Town of Wadena

Waterworks System Assessment

FINAL REV 2

KGS Group 15-1950-001
July 2016

Prepared By

Ashref Darbi, Ph.D., P.Eng.
Environmental Engineer

Reviewed By

Sean Bayer, M.Eng., P.Eng., PMP
Assistant Department Head
Environmental Services, Municipal Group

Approved By

Bruce McLeod, M.Sc., P.Eng.
Department Head
Environmental Services

KGS Group
Regina, Saskatchewan

KGS GROUP
CONSULTING ENGINEERS

ADDENDUM NO. 1

PROJECT: Town of Wadena
Waterworks System Assessment

DATE: January 23, 2017

PROJECT NO: 15-1950-001

The third paragraph of Page 24 should read as follows:

As the source is groundwater, virus inactivation requirements are the limiting constraint for groundwater sources. CT calculations for this system were based on a peak hourly flow of 1,122 L/min, pH of 7.5, temperature of 5ºC, and a baffle factor of 0.3 for the clear well. The system is meeting the CT requirement if the clear well is full and the free chlorine concentration is at an average of 0.15 mg/L. The system also meets the CT requirement if the reservoir is half full and the free chlorine concentration is in the range of 0.3 mg/L.

Distribution:

Kelly Dodd, Administrator, Town of Wadena
Rick Sheichuk, EPO, Water Security Agency

TABLE OF CONTENTS

PAGE

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 BACKGROUND AND GENERAL OVERVIEW

Section 32 of *The Waterworks and Sewage Works Regulations* requires that the owner of a waterworks system, supplying water intended or used for human consumptive use, conduct a Waterworks System Assessment (WSA) once every five years beginning in 2005. The Round 2 WSA for the Town of Wadena was completed by Kontzamanis, Graumann, Smith, MacMillan Inc. (KGS Group) in early 2011. KGS Group has again been retained by the Town of Wadena to complete the Round 3 WSA in compliance with Section 32.

The Town of Wadena is located east of Saskatoon, north of Fort Qu'Appelle and north-west of Yorkton on the eastern shore of the Quill Lakes.

The Town of Wadena currently has a population of approximately 1,306 residents, as obtained from Statistics Canada 2011 census information which is virtually identical to the reported population of 1,315 from the 2006 census. Based on this information and for the purposes of this assessment, KGS Group will use a generally flat growth trend for this community with a total projected future population of 1,315 people.

KGS Group completed a site investigation on September 11, 2015 with the co-operation of the Town of Wadena. Sean Bayer, P. Eng. (KGS Group), and Dave Clark of Dave Clark Water Consulting as well as Water Treatment Plant Operators Jason Foster and Garrett Cull were present for the site visit.

2.0 REVIEW OF AVAILABLE INFORMATION

2.1 PREVIOUS WSA REPORT RECOMMENDATIONS

The previous WSA report was completed in early 2011 by KGS Group Consulting Engineers. Identified issues, risks and recommendations from the previous assessment are summarized in the following table.

TABLE 1
2010 WSA RECOMMENDATIONS

2010 WSA RECOMMENDATIONS	STATUS
IMMEDIATE ISSUES AND RISKS	
GUDI screening study	Incomplete
Optimizing manganese removal	Complete
Reservoir access hatch upgrade	Complete

2.2 WATER SUPPLY SYSTEM

The Town of Wadena water treatment plant currently receives raw water from two supply wells located approximately 6 km (3.7 mi) south of town. The supply wells that are in use are numbered 4 and 6. Well 1, 2 and 3 have been decommissioned since 2010 and at the time of inspection Well # 5 required repair due to reported cavitations and therefore its use has been discontinued. Wells 4 and 6 are operated together and pumped to the water treatment plant where it aeration, filtration, chlorination, storage and distribution system capacity exists. The water treatment plant is primarily used to remove iron and manganese. Operation of the waterworks is governed by the Water Security Agency Permit #00002553-04-00.

2.3 WATER QUANTITY

The Town of Wadena water consumption records are shown below:

YEAR	AVERAGE (m^3/d)	MAX (m^3/d)
2015	634	998
2014	676	1427
2013	572	941
2012	568	976
2011	589	1048
Overall Average	**608**	**1078**

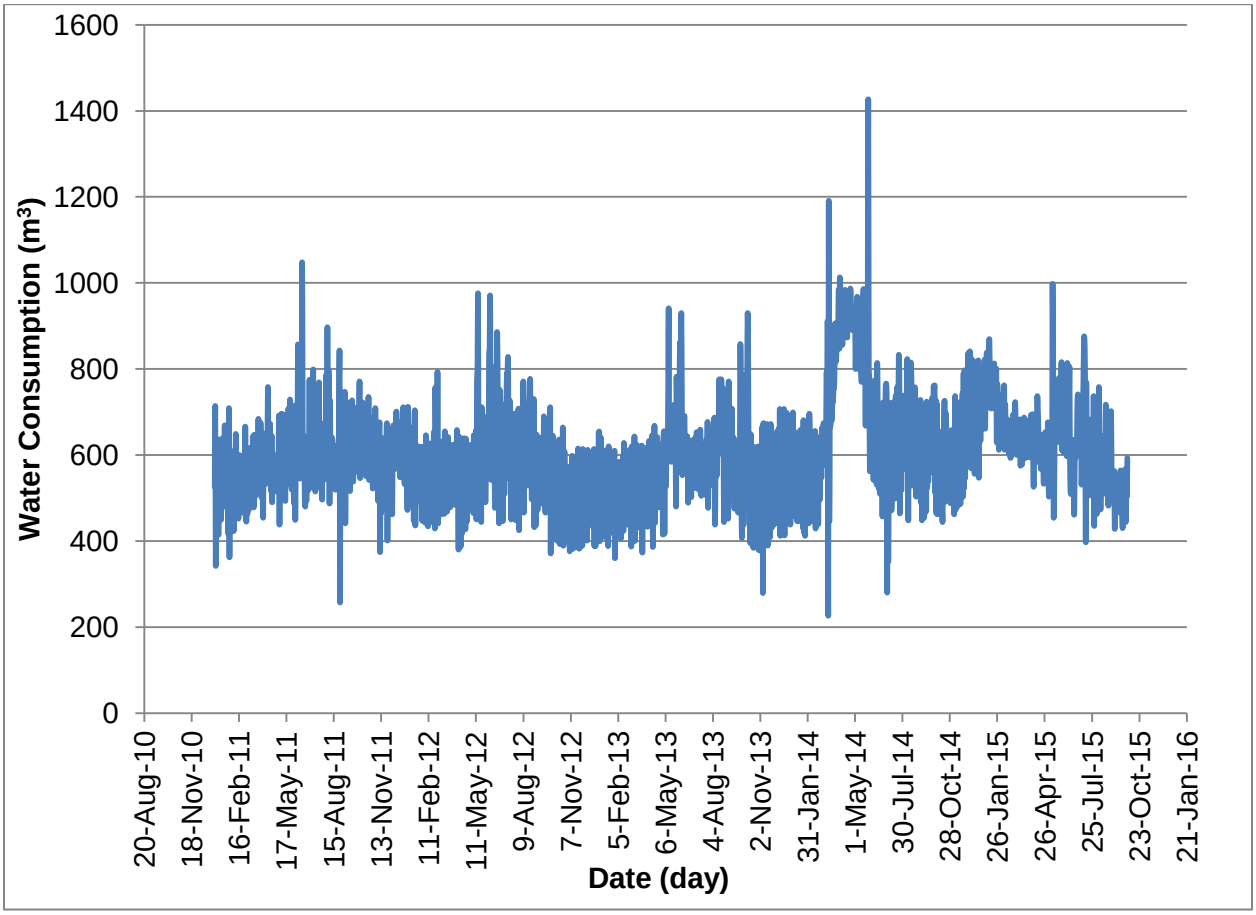
The Town of Wadena water consumption records from 2011 to September 2015 show a daily average water demand that ranged from 568 to 676 m^3/day. The average maximum day demand in that time period recorded was 1078 m^3/day. The maximum per capita demand of 819 L/cap/d were calculated based on a population of 1315 using the system.

- Average Day Demand = 608 m^3/day
- Maximum Day Demand = 1078 m^3/day
- Peak Hourly Flow = 1617 m^3/day (1122 L/min)

2.3.1 Water Consumption

The figure below shows the water demands from 2011 to 2015.

FIGURE 1
2011- 2015 DAILY WATER DEMANDS



2.3.2 Future Water Quantity Requirements

There are currently no plans to expand the water supply system. This report will provide estimates of available capacity for planning purposes.

2.4 WATER QUALITY

2.4.1 Raw Water Quality

The raw water is very hard and very highly mineralized with a Total Dissolved Solids (TDS) concentration between 1406 and 4000 mg/L. The major ions of concern are hardness, alkalinity

and likely sulphates. In addition to the major ions, raw water parameters which are of concern for the Town of Wadena are turbidity, arsenic, iron and manganese.

2.4.2 Treated Water Quality

The treated water is very hard and very highly mineralized. The total dissolved solids (TDS) are between 1406 and 4050 mg/L. In 2014 the TDS exceeds the aesthetic objective of 1500 mg/L. following communications with operating personnel, additional sampling will be conducted to review the 2014 TDS level. Magnesium, total hardness and total alkalinity also exceed their respective aesthetic objectives. Although no sulphate data is available, it is also likely very high.

Arsenic is present in the raw water, although the levels of arsenic in the raw water were not available. Arsenic is classified as carcinogenic to humans and must be removed to less than 0.010 mg/l in the treated water.

Iron and manganese are relatively abundant in the earth's crust and cause aesthetic problems in potable water systems. Some water users may note the taste and smell of manganese or iron at concentrations above the drinking water guidelines. Based on *Saskatchewan Drinking Water Quality Standards and Objectives* iron and manganese in drinking water should not exceed 0.30 mg/L and 0.05 mg/L, respectively.

The most common methods of iron and manganese removal involve oxidation by aeration, chlorination, potassium permanganate, followed by some form of filtration.

Arsenic

A water sample analyzed from the distribution system (SASK H_2O), in 2014 showed arsenic (As) concentration was 1.1 µg/L while a sample analyzed in 2010 showed concentration of 16 µg/L. Currently there is a maximum acceptable concentration (MAC) of 10 µg/L for Arsenic.

Arsenic is a naturally occurring element. Arsenic is the twentieth most abundant element in the earth's crust. Generally, arsenic enters the water system naturally from mineral deposits or rocks. It can, however, also get into the water supply from industrial practices such as burning fossil fuels (especially coal), metal production, agricultural uses (such as pesticides and feed

additives) and by burning industrial waste. Arsenic is classified as a Class 1 carcinogen (carcinogenic to humans) and has been shown to exhibit other health effects as a result of ingestion through drinking water. Conventional treatment processes can somewhat reduce arsenic levels in drinking water, however, the only effective treatment capable of producing low arsenic levels is activated alumina or reverse osmosis after proper pretreatment. Manganese greensand filtration also has the ability to reduce arsenic from the raw water.

Iron and Manganese

Iron concentration after treatment was in the range of 0.0 - 0.51 mg/L with an average of 0.03 mg/L. 99.6% of the samples analyzed were lower than the aesthetic objective of 0.3 mg/L. Manganese concentration was in the range of 0.0 – 0.8 mg/L with an average of 0.08 mg/L. 40% of the samples analyzed were higher than the aesthetic objective of ≤0.05 mg/L. The samples were collected daily between the years of 2011 and 2015. Iron and manganese in the raw water should be analyzed daily to study the efficiency of the greensand filters and to optimize the $KMnO_4$ dosage.

Fluoride

Fluoride concentration in the treated water is in the range of 0.24 to 0.78 mg/L with an average of 0.44 mg/L. Based on data collected between 2011 and 2015, 100% of the samples analyzed were less than the limit. The maximum allowable concentration (MAC) of fluoride in treated water is 1.5 mg/L. Fluoride is toxic in high concentrations to human and animals; while in low concentration can help prevent dental cavities in children. Fluoride is usually added to drinking water for good dental formation. Fluoride in drinking water can cause discoloration of teeth.
Fluoride addition into the treated water has been discontinued on August 2015.

