480V motors instead of 2400V motors, then the second incoming power feed would be 480V, instead of 12.47kV, requiring Westar to provide the step down transformers which would feed a 480V low voltage switchboard with an auto throw-over (ATO) system. The advantage to this option would be that the maintenance of the transformers would be the responsibility of Westar. There would be no transformers for the plant to maintain, and there would be no maintenance required for a medium voltage system. A redundant second 480V power feed, including backup to the wells would be $210,000.

Table 8-1: Summary of Options for Emergency Power

OPTION 1 - Generator	
Generator - 1000kW, 480V	$ 275,000
Transformer - 1000kVA, 12kV-480V	$ 35,000
TOTAL	$ 310,000
Option 2a – Second 12.47kV Utility Feed	
Westar installation costs	$ 150,000
TOTAL	$ 150,000
OPTION 2b - Second 12.47kV Utility Feed - Guaranteed	
Westar installation costs	$ 250,000
TOTAL	$ 250,000
OPTION 3 - Second 480V Utility Feed - Guaranteed	
Westar installation costs	$ 210,000
TOTAL	$ 210,000

Option 3 is recommended in conjunction with the high and low service pumps replacement with 480V motors instead of 2400V motors.

8.3.2 Water Supply Wells

There are currently nine active water supply wells that feed the water treatment plant. None of these wells currently have standby power. Westar indicated that providing backup power to the wellfield would be approximately $20,000. This price is based on the assumption that the second utility feed would be brought to the plant. Since the wells will be on the same circuit as the water treatment plant, power to the wells will be manually or automatically switched, depending on how the switching is installed for the plant.

8.4 RECOMMENDATIONS

The following is a summary of the recommendations for the plant electrical system:

- Replace in the 15kV switchgear with a 480v switchgear, eliminating the need for transformers T-1 and T-2
- Install a 480V secondary plant feed with feed to the wells for backup power to the plant

Costs for these improvements are detailed in Appendix A. Phasing of these improvements will be discussed in Section 11.

9 SCADA/INSTRUMENTATION

9.1 EXISTING FACILITIES

The plant does not currently have a plant wide Supervisory Control and Data Acquisition (SCADA) system. Control of equipment and chemical dosing is manual, although there is some readout capability in the control room via a panel of indicating devices, see Figure 9-1. Not all of these devices are operable or accurate. There is an existing HMI (Human Machine Interface) on the control room panel wall which only displays signals for Well No. 18, Spruce Street Tank, Spruce Street Tower and Ash Street Tank.

Figure 9-1: Existing Plant Control Room

The following is a summary of the control and monitoring capabilities:

- All the wells are capable of remote start/stop manually via a phone line signal with the following exceptions: Well #18 is operated from the control room via radio telemetry. The remote control capability for Wells #6, 11, and 17 currently does not work and therefore these pumps have to be started and stopped locally.
- Well flow and level are read locally at the meters, with the exception of Well 18, which is transmitted to the plant and is indicated in the plant control room.

- Filter backwash takes place based on differential pressure between the filter influent and filter effluent; the differential pressure signal is read remotely in the control room. Based on this signal, the operators can manually open and close the pneumatic backwash valves from the control room to start or end the backwashing process.
- Filter effluent turbidity is measured based on laboratory analysis of grab samples.
- Lime dosages are manually adjusted based on laboratory testing of pH and alkalinity of samples from the primary softening basins.
- Chlorine dosages are manually adjusted based on laboratory testing of the residual. There is a Hach CL17 instrument that provides online monitoring of chlorine residual; however it is an old, hand-me-down unit and the accuracy is questionable by the plant staff.
- Sodium hexametaphosphate metering pump dosage rates are adjusted manually.
- Fluoride dosages are flow paced based on the raw water venturi flow meter.
- The transfer pumps are automatically operated based on a level bubbler system in the sub-filter clearwells.
- The tank level signals for the Ash Street elevated tank and Spruce Street ground and elevated storage tanks are transmitted to the plant via phone line signal and are also indicated locally at each tank. The high and low service pumps are manually started and stopped based on remote readings of distribution storage tank level.
- The raw water and high/low service pump venturi meter flow rates are transmitted to chart recorders in the plant control room.
- The recovery pumps are automatically operated based on mechanical floats in the recovery tank.
- The lime sludge pumps are manually started and stopped.

9.2 RECOMMENDATIONS

Installation of a SCADA system is recommended for remote control and monitoring of plant processes, including pumps, chemical equipment, and cleaning equipment. A SCADA system will improve reliability of the process as well as improve safety and efficiency for the plant operators. As projects are completed to improve the plant, such as replacement of pumps and addition of chemical systems, control equipment should be specified that is compatible with a future SCADA system. For example, motor starters should be equipped with dry contacts for running, fail and remote status as well as be capable of accepting a dry contact for remote starting. Additionally, as instruments fail and are replaced outside of capital improvement projects, they should be replaced with instrumentation that is compatible with a future SCADA system.

The future SCADA system would consist of a main plant PLC in the control room, main and historian SCADA servers. The main plant PLC would be connected to a main plant workstation, other PLC's and remote I/O racks within the plant via Ethernet switches. The main plant workstation would be located in the control room which would consist of a desktop PC, flat screen monitor and a printer for monitoring, control

and report printing capability. All of the signals that are currently being monitored on the control room panel wall would be sent to a PLC and monitored from this PC. Other plant equipment and remote sites will be evaluated to determine what additional I/O signals would be beneficial. Remote terminal services could also be implemented to allow the monitoring and control of the plant via internet, smart phones or tablets.

Remote monitoring and control of the well and tank sites could be accomplished by a variety of methods, including cellular, radio, fiber optic or phone line. It is recommended that an evaluation be performed to determine the most reliable and efficient method for providing remote telemetry at the wells and tanks. These signals would be transmitted back to the plant SCADA for monitoring and control.

Veolia Water staff report that the phone line signal from Wells #6, 11, and 17 are no longer functional. It is recommended to replace the controls at these wells with new controls. At this time, radio telemetry is thought to be the recommended option, since a radio and antenna have already been installed at the Water Treatment Plant for monitoring and control of Well #18; additional investigation will be needed during design.

The following is a summary of recommendations for SCADA/instrumentation:

- Install a plant SCADA system
- As equipment and instrumentation is replaced within the plant, provide equipment/instrumentation compatible with SCADA
- Conduct an evaluation during design for the most reliabile and efficient method of remote telemetry to the wells and tanks
- Replace non-functioning controls at Wells #6, 11, and 17 with radio telemetry (costs for this improvement is included in well field improvement costs in Appendix A)

Costs for these improvements are detailed in Appendix A. Phasing of these improvements will be discussed in Section 11.

10 PLANT MAINTENANCE

10.1 WELL MAINTENANCE

A reasonable frequency interval for major maintenance activities on municipal wells constructed in alluvial environments is between two (2) and (5) years. However, the frequency of well treatment should be based on the analysis of the monitoring data collected. If the specific capacity of a well declines by more than 25% of the original specific capacity, then a treatment of the well should be scheduled. Regardless of the specific capacity, an alluvial well should be treated at a minimum every five (5) years. Based on the existing active wells; this results in cleaning at least two wells per year, more if specific capacity declines are realized.

The well pump should be removed prior to beginning the well treatment. Once the pump is removed, the inside of the well should be cleaned with a wire brush. Wire brushes are a common tool used to remove debris that is attached to the well casing and screen, which most commonly consists of mineral scale and biomass. Next, a pre-chlorination of the well should be performed to help remove biological incrustation from the well screen and casing. Following the pre-chlorination, a chemical treatment solution consisting of acidification, chlorination, and the addition of specialty chemicals should be performed. The most common acid used is muriatic acid (HCL), given its effectiveness at removing mineral and inorganic metal oxide scale. The chemical solution should be introduced into the well using a double disc surge block, not a well pump. Surging should be conducted with tools capable of a 2 to 3 ft/sec stroke and capable of working the screen in 2 to 5 foot sections, concentrating on trouble spots identified via the downhole video survey (if applicable). A series of surging and over-pumping should be performed for each isolated 5 foot section of the well to enhance the displacement of the chemicals used in the rehabilitation of the well. Following the treatment, the well should be sterilized by using a pH adjusted chlorination and be pump tested to determine the amount of improvement in specific capacity.

10.2 CLEANING AND PAINTING OF PIPING AND EQUIPMENT

There are several areas of the plant where maintenance activities such as cleaning and painting are needed. Such areas include the following:

- The wells and associated piping are in need of painting.
- The aerators are in need of a cleaning of the exterior. The interior was not inspected but likely also needs cleaning.
- It is likely that, based on the calcium carbonate deposits on the weirs in the primary basins, that all plant piping downstream of the lime addition needs cleaning to restore plant hydraulics.
- Piping inside the Sludge Control Buildings is in need of painting; however, this can be done in conjunction with the project for improving the lime sludge withdrawal.

- Much of the piping in the filter gallery, filter effluent piping and backwash piping in particular, has experienced corrosion and is need of painting.
- The high and low service discharge lines are in need of painting. This painting should be done in conjunction with the project for installing surge relief valves and replacement of the venturi flow meters.
- The plant ground storage clearwell is in need of painting, as discussed previously.

During design of Phase I of the capital improvements plan, it is recommended to do a detailed hydraulic survey and profile of the plant processes in order to assess the impact of the reduced hydraulics the calcium carbonate deposits have on the plant piping.

10.3 BUILDING ROOF

Veolia Water staff report that there are several areas within the water treatment plant building where the roof has been leaking. This has been an on-going problem for at least 8 years when the plant receives more than just a light rain. The roof primarily leaks through penetrations for ducts, piping and at joints between the walls and the roof. The floor of the filter room can get covered in standing water, although Veolia Water staff try to keep it mopped up or contained in buckets. In addition, the roof of the chemical storage room, which has a roof at a lower elevation, leaks into the second floor of the building if the wind blows the rain from the north.

The existing roof is precast concrete roof deck with an EPDM membrane. The flashing around the skylights or the sealant may have shifted causing leakage or the sealant may have degraded over time.

It is recommended that the building roof membrane be replaced. Skylights are beneficial for providing natural lighting in a building; however, they are not necessary and can be a source of leakage as has been experienced. If skylights are desired to be put back, they will need to include fall protection devices to meet current building codes. Additionally, because the lime storage bins are accessible equipment on the rooftop of the chemical room, that area will need to have guardrail installed to meet current building codes.

