City of Brandon Water Supply Evaluation

PREPARED FOR:

City Brandon, South Dakota

AE2S Project No. P05588-2018-000

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Final Report

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Chapter 1 INTRODUCTION AND BACKGROUND

The City of Brandon has been experiencing rapid growth, along with the surrounding communities. This growth has increased water demand to the point that the City of Brandon implemented water conservation measures to manage water consumption. Additionally, the City of Brandon residents have expressed concern with the overall water quality. To address these items, the City of Brandon contracted with AE2S to prepare this Water Supply Evaluation. The overall objective of this Evaluation was to explore water source and treatment options for the City of Brandon and prepare a report that provides a roadmap for water source and supply decisions for the next 50 years.

1.1 Background

The City of Brandon currently has a population of about 10,000 people and has experienced sustained growth in previous years. This growth is anticipated to continue into the future. The City currently obtains water from three wells, one (Well 1) in the Big Sioux Aquifer and two (Wells 3 and 6) in the Split Rock Creek (SRC) Aquifer. Well 6 produces the majority of the City's water. The combined flow from the other two remaining wells, Well 1 and Well 3, is approximately half of the flow capacity from Well 6. A fourth well, Well 7 in the Split Rock Creek Aquifer, is fully constructed but has not been operated due to concerns about relatively high radionuclides present in this well. Therefore, Well 6 has no redundant well that can produce a similar flow rate, although the City is currently constructing Well 8 to be redundant to Well 6. This lack of redundant wells leaves the City vulnerable to water production capacity issues should Well 6 ever be offline.

The City's water treatment plant (WTP) is near its full design capacity of 2,000 gpm. With future projected growth, water demands will reach the WTP capacity by 2025. In order for the City to continue to grow, additional treatment capacity will be needed, as well as additional source capacity.

The City currently draws the majority of their water from the SRC aquifer, with a small portion coming from the Big Sioux Aquifer. The two aquifers present treatment challenges for the city as the Big Sioux Aquifer contains elevated levels of nitrate, while parts of the SRC aquifer have radionuclide concentrations in excess of the EPA's maximum contaminant levels (MCLs).

1.2 Water Evaluation Study

This Water Supply Evaluation analyzes the sustainability of water sources, estimates water demands for 25 and 50 years, presents possible implementation options, and presents anticipated costs to produce water.

The water source evaluation evaluated the water source needs for years 2045 and 2070. Population projections for the City of Brandon were prepared along with anticipated water demands, providing the basis for planning of future water demands and creating the target water volumes used in assessing water supply options. Water quality regulations were reviewed and used for comparison to potential water sources that are considered for the City of Brandon. Potential water sources need to be capable of meeting the water quality standards set by the Environmental protection Agency, the State of South Dakota, and additional treatment objectives desired by the City of Brandon.

The existing City of Brandon water system was reviewed to summarize existing water treatment processes and associated capacities and finished water quality. Current treatment residual disposal practices were reviewed, requirements for future residual disposal options were investigated.

Groundwater, surface water, and regional water sources were reviewed as potential future water sources for Brandon. A hydrogeological subconsultant, WSP USA Inc., (WSP) created hydrogeological conceptual models of the Big Sioux Aquifer and the Split Rock Creek Aquifer in a three-mile radius of Brandon. WSP reviewed the water quality from the two aquifers and estimated the productivity and potential locations of wells in each aquifer that could supply water to Brandon. In addition to the local aquifers, other water sources were evaluated including nearby municipal and regional water providers such as the City of Sioux Falls, Minnehaha Community Water Corporation (MCWC), the Lewis and Clark Regional Water System (L&C), and the possibility of utilizing the Big Sioux River.

From these efforts, short-term and long-term alternatives were developed that could be part of the water supply solution to the City of Brandon. A 5-year offer from MCWC to supply treated water to Brandon was compared with near term development of groundwater resources available to Brandon. Long-term alternatives included source water and treatment process alternatives that will meet the estimated water demands and achieve various levels of finished water quality – 1) treatment that provides the existing water quality, 2) providing existing treatment plus additional radionuclide removal at Well 7, and 3) providing reverse osmosis to achieve treated water hardness equivalent to neighboring communities.

Long-term alternatives were compared using non-economic and alternative cost factors. A Kepner-Tregoe Analysis was conducted to rank the alternatives using the non-cost criteria and ranking established by a team of Brandon stakeholders and project personnel. An opinion of probable construction cost was created for each alternative. Non-economic ranking and cost scoring were reviewed to select favorable future water supply alternatives. Estimated water rate impacts of alternatives were compared. An implementation approach for the favorable alternatives was presented.

Chapter 2 BASIS OF PLANNING

To plan for a sufficient and reliable future water supply, historical water supply, treatment, historical water demands, and future growth areas must be analyzed and combined with future population projections and per-capita water use for the desired planning period. This chapter details the basis of planning for the Water Supply Evaluation for the City of Brandon and includes the following sections: Planning Periods and Study Area, Population Projections, and Water Demand Evaluations.

2.1 Planning Period and Study Area

Establishing a planning period is an essential component for the development of water system improvements. Improvements to distribution systems, such as tanks and piping infrastructure may have long service lives, often 50 years or more. As long as adequate maintenance is performed, these long service lives can often be fully utilized with careful planning before system improvements are made in order to estimate future water needs best.

Two future design years were considered 2045 and 2070. These planning horizons of approximately 25 and 50 years were chosen to best match the useful lives of many well-maintained distribution system components, but also provide a long-term approach to water source acquisition, providing assurance that water will be available when needed.

The study area for future growth will focus on areas to the west, south, and east of the city. The City of Brandon has a large growth potential in these areas around the City, with a substantial portion planned for residential dwellings. Future growth areas are covered in greater detail in Section 2.2.3.

2.2 Population Projection

The number of people in a community is often closely related to how much water that community uses. Thus, population projections are an integral part of estimating future water needs. By reviewing historical data, available land, and other contributing factors, population ranges for the City of Brandon were generated.

2.2.1 *Historical Population Trends and Growth Characteristics*

Census data for the City of Brandon are summarized in Table 2.1. The estimated population in 2017 by the US Census Bureau was 9,957. Assuming a linear trend of population growth between census populations, annual rate population increase ranged from 96 people per year in the 1980-1990 decade to 309 people per year for the 2000-2010 decade and is estimated at 167 people per year in the 2010-2017 7-year period. The average annual percent increase ranged between 1.9 percent during the 1980 to 1990 decade to 6.1 percent during the 1990 to 2000 decade.

Table 2.1 Brandon Census Population Data

Year	1980	1990	2000	2010	2017 (Census Estimate)
Population	2,589	3,545	5,693	8,785	9,957
Annual Percent Increase (10-year interval, 7-year for 2017)		3.7	6.1	5.4	1.9
Average Annual Population Increase		96	215	309	167

Given the date of this study is near the end of a decade, it is appropriate to justify the census population estimate with other population indicators. Population growth is accompanied by housing construction and associated water meter installations that can be tracked by association with building permitted household living units, census households, and water accounts data. Using data provided by the city of Brandon, building permitted households, the number of water accounts, census households, and unit population per tracking parameter were plotted in Figure 2.1.

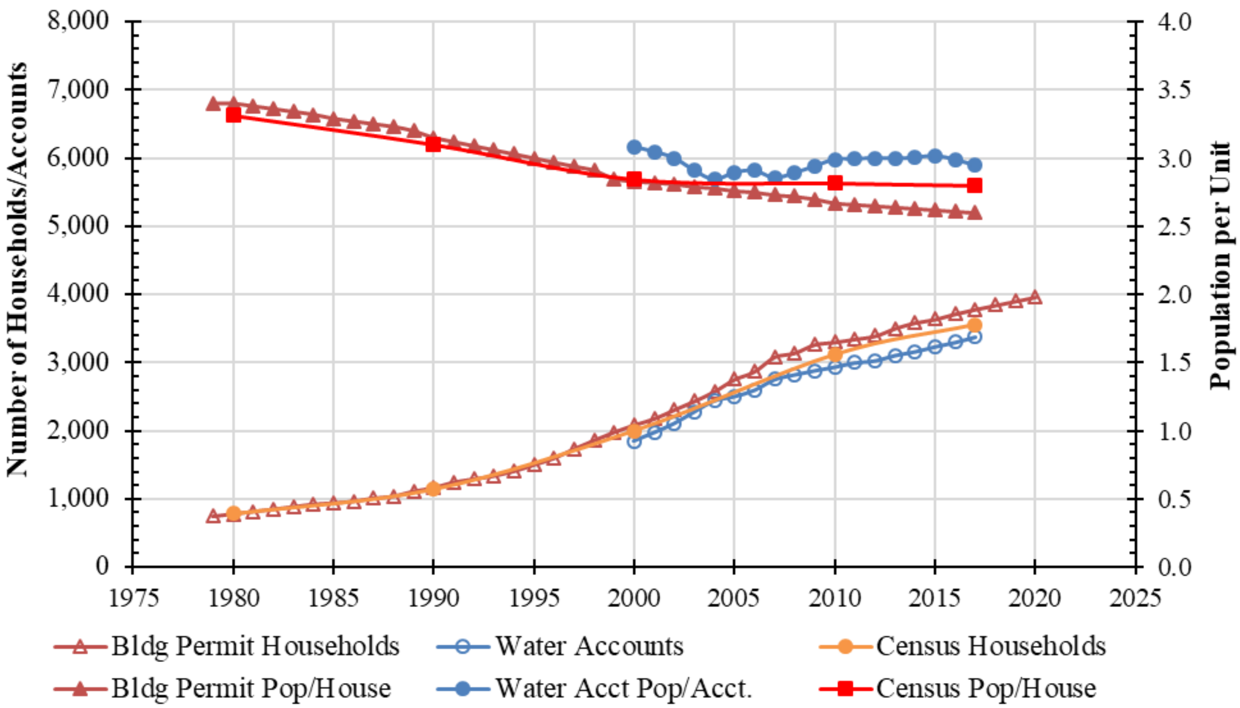


Figure 2.1 Census, Building Permit, Water Account Trends

From the trends exhibited in Figure 2.1, building permit households, census households, and water accounts appear to follow similar trends, showing an increasing rate of growth from 1990 to 2007, and then flattening to a nearly linear growth trend after 2007. The recession of the late