Hardness

Treated water hardness was in the range of 879 to 3160 mg/L (as $CaCO_3$). Hardness levels between 80 and 100 mg/L (as $CaCO_3$) are considered to provide an acceptable balance between corrosion and incrustation. Water with hardness levels in excess of 200 mg/L are considered poor but have been tolerated by consumers. Waters with hardness in excess of 500 mg/L are unacceptable for most domestic purposes although hardness does not pose a health risk. As reviewed on Page 5, follow up communication regarding hardness results in 2014 indicated additional sampling should be conducted to confirm the 3160mg/L hardness value obtained.

Hard water has elevated levels of dissolved minerals, mainly calcium and magnesium. In general, hardness is a measure of the water's ability to react with soap and generate lather. Thus, hard water interferes with almost any cleaning task because of poor soap and detergent performance.

Hard water also contributes to inefficient and costly operation of water-using appliances. Heated hard water forms a scale of calcium and magnesium minerals that can contribute to the inefficient operation or failure of water-using appliances. Pipes can become clogged with scale that reduces water flow and ultimately requires pipe replacement.

Two basic methods of hardness removal (softening) are ion exchange (such as most residential softening systems) or chemical precipitation. The latter is widely used at larger plants, but is so operationally complex and expensive that it is almost never used for small installations.

Although the Town of Wadena raw water and treated water can be considered very-hard, hardness removal is not strictly required and will depend on consumer acceptance of the treated water supply.

Total Coliform / Escherichia Coli

Total coliform bacteria tests are used primarily as a measure of effectiveness of water supply treatment and of health risk. Monitoring of the bacteriological quality of drinking water is needed to control the presence of microorganisms that can cause illness or disease. Coliform bacteria

occur naturally in the environment and are not generally harmful. However, their presence suggests other disease causing organisms may exist in the drinking water supply.

Escherichia coli is a member of the total coliform group of bacteria and is the only member that is found exclusively in the faeces of humans and animals. Its presence in water indicates not only recent faecal contamination of the water but also the possible presence of intestinal disease-causing bacteria, viruses, and protozoa. The maximum acceptable concentration (MAC) of total coliform and E. coli in drinking water is zero detectable per 100 mL.

The total coliform and E. coli levels in the treated water samples were 0 CFU/100 mL. Thus, the town fulfilled its regulatory obligations to produce water which meets the relevant biological requirements.

Available treated water quality data was obtained from the Water Security Agency. The following table summarizes the results.

TABLE 2
TREATED WATER QUALITY SUMMARY

PARAMETER	RANGE (mg/L)	LIMIT	COMMENTS
Chlorine (WTP)	Free Chlorine: 0.03-2.2 mg/L Average: 0.71 mg/L	≥ 0.1 mg/L free Chlorine	10 samples out of 1733 samples were under 0.1 mg/L limit. Data from 2011 to 2015.
	Total Chlorine: 0.1– 4.4 mg/L Average:1.06 mg/L		Data from 2011 to 2015.
Chlorine (Distribution System) Sask H2O	Free Chlorine: 0.05-1.61 mg/L Average:0.61 mg/L	≥ 0.1 mg/L free Chlorine	2 samples out of 253 samples were below 0.1 mg/L. Data from 2010 to 2015.
	Total Chlorine: 0.15– 2.19 mg/L Average:0.94 mg/L	≥ 0.5 mg/L Total Chlorine	21 samples out of 252 samples were below 0.1 mg/L the limit. Data from 2010 to 2015.
Turbidity (Filters)	0.0 to 2.0 NTU Average: 0.67 NTU	≤ 0.3 NTU	63 samples out of 1498 samples were higher than the limit. Data from 2011 to 2015.

TABLE 2 (CONT'D)
TREATED WATER QUALITY SUMMARY

PARAMETER	RANGE (mg/L)	LIMIT	COMMENTS
Turbidity (Distribution System)	0.01 to 2.95 NTU Average: 0.38 NTU		Data from 2011 to 2015.
Total Coliforms	0	Zero organisms/ 100 mL	0 samples out of 251 samples was higher than the limit. Data from 2011 to 2015.
E. coli	0	Zero organisms/ 100 mL	0 samples out of 251 samples were higher than the limit. Data from 2011 to 2015.

FIGURE 2
DAILY IRON LEVELS AT THE WTP

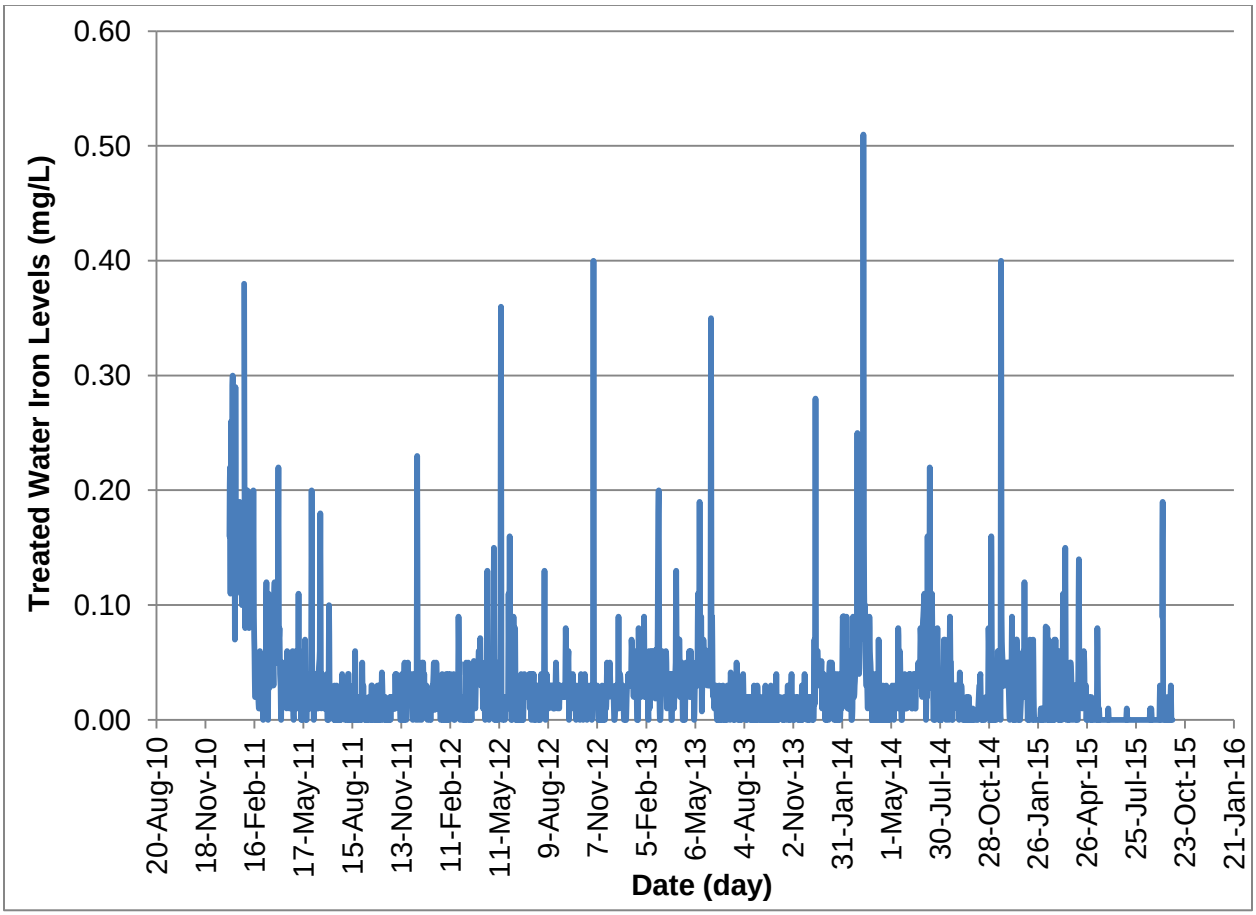
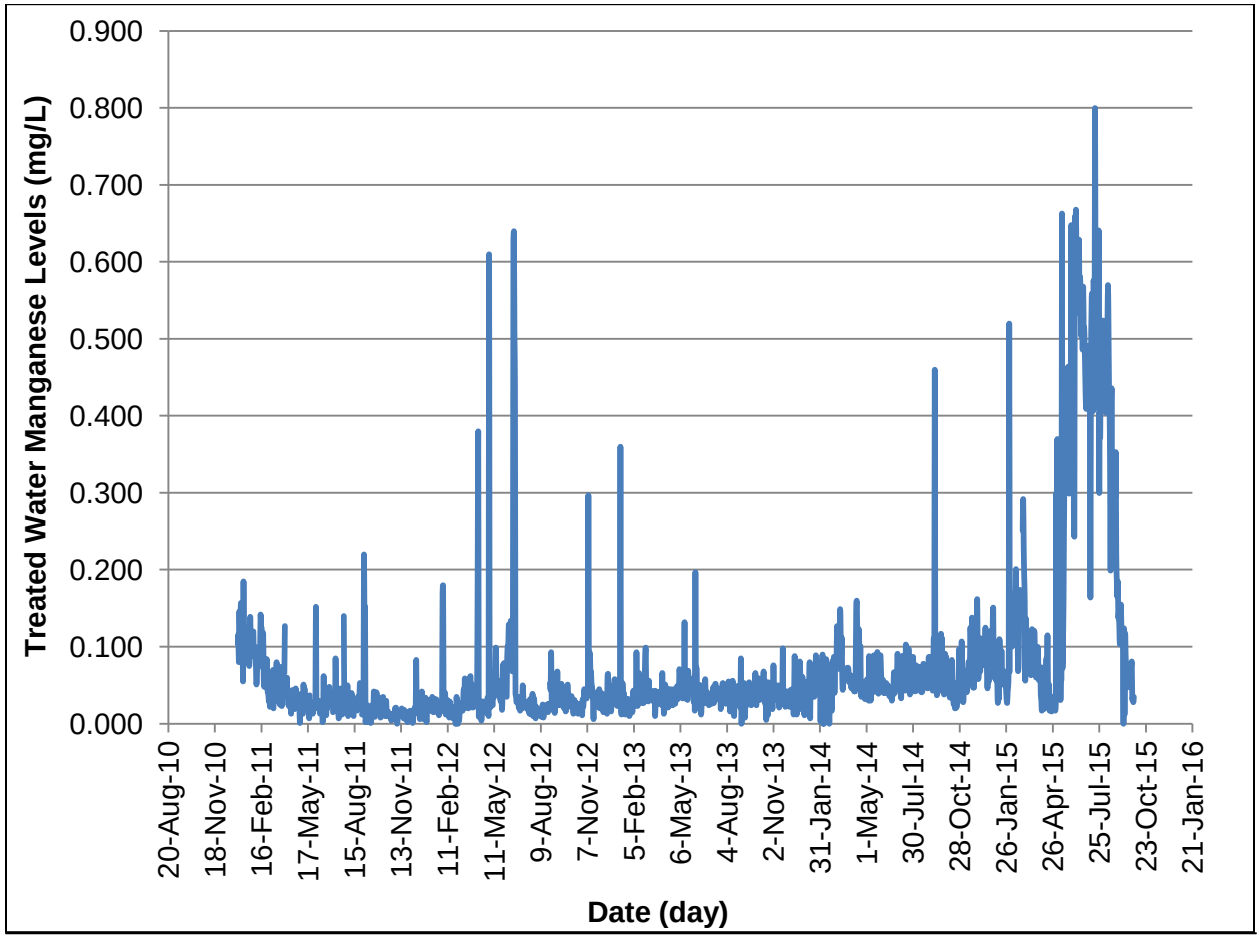
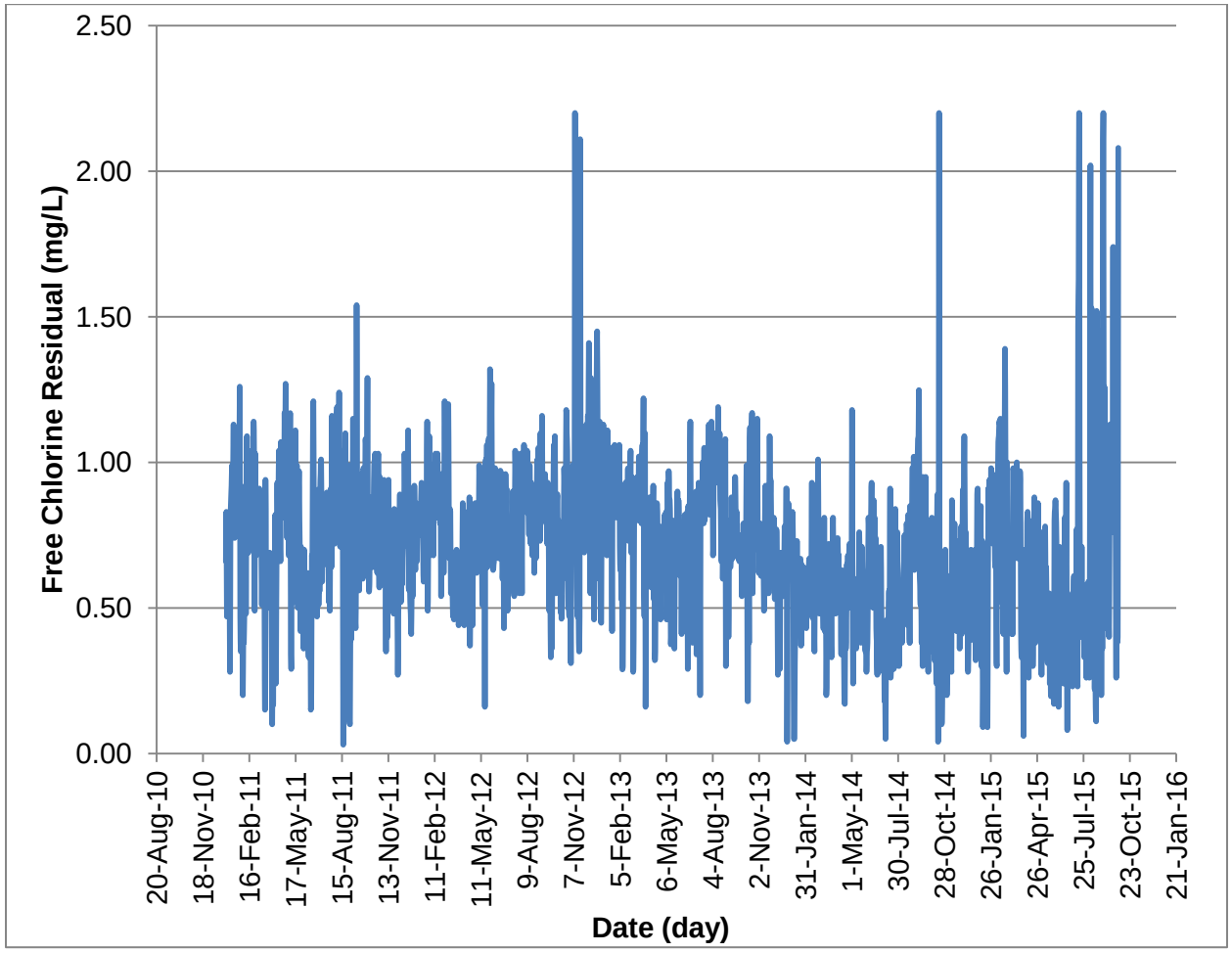