10.4 BUILDING HVAC

There is an antiquated HVAC control systems that maintains the heating and cooling of the entire building; it is difficult to maintain and only provides limited control. Veolia Water staff report that when the heater is running the office/control room on the first floor, the offices on the second floor, and the distribution shop/storage room in the basement are extremely warm. Similarly, if the air conditioner is running, these rooms are extremely cold. Additionally there is high humidity throughout the building, which causes problems in the laboratory with filter testing because the glass fogs up.

We recommend the following HVAC infrastructure upgrades be undertaken. The recommendations listed below will improve air quality throughout the entire facility. They are prioritized from most important to least important.

- Replace AHU-1: Remove and replace existing AHU-1 and existing water cooled condensing unit. Existing ductwork and electrical connections will be reused to the maximum extent possible. Unit will be sized to provide temperature and humidity control to all spaces it serves. .
- Replace AHU-2: Remove and replace existing AHU-2 with new heating and cooling heating and cooling unit with hot water heating and air cooled DX cooling. Unit shall be sized to provide adequate temperature and humidity control in all spaces it serves.
- Replace AHU-3: Remove and replace existing AHU-3 with new HW heated air cooled DX unit that has dehumidification of existing spaces incorporated into the unit. Existing ductwork and electrical connections will be reused to the maximum extent possible. Unit shall be sized to provide temperature and humidity control to all lower level spaces. Additional dehumidification capability will be considered in this unit to control excess humidity in lower level. .
- Replace AHU-4: Remove and replace existing AHU-4 with new DX cooled hot water heated unit. Condensing unit will be roof mounted. Existing ductwork and electrical connections will be reused to the maximum extent possible. Existing ductwork will be reused to the maximum extent possible.
- Upgrade controls to all areas: Remove all existing controls and install new DDC controls on all HVAC equipment. At the minimum, the units will provide monitoring and start stop status for all air units. The controls will also have the ability to start and stop equipment either automatically or manually override all systems.
- Boiler Upgrade: remove and replace existing gas fired boilers with high efficiency condensing gas fired boiler systems. New combustion air and flues will be installed in the building. Existing electrical connections will be reused to the maximum extent possible. Pumping and piping will be reused to the maximum extent. All associated piping appurtances will be reused.System will be sized for dual boilers to operate at higher efficiencies.
- Dedicated lab unit: Remove the ductwork serving the laboratory area (rooms 104, 105, 106) from AHU-1. Install new dedicated air handling unit to provide close temperature and humidity control for the laboratory space to improve existing air quality.

10.5 SITE WORK

The existing asphalt paving on the plant site appears to be in good condition; therefore re-paving this area is not necessary at this time. There may be improvements to the pavement to accommodate chemical trucks, particularly carbon dioxide; however any site work improvements required as a result of those projects will be budgeted as a part of those projects.

The access to the individual wells is by a gravel road from the north along the river. At this time, the road is accessible. Plant staff have improved some areas of the road; however some areas are not in the best shape particularly along the river. This road could be improved by paving or by putting down a new gravel layer with compaction; this work could be done in conjunction with the well field improvement project or at a later time. Since the road is not frequently accessed, it is recommended that a new gravel layer be installed.

11 PROJECT PRIORITIZATION AND CONSTRUCTION PHASING

11.1 SUMMARY OF RECOMMENDATIONS

The following are the recommended capital improvement projects based on the previous sections:

- Replace raw water meter
- Replace high and low service meters
- Implement conservation water rates
- Submit an application to DWR for Water Assurance District storage to be withdrawn through existing wells
- Install a horizontal collector well (or do improvements within the existing well field as an alternative option)
- Install a chlorine feed in the raw water meter vault prior to the aerators
- Install carbon dioxide feed to the softening basin effluent
- Improve the lime sludge piping from the Sludge Control Buildings to the Lime Sludge Lagoons and replace the solids contact equipment in the softening basins
- Construct a connection to the plant sanitary sewer for the lagoon decant recycle pumps to discontinue the practice of recycling the flow to the head of the plant.
- Install ferric and polymer feeds to the softening basin effluent (pending verification by jar-testing) and replace the equipment in the secondary basins
- Install individual and combined filter effluent turbidimeters; add sonar level indication for the transfer pumps
- Construct improvements to the lime feed system, including improved access to the lime storage bin dust collector and replacement of the pneumatic conveyance piping
- Install a new fluoride chemical feed system
- Install containment for all existing chemical systems
- Convert secondary disinfection to chloramines with an ammonia feed prior to clearwell storage
- Install automatic shut off valves on the existing chlorine ton cylinders
- Convert the exiting chlorine gas pressure feed system to a vacuum system with automatic switchover
- Retrofit the existing high and low service pump station with new high and low service pumps and replacement of the 2400V motor control line-up with a new 480V motor control line-up
- Install surge relief valves on the high service transmission main leaving the plant
- Install soft starts for the low and high service pumps
- Construct a 0.5 MG tank in the high service pressure zone

- Sandblast and paint the inside and outside of the ground clearwell
- Construct an additional 1 MG ground clearwell
- Install a mixing system in the ground clearwell
- Replace the 15 kV switchgear (abandon transformers T-1 and T-2)
- Install a second power utility feed to the plant and well field (automatic transfer for the well field is optional)
- Install a system-wide SCADA system
- Replace well controls to be compatible with SCADA (replace Wells #6, 11, and 17 initially with replacement of the remaining controls in the future)
- Clean interior of plant piping of calcium carbonate deposits downstream of lime addition
- Paint exposed piping and equipment, plant-wide
- Replace the building roof and skylights
- Replace existing AHU-1 and existing water cooled condensing unit
- Replace existing AHU-2 with new heating and cooling heating and cooling unit with hot water heating and air cooled DX cooling
- Replace existing AHU-3 with new HW heated air cooled DX unit that has dehumidification of existing spaces incorporated into the unit.
- Replace existing AHU-4 with new DX cooled hot water heated unit and roof-top condensing unit.
- Remove all existing controls and install new DDC controls on all HVAC equipment.
- Replace existing gas fired boilers with high efficiency condensing gas fired boiler systems.
- Install a new dedicated air handling unit for the laboratory area.
- Gravel surface the access road to the wells.

The following are the recommended maintenance items to be considered in future maintenance budgeting:

- Calibrate well flow meters once every three years
- Clean aerator inside and outside and periodically chlorinate the raw water to limit biological growth inside the aerator
- Clean the filter media to extend the life
- Clean wells a minimum of every five years
- Replace instrumentation as needed to be compatible with future SCADA

The projects the City has identified for the water distribution system include the following:

- Installation of distribution system sampling stations. Under the Total Coliform Rule, the City is required to take 25 samples per month throughout the water distribution system to sample for total coliforms. Currently, the City has to enter the home or business located at the sample site. With the installation of the distribution system sampling stations, the City will be able to access the water distribution system for samples at their convenience.

- Replacement of customer meters, beginning with the large user meters and working down to residential meters. The purpose of the meter replacement is to replace outdated and inaccurate meters in order to improve accuracy in water use reporting and water sales.
- Rehabilitation of the Spruce Street Booster Station. The 2007 Water Master Plan indicated the installation of a new prepackaged pump station to replace the existing pump station, which dates back to the 1950s and runs constantly.
- Inspection of three tanks at Spruce Street Booster Station and the Ash Tower and a future tank maintenance program.
- Bulk water station for customer purchase of bulk water to reduce possible theft of water and associated unaccounted-for water.

11.2 PROJECT PRIORITIZATION

Based on the above recommended projects, the projects have been prioritized based on the criticality of the project. Projects have been prioritized based on the following driving factors:

- Regulatory – meeting current or near-term Federal and State regulations.
- Safety – improving the safety of plant personnel and visitors.
- Water Quality – improving the finished water quality delivered to customers.
- Capacity – Phase I projects that are classified under Capacity are important for meeting current and future customer demands and providing reliability in meeting those demands.
- Critical Asset – maintaining the integrity of critical plant assets and ensuring continued service
- Financial – improving the financial position of the water system based on accurate water sales and reporting for funding capital improvement projects
- Reliability – maintaining reliable service for less-critical assets
- Service Life – will require replacement at some point in the future at the end of their service life. At that time, they will be required for maintaining reliable service.
- Productivity – will improve productivity of plant staff.

Table 11-1 presents the recommended project prioritization into Phase I, II and III projects.

The following is a summary of the projects by phase:

<u>Immediate Needs</u>

- Submit an application to DWR for Water Assurance District storage to be withdrawn through existing wells
- Install automatic shut off valves on the existing chlorine ton cylinders
- Convert the exiting chlorine gas pressure feed system to a vacuum system with automatic switchover

Phase I Projects

- Install a horizontal collector well (or do improvements within the existing well field as an alternative option)
- Install carbon dioxide feed to the softening basin effluent
- Improve the lime sludge piping from the Sludge Control Buildings to the Lime Sludge Lagoons and replace the solids contact equipment in the softening basins
- Install individual and combined filter effluent turbidimeters; add sonar level indication for the transfer pumps
- Construct improvements to the lime feed system, including improved access to the lime storage bin dust collector and replacement of the pneumatic conveyance piping
- Install containment for all existing chemical systems
- Convert secondary disinfection to chloramines with an ammonia feed prior to clearwell storage
- Retrofit the existing high and low service pump station with new high and low service pumps and replacement of the 2400V motor control line-up with a new 480V motor control line-up
- Install soft starts for the low and high service pumps
- Sandblast and paint the inside and outside of the ground clearwell
- Install a mixing system in the ground clearwell
- Replace the 15 kV switchgear (abandon transformers T-1 and T-2)
- Install a second power utility feed to the plant and well field (automatic transfer for the well field is optional)
- Replace well controls to be compatible with SCADA (replace Wells #6, 11, and 17 initially with replacement of the remaining controls in the future)
- Clean interior of plant piping of calcium carbonate deposits downstream of lime addition
- Replace the building roof and skylights
- Replace existing AHU-1 and existing water cooled condensing unit
- Replace existing AHU-2 with new heating and cooling heating and cooling unit with hot water heating and air cooled DX cooling
- Replace existing AHU-3 with new HW heated air cooled DX unit that has dehumidification of existing spaces incorporated into the unit.
- Replace existing AHU-4 with new DX cooled hot water heated unit and roof-top condensing unit.
- Gravel surface the access road to the wells.
- Replace customer meters (Phase I of 3)
- Contract for distribution system storage inspection and maintenance
- Construct bulk water station