2000's likely affected the growth rate of housing in Brandon, although the growth continues at a consistent but lower rate since 2007. These data support the statistics shown in Table 2.1. Although the number of people per household based on building permit data declined throughout the time period to a value of 2.6 people per household, the census population per household has remained at approximately 2.8 people per household, and the water account data have remained at or near 3 people per residential water account.

The number of people per household appears to be correlated with a growth pattern for any given community. To examine this characteristic, the data from several South Dakota cities were compared in Table 2.2 (Brandon data highlighted in yellow), in which the cities are listed in order of increasing persons per household, ranging from 2.14 (Mitchell) to 3.1 (Harrisburg). General trends noted from these data include:

- Lower person per household cities tend to have a greater percentage of the population older than 65 years old, and a lower percentage of population under 18 years, and lower population growth rates.
- Higher person per household cities tend to have a lower percentage of the population older than 65 years old, and a higher percentage of population under 18 years and higher population growth rates.

Table 2.2 Household Characteristics for South Dakota Cities

City	2017 Population	Population Growth 2010-2017, % of 2010 Census Pop.	Persons per household	% over 65	% under 18
Mitchell	15,063	2.29	2.14	16.2	23
Yankton	14,516	0.43	2.19	17.8	21.5
Huron	13,118	4.18	2.3	16.2	26.6
Sioux Falls	176,888	13.30	2.43	11.9	24.8
Brandon	9,957	13.34	2.8	9.9	33.1
Tea	5,448	43.14	3.03	1.9	36.9
Harrisburg	5,968	45.95	3.1	2.7	37.6

Comparing the data from Table 2.2 with that of Figure 2.1, it appears that Brandon's growth rate is transitioning from an exponential phase to a more linear phase and that growth rates may be more closely tracking with Sioux Falls. Tea and Harrisburg appear to be in the exponential phase that Brandon experienced from 1990 to 2007. The 2017 Estimated Census data appear to correlate with various stages of growth in cities.

As a final step in affirming a 2017 population for Brandon, the building permit data, US Census estimates, and Brandon Water account data were used to estimate the populations in each year from 2010 through 2017. The results are shown in Table 2.3.

Table 2.3 Estimated Brandon 2017 Population by Three Methods

Year	Building Permit Analysis	US Census Estimate	Water Account Analysis
2010	8,814	8,785	8,785
2011	8,900	8,977	8,850
2012	8,989	9,091	8,939
2013	9,248	9,311	9,172
2014	9,434	9,505	9,337
2015	9,529	9,762	9,552
2016	9,701	9,863	9,741
2017	9,836	9,957	9,974

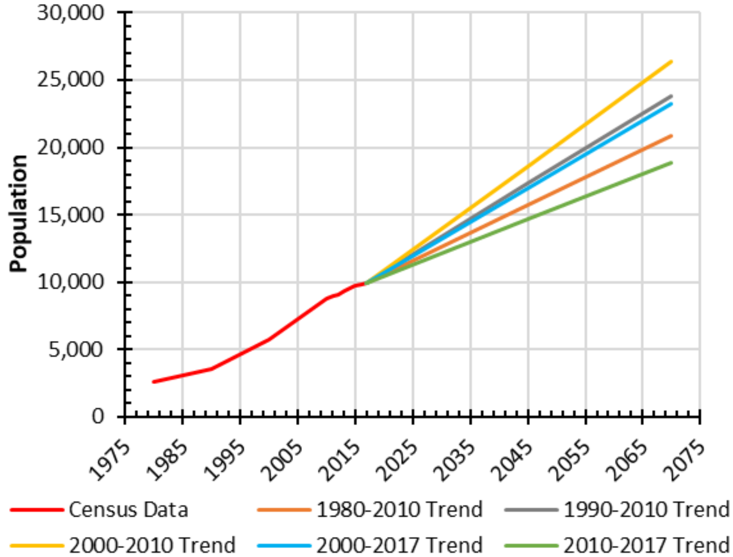
The water account method produced the highest population estimate (9,974), and the building permit method produced the lowest population estimate (9,836), a range of only 138. These method results bracketed the US Census Estimate (9,957), verifying the legitimacy of the US Census Estimate, which was included as a data value in trend analysis for future population growth Brandon.

2.2.2 *Projected Population Growth*

Several methods can be used to predict population growth. As mentioned in Section 2.2.1, Brandon may be transitioning between an exponential growth trend and a linear growth trend. Thus, Brandon's population was projected using both trend methods.

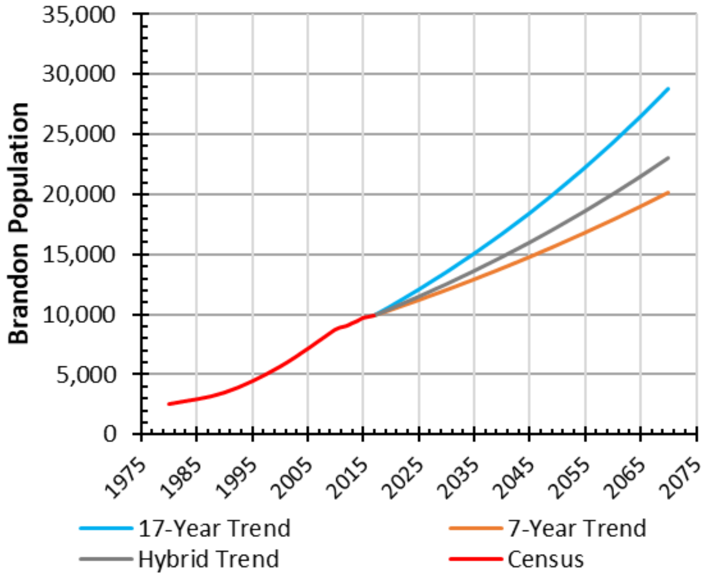
Linear growth projections for Brandon are presented in Figure 2.2. Five different projections are shown, using linear growth rates depending on population growth over a range of time spans. The projected populations depended on the time span establishing the growth basis – the 2010-2017 trend basis produced 2045 and 2070 projections of 14,645 and 18,831, respectively, whereas the 2000-2010 trend basis produced 2045 and 2070 projection of 18,615 and 26,645. Considering the range of projections produced by this method, a likely projection is based on the growth rate between 2000 and 2017, yielding 2045 and 2070 projections of 16,980 and 23,251.

An exponential growth projection method is similar to a compounding approach – rather than simply assuming constant growth, the growth is a function of the existing population, and the increase is a percentage of the population existing in any given year, so as the population increases, the number of people added to that population increase. Exponential growth trends for Brandon are presented in Figure 2.3.



Trend Basis	2045	2070
1980-2010	15,740	20,903
1990-2010	17,293	23,843
2000-2010	18,615	26,345
2000-2017	16,980	23,251
2010-2017	14,645	18,831

Figure 2.2 Brandon Estimated Population Using Linear Trends



Trend Basis	2045	2070
7 Year (2010-2017)	14,823	20,182
17 Year (2000-2017)	18,450	28,800
Hybrid	16,040	23,090

Figure 2.3 Brandon Estimated Population using Exponential Trends

The growth rate from this method depends on the time span used to obtain the rate of increase. As shown in Figure 2.3, the projection based on the 2000 - 2017 period is substantively greater than that based on the 2010 - 2017 period. Perhaps a hybrid of those two options would be appropriate for Brandon, yielding a 2045 projection of 16,040 and a 2070 projection of 23,090 people.