FIGURE 3
DAILY MANGANESE LEVELS AT THE WTP



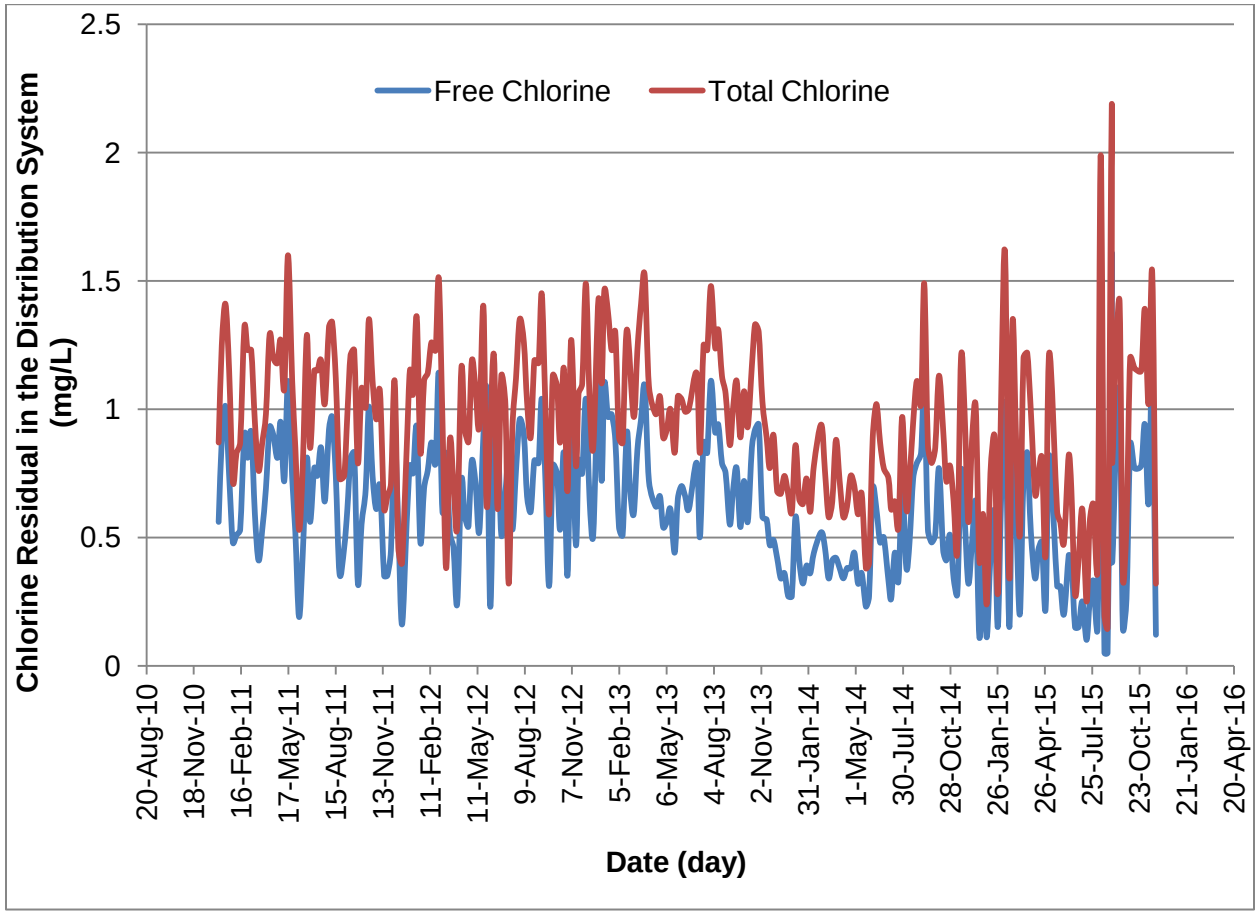
Free chlorine levels leaving the water plant from January 2011 until September 2015 were mostly compliant with 1720 of the 1733 tests being greater than the minimum 0.1 mg/L as required by the operating permit. The average free chlorine level leaving the water treatment plant was 0.71 mg/L. Daily data contained occurrences of high chlorine residuals. The following figure shows both the free and total chlorine residuals leaving the water treatment plant.

FIGURE 4
DAILY CHLORINE RESIDUALS AT THE WTP



Free and total chlorine residuals in the distribution system are recorded twice daily by WTP operators and in conjunction with bacteriological samples. The average free chlorine residual in the supplied information was 0.61 mg/L while the total chlorine residual averaged 0.94 mg/L. Free chlorine in the distribution system was above the minimum of 0.1 mg/L 99% of the 253 tests. For total chlorine in the distribution system, there were only 8% occurrences out of 252 tests that were below the 0.5 mg/L minimum. The total chlorine leaving the water treatment plant averaged 0.94 mg/L over the same time period. The following figure shows both the free and total chlorine residuals in the distribution system.

FIGURE 5
DAILY CHLORINE RESIDUALS IN THE DISTRIBUTION SYSTEM



Turbidity

Turbidity in ground water is difficult to interpret. Typically, oxidized materials such as iron or manganese cause turbidity in groundwater. The iron and manganese are usually in a dissolved state when the water is in the ground. When these substances are exposed to oxygen, or an oxidizing agent such as chlorine or potassium permanganate, the particles will precipitate out of solution causing turbidity. If filtration is not optimized, filter effluent turbidity can increase through the filtration process.

Although turbidity is not a direct indicator of health risk, there is a strong relationship between the removal of turbidity and the removal of harmful protozoa. The particles of turbidity provide “shelter” for microbes by reducing their exposure to attack by disinfectants.

True groundwater plants are required to distribute treated water at a turbidity less than 1.0 NTU, 95% of the time. From the water analysis data, turbidity was in the range of NTU in the treated water with an average of 0.67 NTU. Daily samples were collected in the plant and analyzed from the years of 2011 to 2015, and 96 of the time turbidity levels were lower than 1.0 NTU.

Based on records from the distribution system, turbidity was in the range of 0.01 to 2.95 NTU with an average of 0.38 NTU. Samples were collected and analyzed from the years of 2011 to 2015.

Based on the data collected between 2011 and 2015 there were 4 months where the turbidity was higher than 1.0 NTU 95% of the time. An audit of the water treatment process was recently held (Sept 9-11th, 2015 – report appended), which targeted three primary concerns with the process, namely the potassium permanganate application process, gas chlorination disinfection process and the backwash rates of the filters. Further work on these issues and the facility as a whole is recommended.

The Saskatchewan Drinking Water Quality Standards and Objectives require a turbidity of less than 1.0 NTU 95% of the time for treated groundwater entering the distribution system. Based on the data available the treated water does not meet Saskatchewan Drinking Water Quality Standards and Objectives for turbidity.