Phase II Projects

- Replace raw water meter
- Replace high and low service meters
- Implement conservation water rates
- Install a chlorine feed in the raw water meter vault prior to the aerators
- Install ferric and polymer feeds to the softening basin effluent (pending verification by jar-testing) and replace the equipment in the secondary basins
- Install a new fluoride chemical feed system
- Install surge relief valves on the high service transmission main leaving the plant
- Install a system-wide SCADA system
- Paint exposed piping and equipment, plant-wide
- Remove all existing controls and install new DDC controls on all HVAC equipment.
- Replace existing gas fired boilers with high efficiency condensing gas fired boiler systems.
- Install a new dedicated air handling unit for the laboratory area.
- Replace customer meters (Phase 2 of 3)
- Overhaul Spruce Street Booster Station

Phase III Projects

- Construct a 0.5 MG tank in the high service pressure zone
- Replace recovery pumps (if required)
- Replace filter media (if required)
- Replace transfer pumps (if required)
- Repave plant access road
- Replace customer meters (Phase 3 of 3)
- Install distribution sample stations

Table 11-1: Recommended Project Phasing

Project	Immediate Needs		Phase I: Need Now		Phase II: Need Soon		Phase I: Need Later		Future: Desirable Projects
	Projects Included	Criticality Basis	Projects Included	Criticality Basis	Projects Included	Criticality Basis	Projects Included	Criticality Basis	
Replace Raw Water Meter at Plant					X	Reporting			
Replace High and Low Service Meters					X	Reporting			
Water Conservation Rates					X	Capacity			
Obtain Additional Water Rights	X	Capacity							
Horizontal Collector Well / Well Field Improvements			X	Capacity					
Chlorine Feed Ahead of Aerators					X	Reliability			
Recarbonation (Carbon Dioxide Feed)			X	Water Quality					
Lime Sludge Piping/Pump Improvements/Primary Basin Equipment			X	Water Quality					
Lime Sludge Lagoon Decant Water Piping to Sanitary					X	Water Quality			
Ferric Feed System/Secondary Basin Equipment					X	Water Quality			
Polymer Feed System					X	Water Quality			
Lime System Improvements			X	Reliability					
Fluoride Feed System					X	Reliability			
Chemical Containment			X	Regulatory					
Filter Effluent Turbidimeters/Transfer Pump Sonar Level			X	Water Quality					
Replace Filter Media							X	Service Life	
Replace Recovery Pumps							X	Service Life	
Chloramines Conversion (Ammonia Feed)			X	Regulatory					
Chlorine Gas Feed System Improvements	X	Safety							
Sodium Hypochlorite System									X
High and Low Service Pumps/Electrical			X	Capacity					
Replace Transfer Pumps							X	Service Life	
Surge Relief Valves					X	Reliability			
Soft Starts for Low and High Service Pumps			X	Critical Asset					
VFDs for Low and High Service Pumps									X
Elevated Water Storage Tank in High Pressure Zone							X	Capacity	
Paint Plant Ground Clearwell			X	Critical Asset					
New Ground Clearwell					X	Reliability			
Mixing System in Existing Ground Clearwell			X	Water Quality					
Emergency Power at Plant/Wells			X	Capacity					
SCADA/Well Controls					X	Reliability			
Replace Well #6, 11, and 17 Controls			X	Capacity	X	Reliability			
Clean Plant Pipelines/Weirs of Deposits			X	Capacity					
Paint Equipment					X	Critical Asset			
Paint Plant Piping					X	Critical Asset			
Replace Building Roof and Skylights			X	Critical Asset					
Replace HVAC AHU-1			X	Critical Asset					
Replace HVAC AHU-2			X	Critical Asset					
Replace HVAC AHU-3			X	Critical Asset					
Replace HVAC AHU-4			X	Critical Asset					
Replace HVAC Controls					X	Reliability			
Replace HVAC Boiler System					X	Reliability			
Install Dedicated AHU for Laboratory					X	Reliability			
Re-Pave Plant Roadway							X	Service Life	
Pave or Gravel Surface Well Field Roadway					X	Reliability			
Customer Meter Replacements			X	Financial	X	Financial	X	Financial	
Distribution Sample Stations							X	Productivity	
Distribution System Tower Inspection/Maintenance			X	Reliability					
Overhaul Spuce Street Booster Station					X	Reliability			
Bulk Water Station			X	Financial					

11.3 COST ESTIMATES

11.3.1 Capital Costs

This section describes the capital cost estimates for the recommended projects. Projects that were discussed but are not recommended at this time were not estimated. The cost estimates represent an accuracy level of -20 to +40 percent. Any opinions of probable construction cost or cost estimates provided by HDR, Inc. are made on the basis of information available to HDR, Inc. and on the basis of cost estimator's experience and qualifications, and represents its judgment as an experienced and qualified professional engineer. However, since HDR, Inc. has no control over the cost of labor, materials, equipment or services furnished by others, or over the contractor(s') methods of determining prices, or over competitive bidding or market conditions, HDR, Inc. does not guarantee that proposals, bids or actual project or construction cost will not vary from opinions of probable cost or cost estimates prepared by HDR, Inc.

Projects that the City has identified prior to this study for the water distribution system are included, but were not estimated by HDR. Costs were obtained from the City as follows:

- Installation of distribution system sampling stations. The City currently has $108,000 budgeted for this project, spread over the years between 2013 and 2020.
- Replacement of customer meters, beginning with the large user meters and working down to residential meters. The City currently has $3.6 million budgeted for this project, equally distributed each year between 2015 and 2020.
- Rehabilitation of the Spruce Street Booster Station. The City has $420,000 budgeted for 2014.
- Inspection of three tanks at Spruce Street Booster Station and the Ash Tower. The City has a total of $80,000 budgeted for these inspections in 2016.

The cost estimates include the following cost factors:

- 15% for Contractor’s Overhead, Profit, and General Requirements (such as mobilization, demobilization, field office, etc.)
- 30% contingency for conditions that are unforeseen at this time
- 20% for legal, administrative, and engineering services including design, bidding, and construction administration

Table 11-2 provides a summary of the capital costs by project and by phase. Detailed cost estimates are provided in Appendix A.

Table 11-2: Summary of Phased Costs

PROJECT		PHASE 1 (2014 - 2015)	PHASE 2 (2016 - 2017)	PHASE 3 (2019 - 2021)
Plant Raw Water Meter			$ 73,000	
High and Low Service Pipe Painting/Meters/Surge Valves			$ 110,000	
Horizontal Collector Well/Repair Well Controls (#6, 11, 17)		$ 3,762,000		
Recarbonation (Carbon Dioxide Feed)		$ 755,000		
Lime Sludge Improvements		$ 714,000		
Lime Sludge Decant to Sanitary Sewer			$ 20,000	
Liquid Ferric Sulfate Feed System			$ 812,000	
Liquid Polymer Feed System			$ 67,000	
Lime System Improvements		$ 77,000		
Fluoride Feed System		$ 67,000		
Chemical Containment		$ 18,000		
Filter Effluent Turbidimeters		$ 19,000		
Replace Filter Media				$ 164,000
Chloramines Conversion (Ammonia Feed)		$ 137,000		
Chlorine Gas Feed System Improvements		$ 63,000		
High and Low Service Pump Upgrades/Electrical		$ 763,000		
Replace Transfer Pumps				$ 173,000
Elevated Water Storage Tank in High Pressure Zone				$ 1,304,000
Ground Clearwell Improvements (Painting and Mixing)		$ 542,000		
Additional Ground Storage Clearwell				$ 1,344,000
Plant/Well Emergency Power		$ 210,000		
SCADA/Well Controls			$ 483,000	
Clean Piping and Basin Weirs of Deposition		$ 55,000		
Paint Plant Piping and Equipment			$ 60,000	
Replace Building Roof and Skylights		$ 271,000		
HVAC Improvements		$ 112,000	$ 91,000	
Re-Pave Plant Roadway				$ 208,000
Gravel Surface Well Field Roadway				$ 116,000
Bulk Water Station		$ 75,000		
SUBTOTAL		$ 7,640,000	$ 1,716,000	$ 3,309,000
Mobilization, Bonding and General Requirements	5.0%	$ 382,000	$ 86,000	$ 165,000
Overhead and Profit	10.0%	$ 764,000	$ 172,000	$ 331,000
SUBTOTAL		$ 8,786,000	$ 1,974,000	$ 3,805,000
Contingency	25.0%	$ 2,197,000	$ 494,000	$ 951,000
SUBTOTAL		$ 10,983,000	$ 2,468,000	$ 4,756,000
Engineering, Legal, Administrative	20.0%	$ 2,197,000	$ 494,000	$ 951,000
SUBTOTAL		$ 13,180,000	$ 2,962,000	$ 5,707,000
Additional Projects (Not Subject to Markups)				
Water Conservation Rates			$ 50,000	
Customer Meter Replacements		$ 600,000	$ 1,200,000	
Water Distribution System Sample Stations				$ 108,000
Distribution System Tank Inspections		$ 80,000		
Spruce Street Booster Pump Station Overhaul			$ 521,000	
TOTAL		$ 13,860,000	$ 4,733,000	$ 5,815,000
TOTAL (ALL PHASES)				$ 24,408,000

11.3.2 O&M Costs

Additional costs will be incurred on an annual basis due to processes added to plant operations, including power, maintenance of new equipment, and purchase of new chemicals. O&M costs were only estimated for new Phase I processes or Phase I processes that are recommended to be upgraded. O&M costs for future projects should be estimated at the time they are under planning and design. The primary Phase I projects that will have annual costs associated with them are as follows:

- Horizontal collector well
- Carbon dioxide feed
- Ferric sulfate feed
- Polymer feed
- Liquid ammonium sulfate feed
- High and low service pumps (net additional horsepower)

Additionally, recommended maintenance programs including cleaning of existing vertical wells and clearwell painting are included since maintenance of these assets will be critical in maintaining the capacity of the water system. Existing processes and chemicals were not estimated; therefore, the costs represent an addition to the existing operation and maintenance budget.