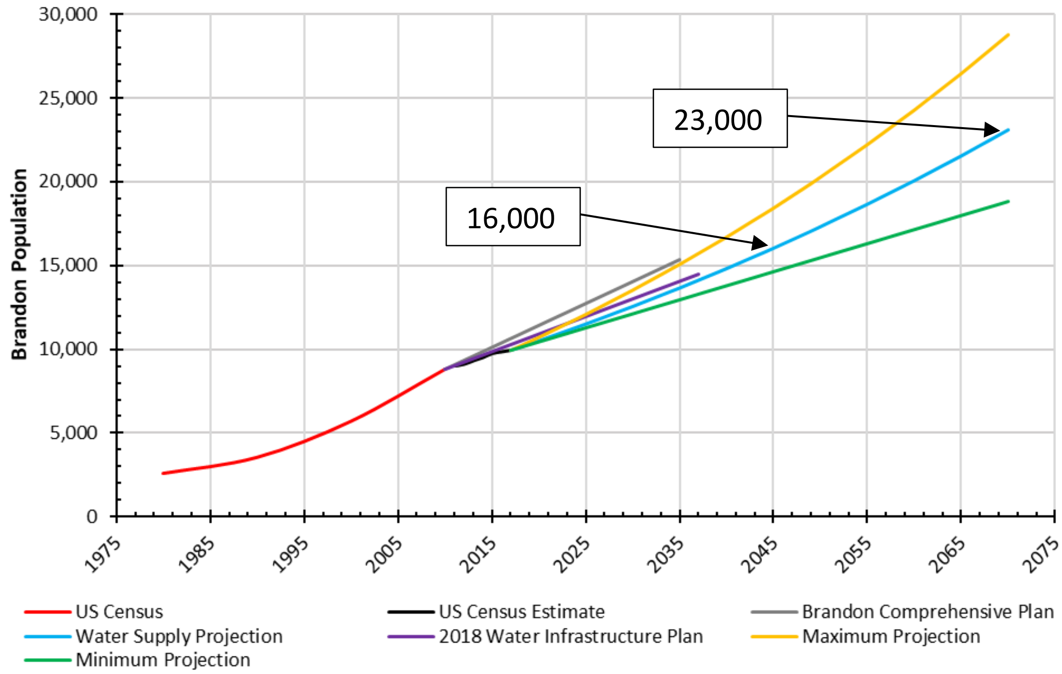


Figure 2.4 Composite Plot of Growth Projections

Figure 2.4 represents a composite of several growth projections from this work as well as other planning efforts, including the Brandon Comprehensive Plan (black line) and the 2018 Water Infrastructure Plan (purple line). Also included are the historical US Census data and the US Census estimates between 2010 and 2017. To establish a visual range of potential projections, the Maximum Projection represents the highest projection from the exponential method, and the Minimum Projection represents the lowest projection from the linear method. The blue line represents a combination the preferred projections from the linear and exponential projection methods and is the chosen projection for this study, yielding a 2045 projected population of 16,000 and a 2070 population projection of 23,000.

AE2S staff met with the City of Sioux Falls Planning and Building Services staff to review future year population projections. The City of Sioux Falls combines population and other growth-related data in Traffic Assignment Zones (TAZ's) which are used in the development of City's regional transportation model. Specific information for the TAZ's in the Brandon area was reviewed for this study. AE2S staff also reviewed population projections with staff from the South Eastern Council of Governments (SECOG) and compared them to projections presented in the Brandon Year 2035 Comprehensive Plan. Similar to the 2018 Comprehensive Water Infrastructure Development Plan, the projected population totals in the 2035 Comprehensive Plan do not include projections to either 2045 or 2070.

Discussions with representatives of the Brandon Valley School District were held. Each of the three future population projection methods was reviewed with district staff. Direct comparisons of school-age children for the City were not obtained as a method of projecting the overall future population of Brandon. However, Brandon Valley School District staff affirmed that the projected populations of for 2045 and 2070 were reasonable.

Finally, the population projections were vetted with the City of Brandon staff. Upon their review, the 2045 projected population of 16,000 and 2075 projected population of 23,000 were used for water demand estimates.

2.2.3 *Land Use Consumption and Characteristics*

Current and future land uses for the City of Brandon were analyzed to determine if the City's area could accommodate the projected populations for the planning period or if additional land consumption is necessary. AE2S staff specifically reviewed the development densities in three recent residential subdivisions on the north, east, and west sections of the community. Figure 2.5 provides an overview of the anticipated future land use. The yellow area in Figure 2.5 represents the area of potential residential development, which has a direct impact on the potential for growth.

Based on the Future Land Use Map in the 2035 Comprehensive Plan, there are approximately 4,300 acres of potentially developable land for future residential growth. Based on the development density analysis that was performed, approximately 3,280 dwelling units could be constructed. Using the current US Census estimate, Brandon has an average of 2.8 persons per dwelling unit. Projecting this dwelling unit occupancy with the potential number of dwelling units, approximately 9,200 people could occupy dwellings in the future developable land area.

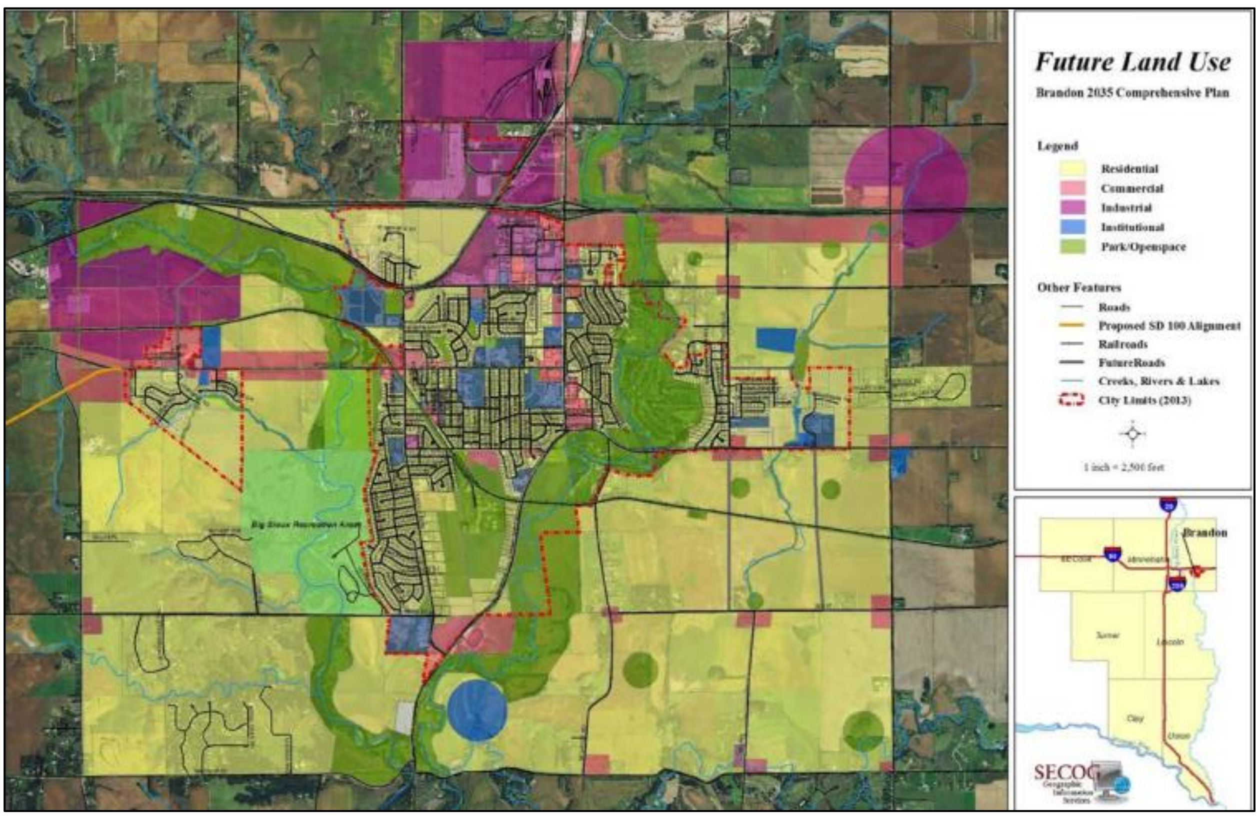


Figure 2.5 Brandon Future Land Use Through 2035

Given the projected population increase of approximately 6,000 people between 2017 and 2045, the current land designated for future residential growth has sufficient space to accommodate the projected population increase for the planning period through the year 2045. Assuming the population density is constant, and the population grows to 23,000 (an increase of approximately 13,000 from the present population), additional land may be necessary to accommodate the projected population growth through the year 2070.

2.3 Water Demand Evaluation

Another important part of estimating the amount of water that will be needed in the future is to evaluate how a community uses the water it produces. This section considers water use characteristics - how water is used by individual water account holders, how water is produced and consumed by various classifications of users and what percentage of water is unaccounted for in the system (produced yet not billed). Historical trends in water use characteristics are observed. Finally, the population estimate is used along with historical trends to estimate future water demands for 2045 and 2070 are projected using two different methods, resulting in the selection of water demands for Brandon's future water needs.

2.3.1 *Historical Water Demand Characteristics*

Historical water production and water use records were provided by the city of Brandon for evaluation of historical demand characteristics. In the water system, water is pumped from the wells to the treatment plant where a small amount of water is lost to sludge disposal. Treated water is then pumped to the distribution system, and an additional amount of water is lost through leakage, meter losses, and unmetered usages. Therefore, metered water demand is less than water pumped from the source. In reviewing water use records, records of water pumped to the distribution system appeared most reliable and available for study. Consequently, water production values are used to estimate water demands, and all demand - related values reported herein are water production values.