FIGURE 6
FILTERED WATER TURBIDITY

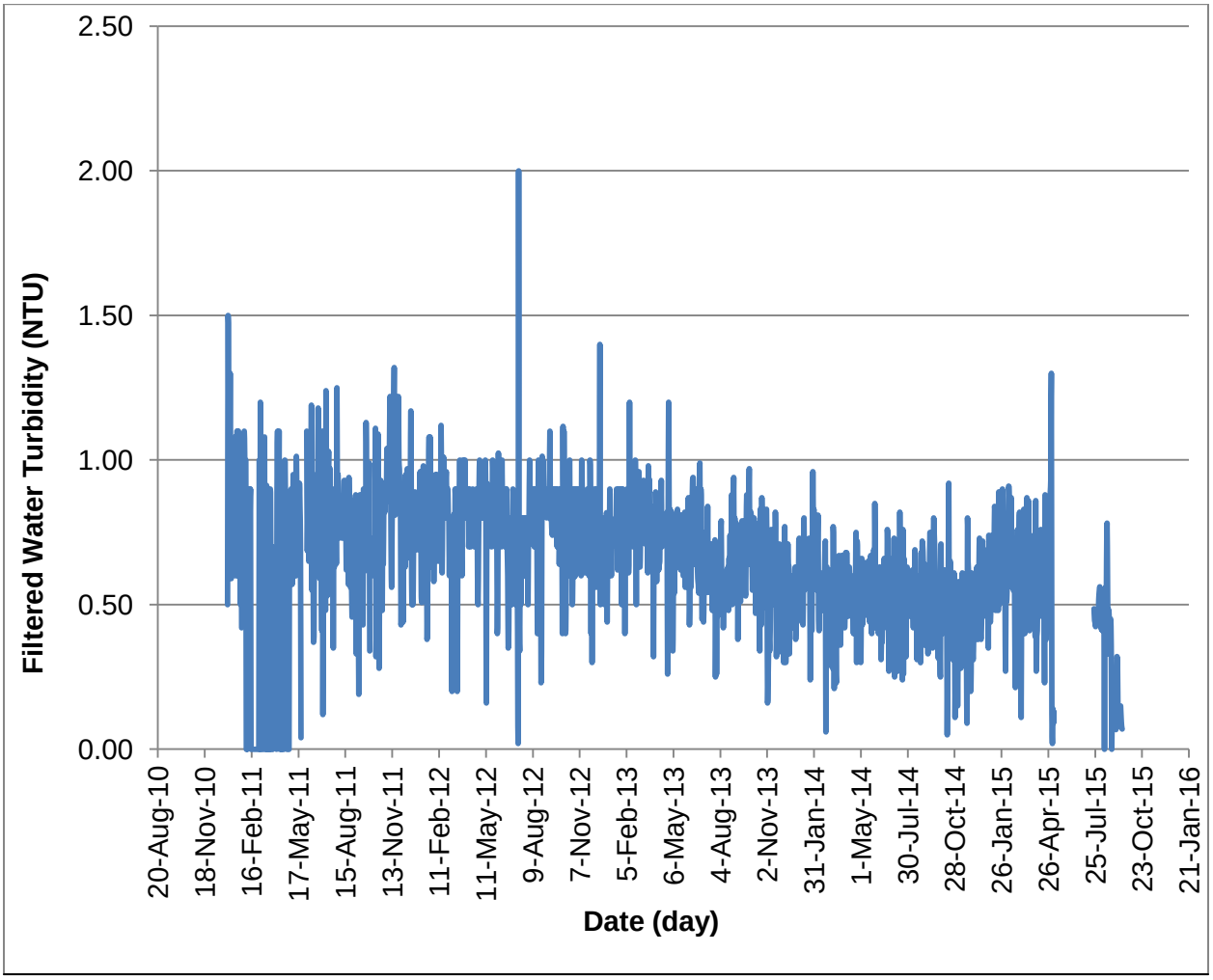
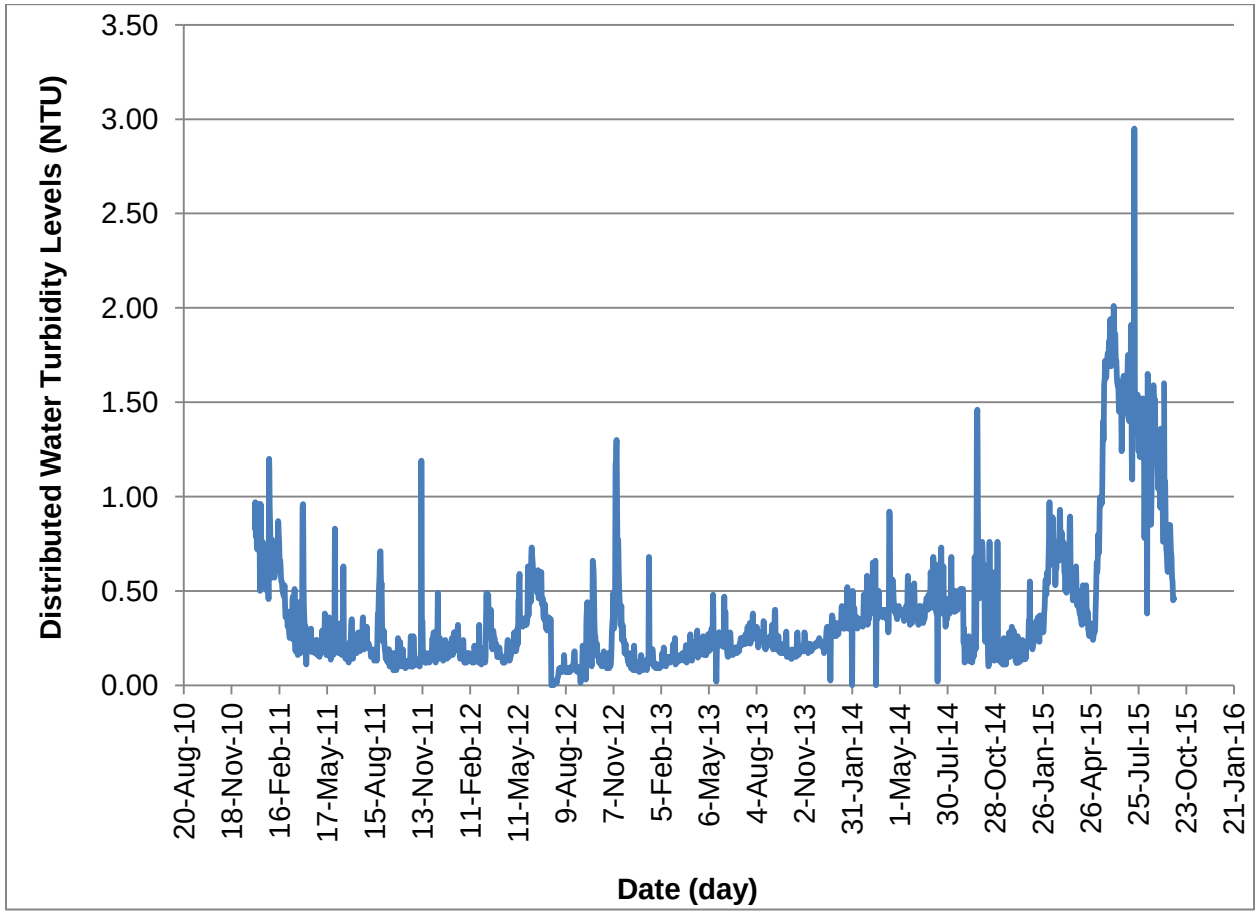


FIGURE 7
DISTRIBUTED WATER TURBIDITY



In addition to the above parameters, the operating permit requires regular testing of General Chemical and Health & Toxicity parameters. None of the parameters were found to be above the Saskatchewan Drinking Water Quality Standards and Objectives other than TDS, alkalinity and magnesium. The complete distributed water quality can be found below.

TABLE 3
DISTRIBUTED WATER QUALITY

PARAMETERS	UNITS	(SASK H2O)	SDWQSO
General Chemical			
Calcium, *Ca*	mg/L	429	-
Magnesium, *Mg*	mg/L	507	200 (AO)
Sodium, *Na*	mg/L	166	300 (AO)
Carbonate, CO_3	mg/L	0	-
Bicarbonate, HCO_3	mg/L	526	-
Hydroxide, *OH*	mg/L	0	-
Sulphate, SO_4	mg/L		500 (AO)
Chloride, *Cl*	mg/L	4.2	250 (AO)
Nitrate, NO_3	mg/L		45 (MAC)
pH	pH Units		6.5 to 9.0 (AO)
Conductivity	µs/cm@25˚C	1560	-
Turbidity	NTU		1 (MAC)
Total Hardness	mg/L as $CaCO_3$	879-3160	800 (AO)
Total Alkalinity	mg/L as $CaCO_3$	551	500 (AO)
Total Dissolved Solids	mg/L	1406-4050	1500 (AO)
Chemical Health			
Aluminium, *Al*	µg/L	4.1	-
Arsenic, *As*	µg/L	1.1	10 (IMAC)
Barium, *Ba*	µg/L	3.9	1000 (MAC)
Boron, *B*	mg/L	0.147	5 (MAC)
Cadmium, *Cd*	µg/L	0.03	5 (MAC)
Chromium, *Cr*	µg/L	0.2	
Copper, *Cu*	µg/L	20.1	1000 (AO)
Fluoride, Dissolved	mg/L	0.25	1.5 (MAC)
Lead, *Pb*	µg/L	0.3	10 (MAC)
Magnesium, Mg	mg/L	507	200(AO)
Selenium, *Se*	µg/L	0.96	10 (MAC)
Uranium, *U*	µg/L	6.5	20 (MAC)
Zinc, *Zn*	µg/L	14.5	5000 (AO)

SDWQSO - Saskatchewan Drinking Water Quality Standards and Objectives (EPB207)
AO - Aesthetic Objective
IMAC - Interim Maximum Acceptable Concentration
MAC - Maximum Acceptable Concentration

2.5 PLANS, REPORTS, MANUALS

The Town of Wadena provided treated water quality analysis and flow records from January 2011 to September 2015. The Town also provided Waterworks Emergency Response Plan (2014). The intent of this emergency plan is to ensure the safety of consumers and the protection of life, property, and the environment in the most efficient way possible in the event of an unexpected incident. In particular, this plan deals with events that may affect water quality.

2.6 HISTORIC PROBLEMS

- Backwash Flow Rates.
- Elevated Manganese in Treated Water.
- Well Communication.
- Gas Chlorination application concerns.
- Turbidity levels in the treated water were in some incidents higher than the guidelines.

2.7 MAINTENANCE RECORDS

Maintenance records are kept at the site and updated with activities as they occur. Daily operator logs were provided for review. All repairs are carried out on an as needed basis, and drawings are updated as necessary.

2.8 NEW COMPONENTS/UPGRADES

The following is a list of new components and/or recent upgrades to the Wadena waterworks:

- New well #6 commissioned.
- Two New vertical distribution pumps installed in 2015.
- New Gas Chlorine system has been installed at the Water Treatment Plant, 2015.
- Water Tower heater was replaced in 2014
- Water Tower recirculation pump was replaced in 2015.

3.0 WATERWORKS ASSESSMENT FINDINGS

3.1 RAW WATER SUPPLY

Raw water is supplied to the Town of Wadena primarily by two wells. All the wells are located in 4-34-13-W3M and are approximately 6 km south of town along Highway 35. Water is pumped 6,600 meters through a 200 mm PE line to the water treatment plant. A 200 mm PVC line connects Well #4 to the supply main inside the well house. Well # 5 has been discontinued due to cavitation issues in 2013. Well #6 has been connected to Well #4 and is being utilized in concert with Well #4. Well #1, 2 & 3 were decommissioned. The total raw water allocation is 290 dam^3/year.

No backup power is available at the well sites. In the event of a power failure, the water treatment facility is without raw water until power is resumed.

Each well is within a building. The two buildings are 2 x 4 construction, metal sided and in good shape. Each building has a concrete floor and is heated using an electrical heater. Each building contains piping associated with the enclosed well, including a water meter, depth and pressure gauges, a blind flange tee for flushing and swabbing purposes, and a throttling valve. The two buildings are lockable and are not alarmed. There have been no vandalism concerns. The primary issue of concern for the wells is the communication with the Water Treatment Plant. Existing Sasktel communication lines have failed regularly since the last assessment and council is considering moving to a full scale SCADA addition.

The wells may be classified as potentially Groundwater Under the Direct Influence of Surface Water (GUDI) based on their close proximity and possible hydraulic connection to the lake/slough which receives drainage from Milligan Creek. The town's wells are artesian and that may classify them as potentially GUDI. Groundwater that has a high incidence of macro-organisms, algae or large diameter pathogens, includes *Giardia lamblia* and *Cryptosporidium*, or incur rapid changes in water characteristics that are closely correlated to climatological or surface water conditions, can be classified as GUDI. A hydrogeological investigation will be required to ascertain the GUDI status of the Wadena wells.

3.2 SUPPLY LINES AND STORAGE RESERVOIRS

There is a 200 mm (8") diameter polyethylene supply line from the well site to the water treatment plant. It was installed in 2002. Ground elevation at the well site is 522.7 meters while the pipe invert is 520.1 m. At the water treatment plant, the ground elevation is 538.6 m and the pipe invert is at 536 m. This is a rise of 15.9 m over 5,600 m or a 0.3% up slope. The pipe cover is maintained at greater than 2.5 m. There are three manual air release valves and four gate valves for isolating sections of pipe. Two road crossings were constructed and one highway crossing, where the pipe was encased.

3.3 OPERATIONS AND MAINTENANCE PROCEDURES

The well pumps can be controlled manually from the water treatment plant. Valves at each of the well houses are used to throttle the flow from each well. The well pumps are controlled by the water level in the clear well/reservoir via buried power/telephone cables from the well houses to the water treatment plant. .

As the raw water has high hardness, iron and manganese, there is potential for deposition to occur within the supply line. The well houses are equipped with pig/swab launching points. It is recommended that a maintenance program for the supply line be considered.

3.4 WATER TREATMENT PROCESS AND DISINFECTION SYSTEM

3.4.1 Water Treatment Plant

The water treatment plant is located in the Town of Wadena on the south side of the town. The building is concrete block construction and is 8.5 m by 9.3 m and includes a 3.2 m by 8.5 m addition that was added in 1987. The roof is flat with a gravel surface, and a clerestory is in place. A number of mechanical vents are present and all are screened. Heat is provided via a roof mounted heating system. A number of equipment alarms will activate the beacon on the rooftop.

The building has a chlorine gas room. There is one entrance from the outside and inspection windows from the inside of the water treatment plant as well as in the outside door. Four - 68 kg

gas cylinders are present; 2 are active and 2 are spare. Water Security Agency Guidelines for Chlorine Gas Use in Water and Wastewater Treatment contains design, construction and operating guidelines for gas chlorination facilities. The guidelines recommend that spare chlorinator parts are kept onsite and that aqueous chlorination feed equipment be available in the event of a breakdown. Also a device to indicate the wind direction is recommended. Each gas chlorinator should be provided with a separate pressure relief vent, independent heat, and a thermostat. Warning signage was placed on the door.