The following are assumptions for calculation of the O&M costs:

- Power costs are based on an average annual finished water demand of 5 MGD, pump efficiency of 70%, motor efficiency of 70%, and electrical costs of $0.10 per kilowatt-hour.
- Maintenance of the horizontal collector well is based on performance of the cleaning at 10 year intervals for a cost of $135,000.
- Maintenance of the existing vertical wells is based on cleaning 3 wells per year at a cost of $15,000 per well.
- Clearwell painting costs are based on painting every 10 years at a unit cost of $7 per square foot of painted area.
- Carbon dioxide costs are based on an average annual finished water demand of 5 MGD, average feed rate of 30 mg/L, and chemical cost of $225 per ton.
- Ferric sulfate costs are based on an average annual finished water demand of 5 MGD, average feed rate of 20 mg/L, and chemical cost of $200 per ton.
- Polymer costs are based on an average annual finished water demand of 5 MGD, average feed rate of 1 mg/L, and chemical cost of $2.00 per pound.
- Liquid ammonium sulfate costs are based on an average annual finished water demand of 5 MGD, average feed rate of 0.75 mg/L, and a chemical cost of $0.34 per pound.

Table 11-3: Summary of Additional O&M Costs for Phase 1 Projects

Operation and Maintenance Cost Item	Annual Cost	Present Worth (3%, 20 Year)
Power		
Horizontal Collector Well	$ 36,000	$ 536,000
Low/High Service Pumps (Net)	$ 92,000	$ 1,370,000
HWC Cleaning	$ 16,000	$ 426,000
Vertical Well Cleaning	$ 45,000	$ 670,000
Clearwell Painting	$ 24,000	$ 631,000
Chemicals		
Carbon Dioxide	$ 52,000	$ 774,000
Ferric Sulfate	$ 31,000	$ 462,000
Polymer	$ 31,000	$ 462,000
Liquid Ammonium Sulfate	$ 41,000	$ 610,000
Equipment Maintenance	$ 82,000	$ 1,220,000
Total	**$ 450,000**	**$ 7,161,000**

REFERENCES

Driscoll, F.G. 1986. Groundwater and Wells. Johnson Division, St. Paul. MN.

Appendix A

City of Junction City, Kansas
Water Treatment Plant
Engineer's Opinion of Preliminary Construction Costs

Item	Quantity	Unit	Unit Cost	Total Cost
Plant Raw Water Meter				
Demolition	1	LS	$10,000	$10,000
20" Magnetic Flowmeter	1	LS	$20,000	$20,000
Piping and Appurtenances	1	LS	$7,000	$7,000
Chlorine Piping	250	LF	$20	$5,000
Chemical Injector	1	EA	$1,000	$1,000
Installation (25% of Above Items)	1	LS	$8,000	$8,000
Concrete Wall/Footing	5	CY	$800	$4,000
Electrical/Instrumentation (15%)	1	LS	$8,000	$8,000
Temporary Provisions	1	LS	$10,000	$10,000
Subtotal				$73,000
Contractor Overhead and Profit, General Requirements (15%)				$11,000
Subtotal - Construction (with Contractor Markup)				$84,000
Contingency (25%)				$21,000
Total - Construction (with Contractor Markup and Contingency)				$105,000
Engineering, Legal, Administrative (20%)				$21,000
Total				**$126,000**
High and Low Service Meters / Surge Protection Valves / Painting of High and Low Service Piping				
12" Magnetic Flowmeter	2	LS	$12,000	$24,000
16" Surge Relief Valves	2	EA	$16,000	$32,000
Piping and Appurtenances	1	LS	$7,000	$7,000
Installation (25% of Above Items)	1	LS	$16,000	$16,000
Electrical & Instrumentation (15%)	1	LS	$12,000	$12,000
Painting - 16" Pipe	160	LF	$20	$3,000
Painting - 24" Pipe	160	LF	$38	$6,000
Temporary Provisions	1	LS	$10,000	$10,000
Subtotal				$110,000
Contractor Overhead and Profit, General Requirements (15%)				$17,000
Subtotal - Construction (with Contractor Markup)				$127,000
Contingency (25%)				$32,000
Total - Construction (with Contractor Markup and Contingency)				$159,000
Engineering, Legal, Administrative (20%)				$32,000
Total				**$191,000**
Water Conservation Rates				
	0	LS	$0	$0
Subtotal				$0
Contingency (0%)				$0
Subtotal - with Contingency				$0
Engineering, Legal, Administrative				$50,000
Total				**$50,000**

Horizontal Collector Well				
Horizontal Collector Well - 5 MGD - with Pumps and House, Installed	1	LS	$3,000,000	$3,000,000
20" Piping	200	LF	$200	$40,000
Piping Tie In	1	LS	$7,000	$7,000
20" Mag Meter	1	EA	$20,000	$20,000
Meter Vault	1	LS	$20,000	$20,000
Replace Well Controls #6, 11, 17	3	EA	$25,000	$75,000
Electrical & Instrumentation (20% of System)	1	LS	$600,000	$600,000
Subtotal				$3,762,000
Contractor Overhead and Profit, General Requirements (15%)				$564,000
Subtotal - Construction (with Contractor Markup)				$4,326,000
Contingency (25%)				$1,082,000
Total - Construction (with Contractor Markup and Contingency)				$5,408,000
Engineering, Legal, Administrative (20%)				$1,082,000
Total				**$6,490,000**
Carbon Dioxide System				
Equipment	1	LS	$370,000	$370,000
Installation (30% of Equip.)	1	LS	$111,000	$111,000
Carbon Dioxide Storage Tank Pad (Footing Included)	27	CY	$800	$22,000
1" Schedule 80 PVC Pipe	271	LF	$14	$4,000
1" Stainless Steel Pipe	145	LF	$46	$7,000
Room Inside Building for Panels (Includes HVAC)	256	SF	$150	$38,000
Electrical & Instrumentation (20% of System)	1	LS	$110,000	$110,000
Additional Fencing	400	LF	$70	$28,000
Civil (10% of System)	1	LS	$65,000	$65,000
Subtotal				$755,000
Contractor Overhead and Profit, General Requirements (15%)				$113,000
Subtotal - Construction (with Contractor Markup)				$868,000
Contingency (25%)				$217,000
Total - Construction (with Contractor Markup and Contingency)				$1,085,000
Engineering, Legal, Administrative (20%)				$217,000
Total				**$1,302,000**

Lime Sludge Improvements				
4" CIPP Liner	254	LF	$100	$25,000
4" DIP	70	LF	$40	$3,000
3" Service Water Line	30	LF	$30	$1,000
4" Cleanouts	10	EA	$1,000	$10,000
4" HDPE inside 8" DIP (Buried)	100	LF	$110	$11,000
4" HDPE (Buried)	1800	LF	$50	$90,000
4" Cleanouts (Buried)	3	EA	$1,200	$4,000
4" Plug Valves	4	EA	$1,000	$4,000
Sludge Pumps	2	EA	$30,000	$60,000
Aerator Drain Line Modifications	1	LS	$5,000	$5,000
Prepare and Paint Existing Piping/Equipment (4" Pipe)	100	LF	$5	$1,000
Replace Softening Basin Internal Equipment	1	LS	$500,000	$500,000
Subtotal				$714,000
Contractor Overhead and Profit, General Requirements (15%)				$107,000
Subtotal - Construction (with Contractor Markup)				$821,000
Contingency (25%)				$205,000
Total - Construction (with Contractor Markup and Contingency)				$1,026,000
Engineering, Legal, Administrative (20%)				$205,000
Total				**$1,231,000**
Lime Sludge Lagoon Decant Discharge to Sanitary Sewer				
5' Diameter Manhole (0-8 feet)	1	EA	$7,000	$7,000
Additional Depth	12	LF	$600	$7,000
8" Piping	70	LF	$80	$6,000
Subtotal				$20,000
Contractor Overhead and Profit, General Requirements (15%)				$3,000
Subtotal - Construction (with Contractor Markup)				$23,000
Contingency (25%)				$6,000
Total - Construction (with Contractor Markup and Contingency)				$29,000
Engineering, Legal, Administrative (20%)				$6,000
Total				**$35,000**

Liquid Ferric Sulfate System				
Demo Existing Ferric Equipment	2	EA	$10,000	$20,000
Ferric Sulfate Feed Skid (includes skid system and metering pumps)	1	LS	$30,000	$30,000
6,000 Gallon Dual Wall Containment Tank	1	LS	$60,000	$60,000
Tank Foundation	12	CY	$800	$10,000
Transfer Pumps (10 gpm at 30')	2	EA	$1,000	$2,000
300 Gallon Day Tank	1	EA	$5,000	$5,000
Tank Scale	1	EA	$4,000	$4,000
Containment	6	yd3	$550	$3,000
Installation (25% of Equip.)	1	LS	$24,000	$24,000
2" Schedule 80 PVC Pipe	500	LF	$20	$10,000
Replace Secondary Basin Equipment with Solids Contact	1	EA	$600,000	$600,000
Electrical & Instrumentation (30% of System)	1	LS	$44,000	$44,000
Subtotal				$812,000
Contractor Overhead and Profit (15%)				$122,000
Subtotal - Construction (with Contractor Markup)				$934,000
Contingency (25%)				$234,000
Total - Construction (with Contractor Markup and Contingency)				$1,168,000
Engineering, Legal, Administrative (20%)				$234,000
Total				**$1,402,000**
Liquid Polymer System				
Demo Existing Polymer Equipment	1	EA	$10,000	$10,000
15 Gallon Dual Wall Containment Tank	1	LS	$1,000	$1,000
Polymer Feed Skid (includes skid system and metering pumps)	1	LS	$25,000	$25,000
Transfer Pumps (1 gpm at 10')	2	EA	$200	$400
Drum Scale with Readout	1	EA	$2,500	$2,500
1" Schedule 80 PVC Pipe	500	LF	$14	$7,000
Installation (25% of Equip.)	1	LS	$7,000	$7,000
Containment	6	yd3	$550	$3,000
Electrical & Instrumentation (30% of System)	1	LS	$11,000	$11,000
Subtotal				$67,000
Contractor Overhead and Profit, General Requirements (15%)				$10,000
Subtotal - Construction (with Contractor Markup)				$77,000
Contingency (25%)				$19,000
Total - Construction (with Contractor Markup and Contingency)				$96,000
Engineering, Legal, Administrative (20%)				$19,000
Total				**$115,000**