Water production data for years 2000 through 2017 are summarized in Table 2.4. Included in the table are calculated values for the peaking factor, which is the demand during the maximum day in a given year divided by the average annual daily demand for that year. The average per capita demand is the average day demand divided by the population, and the peak day per capita demand is the maximum day demand divided by the population for any given year. Trends of the Brandon water production data were evaluated to enable projections of future water demands.

Historical water demands are plotted in Figure 2.7. Average day demands have trended upward, approaching 900,000 gallons per day. Average day demand will generally trend with population growth, with peaks and valleys affected primarily by the impacts of timely rainfall events on water demand for lawn irrigation. In 2017, a watering ban during a dry season decreased the average daily demand.

Table 2.4 Brandon Water Production Data

Year	Population	Average Day Demand (gallons)	Max Month (Gallons)	Maximum Day Demand (gallons)	Peaking Factor	Average Per-capita Demand (gal/cap-day)	Peak Day per-capita Demand (gal/cap-day)
2000	5,693	621,191	29,172,000			109.1	
2001	6,139	577,605	29,946,000			94.1	
2002	6,485	687,205	41,105,000			106.0	
2003	6,791	747,381	46,282,000			110.1	
2004	7,164	763,675	41,489,000			106.6	
2005	7,601	755,688	43,466,000	1,988,000	2.63	99.4	261.5
2006	7,893	836,271	48,683,000	1,909,000	2.28	106.0	241.9
2007	8,417	824,419	46,693,000	2,184,600	2.65	97.9	259.5
2008	8,546	852,027	45,201,000	2,016,100	2.37	99.7	235.9
2009	8,818	826,334	36,337,000	1,788,700	2.16	93.7	202.8
2010	8,785	753,764	31,746,000	1,458,000	1.93	85.8	166.0
2011	8,977	809,962	43,547,000	1,819,000	2.25	90.2	202.6
2012	9,091	907,606	48,650,280	2,131,500	2.35	99.8	234.5
2013	9,311	830,885	39,476,048	1,750,000	2.11	89.2	187.9
2014	9,505	792,256	39,301,480	1,810,000	2.28	83.4	190.4
2015	9,762	862,455	43,154,072	1,933,000	2.24	88.3	198.0
2016	9,863	920,843	50,590,848	2,054,000	2.23	93.4	208.3
2017	9,957	782,910	45,092,804	2,019,900	2.58	78.6	202.9
					Average	96.2	214.8

Peaking Factor

While the average day demand is used to determine the total water use, the maximum day demand is used to size treatment facilities and maximum source water withdrawal rates. One method to project future maximum day demand is by projecting the average day demand and then multiplying the average day demand by the peaking factor to predict the maximum day demand. Maximum day demands and peaking factors can also trend with population but are more substantially affected by seasonal lawn irrigation that may be influenced by rainfall. To illustrate this concept, monthly water demands were plotted for 2012, 2016, and 2017 in Figure 2.6.

During the years shown in Figure 2.6, water demands were quite constant through the winter months but rose during the summer. The peak month for each of these years was July. Although 2016 and 2016 data followed similar trends throughout the year, the steep drop in demand in August of 2017 was due to a lawn irrigation ban in response to a stressed water supply system.

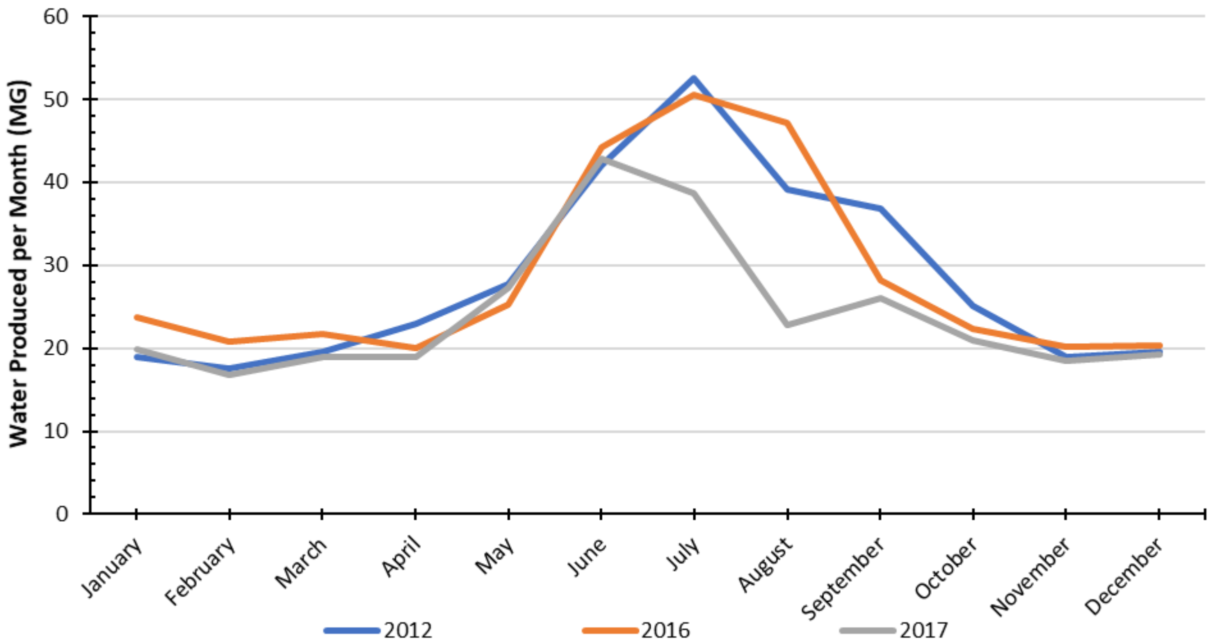


Figure 2.6 Brandon Monthly Water Demands for 2012, 2016, and 2017

Figure 2.7 shows the average day demand (blue line) and the maximum day demands (orange line) and the peaking factors (grey line). The influence of rainfall on the peaking factor was examined by plotting annual rainfall along with peaking factor in Figure 2.8. The peaking factor during this 12-year period varied between 2.6 and 1.9. A relative low peaking factor occurred in 2010, the year of highest rainfall, and a relative high peaking factor occurred in 2012, which was a very dry year. Although some years may experience relatively high rainfall, the timing of that rainfall may be such that dry spells still occur, causing lawn irrigation that can create a relatively high peaking factor. The dashed line in Figure 2.8 shows a shallow decline in peaking factor over the 12-year time span which these data were plotted. A peaking factor greater than 2.5 were experienced three years during this time span. Considering the trend but also considering the maximum peaking factors, a peaking factor of 2.5 was chosen for use in maximum day demand evaluations.