3.4.2 Water Treatment Process Equipment

Major water treatment process equipment consists of the following:

- 1 – Tray aerator (1524 mm x 1524 mm) with fan (Model 013, Size 012, 1600 cfm at $^3/_8$", $^1/_3$ hp, 3450 rpm);
- 1 – Retention Chamber 35 m^3 with baffles;
- 2 – 2425 mm x 2425 mm gravity manganese greensand filters;
- 1 – Chlorine Room Fan 708 L/s, 93 pa, 1750 rpm, ½ hp, Model WAR-24;
- 1 – Chlorine Room Fan 245 L/s, 93 pa, 1750 rpm, $^1/_6$ hp, Model WAR-94;
- 1 – 10 hp Blower for air scour 300 cfm at 5 psi, 3250 rpm, Cord Model CA3-9;
- 1 – Regal Chlorinator Model 216 Chlorinator 100 lb/24 hr;
- 1 – Prominent chemical feeder pumps;
- 1 – LMI chemical feeder pump;
- 2 – 20 hp Goulds Model 8JHO 6 stage vertical turbine distribution pumps, 1800 rpm rated at 266 igpm at TDH of 150' and 358 igpm at TDH of 100';
- 1 – 80 hp Goulds Model 12JHO vertical turbine standby distribution pump, 2600 rpm rated at 828 igpm at TDH of 64' and 1272 igpm at TDH of 152' natural gas fired.

As water enters the filtration plant, it is passed through the aerator. After the aerator, water enters the retention chamber. Following the retention time, the flow is split between two gravity manganese greensand filters. The water is pumped from the bottom of the filters to the clear well.

Pressure from the well pumps push the water to the top of the tower aerator that has a cross-sectional area of 2.17 m^2 and 16 trays. According to supplied documents, the tower aerator is a fiberglass shell with redwood timber slat trays. Air is also pushed up through the filter and exhausted through a vent in the roof to the outside atmosphere. The original design capacity was 104 m^3/hr (380 igpm). Based on maximum day flows, the current loading of the tray aerator is 0.264 L/s per m^2. Based on Water Security Agency *A Guide to Waterworks Design* a loading

rate of 0.7 to 3.4 L/s per m^2 is recommended. The loading rate is less than the maximum loadings recommended by the Water Security Agency.

The retention chamber is 35 m^3 (7750 igal) and is constructed of concrete. Three cedar baffles originally divided the chamber into 4 -1.4 m wide bays that decreased the possibility of short-circuiting occurring through the retention chamber. At maximum day flows, the retention time is approximately one hour while at average day flows the retention time is approximately 83 minutes. The retention chamber allows time for the air and the other oxidizing agents to react with components in the water prior to filtration.

After the retention time, the flow is split between two 2.4 m by 2.4 m concrete filters located on either side of the retention chamber. The media in each filter originally consisted of 600 mm (24") of manganese greensand underneath 300 mm (12") of Anthrafilt sand. There was a 3/8" think galvanized steel underdrain support plate and 121 strainers per filter. The original design capacity of each filter was 14.4 L/s (190 igpm). The manufacturer literature recommends a service filtration rate of 7.3 to 12.3 m/h (2.5 to 4.2 igpm/ft^2). Water Security Agency's Design guidelines recommend 5 to 12.5 m/hr. Based on maximum day flows the filtration rate is 5.74 m/h, which is within the recommended rates for one filter. Based on the Water Security Agency's design guidelines each filter has a capacity in the range of 28.8 to 72 m^3/hr.

Manganese greensand filters require regeneration after a certain time period of operation due to solids accumulation. The backwash cycle starts with one filter at a time and the second filter is kept on-line. The backwash water used for filter cleaning is drawn from the underground reservoir using the standby distribution pump. The backwash filtration rate based on *A Guide to Waterworks Design EPB 201* is between 36 and 45 m/h. The first phase in the backwash cycle is the air scour, which occurs for two minutes. After the air scour, a hydraulic backwash occurs. Supplier's documentation recommends that a backwash rate of 45.6 m/hr (15 igpm/ft^2) is appropriate for manganese greensand. The original design backwash rate was 35.5 m/h for 8 to 10 minutes, operations staff also noted that the backwash occurs for 3 to 5 minutes. During the recently completed audit actual backwash capacity was deemed to be inadequate and the metering equipment inaccurate. Upgrades to the backwash capacity need to be considered in short order.

Based on minimum required backwash filtration rate of 36 m/hr, flow rate required is 8.64 m^3/hr.

Raw water iron and manganese should be measured daily to evaluate the filters performance and to determine the potassium permanganate dose required. It should be noted that the Provincial document, *A Guide to Waterworks Design*, recommends that filtration be provided in a duplex configuration that will allow for continuous production of water to meet the maximum day demand with the largest filter out of service. Due to the large surface area of the filters it is recommended to use one filter at a time. Using both filters at the same time will result in too low of a filtration rate.

Water produced by the treatment train is stored in the clear well and the attached storage reservoir.

The original design capacity of the filtration system and the tower aerator were 28.8 L/s and 28.9 respectively. The treatment is capable of meeting the demand of 3000 people based on the current usage and demand.

The town conducted study to optimize manganese removal. The study included a review of the greensand media and optimizes potassium permanganate dosages.

3.4.3 Water Treatment Plant Wastewater Disposal

Wastewater generated at this water treatment plant is disposed of into the town's sanitary sewer. Operations staff indicated that there is backflow prevention on this line.

3.4.4 Chemicals, Equipment and Dosages

Two chemicals are added to the water during treatment; chlorine and potassium permanganate as fluoridation has been discontinued. The potassium permanganate is added to the bottom of the retention chamber, and chlorine is added to the effluent of the north filter. In general, the exact chemical dosages required must be determined by trial and error. However, there are a number of rules of thumb that can be used.

Potassium Permanganate

Potassium permanganate ($KMnO_4$) is used to oxidize both iron (Fe) and manganese (Mn). It is

also used to regenerate manganese greensand filters. $KMnO_4$ usually comes as purple crystals in 25 kg drums. The active ingredient is 95% to 99% strength depending on the supplier. The current dosage was not known.

According to the operations staff, the potassium permanganate is mixed in a barrel at a 12% solution. A mixer is utilized to keep the chemical in suspension as $KMnO_4$ will only dissolve between a 1% and 4% solution. Operation's staff note that two (2) 25 kg drums of potassium permanganate are used every 30 to 35 days.

There are no records for the levels of iron and manganese in the raw water. Iron and manganese levels should be recorded to estimate the dose of $KMnO_4$ required.

Hydrofluorosilicic acid

Fluoridation of the treated water in Wadena has been discontinued on May 2015. At that time the average dosage was 0.3 mg/L.

Chlorine gas

Chlorine is added as chlorine gas to provide disinfection. Chlorine is fed from two (2) 68 kg cylinders to an injector where it is mixed with water. Based on the average day demand, the average chlorine dosage was 5.6 mg/L.

The chemical dosages were less than the maximum use level (MUL)

3.4.5 Disinfection Process Effectiveness

A review of the operator's daily test results and historical treated water results indicate the free chlorine residual at the water treatment plant was in the range of 0.03 to 2.2 mg/L with an average of 0.71 mg/L. Total chlorine was in the range of 0.1 to 4.4 mg/L with an average of 1.06 mg/L.

Disinfection is required for surface water supplies, groundwater under the direct influence of surface water and any groundwater supply. Continuous disinfection is recommended for all

water supplies. Consideration must be given to the formation of disinfection byproducts (DBP) when selecting the disinfectant.

A public water supplier using surface water or groundwater under the direct influence of surface water (GUDI) has to ensure that all water entering the water distribution system meets the Drinking Water Quality Standards regulation of 99.9 % reduction of *Cryptosporidium oocysts* and *Giardia lamblia cysts* and 99.99% reduction for viruses. In order to determine if the plant meets the above reduction requirements, Contact Time (CT) factors were calculated. In general, the CT factor is the concentration of the disinfectant (in mg/L) multiplied by the contact time. A disinfection profile was developed from the water treatment plant consumption data and the KGS Group calculations performed.

As the source is groundwater, virus inactivation requirements are the limiting constraint for groundwater sources. CT calculations for this system were based on a peak hourly flow of 1122 L/min, pH of 7.5, temperature of 5ºC, and a baffle factor of 0.3 for the clear well. The system is meeting the CT requirement if the clear well is full and the free chlorine concentration is at an average of 1.5 mg/L. The system also meets the CT requirement if the reservoir is half full and the free chlorine concentration is in the range of 3.0 mg/L.

To use the treated water reservoir (1140 m^3) in the CT calculation it is required to have the distribution pumps suction points transferred from the clear well to the large reservoir, or the treated water from the filters would have to be diverted to supply the large reservoir with water being withdrawn from the clear well to the distribution system. This would eliminate any short circuiting within the clear well.

Currently the water treatment plant is considered to rely upon a groundwater source and would be meeting CT requirements for treated water supplies. It should be noted that if the wells are classified as potentially GUDI, the system may not meet the CT requirements.

3.4.6 Testing Procedures and Equipment

The operator tests the treated water daily for free chlorine, total chlorine, iron, manganese, and fluoride using a DR 890 colorimeter (HACH). A turbidimeter is used for turbidity measurements.

Raw water and treated water flows are monitored through two (2) meters located in the water treatment plant. Water flows are recorded daily.

Water Security Agency's minimum standards require the daily reading of the water meters, and daily testing of free chlorine residuals and turbidity levels at the water treatment plant.

3.4.7 Operations and Maintenance Procedures

Chlorine gas usage is tracked by the weight of the chlorine in the cylinders that is remaining. Potassium permanganate is also tracked daily.

Operations staff indicated that the $KMnO_4$ feed line is cleaned daily. During the September 2015 audit, establishing a potassium permanganate feed system without a saturator was deemed beneficial. Original documentation of the plant recommended using a 2% solution combined with a chemical feed pump with a capacity of 150 mL/min (47.5 gpd).

Water Secuirty Agency documentation recommends that an adequate means of flushing one's eyes is available when chlorine gas is used. In addition, a self-contained breathing apparatus, rubber gloves, apron and face shield or goggles should be provided to the operations staff. Currently a self-contained breathing apparatus and rubber gloves are available for the staff. Safety equipment such as an eyewash station was available.

All of the chemical feeders are engaged when the plant is producing water and are otherwise not powered.

It should be noted that the water treatment plant appears to be well run by a relatively new operations staff. An openminded proactive approach to tackle problems and establish a long term life cycle approach to capital expenditure should also be commended. The plant in general is aging and consideration for a replacement plan should be moved forward.

3.5 TREATED WATER SUPPLY, STORAGE AND DISTRIBUTION SYSTEM

3.5.1 Treated Water Supply

The distribution pumps are located in the water treatment plant on top of the concrete clear well and draw water from the clear well. Two (2) 20 hp vertical turbine pumps are used as the primary source of pressure to the distribution system. New pumps were installed using the existing motors. Both pumps can operate simultaneously; however, if operated independently they are alternated. The pumps pressurize the distribution system to between 46 and 48 psi.

A backup natural gas fired motor attached to a 2 stage vertical turbine pump can maintain the system pressure in the event of a power failure. The backup pump has 80 hp and is activated manually. However, the raw water would not be supplied to the treatment process in the event of a power failure. The amount of time that pressure could be maintained would therefore be limited by the water demand and the size of the reservoirs.

The benefits of adding variable frequency drives to the distribution pumping system are being reviewed and should continue to be considered, although their merits when a tower remains in play need to be considered.

3.5.2 Treated Water Storage Reservoirs

There are three reservoirs in the system; a 227 m^3 clear well, a 227 m^3 elevated reservoir, and a 1135 m^3 underground storage reservoir.

The water tower is a Horton Waterspher (25'ϕ x 106' – 50,000 igal) and is believed to have been built in the 1961. The water tower is within the distribution system as customers are supplied prior to water entering the tower and there is one shared effluent/influent pipe. The inside of the tower is reported to be epoxy lined. A new circulation pump (2012) and heater (2014) were installed in the tower. The tower is used for storage only, and cannot be used for CT calculations as it has a common header/discharge pipe. The building at the base of the tower is heated with a suspended natural gas furnace and the recirculation system operates with a natural gas furnace. The tower has been flushed every year. Based on the operations staff a robot with a camera will be used to examine the tower from the inside.