Liquid Fluoride Feed System				
Demo Existing Feed Equipment	1	EA	$10,000	$10,000
10 Gallon Dual Wall Containment Tank	1	LS	$1,000	$1,000
Feed Skid (includes skid system and metering pumps)	1	LS	$25,000	$25,000
Transfer Pumps (1 gpm at 10')	2	EA	$200	$400
Drum Scale with Readout	1	EA	$2,500	$2,500
1" Schedule 80 PVC Pipe	500	LF	$14	$7,000
Installation (25% of Equip.)	1	LS	$7,000	$7,000
Containment	6	yd3	$550	$3,000
Electrical & Instrumentation (30% of System)	1	LS	$11,000	$11,000
Subtotal				$67,000
Contractor Overhead and Profit, General Requirements (15%)				$10,000
Subtotal - Construction (with Contractor Markup)				$77,000
Contingency (25%)				$19,000
Total - Construction (with Contractor Markup and Contingency)				$96,000
Engineering, Legal, Administrative (20%)				$19,000
Total				**$115,000**
Lime Silo Improvements				
4" Steel Piping, Schedule 40, Grooved Joint	400	LF	$60	$24,000
4" Chrome Alloy Fittings	8	EA	$2,000	$16,000
Replace Dust Collector Filter Media	1	LS	$10,000	$10,000
Installation (25%)	1	LS	$12,000	$12,000
Walkway Grating	140	SF	$35	$5,000
Walkway Supports	1	LS	$10,000	$10,000
Subtotal				$77,000
Contractor Overhead and Profit, General Requirements (15%)				$12,000
Subtotal - Construction (with Contractor Markup)				$89,000
Contingency (25%)				$22,000
Total - Construction (with Contractor Markup and Contingency)				$111,000
Engineering, Legal, Administrative (20%)				$22,000
Total				**$133,000**
Chemical Containment				
Chemical Containment	6	EA	$3,000	$18,000
Subtotal				$18,000
Contractor Overhead and Profit, General Requirements (15%)				$3,000
Subtotal - Construction (with Contractor Markup)				$21,000
Contingency (25%)				$5,000
Total - Construction (with Contractor Markup and Contingency)				$26,000
Engineering, Legal, Administrative (20%)				$5,000
Total				**$31,000**

Filter Effluent Turbidimeters				
Turbidimeters (Individual and Combined)	5	EA	$900	$5,000
Controllers	3	EA	$1,000	$3,000
Transfer Pump Sonar Backup Controls	1	LS	$5,000	$5,000
Installation (50% of Equip.)	1	LS	$4,000	$4,000
Electrical & Instrumentation (30% of System)	1	LS	$2,000	$2,000
Subtotal				$19,000
Contractor Overhead and Profit, General Requirements (15%)				$3,000
Subtotal - Construction (with Contractor Markup)				$22,000
Contingency (25%)				$6,000
Total - Construction (with Contractor Markup and Contingency)				$28,000
Engineering, Legal, Administrative (20%)				$6,000
Total				**$34,000**
Filter Media Replacement				
Filter Media Replacement, Installed	4	EA	$41,000	$164,000
Subtotal				$164,000
Contractor Overhead and Profit, General Requirements (15%)				$25,000
Subtotal - Construction (with Contractor Markup)				$189,000
Contingency (25%)				$47,000
Total - Construction (with Contractor Markup and Contingency)				$236,000
Engineering, Legal, Administrative (20%)				$47,000
Total				**$283,000**
Liquid Ammonium Sulfate Feed System				
Chemical Feed Equipment (Pump Skid) with Day Tank, Scale	1	LS	$40,000	$40,000
Tank Scale	1	LS	$3,000	$3,000
Transfer Pumps (5 gpm at 10')	2	EA	$500	$1,000
70 Gallon Dual Wall Containment Tank	1	LS	$1,500	$2,000
Installation (25% of Equip.)	1	LS	$12,000	$12,000
Containment	6	yd3	$550	$3,000
1/2" PVC Tubing	170	LF	$5	$1,000
2" Schedule 80 PVC Pipe	170	LF	$20	$3,000
Injection Quill	1	EA	$1,000	$1,000
Chlorine Analyzer	2	LS	$7,000	$14,000
Ammonia Analyzer with Sample Piping	1	LS	$25,000	$25,000
Electrical & Instrumentation (30% of System)	1	LS	$32,000	$32,000
Subtotal				$137,000
Contractor Overhead and Profit, General Requirements (15%)				$21,000
Subtotal - Construction (with Contractor Markup)				$158,000
Contingency (25%)				$40,000
Total - Construction (with Contractor Markup and Contingency)				$198,000
Engineering, Legal, Administrative (20%)				$40,000
Total				**$238,000**

Chlorine Gas Feed System Improvements				
Actuator Equipment	1	LS	$20,000	$20,000
Vacuum Regulator and Automatic Switchover	1	LS	$12,000	$12,000
Installation (25% of Equip.)	1	LS	$8,000	$8,000
1" Schedule 80 PVC Pipe	80	LF	$14	$2,000
Electrical & Instrumentation (30% of System)	1	LS	$13,000	$13,000
Subtotal				$55,000
Contractor Overhead and Profit, General Requirements (15%)				$8,000
Subtotal - Construction (with Contractor Markup)				$63,000
Contingency (25%)				$16,000
Total - Construction (with Contractor Markup and Contingency)				$79,000
Engineering, Legal, Administrative (30%)				$24,000
Total				**$103,000**
High and Low Service Pump Station Upgrades - Replace at 480V				
Low Service Pumps	3	EA	$40,000	$120,000
High Service Pumps	3	EA	$60,000	$180,000
Motor Control Lineup (480V) / Soft Starters	6	EA	$10,000	$60,000
480V Switchgear	1	LS	$125,000	$125,000
Installation (25% of System)	1	LS	$121,000	$121,000
Piping Allowance (20%)	1	LS	$60,000	$60,000
Electrical & Instrumentation (20% of System)	1	LS	$97,000	$97,000
Subtotal				$763,000
Contractor Overhead and Profit, General Requirements (15%)				$114,000
Subtotal - Construction (with Contractor Markup)				$877,000
Contingency (25%)				$219,000
Total - Construction (with Contractor Markup and Contingency)				$1,096,000
Engineering, Legal, Administrative (20%)				$219,000
Total				**$1,315,000**
Transfer Pump Replacement				
Pumps	3	EA	$35,000	$105,000
Installation (25% of System)	1	LS	$26,000	$26,000
Piping Allowance (20%)	1	LS	$21,000	$21,000
Electrical & Instrumentation (20% of System)	1	LS	$21,000	$21,000
Subtotal				$173,000
Contractor Overhead and Profit, General Requirements (15%)				$26,000
Subtotal - Construction (with Contractor Markup)				$199,000
Contingency (25%)				$50,000
Total - Construction (with Contractor Markup and Contingency)				$249,000
Engineering, Legal, Administrative (20%)				$50,000
Total				**$299,000**

High Service Pressure Zone Storage				
Elevated Storage Tank - 0.5 MG (Includes Site Work, Electrical)	1	LS	$1,304,000	$1,304,000
Subtotal				$1,304,000
Contractor Overhead and Profit, General Requirements (15%)				$196,000
Subtotal - Construction (with Contractor Markup)				$1,500,000
Contingency (25%)				$375,000
Total - Construction (with Contractor Markup and Contingency)				$1,875,000
Engineering, Legal, Administrative (20%)				$375,000
Total				**$2,250,000**
Existing Ground Storage Clearwell Improvements				
Tideflex Mixing System	1	LS	$60,000	$60,000
Installation (25%)	1	LS	$15,000	$15,000
Sandblast and Paint Exterior of Tank, with Containment for Lead Paint	15000	SF	$18	$270,000
Sandblast and Paint Interior of Tank, with Containment for Lead Paint	13000	SF	$9	$117,000
New Drainage Hydrant	1	LS	$10,000	$10,000
Temporary Storage Facilities (2 Months)	1	LS	$70,000	$70,000
Subtotal				$542,000
Contractor Overhead and Profit, General Requirements (15%)				$81,000
Subtotal - Construction (with Contractor Markup)				$623,000
Contingency (25%)				$156,000
Total - Construction (with Contractor Markup and Contingency)				$779,000
Engineering, Legal, Administrative (20%)				$156,000
Total				**$935,000**
Additional Ground Storage Clearwell				
1 MG Prestressed Concrete Tank	1	LS	$667,000	$667,000
Appurtenances - Allowance	1	LS	$200,000	$200,000
Piping Allowance (25%)	1	LS	$167,000	$167,000
Site Work (10%)	1	LS	$103,000	$103,000
Electrical/Instrumentation (20%)	1	LS	$207,000	$207,000
Subtotal				$1,344,000
Contractor Overhead and Profit, General Requirements (15%)				$202,000
Subtotal - Construction (with Contractor Markup)				$1,546,000
Contingency (25%)				$387,000
Total - Construction (with Contractor Markup and Contingency)				$1,933,000
Engineering, Legal, Administrative (20%)				$387,000
Total				**$2,320,000**

Secondary Power Feed (480V)				
Second Utility Feed to Plant and Wells	1	LS	$210,000	$210,000
Subtotal				$210,000
Contractor Overhead and Profit, General Requirements (0%)				$0
Subtotal - Construction (with Contractor Markup)				$210,000
Contingency (25%)				$53,000
Total - Construction (with Contractor Markup and Contingency)				$263,000
Engineering, Legal, Administrative (20%)				$53,000
Total				**$316,000**
SCADA/Well Controls				
SCADA	1	LS	$275,000	$275,000
Installation	1	LS	$83,000	$83,000
Replace Well Controls	5	EA	$25,000	$125,000
Subtotal				$483,000
Contractor Overhead and Profit, General Requirements (15%)				$72,000
Subtotal - Construction (with Contractor Markup)				$555,000
Contingency (25%)				$139,000
Total - Construction (with Contractor Markup and Contingency)				$694,000
Engineering, Legal, Administrative (20%)				$139,000
Total				**$833,000**
Clean Piping and Basin Weirs of Deposition				
Cleaning of Piping	1	LS	$15,000	$15,000
Cleaning of Weirs - Primary Basins	1	LS	$20,000	$20,000
Cleaning of Weirs - Secondary Basins	1	LS	$20,000	$20,000
Subtotal				$55,000
Bonds, Mobilization, OH&P (15%)				$8,000
Subtotal - Construction (with Contractor Markup)				$63,000
Contingency (25%)				$16,000
Total - Construction (with Contractor Markup and Contingency)				$79,000
Engineering, Legal, Administrative (20%)				$16,000
Total				**$95,000**