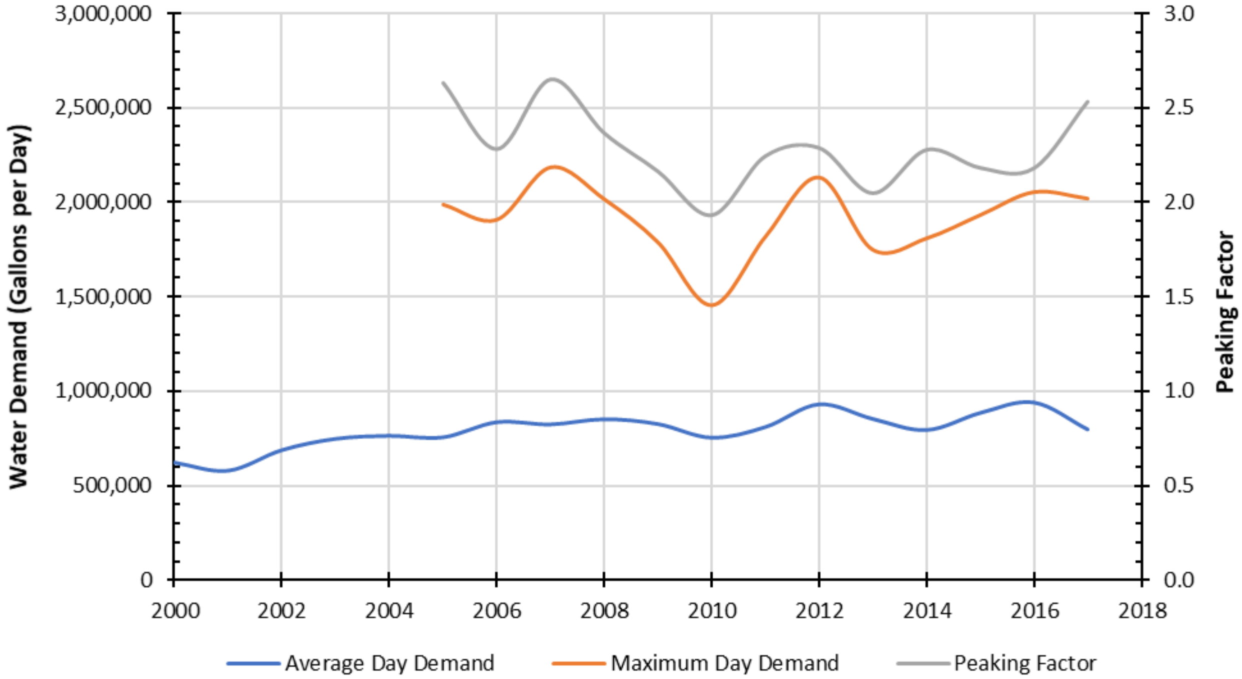


Figure 2.7 Historical Water Demand Trends

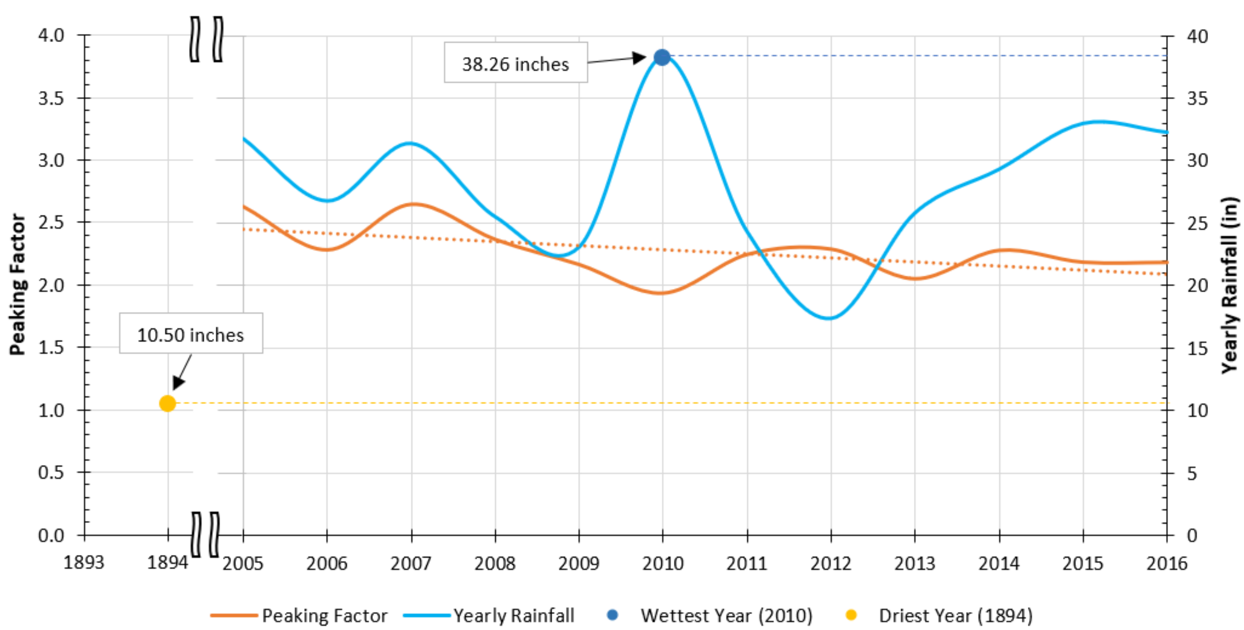


Figure 2.8 Peaking Factor and Rainfall Totals

Trends in Water Consumption by User Type

Customer water meter data for the years 2000-2017 were obtained to evaluate trends in the relative contributions of residential, commercial and institutional, and industrial water usage in Brandon. These data are plotted in Figure 2.9.

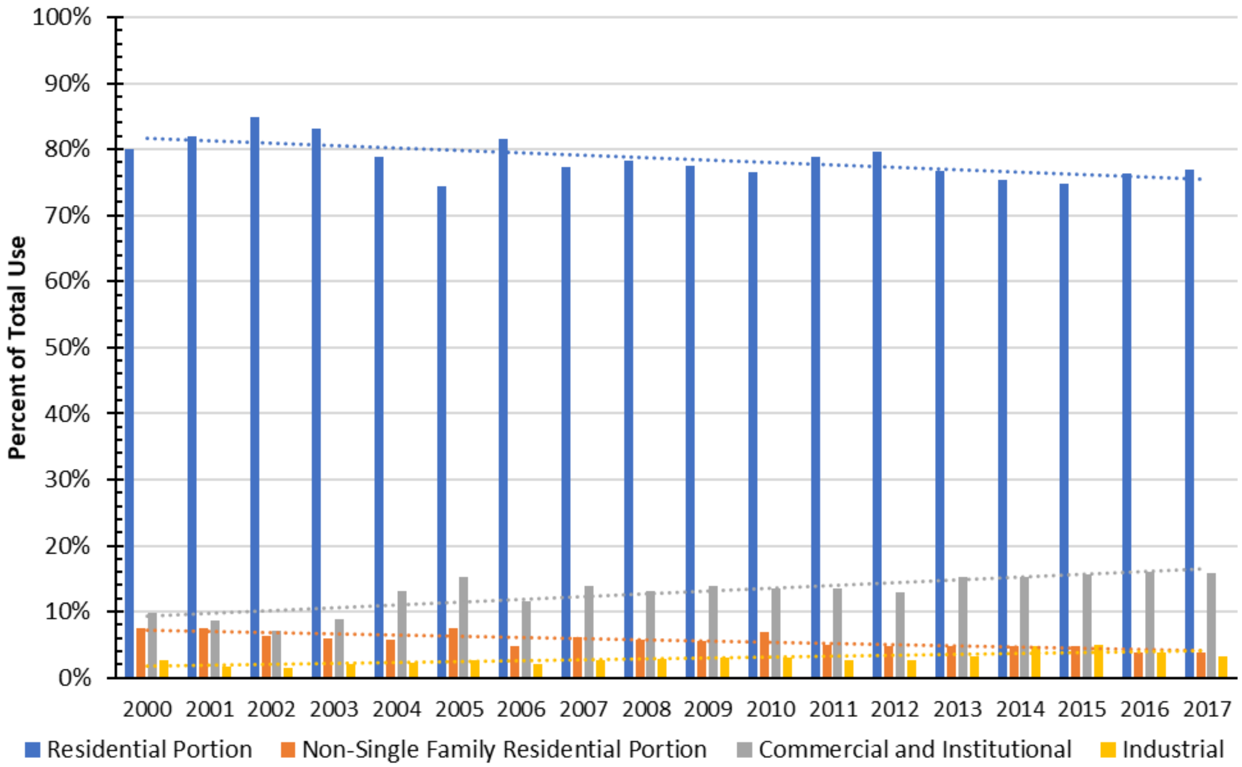


Figure 2.9 Relative Percentage of Water Usage by Customer Type

The majority of billed customer accounts in Brandon serve residential or domestic demands. Domestic water demands mostly consist of water consumed at single-family houses and apartments (non-single family housing) for drinking, bathing, washing, sanitary, and lawn watering/irrigation purposes. The demand variations serving residential customers contribute a major fraction of the overall demand in a non-industrial city like Brandon, as shown in Figure 2.9. The trends for the residential portion of the demand and the non-single family residential portion of the demand are decreasing, indicating that, while the overall demand due to population growth is increasing, businesses and commercial establishments are moving to the community, increasing the relative demand of the commercial and institutional demand relative to the residential demand. Due to the direct relationship between water use and the number of residents in Brandon, future water demands for residential users will be estimated as a function of population.

In the past 17 years, the commercial and institutional water demand has increased from 10% to greater than 15% of the water demand in Brandon. Commercial and institutional water users consist of entities such as small businesses, offices, hotels, hospitals, restaurants, schools, etc. The water consumed by commercial and institutional accounts is used for similar function as would be expected from residential accounts. For example, the primary water use for a school or office likely comes from restroom use, and the primary water use for a restaurant comes from food prep and dishwashing. Some commercial accounts are more water-intensive, such as laundries and car washes. The water use by commercial and institutional entities are closely related to the number of people in a community. As the population grows, more students attend schools, and restaurants have more customers. The increase in students and customers at these facilities increases the facility's overall water use. Thus, the commercial and institution demand will also be projected in the overall demand as a function of population growth.

Industrial water users are often manufacturers of various goods or services. Their water use is often much different than residential use. Some industries are water-intensive, and water may be consumed in large quantities and at various or unpredictable times over a 24-hour period. Industrial users may have varying levels of water needs depending on the items being manufactured. Each industrial user should be considered on a case-by-case basis as to their impact on future water needs for the City of Brandon. Currently, the fraction of total water consumed by commercial and industrial use in the City is slightly increasing, ranging from 2 – 4 percent. Based on conversations with Brandon staff and planning groups, no anticipated large water-consuming industrial users are expected to connect to the water system in the foreseeable future, so the fraction of water used by industrial customers is assumed to remain small over the planning period and to increase with population.

Un-accounted for water is water that has been treated and pumped into the distribution system but is not metered. This water may be used by various municipal activities or hydrant flushing. Other sources of unaccounted for water include loss from leaking pipes, unauthorized or unmetered hookups and meter inaccuracies. Unaccounted for water typically makes up 5 – 15 % of the total water produced.

Unaccounted-for water is typically calculated by expressing the difference between the water pumped into the system and metered water as a percentage of water pumped into the system. Based on the data provided by the City of Brandon, the percentage of unaccounted-for water was calculated and tabulated in Table 2.5.