There is a clear well under the water treatment plant. It was constructed of concrete in 1965 and contains no baffles. High water and low water level floats are used to control the plant operation. According to operations staff the floats are set approximately 0.45 m (1.5') apart. The pump intakes appear to be located approximately 6 m from the filter effluent lines. This may produce some short-circuiting and negatively impact the inactivation of viruses and bacteria. Baffles could be installed to ensure that the water utilizes a maximum length flow path. There is one hatch to access the reservoir. The reservoir hatch has a 150 mm lip and with water tight seal.

There is a storage reservoir located beside the water treatment plant. It was constructed of concrete in 1979 and contains no baffles. There is an overflow that drains to a manhole. From there, a submersible pump moves overflow water to the sewage lift station. There is an outside hatch, which is kept locked, and there are two screened vents. There is a 250 mm (10") steel pipe that connects this reservoir to the clear well. A knife gate valve is present to allow this reservoir to be isolated from the clearwell.

To use both reservoirs for CT requirements, it remains our recommendation to have the distribution pumps suction points transferred from the clear well to the large reservoir, or the treated water from the filters could be directed to supply the large reservoir and water withdrawn from the clear well to the distribution system. Both clear well and the large reservoir could then be used to meet CT requirements, thereby reducing any short circuiting within the reservoirs.

3.5.3 Distribution System

According to supplied information, the distribution system was constructed in 1965 and consists of 14,000 metres of 150 mm (6") diameter asbestos cement pipe and 1,800 metres of 200 mm (8") asbestos cement pipe. Some plastic pipe is present in the northeast portion of town but the quantity is uncertain. When the system was installed it was placed in the same trench as the sanitary sewer. However, the sewer is 30 cm (1') lower and is displaced horizontally from the water line. It is reported that the water mains are approximately 3 metres deep and there have been no main line water breaks, although there have been some breaks in services.

According to the supplied plans, the system is looped though there is a number of dead-ends. Dead-ends are understood to still exist in the following locations:

- Anton Place;
- N. Railway Avenue and 4th Street West;
- South end of 2nd Street West;
- End of the line that runs south from the water treatment plant;
- The bay located on the east end of 1st Avenue South;
- 3rd Avenue and 1st Street East;
- 3rd Avenue and 2nd Street East;
- Horkoff Avenue and 3rd Street East;
- 4th Street East and the CPR tracks; and,
- East end of Pierce Avenue.

According to supplied plans, all of the above locations appear to have hydrants near the end of the dead-end with the exception of the intersection of Horkoff Avenue and 3rd Street East, the bay located on the east end of 1st Avenue South, the intersection of 4th Street East and the CPR tracks; and, the east end of Pierce Avenue. No new hydrants installed at these dead ends. As long as the water quality is monitored and the water flushed when required, further looping does not appear to be necessary, though hydrants should be installed where noted.

Based on operations staff there is no pressure problems through out the distribution system.

3.5.4 Fire Prevention

Fire protection is provided to the Town through 76 fire hydrants. The recommended distance between fire hydrants is 110m (350 ft) to 180m (600 ft). Other than the area north of Kennedy Avenue and west of 3rd Street East, all areas appear to have adequate hydrant spacing. Three old hydrants were recently replaced with new hydrants.

The reservoirs located at the water treatment plant provide storage for approximately 2.25 days at average day flows. For systems where fire protection is provided, a minimum storage of twice the average daily consumption is recommended. The minimum required is 1,210 m^3. The actual capacity of the Town's two reservoirs is 1,362 m^3, which indicates that the storage volume is adequate. Pressure for fire flow activities is supplied by the distribution pumps and could be supplemented with the natural gas backup pump.

3.5.5 Backflow Prevention

There is one truck fill station in the town that is open to the public. Operations staff indicated that there is an air break on the fill line. Chemical tanks are prohibited from filling at this location.

Throughout town many of the commercial and industrial customers have backflow prevention devices on their service connections. Residential services do not have backflow prevention devices installed. Some consideration should be given to ensuring that backflow prevention devices are installed for every industrial or commercial customer.

3.5.6 Metering

Meters are located on the treated water and the raw water lines. These two meters should be examined to ensure that they are functioning properly as the raw water usage is shown as being less than the treated water usage. Each service connection has a meter. The service connection meters are being replaced as they breakdown.

The watering system that is served from the tower is also metered.

3.5.7 OPERATIONS AND MAINTENANCE PROCEDURES

Both reservoirs are cleaned regularly with the last cleaning occurring in August of 2015.

The tower is checked daily in the winter and the recirculation system is operated in the winter to prevent freezing. A new circulation pump and heater have been recently installed. The tower is flushed once per year. A robot with a camera will be used to examine the tower from inside.

Every fall the water lines are flushed. The flushing program starts at the tower and works its way down to the water treatment plant. Valves are closed to isolate different sections of pipe. This is the preferred method of flushing a distribution system. Operations staff indicated that the flush water is a rusty colour at first followed by clear water. The flush water is directed to the sanitary sewer and is used to flush the collection system. It is good practice to exercise each valve yearly to ensure that it is functional and to extend its service life.

3.6 ESTIMATED CAPITAL REPLACEMENT COSTS AND REMAINING SERVICE LIFE

The timelines used are inferred from available information. This table is meant to convey the estimate costs if the complete waterworks were to be replaced.

TABLE 4
REMAINING SERVICE LIFE AND REPLACEMENT COST

ITEM	TYPICAL SERVICE LIFE	ESTIMATED REMAINING SERVICE LIFE	TOTAL COST ($)
Raw Water Supply			
Well Buildings	40-60 Years	0-20 Years	75,000.00
Wells	20-30 Years	10-20 Years	75,000.00
Supply Lines	40-60 Years	30-50 Years	750,000.00
		Subtotal	***900,000.00***
Water Treatment Plant and Distribution Pumping			
Water Treatment Plant Building	40-60 Years	5-15 Years	250,000.00
Retention Chamber	40-60 Years	5-15 Years	25,000.00
Filters	20-30 Years	5-15 Years	80,000.00
Aerator	20-30 Years	5-15 Years	40,000.00
Mechanical	20-30 Years	5-15 Years	80,000.00
Electrical	20-30 Years	5-15 Years	80,000.00
Chemical Feed Systems	10-20 Years	5-15 Years	20,000.00
Gas Chlorination Equipment	20-30 Years	15-25 Years	15,000.00
Filter Pumps	20-30 Years	5-15 Years	10,000.00
Distribution Pumps	20-30 Years	5-15 Years	60,000.00
Standby Pump	20-30 Years	5-15 Years	75,000.00
Water Tower	20-30 Years	10-20 Years	600,000.00
Water reservoirs	40-60 Years	10-20 Years	750,000.00
		Subtotal	***2,085,000.00***
Distribution System			
Assume 14 km	40-60 Years	0-20 Years	1,870,000.00
Hydrants	20-30 Years	0-20 Years	370,000.00
		Subtotal	***2,240,000.00***
		Contingency & Engineering	***1,567,500.00***
TOTAL ESTIMATED REPLACEMENT COST			**6,792,,000.00**

4.0 WATERWORKS COST ANALYSIS AND SUSTAINABILITY

4.1 INTRODUCTION

The American Water Works Association (AWWA) believes that a number of principles should be used by water utilities to ensure the long-term financial integrity of water utilities. These principles are summarized below.

- Water utilities' revenues from water service charges, user rates, and capital charges (e.g., impact fees and system development charges) should be sufficient to enable utilities to provide for:
    - Annual operation and maintenance expenses;
    - Capital costs (e.g., debt service and other capital outlays); and
    - Adequate working capital and required reserves.
- Water utilities should account for and maintain their funds in separate accounts from other governmental or owning entity operations. Water utility funds should not be diverted to uses unrelated to water utility services.
- Water utilities should adopt a uniform system of accounts based on generally accepted accounting principles.
- Water rate schedules should be designed to distribute the cost of water service equitably among each type and class of service.
- Water utilities should maintain asset records that detail sufficient information to provide for the monitoring and management of the physical condition of infrastructure.

(Source: http://www.awwa.org/about-us/policy-statements/policy-Statement/articleid/201/financing-accounting-and-rates.aspx)

4.2 ANNUAL OPERATIONS AND MAINTENANCE COST

The Town of Wadena supplied the annual waterworks financial overview. The waterworks operating costs, or expenditures, include waterworks' staff salaries, benefits and training, power, telephone, heat and chemicals associated for 2014. The majority of the capital costs and operating costs were due to the salaries

Summarizing the cost information provides the following cost breakdowns.

TABLE 5
BASE YEAR OPERATION AND MAINTENANCE COSTS

CATEGORY	WATER AND SEWER
Power/Energy/Telephone	$60,230.73
Chemicals	$15,731.00
Wages	$175,555.00
TOTAL WATER O&M	$251,516.73

The town planning water and sewer rates increase by ten per cent (10%) per year.

The planned water rate increases of ten percent (10%) per year for the next four years are shown in Table 6.

TABLE 6
10% PER YEAR WATER AND SEWER RATE INCREASE

MINIMUM CHARGE	RATE /CUBIC METRE	ESTIMATED
January 1, 2013	$4.06	$30.73
January 1, 2014	$4.47	$33.80
January 1, 2015	$4.92	$37.18
January 1, 2016	$5.41	$40.89

The Council will work towards generating waterworks revenue that will cover the operating costs of the waterworks system. Waterworks system operating costs, or expenditures, include staff salaries, benefits and training, power, telephone, fuel, heat, insurance, chemicals, repairs, maintenance, supplies, etc. Any surplus in the utility department will be transferred to the Utility Reserve account to address utility system infrastructure problems that arise and to replace aging utility system infrastructure as required.

The actual revenue earned by the Town of Wadena for 2014 was $565,651.00.

4.3 IMMEDIATE ISSUES AND RISKS

The following immediate issues and risks have been identified for the Town of Wadena water treatment facility:

- The Town of Wadena should consider completing a hydrogeological assessment to ensure that the raw water can be characterized as strictly groundwater. The wells are artesian and have been developed near sloughs in aquifers overlain by till of varying thickness. It would be beneficial for the Town to complete this study as the treated water requirements for a groundwater source are less onerous than those for a GUDI supply.

- If the raw water supply is found to be GUDI, then additional treatment would be required to meet surface water/GUDI treated water quality standards. Different treatment technologies are available to treat this water and chemically enhanced filtration should be considered, as it is suitable for GUDI sources.

- Arsenic concentration in the Town of Wadena treated water was in the range of 1.1 µg/L to 16 µg/L which is higher than the maximum acceptable concentration (MAC) of 10 µg/L. Raw water and treated water samples should be analyzed frequently. Greensand filters should be able to reduce arsenic to acceptable levels. If the raw water has a high arsenic concentration and the current greensand filters are not able to reduce it to less than the MAC then an activated alumina filter or ion exchange system should be considered.

4.4 RECOMMENDATIONS AND IMPROVEMENTS

- The Town of Wadena should engage a consultant to conduct a GUDI screening study on the existing wells. The estimated cost for completing a screening study can range from $5,000 to $20,000 depending on the level of effort required.

- It is recommended that a backwash meter be installed and that a dedicated backwash pump eventually be considered as part of any upgrade facility.

- Upgrading of the well communications should be reviewed.

- The merits of adding VFD’s to the distribution pumping system should be reviewed.

4.5 WATER TREATMENT PLANT RECOMMENDATIONS

The primary purpose of this assessment is to deal with issues that directly affect the quality and safety of the water supplied to the residents of Wadena. However, there are also a number of other potential actions that should be considered by the Town. These actions may reduce costs

and risks and increase the efficiencies and capabilities of the waterworks operation. They are as follows:

- It is recommended that arsenic levels continue to be monitored in the raw and treated water regularly.
- It is recommended that turbidity levels be monitored in the raw water.
- It is recommended that manganese levels be measured in the raw and treated water to confirm treatment performance.
- It should also be noted that the waterworks system is aging and much of it may require replacement or significant maintenance in the next 15 years. Predesign work on an updgraded water treatment plant should be considered.

4.6 CONCEPTUAL COST ESTIMATES

The table below is intended to show the conceptual costs of implementing the recommendations and improvements.