Paint Plant Pipe and Equipment				
Painting - 36" Pipe (Inside Building)	70	LF	$80	$6,000
Painting - 24" Pipe (Inside Building)	275	LF	$38	$10,000
Painting - 14" - 18" Pipe (Inside Building)	80	LF	$20	$2,000
Painting - Other	1	LS	$15,000	$15,000
Painting - Wells	9	EA	$3,000	$27,000
Subtotal				$60,000
Bonds, Mobilization, OH&P (15%)				$9,000
Subtotal - Construction (with Contractor Markup)				$69,000
Contingency (25%)				$17,000
Total - Construction (with Contractor Markup and Contingency)				$86,000
Engineering, Legal, Administrative (20%)				$17,000
Total				**$103,000**
Roof and Skylight Replacement				
Skylight Removal	33	EA	$100	$3,000
Replace EPDM Roof Membrane	120	100 ft^2	$1,900	$228,000
Skylights	33	EA	$50	$2,000
Skylight Safety Screens	33	EA	$500	$17,000
Guardrail (around Lime Silos)	120	LF	$175	$21,000
Subtotal				$271,000
Contractor Overhead and Profit, General Requirements (15%)				$41,000
Subtotal - Construction (with Contractor Markup)				$312,000
Contingency (25%)				$78,000
Total - Construction (with Contractor Markup and Contingency)				$390,000
Engineering, Legal, Administrative (20%)				$78,000
Total				**$468,000**
HVAC				
HVAC - Phase I	1	LS	$112,000	$112,000
HVAC - Phase II	1	LS	$91,000	$91,000
Subtotal				$203,000
Contractor Overhead and Profit, General Requirements (15%)				$30,000
Subtotal - Construction (with Contractor Markup)				$233,000
Contingency (25%)				$58,000
Total - Construction (with Contractor Markup and Contingency)				$291,000
Engineering, Legal, Administrative (20%)				$58,000
Total				**$349,000**

Re-Pave Plant Access Road				
Site Pavement Demolition	2,700	yd^2	$10	$27,000
Site Pavement Resurface	2,700	yd^2	$55	$149,000
Pavement Curbing	1,600	lf	$20	$32,000
Subtotal				$208,000
Contractor Overhead and Profit, General Requirements (15%)				$31,000
Subtotal - Construction (with Contractor Markup)				$239,000
Contingency (25%)				$60,000
Total - Construction (with Contractor Markup and Contingency)				$299,000
Engineering, Legal, Administrative (20%)				$60,000
Total				**$359,000**
Well Field Access Road				
6" Compacted Subgrade	2,500	yd3	$10	$25,000
8" Gravel Course	4,530	Tons	$20	$91,000
Subtotal				$116,000
Contractor Overhead and Profit, General Requirements (15%)				$17,000
Subtotal - Construction (with Contractor Markup)				$133,000
Contingency (25%)				$33,000
Total - Construction (with Contractor Markup and Contingency)				$166,000
Engineering, Legal, Administrative (20%)				$33,000
Total				**$199,000**
Bulk Water Station				
Packaged Bulk Water Station - 3" Single Feed	1	LS	$50,000	$50,000
Civil Site Work (30%)	1	LS	$15,000	$15,000
Electrical Work (20%)	1	LS	$10,000	$10,000
Subtotal				$75,000
Contractor Overhead and Profit, General Requirements (15%)				$11,000
Subtotal - Construction (with Contractor Markup)				$86,000
Contingency (25%)				$22,000
Total - Construction (with Contractor Markup and Contingency)				$108,000
Engineering, Legal, Administrative (20%)				$22,000
Total				**$130,000**
Water Distribution System Meters				
Project Cost (from City)	1	LS	$3,600,000	$3,600,000
Total				**$3,600,000**
Water Distribution System Sample Stations				
Project Cost (from City)	1	LS	$108,000	$108,000
Total				**$108,000**
Spruce Street Booster Pump Station				
Project Cost (from 2007 Water Master Plan with Cost Index Factor of 1.24)	1	LS	$521,000	$521,000
Total				**$521,000**

Storage Tank Inspections				
Project Cost (from City)	1	LS	$80,000	$80,000
Total				**$80,000**

Appendix B

Coagulation Chemical Options

Alum

Aluminum sulfate, commonly referred to as 'alum', is used in water treatment for coagulation. It is one of the most commonly used coagulants in potable water treatment. Alum is usually provided in two basic forms in water treatment; dry and liquid. Feeding dry alum requires a gravimetric or volumetric feeder and a solution tank. The dry chemical is fed into a solution tank immediately below the feeder where it is diluted before being fed to the application point. This dilution of dry alum must be carefully controlled. Too much dilution of the alum solution may cause the alum to lose its coagulating efficiency. Adding too little water can result in incomplete dissolution of the dry alum in the solution tank. The liquid form of alum, which is normally about 50 percent alum by weight, is a clear amber or green liquid. Often the liquid alum is diluted with carrier water to aid in moving the chemical through the piping system and dispersing the alum into the process stream. The dosage range is highly dependent on the individual water quality and treatment goals.

Advantages

- Most effective at a pH range of 6.5 to 7.5.

Disadvantages

- Alum adds dissolved solids (salts) to the water.
- Alum reacts over a limited pH range.

Ferric Sulfate

Ferric sulfate is used as a primary coagulant to assist in removing both suspended and dissolved material in the water. Ferric sulfate is available in powder and liquid forms, with liquid being the most common. Liquid ferric sulfate is a reddish brown colored liquid, normally 50% ferric sulfate by weight. The dosage of ferric sulfate is highly dependent on water quality and finished water quality goals.

Advantages

- Ferric sulfate is effective between the pH range of 4-6 and 8-9.
- Ferric sulfate is very effective in purifying high turbidity water; hence requires low dosages for the treatment.

Disadvantages

- Ferric sulfate adds dissolved solids (salts) to water.
- Ferric sulfate is very corrosive and difficult to handle. However, ferric sulfate is less corrosive and difficult to handle than ferric chloride, which will not be considered here.

Polymer

Polymers are long chained molecules which are used to enhance coagulation and flocculation. Polymers are available in positively charged (cationic), negatively charged (anionic) or neutral charge (nonionic). Polymers have several different applications in potable water treatment such as:

- Coagulation aid
- Flocculation aid
- Filtration aid
- Sludge conditioning

As a coagulation aid and flocculation aid, polymer is added with the coagulant to help build larger, heavier floc particles during flocculation. The large floc particles will allow better removal of particles in the water leading to lower effluent turbidities. .

Polymers come in either dry powder or liquid form. Dry polymer can be provided in either bags or drums. Liquid polymer is provided in 55 gallon drums or totes and is fed in neat form with dilution water to the point of application. Liquid polymer is more commonly used due to its ease of handling when compared to dry polymers.

Polymer dosages for flocculation aid in water treatment usually vary over a small range even under various settling conditions and types of polymer. The common dosage range for softening/blending basins is 0.1 to 3.0 mg/L. There are many different types of polymers available. Several polymer manufacturers should be consulted and jar testing conducted before final selection of a polymer.

Advantages

- When used as a coagulation and flocculation aid, polymers are effective over a wider pH range than inorganic coagulants.
- When used as a coagulation and flocculation aid, polymers can be applied in lower doses and they do not consume alkalinity.

Disadvantages

- Polymers are significantly more expensive than inorganic coagulants.
- Selection of the proper polymer for the application requires considerable jar testing under simulated plant conditions, followed by pilot or plant scale trials.
- Liquid polymers can be very slippery if spilled, requiring special consideration in the design of appurtenant facilities.

Chloramination Chemical Options

Anhydrous Ammonia

Anhydrous ammonia is available as a colorless gas with a very pungent odor. At normal pressures and temperatures it is a gas but is easily liquefied under pressure; therefore, anhydrous ammonia is commonly stored and transported as a liquid in pressure vessels similar to chlorine. It comes in container sizes from 150 pound cylinders to 50,000 pound rail-tank cars.

Anhydrous ammonia is applied to the process stream by using an ammoniator. An ammoniator is a modular unit with a pressure reducing valve, gas flow meter, feed rate control valve, and miscellaneous piping to control the flow of ammonia.

Anhydrous ammonia can be fed by two methods: direct feed and solution feed. The direct feed method is typically used when the process stream has a low pressure and the maximum ammonia feed rate is less than 1,000 pounds per day. Ammonia is drawn from the high-pressure storage tank, then the pressure is reduced by pressure reducing valve to approximately 40 psi. The ammoniator then feeds the ammonia to the process stream at 15 psi.

The solution feed method is similar to a chlorine vacuum feed system. The pressure in the supply tank is reduced by a pressure reducing valve to create a vacuum. An eductor is used to withdraw ammonia from the ammoniator. The ammonia is then combined with a softened side water stream and pumped into the process stream. The side water stream must be softened to avoid precipitating calcium and magnesium that plugs the eductor and the application point.

Advantages:

- Operator familiarity with gas feed systems (chlorine gas currently implemented at the plant)
- Least expensive in terms of chemical cost

Disadvantages:

- Requires construction of a room within the existing building or a separate building for storage of ammonia cylinders
- A separate room is required for the ammonia feed equipment
- Hazardous material requires risk management planning (NFPA Hazard Rating – Health = 3)
- Risk of theft (ammonia gas can be used in the manufacture of methamphetamine)

Aqueous (Aqua) Ammonia

Aqua ammonia is a safer alternative compared to anhydrous ammonia. It is produced by dissolving anhydrous ammonia into deionized or softened water. It is delivered and stored in liquid form, making it easier to feed. It is available in 19 – 30% strength solutions and in 55 gallon drums.

Aqua ammonia is typically stored on site in low pressure steel or fiberglass tanks. Warm temperatures will cause the ammonia gas to vaporize (off-gassing); off-gassing reduces the strength of the aqua ammonia and may require more ammonia to be fed to achieve the desired chloramine residual. A separate corrosion-resistant ventilation system is required to capture mist or fumes and vent them to the outside of the building; therefore a separate building or construction of a separate room within the existing building is required. The aqua ammonia is fed to the application point via chemical metering pumps such as positive displacement or progressive cavity type metering pumps.

Advantages:

- Liquid form is easier and safer to handle than anhydrous ammonia
- Simple feed system with storage tank and chemical feed pumps

Disadvantages:

- Off-gassing during warmer temperatures reduces strength of solution requiring more liquid to be fed
- Ammonia vapors resulting from off-gassing are toxic (ammonia vapors have NFPA Hazard Rating – Health = 3)

<u>Liquid Ammonium Sulfate</u>

Liquid ammonium sulfate (LAS) is gaining in popularity and can be stored in bulk tanks and injected at the appropriate points using typical metering pumps. LAS is available in 55 gallon drums, 275 gallon totes, and larger bulk quantities.