Table 2.5 Brandon Unaccounted-for Water

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	2.7%	5.9%	21.6%	9.2%	8.6%	29.3%	1.4%	2.9%	1.8%	11.1%	2.9%	17.1%
2013	4.1%	10.8%	22.9%	23.1%	17.0%	15.7%	11.5%	1.7%	8.3%	43.9%	35.0%	17.7%
2014	1.6%	4.8%	22.3%	15.8%	22.9%	9.8%	18.2%	10.4%	2.2%	5.5%	5.3%	8.6%
2015	13.5%	8.3%	22.3%	21.9%	6.4%	15.9%	15.4%	0.6%	0.8%	13.4%	11.9%	24.5%
2016	22.9%	14.0%	18.2%	12.6%	24.0%	19.4%	10.8%	5.5%	21.2%	1.5%	5.8%	17.9%
2017	8.4%	19.1%	20.7%	2.0%	23.4%	9.5%	16.0%	8.6%	9.3%	9.4%	2.5%	9.0%

*Red values indicate negative unaccounted-for water percentages

The calculated unaccounted-for water varies greatly from month to month, and periodically exhibits negative values. Although month-to-month variations are not unusual, the variations exhibited by these data indicate that differences between meter read timing and the timing of pumped water readings significantly impact the calculated results. These differences were not resolved during the study, primarily because the study was interested in water production to estimate water source needs. Moving forward, city personnel should investigate these differences to enable better estimates of water loss in the system and work towards mitigating water losses so that unaccounted-for water percentages fall within an appropriate range.

2.3.2 *Demand Estimate Assumptions and Approach*

It is reasonable to assume that as the population of a community grows, an expansion of residential, commercial and public services is required to accommodate the growth, and an increase in water use is directly correlated to the expansion of services. Given the lack of significant water use that is not related to the characteristics and growth of Brandon's population, future water demands for the City of Brandon will be estimated as a function of population.

Basing water demand on a function of the population is reasonable and widely practiced in the water industry. This practice stands up particularly well for residential, commercial, and light industrial users where residential growth requires new jobs and new jobs spur residential growth, all of which result in increased water demands.

Several assumptions were required to complete water demand projections for the City of Brandon. These assumptions include:

(1) Residential, commercial, institutional, and light industrial growth are a function of population.

(2) Residential, commercial, institutional, and light industrial use will increase at the same rate as the population of the City of Brandon

(3) A chosen maximum day to average day peaking factor based on historical trends for peak day is assumed to remain constant through the planning period.

(4) No external or large single demands, such as service to a regional water system or a large industrial user, are anticipated over the planning period.

Two methods for estimating future water requirements will be evaluated in the following sections: (1) account-based and (2) water production-based.

2.3.3 *Account-Based Evaluation*

Similar to the City's population projections, the historical number of accounts can be trended and used to estimate the number of future accounts. Additionally, the number of water accounts can be combined with population to see trends in the number of persons per account. The City of Brandon differentiates between different types of water customers in their billing records. These different customer types which include: residential, commercial & institutional, non-single family residential, and industrial all use water in different ways. The fraction of water used in each category can also be evaluated to determine what trends may exist between different classes of water customers.

Account Number Evaluation

The City provided information on the number of historical water accounts through the year 2000. This historical information can provide useful guidance on predicting the number of accounts likely to exist in the future. The historical number of water accounts can also be combined with population and water consumption over the same time period to evaluate other trends in water use and population demographics such as water used per account and the number of people per water account. Figure 2.10 provides a graph of the historical number of water accounts and a graph of the total monthly water pumped from the water treatment plant per account with future anticipated trends.

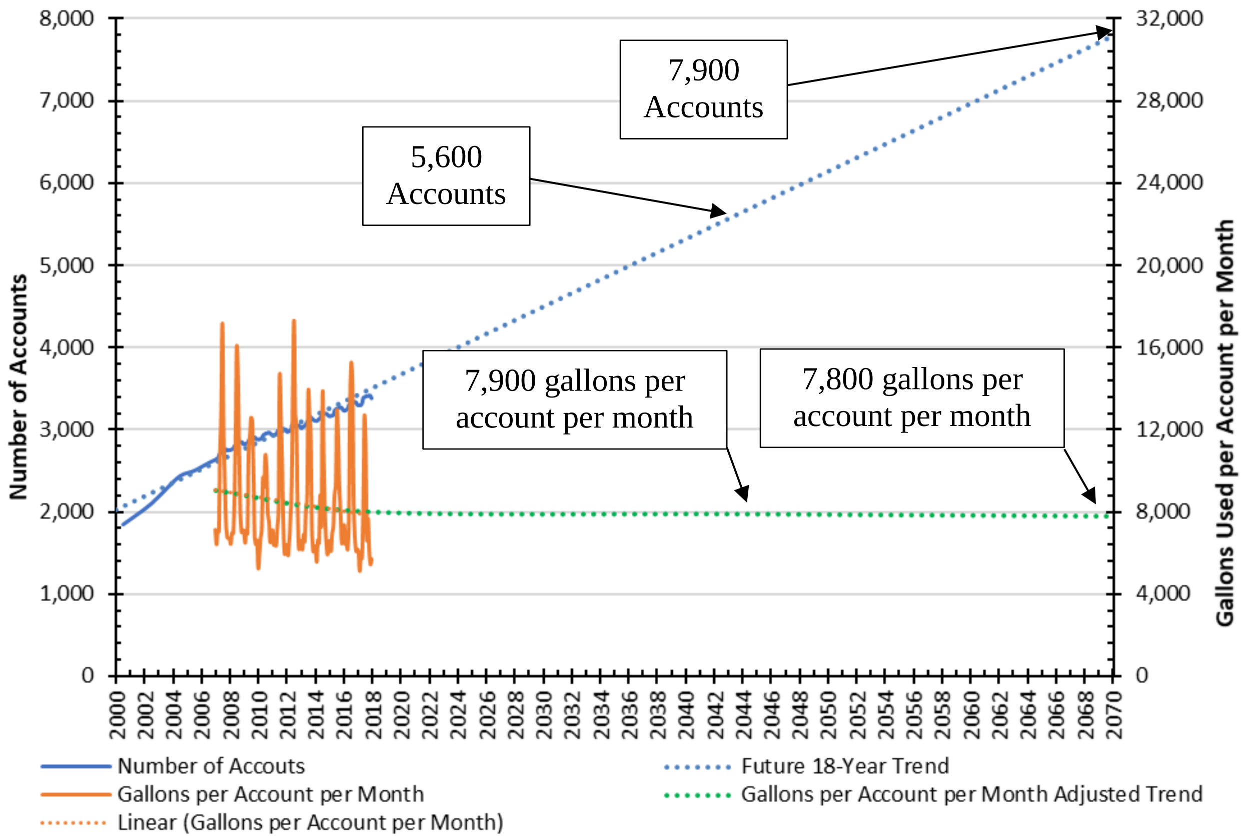


Figure 2.10 Historical Number of Water Accounts and Consumption per Account with Future Trends

The data in Figure 2.10 show the rate of water accounts (solid blue line) increase with time, as well as the monthly water consumed per account (solid orange line). If a linear trend line were applied to the number of water accounts over the past 18 years (blue dotted line), approximately 5,600 and 7,900 water accounts may be expected in 2045 and 2070 respectively. If a linear trend line were also applied to the water consumed per month per account for the past 11 years, a future consumption rate of fewer than 2,000 gallons per account per month would be predicted in 2070. These trends indicate that water customers are using water more efficiently through the increased use of high-efficiency appliances such as dishwashers, laundry machines, showerheads, and toilets. However, these appliances still require a certain minimum amount of water to function which suggests that the decrease in water use per account per month (solid orange line) seen in the historical data is likely to level off over time as most of the homes and businesses will have high-efficiency appliances installed. Another contributing factor to the decline in water consumed per account is the number of persons per account. These trends in persons per account are harder to predict over a long period of time as economic and other social factors contribute to these demographic changes. Since the effects of future water use trends, climate, demographics, and potential water needs are largely unknown, the amount of water used per account was assumed to remain nearly constant through 2070, dropping to a minimum of 7,800 gallons per account per month (dotted green line).

Multiplying the number of accounts by the water usage per account provides an estimate of average day water use. Multiplying the average day water use by the estimated peaking factor of 2.5 discussed in Section 2.3.1.1, future water consumption is calculated. The results of these estimates are summarized in Table 2.6.

Table 2.6 Demand Estimates Using a per Account Basis

Year	Accounts	Demand/Acct (gal/month)	Average Monthly Demand (gal/month)	Average Day Demand (gal/day)	Peaking Factor	Peak Day Demand (gal/day)
2018	3,500	8,000	28,000,000	933,300	2.5	2,333,250
2045	5,600	7,900	44,240,000	1,474,700	2.5	3,686,750
2070	7,900	7,800	61,620,000	2,054,000	2.5	5,135,000

2.3.4 *Water Production-Based Evaluation*

Future water demand can also be estimated by looking at the historical water production records from the water treatment plant. The water production numbers can be compared with population values to evaluate the per-capita water demands and estimate the per-capita water demands that may occur in the future.