TABLE 7
CONCEPTUAL COST ESTIMATES – IMPROVEMENT ALTERNATIVES

RECOMMENDED UPGRADES	CONCEPTUAL COST ($)
Backwash Pump Upgrades	50,000.00
Well Communication Review	10,000.00
Backwash Flow Meter Upgrades	5,000.00
PreDesign for New Water Treatment Plant	20,000.00
Sub-Total	*85,000.00*
Contingency	20,000.00
TOTAL	**190,000.00**

Prior to moving forward with some of the excellent recommendations provided within the audit, it may make more sense to move to a predesign for an upgraded/expanded water treatment plant.

5.0 STATEMENT OF LIMITATIONS AND CONDITIONS

5.1 THIRD PARTY USE OF REPORT

This report has been prepared for the Town of Wadena to whom this report has been addressed and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

5.2 GEO-ENVIRONMENTAL STATEMENT OF LIMITATIONS

KGS Group prepared the geo-environmental conclusions and recommendations for this report in a professional manner using the degree of skill and care exercised for similar projects under similar conditions by reputable and competent environmental consultants. The information contained in this report is based on the information that was made available to KGS Group during the investigation and upon the services described, which were performed within the time and budgetary requirements of the Town of Wadena. As the report is based on the available information, some of its conclusions could be different if the information upon which it is based is determined to be false, inaccurate or contradicted by additional information. KGS Group makes no representation concerning the legal significance of its findings or the value of the property investigated.

5.3 CAPITAL COST ESTIMATE STATEMENT OF LIMITATIONS

The cost estimates included with this report have been prepared by KGS Group using its professional judgment and exercising due care consistent with the level of detail required for the stage of the project for which the estimate has been developed. These estimates represent KGS Group's opinion of the probable costs and are based on factors over which KGS has no control. These factors include, without limitation, site conditions, availability of qualified labour and materials, present workload of the Bidders at the time of tendering and overall market conditions. KGS does not assume any responsibility to the Town of Wadena in contract, tort or otherwise in connection with such estimates and shall not be liable to the Client if such estimates prove to be inaccurate or incorrect.

5.4 DECLARATION

"I, the undersigned, declare that the information contained within this submission is, to the best of my knowledge, complete and accurate, and has been prepared in accordance with the standard for this submission as published by the Saskatchewan Water Security Agency."

(Seal)

APPENDIX A

PERMIT TO OPERATE WATERWORKS

Saskatchewan
Ministry of
Environment

Permit to Operate Waterworks

Environmental Protection and Audit Division

Issued Pursuant to Section 34 of *The Environmental Management and Protection Act, (2002)*

File #: Y21020-50/WW/OP/Wadena

Permit #: 00002553-03-00

To: The Town of Wadena (the **Permittee**), the person responsible for the waterworks located at Lot 3, Blk J, Pln 66H02507 Wadena, Saskatchewan, which provides water for human consumptive use to the Town of Wadena

WHEREAS, the Minister is satisfied that it is in the public interest to issue the permit to the Permittee.

PURSUANT to section 34(2)(e) of *The Environmental Management and Protection Act, 2002*, Permit # 0002553-02-00, issued March 1st, 2007 is altered in accordance with the terms and conditions attached.

This alteration, hereinafter called Permit # 00002553-03-00, takes effect on the 1st day of March, 2009.

Permit # 00002553-03-00 expires on the 1st day of March, 2015 unless canceled or suspended before that date.

Issued

Email – Feb. 7, 2014

Ries Mansuy, A.Sc.T.
Environmental Project Officer
Environmental Protection and Audit Division, South EcoRegion
Ministry of Environment
Acting for and on Behalf of the Minister of the Environment

Terms and Conditions

Section One: Definitions

1.1 All words and phrases have the same definitions as set out in *The Environmental Management and Protection Act, 2002*, or *The Water Regulations, 2002*, as the case may be.

1.2 In this Permit:

(a) "*Act*" means *The Environmental Management and Protection Act, 2002;*

(b) "*Regulations*" means *The Water Regulations, 2002;*

(c) "Environmental Protection and Audit Division" means the Environmental Protection and Audit Division of the Ministry of Environment of the Government of Saskatchewan;

(d) "Accredited" means attainment of the Standards Council of Canada, National Standards System, General Requirements for the Competence of Testing and Calibration Laboratories, (ISO/IEC17025-1999) CAN-P-4D, March 2002, including but not limited to attaining the parameters necessary to undertake the reports required by Part V of the *Regulation* or by a permit to operate a Waterworks issued for the purposes of subsection 21(1) of the *Act*;

(e) "Positive Bacteriological Result" means a test result showing the presence of total coliforms, fecal coliforms, *Escherichia coli* or 200 or more organisms per 100 millilitres as an overgrowth of background bacteria.

Section Two: Effective Date and Expiry

2.1 This Permit takes effect on the date shown on the Permit.

2.2 This Permit expires on the date shown on the permit unless canceled or suspended before that date.

2.3 The Permittee shall apply for renewal/alteration of this permit at least 60 days prior to its expiry

Section Three: Alternative Supply of Safe Drinking Water

3.1 The Permittee shall provide an alternate source of water that is suitable and safe for human consumption to the consumers served by the hygienic waterworks.

3.2 Where the alternate source of safe drinking water is a point of use or point of entry treatment device, the Permittee shall provide the Minister with an annual report on the status of operation and maintenance of the treatment device.

3.3 Where the alternate source of safe drinking water is bottled water, the Permittee shall deliver an adequate supply and provide the Minister with an annual report on the source and volume of bottled water provided to consumers.

Section Four: Operation

4.1 The Permittee shall comply with the *Act* and the *Regulations*, and the Terms and Conditions of this Permit.

4.2 In the event of an inconsistency between the *Act* and this Permit, or the *Regulations* and this Permit, the more stringent requirement shall apply.

(a) The Permittee shall not extend or alter the Waterworks without a permit issued pursuant to section 23 of the *Act*.

4.3 Where all or part of a distribution system is new, extended, altered or repaired, the Permittee shall, before the commencement of its use, after completion of the new waterworks or the alteration, extension or repair:

(a) disinfect the portion of the distribution system that is new or has been extended, altered or repaired; and take water samples from the distribution system that is new or has been extended, altered or repaired, and have the samples analyzed for bacteria.

Section Five: Sampling and Monitoring and Water Quality

5.1 The Permittee shall cause water samples to be taken from the Waterworks to test for bacteria, and chlorine residual, at the locations, times and frequency set out in Appendix A.

5.2 The Permittee shall ensure that the water provided to consumers does not exceed the limits set out in Appendix B for bacteria. The Permittee shall cause to be maintained the free chlorine residual and the total chlorine residual as set out in Appendix B.

5.3 Subject to 5.2, the Permittee shall have water samples analyzed by an accredited laboratory in accordance with the *Regulations*.

5.4 The Permittee may perform water sampling and analysis for chlorine residual by means of on-site testing.

5.5 The Permittee shall take water samples in accordance with the instructions provided by the institution or laboratory which provides the sampling bottles or containers.

Section Six: Record keeping

6.1 The Permittee shall maintain records containing the following information:

(a) total water pumped into the distribution system on a daily basis or the total raw water used;
(b) the types, dosages and total amounts of chemicals applied to the water for treatment;
(c) the locations from which samples for any tests conducted by the Permittee of the Waterworks were taken in accordance with this permit and the name of the person who conducted the sampling or testing and the results of those tests;
(d) any departures from normal operating procedures that may have occurred and the time and date that they occurred;
(e) any instructions that were given during operation of the Waterworks to depart from normal operating practices and the name of the person who gave the instructions;
(f) any upset condition or bypass condition, the time and date of the upset condition or bypass condition and measures taken to notify others and resolve the upset condition or bypass condition;
(g) any condition of low disinfectant levels, the time, date and location of occurrence and measures taken to restore disinfectant levels to required values;
(h) the dates and results of calibrating any metering equipment and testing instruments; and
(i) the dates and types of maintenance performed on equipment and any actions taken to ensure the normal operation of the Waterworks.

6.2 The Permittee shall cause the operational records or logs mentioned in 6.1 to be recorded and maintained in the following manner:

(a) operational records or logs must be made in chronological order, with the dates, times and testing locations clearly indicated;
(b) entries in an operational record or log must only be made by the Permittee, which includes by definition any principal or agent of a Permittee;

(c) any person making an entry in an operational record or log must do so in a manner that allows the person to be unambiguously identified as the maker of the entry; operational records or logs must be maintained on a daily basis and retained for at least five years;
(d) any anomalies or instances of missing entries in an operational record or log must be accompanied by explanatory notes;
(e) operational records or logs must only contain data or information that is actually observed or produced;
(f) operational records or logs must not contain default values generated manually or by automated means;
(g) operational records or logs maintained pursuant to clause (d) must be made available promptly on request of the Minister.

6.3 The Permittee shall review the records and logs mentioned in 6.1 on a monthly basis to ensure that the operating parameters are being achieved and that the limits set out in Appendix B are not exceeded.

6.4 The Permittee shall report the findings to the Minister as soon as is reasonably practicable after each review required by 6.3 should the review of the records and logs indicate that the quality of water from the Waterworks has been adversely affected.

Section Seven: Reporting and Consumer Reporting

7.1 The Permittee shall submit the results of water sampling analysis performed in accordance with this Permit to the Environmental Protection and Audit Division:
(a) in the case of a positive bacteriological result, within 24 hours following completion of the sampling analysis;

7.2 The Permittee shall direct the laboratory performing its water sampling analysis to submit the results within the timeframes mentioned in 7.1 directly to the Environmental Protection and Audit Division, in a format acceptable to the Minister, in addition to submitting the written results to the Permittee.

7.3 The Permittee shall report to the Minister any known or anticipated upset condition, bypass condition or events at or affecting a Waterworks that could adversely affect the quality of water produced by the Waterworks.

7.4 The Permittee shall immediately report to the Minister any instance where:
(a) disinfection equipment fails;
(b) the level of disinfection identified in Appendix B is not achieved or is not anticipated to be achieved;
(c) any other parameter level identified in Appendix B is not achieved or is not anticipated to be achieved;
(d) there is a, retirement, suspension, resignation, scheduled absence or termination of employment of any Waterworks distribution or Waterworks treatment operator, or any anticipated retirement, suspension, resignation or termination that results in the waterworks not being under the direction of an operator;
(e) a system depressurization has occurred.

7.5 The Permittee shall instruct its employees, agents and contractors performing work or service in relation to the Waterworks, of their obligation under section 37(1) of the *Regulations* and to report to the Minister any instance as described in 7.4 and any known or anticipated upset condition, bypass condition or events at or affecting a Waterworks that could adversely affect the

quality of water produced by the Waterworks.

7.6 The Permittee shall as soon as reasonably practical report any of the events mentioned in 7.3 or 7.4 to the Minister.

7.7 The Permittee shall, once per calendar year, provide the consumers supplied by the Waterworks with a notification of:

(a) the quality of water produced or supplied by the Waterworks in comparison with the levels set out in this permit;

(b) the Permittee's compliance with sample submission requirements described in this permit.

(a) Within 30 days after providing consumer notification required by 7.7, the Permittee shall provide a written copy of the notification to the Minister..

7.8 The Permittee shall maintain records of on-site testing of free and total chlorine residual, Fluoride and Turbidity and make them available to the Minister upon request. For all other parameters, the Permittee shall ensure that reporting is conducted in accordance with Section 39 of *The Water Regulations.*

Section Eight: Inspection

8.1 An Environmental Project Officer may enter the Waterworks at any time to conduct an inspection to ensure that the Permittee is complying with this Permit, the *Act* or the *Regulations*.

8.2 Upon the request of an Environmental Project Officer, the Permittee shall immediately provide any books, records, logs, graphs, papers, documents, or data, including any computer, digital or electronic records, logs, graphs, files or data maintained with respect to the Waterworks.

Section Nine: General

9.1 A copy of this Permit shall be posted in a conspicuous place at the Waterworks.

9.2 The Permittee shall provide each operator of the Waterworks with a copy of this Permit and the *Regulations*.

9.3 The Minister may cancel, alter or suspend this Permit for the reasons and in the manner set out in the Act.

9.4 In the event of any inconsistency between an Approval to Operate Works or a Minister's Order (as set out on the first page), and the Terms and Conditions of this Alteration of Permit to Operate a Waterworks, the Terms and Conditions of this Alteration prevail.