Advantages:

- Liquid is easy to handle
- Simple feed system with storage tank and chemical feed pumps
- Does not require specialized HVAC
- Chemical storage and feed equipment can be housed in the same room
- Non-hazardous and does not require a risk management plan (NFPA Hazard Rating – Health = 1)
- Least expensive in terms of capital costs

Disadvantages:

- Most expensive in terms of chemical costs

Appendix C

K&E 17 0153 4-75 MC 3628

PRIMARY BASIN NO. 1

PRIMARY BASIN NO. 2

STOP PLATE DETAILS
Scale: 1½" = 1'-0"

LIME TROUGH SUPPORT
Scale: ½" = 1'-0"

SECTION
Scale: 3/8" = 1'-0"

LIME TROUGH DETAILS
Scale: 1½" = 1'-0"

CHEMICAL FEED FLOOR PLAN-ELEV. 1085.00
Scale: ¼" = 1'-0"

DETAIL F
Scale: 1½" = 1'-0"

Ammonium Sulfate Storage and Feed System

Polymer Storage and Feed System

Fluoride Storage and Feed System

REMOVE existing Flouride Feed System

REMOVE existing Ferric Sulfate Storage and Feed System

REMOVE existing Polymer Storage and Feed System

6 x 275 gal. Tote Tanks

Transfer Pump

70 gal. Day Tank w/ Scale

Chemical Feed Pumps

1 x 275 gal. Tote Tank

10 gal. Day Tank w/ Scale

CONTRACT NO. 4 CITY PROJECT NO. 86203

JUNCTION CITY, KANSAS
WATER WORKS IMPROVEMENTS

CHEMICAL AND FILTER BUILDING
CHEMICAL FEED FLOOR PLAN

BLACK & VEATCH
CONSULTING ENGINEERS, KANSAS CITY, MO.

DESIGNED KDJ, WTF CHECKED FHM, JLW, PJD
DETAILED WND, ACW, CWB APPROVED
DATE 5-12-76

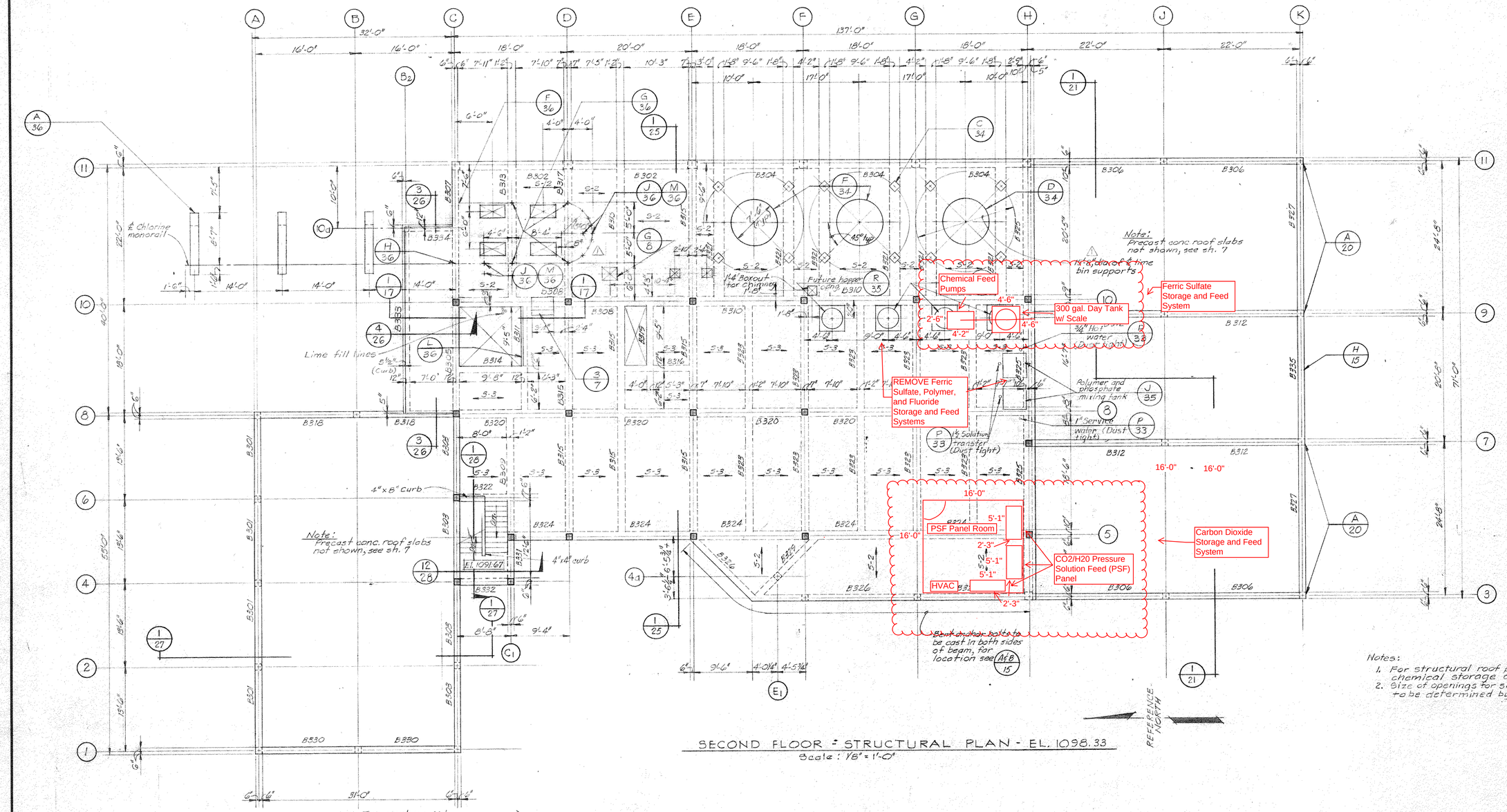
SHEET 31 OF 69

NO.	DATE	REVISION	BY	CHK'D
1	11-26-80	Conformed To Construction Records	TLL	PJD

JOHN H. ROBINSON LICENSED 3789 KANSAS PROFESSIONAL ENGINEER

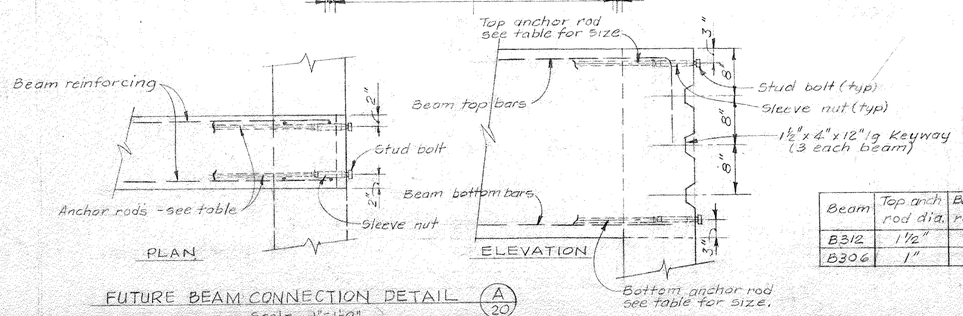
PROJECT 6292

K&E 17 0153 6-75 MC 3628



SECOND FLOOR - STRUCTURAL PLAN - EL. 1098.33

Scale: 1/8" = 1'-0"



Beam	Top anch rod dia.	Bott. anch rod dia.	Top rod length	Bott. rod length
B312	1½"	1¼"	8'-0"	6'-8"
B306	1"	⅞"	4'-2"	3'-2"

FUTURE BEAM CONNECTION DETAIL (A/20)

Scale 1" = 1'-0"

Notes:
1. For structural roof plan over second floor chemical storage area see sheet 8.
2. Size of openings for skylights and roof ventilators to be determined by equipment furnished.

NO.	DATE	REVISION	BY	CHK'D
1	11-25-80	Conformed To Construction Records	TLL	PJD

JOHN H. ROBINSON LICENSED 3789 KANSAS PROFESSIONAL ENGINEER

CONTRACT NO. 4 CITY PROJECT NO. 86203

JUNCTION CITY, KANSAS
WATER WORKS IMPROVEMENTS

CHEMICAL AND FILTER BUILDING SECOND FLOOR - STRUCTURAL PLAN

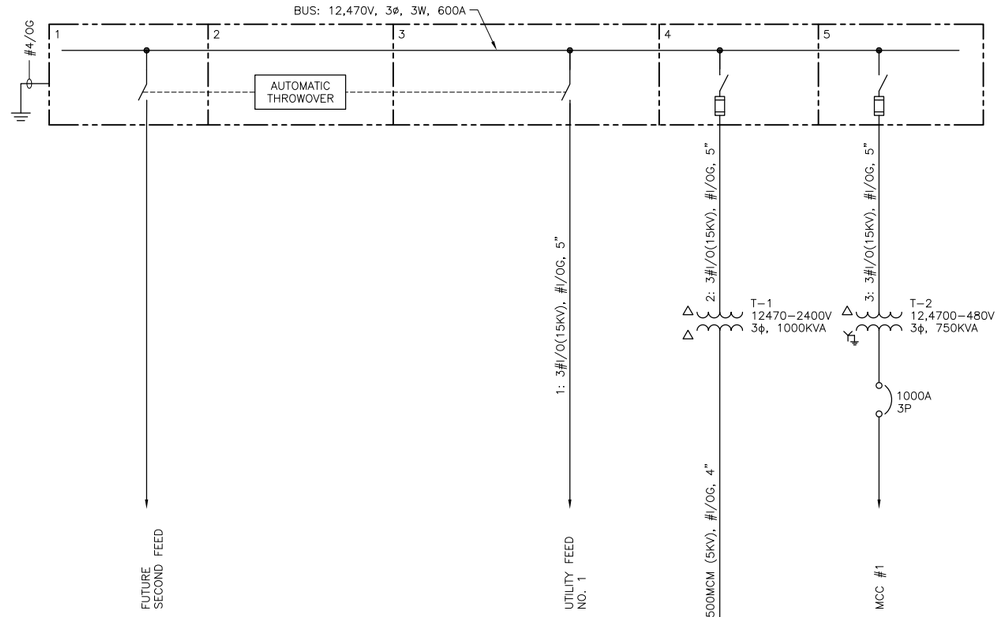
BLACK & VEATCH
CONSULTING ENGINEERS, KANSAS CITY, MO.