2.3.4.1 Water Production Trends

Historical records on population, average day, maximum month, and maximum day demand were provided in Table 2.4, as well as the water production per person (per capita). Per-capita water use is different from the amount of water used per account in that per-capita water use does not depend on the number of persons per account. Thus, changes in per-capita water use are driven by changes in overall water consumption and not demographic changes.

Per-capita water usage in Brandon (based on water production) is plotted in Figure 2.11. The per-capita water demand is decreasing with time, similar to the water used per account per month values. This drop in per-capita water use likely corresponds primarily to more efficient water-using appliances.

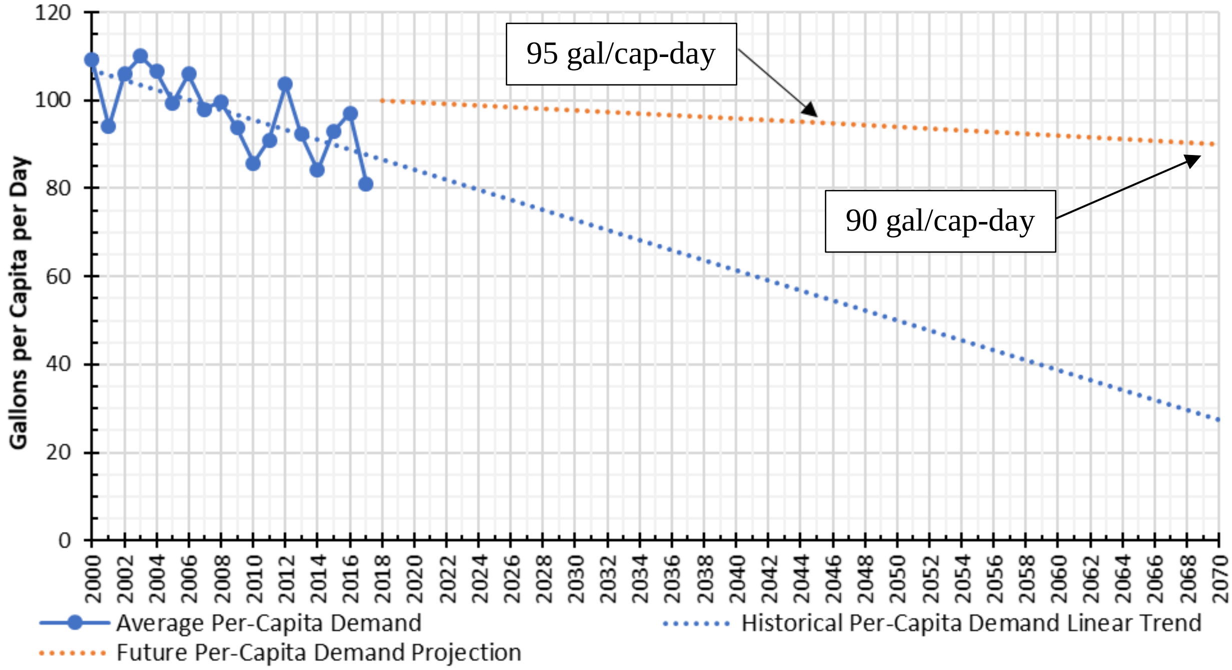


Figure 2.11 Historical Per-Capita Water Use and Future Projections

Water Production Future Projections

A linear trend of historical per-capita water use data set indicates that by 2070, per-capita water use would drop to less than 30 gal/capita-day. Further improvements in water use efficiencies will have diminishing returns on water savings. Additionally, future water consumption patterns and trends are not known, given that a more plentiful supply of water may positively influence water demand. Consequently, more conservative future average day per-capita values were assumed to be 95 and 90 gal/cap-day for 2045 and 2070 respectively.

These per-capita values are applied to population estimates to calculate the average day demand, which is then multiplied by the 2.5 peaking factor to calculate the maximum day demand. The resulting demands are summarized in Table 2.7.

Table 2.7 Demand Estimates using a Per Capita Production Basis

Year	Gallons per Capita/Day	Population	Average Day Demand	Peaking Factor	Max Day Demand
2018	100	9,957	995,700	2.5	2,489,250
2045	95	16,000	1,520,000	2.5	3,800,000
2070	90	23,000	2,070,000	2.5	5,175,000

2.4 Summary

Table 2.8 presents a summary of the two methods used to forecast future water demands for the City of Brandon. The final water production values (shaded in green) chosen for this report are 1.52 and 2.1 MGD for average day demand and 3.8 and 5.2 MGD for the maximum day in 2045 and 2070 respectively. These values are presented graphically in Figure 2.12.

Table 2.8 Demand Forecasting Summary

	Average Day Demand (MGD)	Peaking Factor	Maximum Day Demand (MGD)	ADD Per-capita demand (gal/cap-day)	MDD Per-capita demand (gal/cap-day)
Account Based 2045	1.45	2.5	3.6	91	227
Account Based 2070	2.02	2.5	5.1	88	220
Production Based 2045	1.52	2.5	3.8	95	238
Production Based 2070	2.10	2.5	5.2	90	225

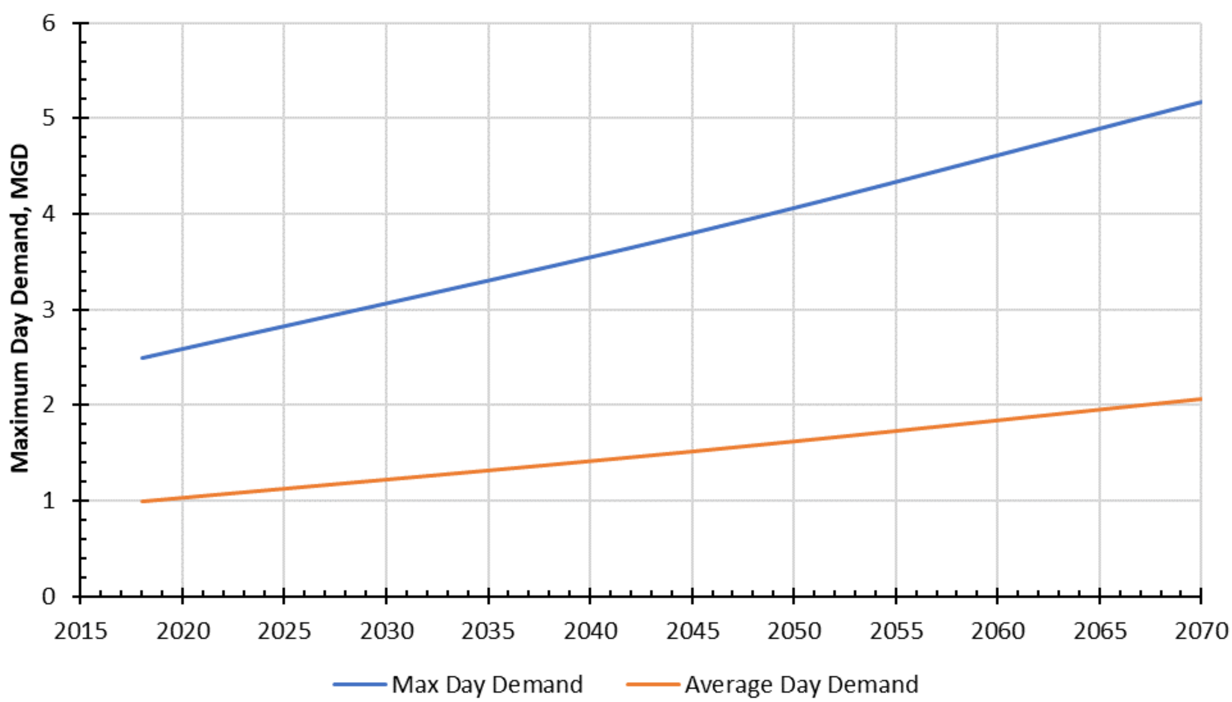


Figure 2.12 Brandon Water Demand Projections

Chapter 3 WATER QUALITY GOALS & OBJECTIVES

Brandon's future water sources not only must meet future water production needs, but it also must be of quality that can directly meet or be treatable to meet water quality goals and objectives. Water quality goals and objectives are created by evaluating the water quality of available sources against regulatory standards and desired aesthetic qualities, and then setting goals and treatment objectives to meet required and desired water quality objectives. This chapter contains a summary of Brandon's well water quality, drinking water regulations and aesthetic water quality standards, a comparison of existing water quality with the regulations and standards, and development of water quality goals and objectives.

3.1 Drinking Water Regulations Overview

The Safe Drinking Water Act (SDWA) was passed by Congress in 1974. Its purpose was to establish a uniform set of regulations and water quality standards for public water systems across the United States. The SDWA focused on identifying substances present in drinking water that had adverse public health effects.

For public water systems, there are two categories of drinking water regulation, primary and secondary drinking water regulations. The primary drinking water regulations are enforceable by the state's environmental regulatory agency. In South Dakota, this responsibility falls under the jurisdiction of the South Dakota Department of Environment and Natural Resources (SD-DENR). The secondary drinking water regulations are non-enforceable guidelines for producing water with generally acceptable aesthetic qualities.