9.5 Where any notice or reporting is required to be given by the Permittee, it shall be provided to:

(a) in the case of the Minister:
Ministry of Environment
Yorkton, Saskatchewan
Fax: (306) 786-5716.
Telephone: (306) 786-1424.
After hours, weekends and holidays, the Department can be contacted by calling the 1-800-667-7525 Spill Report Line.

(b) in the case of the Environmental Protection and Audit Division
Environmental Protection and Audit Division
3211 Albert Street
Regina, Saskatchewan S4S 5W6
Fax: (306) 787-0197
Telephone (306) 787-6504

Permit Number: 00002553-03-00
Appendix A

File: Y21020-50/WW/OP/Wadena

Waterworks Schedule

Wadena Distribution System Station Number: SK05MA0014
Wadena Water Treatment Plant Station Number: SK05MA0018

Parameter	Testing Requested Yes	Limit[1] Applied Yes	Treated Water Sampling Locations and Minimum Sampling Frequency
1. Bacteriological (samples to be submitted to the H.E. Robertson (Provincial) Laboratory, Regina or an approved laboratory).	X	X	Once (1) every (1) week from representative locations in the distribution system. (Repeat and Special samples resulting from follow-up to a contaminated regular sample are not considered as regular sample submissions).
2. Turbidity (on-site)	X	X	Daily from water entering the distribution system for Groundwater plants; and, at the same frequency and locations as for bacteriological sampling.
3. Fluoride (on-site testing)	X		Daily, from the treated water at the water treatment plant.
4. Fluoride (off-site testing)	X		Once (1) every week from representative locations in the distribution system.
5. Residual (on-site testing)	X	X	At least once (1) per day for free chlorine residual in the water entering a distribution system; and, at the same frequency and locations as for bacteriological sampling, for free and total chlorine residuals.
6. Chemical - General [alkalinity; bicarbonate; calcium; carbonate; chloride; conductivity; fluoride (for non-fluoridating communities); hardness; magnesium; nitrate; pH; sodium; sulphate; and total dissolved solids].	X		Once (1) every two (2) years, from the treated water at the water treatment plant. The next sample to be taken in the 2011 calendar year.
7. Chemical – Health Category [aluminium; arsenic; barium; boron; cadmium; chromium; copper; iron; lead; manganese; selenium; uranium; and zinc].	X		Once (1) every two (2) years from the treated water at the water treatment plant. The next sample to be taken in the 2010 calendar year.
8. Pesticides [atrazine; bromoxynil (Buctril); carbofuran; chlorpyrifos; dicamba (Banvel); dichlorophenoxyacetic acid 2,4 (2,4-D); diclofop-methyl (Hoe Grass); dimethoate; malathion; pentachlorophenol (PCP); picloram; trifluralin (Treflan)].			
9. Trihalomethanes			
10. Cyanide and Mercury			
11. Organics [benzene; benzo(a)pyrene; carbontetrachloride; dichlorobenzene 1,2; dichlorobenzene 1,4; dichloroethane 1,2; dichloroethylene 1,1; dichloromethane; dichlorophenol 2,4; ethylbenzene; monochlorobenzene; nitrilotriacetic acid (NTA); tetrachlorophenol 2,3,4,6; toluene; trichloroethylene; trichlorophenol 2,4,6; vinyl chloride].			
12. Radiological [gross alpha, gross beta]			

[1] Limits for identified parameters are provided in Appendix B

Permit Number: 00002553-03-00
Appendix B – Permit Limits File: Y21020-50/WW/OP/Wadena

The following Water Quality limits apply where identified in Appendix A

Bacteriological:
(i) total coliform levels of zero organisms detectable per 100 millilitres;
(ii) fecal coliform levels of zero organisms detectable per 100 millilitres; and
(iii) background bacteria levels on a total coliform or a fecal coliform membrane filtration plate of less than 200 organisms per 100 milliliters or no overgrowth.

Chlorine Residual
(a) free residual of not less than 0.1 milligrams per litre in the water entering a distribution system; and
(b) a total chlorine residual of not less than 0.5 milligrams per litre or a free chlorine residual of not less than 0.1 milligrams per litre in the water throughout the distribution system.

Turbidity - Interim requirements:
Waterworks employing groundwater beyond the direct influence of surface water shall maintain turbidity levels for water entering the distribution systems at levels that will always result in acceptable microbiological quality and which will not compromise disinfection. Waterworks employing groundwater beyond the direct influence of surface water shall maintain turbidity at the lowest possible levels below or approaching 1.0 Nephelometric Turbidity Units for water entering the distribution system.

Future Requirements by Source/Treatment type:

Source/Treatment	Routine Standard	Continuous Monitoring Time Duration Max.	Absolute Maximum
Groundwater [1]	Less than 1.0 NTU, 95% of discrete measurements or 95% time if continuous monitoring employed.	No Requirement.	No requirement.

[1] Turbidity value for water entering the distribution system

Chemical – Health Category	Parameter	MAC (mg/L)	IMAC (mg/L)
	Arsenic		0.025
	Barium	1.0	
	Boron		5.0
	Cadmium	0.005	
	Chromium	0.05	
	Fluoride	1.5	
	Lead	0.01	
	Nitrate	45.0	
	Selenium	0.01	
	Uranium	0.02	

APPENDIX B

CT CALCULATIONS

CT Calculation Table Date 12-Apr-16 Disinfectants CL_2

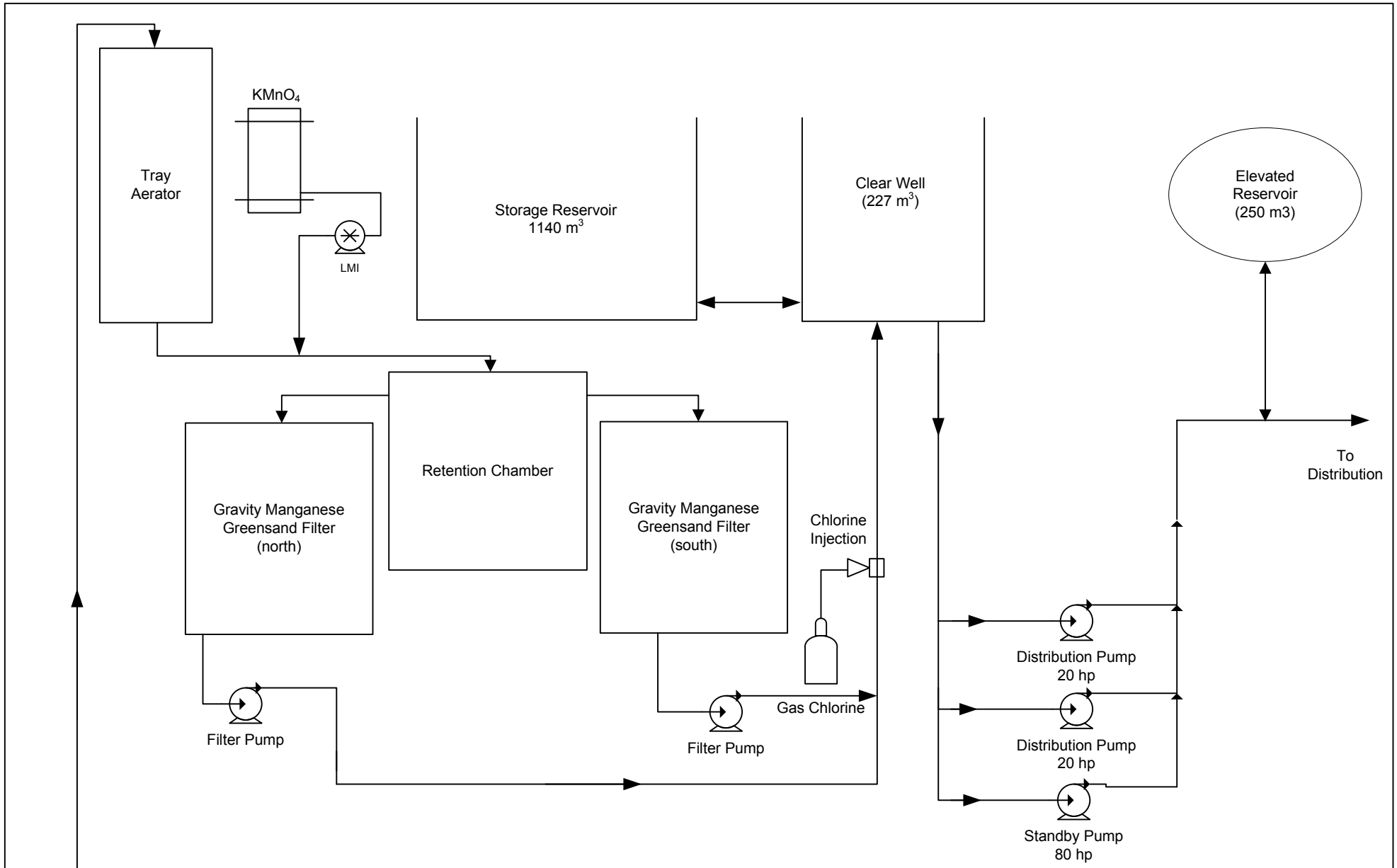
Segment	Volume (L)	Peak Hourly Flow (L/min)	Temp (deg. C)	pH	Free CL_2 Conc. (mg/L)	Baffle Factor
Smaller reservoir	113,650	1122	5	7.5	0.3	0.3

Process Name	Smaller reservoir					
Volume (L)	113650					
Baffling Condition (T_{10}/T)	0.3					
Peak Hourly Flow (L/min)	1122					
Theoretical Detention (min)	101.3					
T_{10} (min)	30.4					
Free Disinfectant Concentration (mg/L)	0.3					
Plant CT Value (mg-min/L)	9.1					
pH	7.5					
Temperature (deg.C)	5					
$CT_{3\text{-log Giardia}}$	177.9					
$CT_{4\text{-log Viruses}}$	8					
Estimated Plant Giardia Log Inactivation	0.2					
Estimated Viruses Log Inactivation	4.6					

Segment Totals		
	T_{10}	30.38770053
	CT	9.11631016
	Giardia Log Inactivation	**0.153695633**
	Virus Log Inactivation	**4.55815508**

APPENDIX C

WATER TREATMENT PLANT SCHEMATIC



KGS GROUP

Town of Wadena

Waterworks System Assessment
General Process Schematic

SIZE	FSCM NO	Project #	REV
		15-1950-001	0
SCALE	NTS	SHEET	1 OF 1

April, 2016

APPENDIX D

PHOTO LOG

Photo 1 – WTP Building

Photo 2 – Well #4

Photo 3 – Well #5

Photo 4 – Filtration System

Photo 5 – Chemical Feed System

Photo 6 – Treated Water Reservoir

Photo 7 – Water Tower

APPENDIX E

ROUND 3 WSA SUMMARY CHECKLIST

Round 3 Waterworks System Assessment Summary

Waterworks: Town of Wadena | Owner(s): Town of Wadena

Env. Project Officer: Rick Sheichuk | Summary Completion Date: Mar-16

Population: Full Time: 1306 | Seasonal:

Source: Groundwater: [X] | Surface Water: [ ] | GUDI (groundwater under direct influence): [ ]
Treated Groundwater: [ ] | Treated Surface Water: [ ] | Treated GUDI: [ ]

Sourcewater Protection Concerns: None

Source/Raw Water Quality Issues that May Affect Treatment/Treated Water Quality:

Parameter:	Level:	Parameter:	Level:
Arsenic			
Iron			
Manganese			

Raw water capacity/allocation:

Treated/Distributed Water Quality Issues (any that exceed Standards and Objectives after treatment):

Parameter:	Level:	Parameter:	Level:
Arsenic	1.1-16 µg/L		
Manganese	0.0 – 0.8 mg/L		

List of Chemicals Used: Potassium permanganate ($KMnO_4$)
Chlorine gas

Description of Treatment Processes in Place:

Gravity filters (greensand), post chlorination,
treated water storage reservoirs and a distribution pumping system.

Treatment Processes with existing issues (including capacity issues):

Other issues identified within the waterworks:

Major Recommendations:

GUDI Study

Any Recommendations that may pose an Immediate Health Concern:

Arsenic concentration in the treated water was in the range of 1.1 µg/L to 16 µg/L

Total Cost of Recommended Upgrades: $190,000

Other Comments:

*Please submit electronic copy to WSA. If more space is required, a longer summary sheet may be requested.

KGS
GROUP
CONSULTING
ENGINEERS