DESIGNED KDJ, RDR CHECKED JLW, PJD
DETAILED WTF, CWS APPROVED
DATE 5-15-76

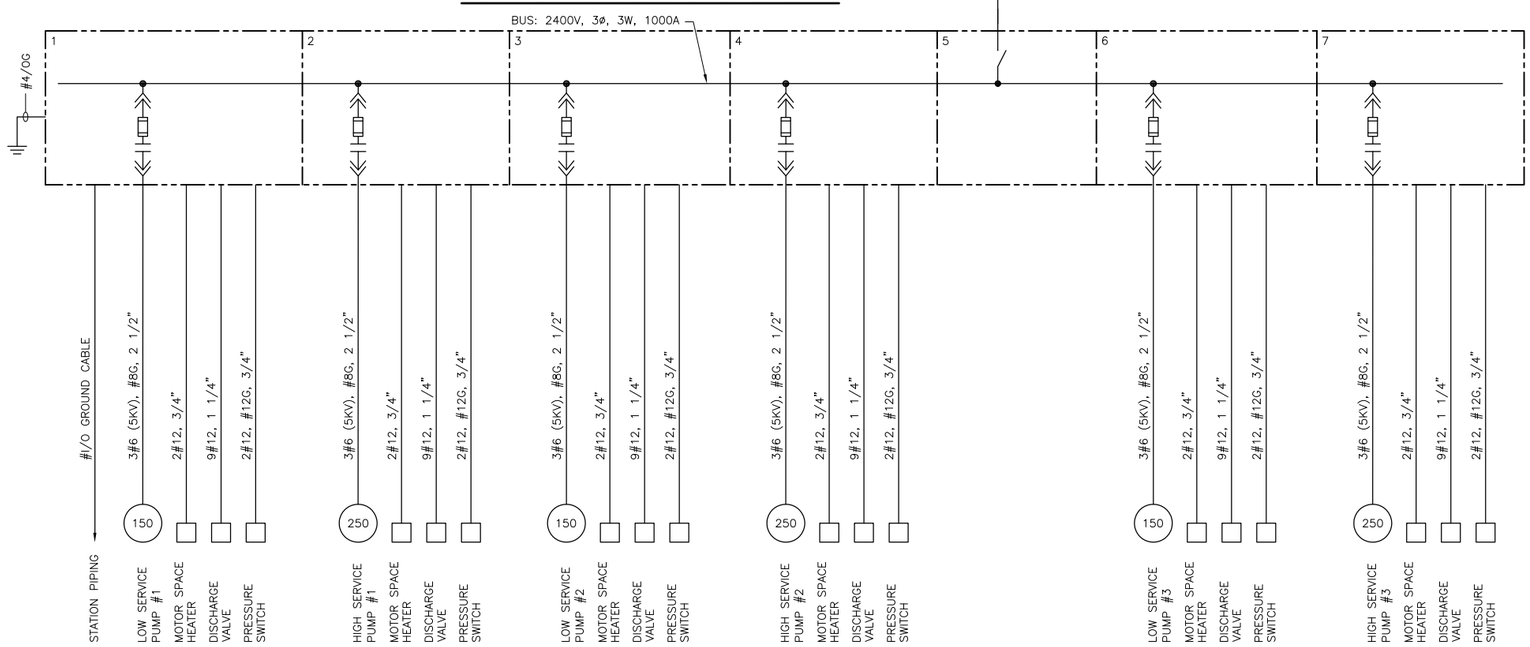
SHEET 20 OF 69

PROJECT 6792

Appendix D



15KV SWITCHGEAR ONE-LINE



2400 VOLT MOTOR CONTROL LINE-UP ONE-LINE

HDR

HDR Engineering, Inc.
MO STATE CERTIFICATE OF AUTHORITY #000856
3741 NE Troon Drive
Lee's Summit, Mo. 64064-1988
(816) 347-1100

PROJECT MANAGER	DON LINDEMAN
PROCESS	LORRIE HILL

City of Junction City, Kansas

Water Treatment Plant Engineering Report

GENERAL ONE-LINE DIAGRAM

APPENDIX D

DRAWING: APPENDIX D.dwg DATE: Oct 30, 2013 - 4:15PM

Appendix E

HDR Engineering

4435 Main St. Suite 1000

Kansas City, MO 64111

Attn: Kathy Buechler

Transformer Recondition and Transformer Rental

We have included all labor, materials, and tools necessary for completion of the electrical work as described herein, for the sum of:

$24,506.00

(Twenty Four Thousand & Five Hundred and Six Dollars & Zero Cents)

Scope of Repair

Repair Procedures:
1) Electrically Test the transformer.
2) Inspect and test core and coil for damage, and untank unit if needed
3) Inspect the core for damage and inadvertent core grounds.
4) Regasket all tank openings with new neoprene gaskets.
5) Vacuum process while filling with hot oil.
6) Complete testing of the transformer.
7) Completely sand and prep tank before painting.
8) The tank will then be primed and painted with acrylic enamel paint.

.

Standard Tests: Turn Ratio Test Megohm Insulation Test Resistance Tests
Excitation Test No-Load Losses Full-Load Losses
Impedance Induced Potential Applied Potential
Doble Power Factor

Test

Customer Witness: No
Testing: Standard

Accessories

Temp Gauge: Unsure
Liquid Level Gauge: Unsure
PVG: Unsure
PRD: Unsure
Drain & Sample Valve:Reuse
Winding Temp: Unsure
Gauge RPRD: Unsure
Seal In-Relay: Unsure
Control Cabinet: Unsure

General Notes:

We will check all gauges and accessories and advise if anything

Nameplate Data*:*

Specifications:

KVA: 1000
Phase: 3
Frequency: 60
HV: 12470 D
LV: 2400 D
Class: OA/FA
Fluid: New Mineral Oil - Type II
Deg rise: 65
Taps: 2-1/2% above and
Below Nominal
Imp: 5.8
Enclosure: Outdoor
Conductor: Aluminum
Wt.: 6900 Lbs.
S/N: gm-249069
Paint: ASA 70 Light Gray

Rental - 1500 kVA Substation Transformer HV: 13200 D LV: 2400 D

Specifications

HV CONDUCTOR: Copper
LV CONDUCTOR: Copper
TAPS: 13860 13530 13200 12870 12540
PHASE: 3
FREQUENCY: 60 HZ
DEGREE RISE: 65
CLASS: ONAN
IMPEDANCE: 6.62
LIQUID: oil
MANUFACTURER: Alstom
OEM SERIAL: PEI-1044
STOCK NO: SUB1099
HV BUSHINGS: Qty: 3, Style: EYEBOLT, Location: Side ANSI 2, Termination: ATC
LV BUSHINGS: Qty: 3, Style: 2-HOLE, Location: Side ANSI 4, Termination: ATC

Accessories

Upper filter press connection
Dial type thermometer
Liquid level gauge
Pressure vacuum gauge
Pressure relief device
Drain and sample valve

Dimensions:

H: 81.5 in. W: 99 in. D: 76 in.

Weight:

10920 lbs 429 gal.

General Conditions/Clarifications:

The beliefs stated below further explain the conditions under which this project is quoted and would be installed. All work accomplished will be based on these stipulations.

1. If additional damage is found during the initial inspection, we will discontinue the repair process. You will then be informed as to the extent of the additional damage and our recommendation for repair.
2. Work to be performed during normal working hours (7:00a.m. to 5:00 p.m., Monday through Friday) Actual dates to be designated by agreement with GC/Lynn Electric.
3. Pricing is effective for 30 days
4. Estimate is subject to change based on market fluctuations of wire and conduit pricing after effective quote date has elapsed.
5. LE will make every effort to provide demolition and installation that does not damage any existing surface; however LE will not be responsible for any damages to surfaces needed to complete demolition and installation.
6. LE will not be held liable for errors or omissions in design by others, nor inadequacies of materials and equipment specified or supplied by others.
7. You agree to be responsible for any applicable taxes on the services and/or materials provided.
8. One year warranty period begins upon final completion of project.
9. Equipment and materials, supplied by others are warranted only to the extent that the same are warranted by the manufacturer.

Please call if you have further questions,

Sincerely,

Jeff White

Electrical Systems Consultant

Lynn Electric, Inc.

Tegg Service

Office: 785-843-5079

Fax: 785-749-5810

Cell: 913-238-1149

Appendix F

Junction City, KS 12/20/2013
WTP Improvements
Generator Load Sequencing

STEP	AREA	LOAD	Volts (V)	Connected KVA	Connected HP	Connected Amps
1	**BUILDING LOADS:**	Lighting Panel FP Transformer	480	37.5		78
		Lighting Panel L1 Transformer	480	37.5		78
		Lighting Panel L2 Transformer	480	25		52
		Lighting Panel L3 Transformer	480	37.5		78
		Electric Boiler	480	240		289
		AHU-1	480		5	7.6
		HWP#1	480		7.5	11
		AHU-2	480		3	4.8
		AHU-3	480		2	3.4
		AHU-4	480		15	21
		F-1	480		0.5	1.1
		F-3	480		3	4.8
		F-4	480		1	2.1
		PRV-1	480		2	3.4
2	**AIR COMPRESSOR:**	Air Compressor No. 1	480		10	14
		Air Compressor No. 2	480		10	14
3A	**BASINS:**	Primary Basin Collector Drive	480		0.75	1.1
		Primary Basin Mixer No. 1	480		1.5	7.6
		Primary Basin Mixer No. 2	480		1.5	7.6
3B		Aerator No. 1	480		1.5	3
		Aerator No. 2	480		1.5	3
		Aerator No. 3	480		1.5	3
3C		Secondary Basin Collector Drive	480		0.5	1.1
		Secondary Basin Mixer No. 1	480		5	7.6
		Secondary Basin Mixer No. 2	480		5	7.6
3D		Sludge Return Pump	480		5	7.6
		Rapid Mixer	480		7.5	11
		Washwater Recovery Pump	480		7.5	11
4	**TRANSFER PUMP:**	Transfer Pump	480		60	77
5	**SERVICE PUMP:**	High Service Pump	2400		250	59
6	**SERVICE PUMP:**	Low Service Pump	2400		150	35
7	**OTHER:**	Lime Feeder #1	480		2	3.1
		Scour Blower	480		65	65

Junction City

HDR

3741 NE Troon Drive
Lee's Summit, MO 64064
816-347-1100 Ph
816-347-1197 Fx

www.hdrinc.com