3.1.1 *Primary Drinking Water Regulations*

Primary drinking water regulations address microbial contaminants, disinfectants and DBPs, maximum residual disinfectant levels (MRDLs), inorganic and organic compounds, radionuclides, treatment techniques (TT), MCLs, and other advisory objectives and parameters. The primary drinking water standards are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water. A different set of regulations apply to water sourced from surface water or groundwater under the influence of surface water (GWUDI). A separate regulation also applies to groundwater supplies.

3.1.2 *Secondary Drinking Water Regulations*

Secondary drinking water regulations are established for contaminants that may adversely affect the finished water appearance, taste, and odor; promote adverse digestive effects; discolor human skin and teeth or have economic impacts (such as the impact of corrosive water on plumbing fixtures and equipment). Established secondary maximum contamination levels (SMCLs) can be grouped into three (3) general categories: aesthetic objectives, cosmetic objectives, and technical effects. The USEPA maintains that the SMCLs represent reasonable goals for non-health threatening contaminants. States may establish higher or lower levels as appropriate for the local conditions. SMCLs are not federally enforceable but can be adopted by individual Primacy Agencies as enforceable standards.

3.2 Drinking Water Source

The City of Brandon may have the option to treat additional groundwater, purchase additional water from nearby regional or rural water suppliers, or treat water from the Big Sioux River. Each potential water source has different considerations in terms of treatment and or combined water quality goals.

3.2.1 *Ground Water Source Considerations*

As various regulations and goals are addressed in this chapter, water quality will be compared against the current well water and treated water qualities. Brandon currently obtains its water from wells that are located in the Big Sioux Aquifer (also called the Quaternary Aquifer) and the Split Rock Creek Aquifer. Well 1 is in the Big Sioux Aquifer, and Wells 3 and 6 are in the Split Rock Creek Aquifer. Well water and treated water quality data provided by the City were reviewed and are summarized in Table 3.1. These data describe the general characteristics of Brandon's water. The wells generally contain greater than desirable concentrations of iron and manganese, hardness and total dissolved solids that can affect the aesthetic character of the water, but this water is typical of groundwater in eastern South Dakota. Water obtained from the Split Rock Creek Aquifer contains radionuclides (radium) that are treated for removal at the Brandon water treatment plant. Radionuclide data will be presented and discussed later in this chapter.

The potential source of new water for the City of Brandon will come from a new groundwater source developed by the City or purchased from a treatment facility that treats groundwater. Any new City well water source would likely be pulling water from either the Big Sioux or Split Rock Creek aquifers. Both aquifers are similar in total dissolved solids (TDS) and hardness types, roughly 60% calcium carbonate hardness. The iron and manganese concentrations in the Split Rock Creek aquifer are in a manageable range. The Split Rock Creek aquifer does contain higher levels of radium not found in the Big Sioux aquifer. However, nitrate has been detected in the Big Sioux Aquifer.

Table 3.1 Brandon Well and Treated Water Quality Summary

Sample	Well #1	Well #3	Well #6	Treated Water	Treated Wells 1&6
Sample Date	7/2/2013	7/2/2013	7/2/2013	7/2/2013	2/8/2016
pH	7.74	7.66	7.91	7.84	7.31
Total Dissolved Solids, mg/L	484	466	540	534	571
Calcium, mg/L	106	92.4	108	106	100
Magnesium, mg/L	27.7	29	34.6	33.3	33
Iron, mg/L	0.06	2.74	1.88	0.14	0.09
Manganese, mg/L	0.06	0.18	0.37	0.12	0.03
Sodium, mg/L	26.1	26.9	29.3	27.3	28
Alkalinity, mg/L as $CaCO_3$	261	307	292	291	254
Sulfate, mg/L	39.4	76.8	142	128	191
Chloride, mg/L	69	9	4	24	17
Nitrate, mg/L as N	7.0	<0.2	<0.2	0.8	0.6
Calcium Hardness, mg/L as $CaCO_3$	265	231	270	265	250
Magnesium Hardness, mg/L as $CaCO_3$	114	119	142	137	139
Total Hardness, mg/L as $CaCO_3$	379	350	412	402	389
Carbonate Hardness, mg/L as $CaCO_3$	261	307	292	291	254
Non-Carbonate Hardness, mg/L as $CaCO_3$	118	43	120	111	135

3.2.2 *Surface Water Source Considerations*

Since the Big Sioux River flows through Brandon, the potential to treat surface water from the Big Sioux River exists for the City of Brandon. However, there are significant disadvantages in treating this source. The intake would be downstream of substantive wastewater discharges which may contain high levels of nitrate and could contain other unknown constituents. The river water also has notable taste and odor excursions and will have a wide range of turbidity, organisms and organic matter. Additionally, the more stringent regulations associated with the SDWA Surface Water Treatment Rules would apply to source water taken from the Big Sioux, requiring extensive and relatively expensive treatment. These disadvantages make surface water an unlikely source water option for the City of Brandon.

3.3 Primary Drinking Water Goals

As discussed previously, the primary drinking water regulations must be met and are enforceable by the SD-DENR. This section considers these regulations and the performance of the current system in producing finished water in compliance with these requirements.

3.3.1 *Total Coliform Rule (TCR) and Revised Total Coliform Rule (RTCR)*

The Total Coliform Rule (TCR) became effective under the SDWA on December 31, 1990, replacing the microbiological monitoring rule. This rule established microbiological standards and monitoring requirements that apply to all public water systems (PWSs). The purpose of the TCR is to prevent outbreaks of waterborne microbial diseases by regulating a group of organisms that include fecal coliform and Escherichia coli (E. coli). The potential health effects of these organisms include gastroenteric and Legionnaires' disease. The presence or absence of total coliform is the general indication used to measure the level of pathogenic contamination within the water. The maximum contaminant level goal (MCLG) for total coliform is zero, and the MCL is based on the population served by the PWS. For all PWSs that collect 40 or more samples per month, no more than five percent of the samples may be positive for total coliform, and for those that collect fewer than 40 samples, no more than one sample may be positive for total coliform under the routine monitoring requirements of the TCR. If any routine sample tests positive for total coliform, repeat samples are required.

The USEPA has promulgated revisions to the TCR that require utilities with water sources that are vulnerable to microbial contamination to identify and fix problems and provide reduced monitoring incentives for water system operation improvements. Specific changes made to the provisions of the original TCR address distribution system concerns, such as cross-connections and backflow events, pipe failures, and maintenance activities. The USEPA published the Revised Total Coliform Rule (RTCR) on February 13, 2013, and the RTCR went into effect in South Dakota on April 1, 2016. The revision establishes an MCL and MCLG of zero positive E. coli tests, which are a more specific indicator of fecal contamination and the revision removed the MCL and MCLG and modified the reporting requirements for positive total coliform samples. The RTCR requires assessments/corrective actions when unsafe samples are reported, encouraging systems to "find and fix" contamination issues.

The routine monitoring frequencies for PWSs based on population for the TCR are presented in Table 3.2. Brandon's 2010 Census population of 8,785 requires the City to collect a minimum of 10 total coliform samples per month. Currently, the City of Brandon collects 10 compliance samples from 20 different sampling sites. During 2017 one positive total coliform sample was detected. No E. coli was present in the first test, and the subsequent tests revealed no additional positive total coliform colonies. The City collects less than 40 samples per month, and only one positive total coliform test occurred in 2017. Thus, no violations of the TCR and RTCR occurred.

Whether additional water sources for the City of Brandon come from groundwater or a surface water source, maintaining disinfection in treatment and maintaining a sustained disinfectant residual in the distribution system will be key factors in selecting future treatment processes. Impacts of water source quality and treatment processes prior to the disinfection process will be considered as these factors impact disinfectant residual decay in the distribution system, which, in turn, ensures compliance with the RTCR.

Table 3.2 PWSs TCR Routine Monitoring Frequencies

Population	Samples per Month	Population	Samples per Month
25 – 1,000	1	8,501 – 12,900	10
1,001 – 2,500	2	12,901 – 17,200	15
2,501 – 3,300	3	17,201 – 21,500	20
3,301 – 4,100	4	21,501 – 25,000	25
4,101 – 4,900	5	25,001 – 33,000	30
4,901 – 5,800	6	33,001 – 41,000	40
5,801 – 6,700	7	41,001 – 50,000	50
6,701 – 7,600	8	50,001 – 59,000	60
7,601 – 8,500	9	59,001 – 70,000	70

3.3.2 *Stage 1 Disinfectants/Disinfection By-Products Rule (Stage 1 D/DBPR)*

Some DBPs are listed as probable human carcinogens by the National Cancer Institute, and some have also been linked to adverse effects on the liver, kidneys, nervous system and reproductive system. For this reason, the Stage 1 Disinfectants/Disinfection By-Products Rule (Stage 1 D/DBPR) established MCLs for eleven DBPs, categorized into two groups of organic by-products (four trihalomethanes (THMs) and five haloacetic acids (HAA5s)) and two inorganic by-products (chlorite and bromate). The Stage 1 D/DBPR also established maximum residual disinfectant level goals (MRDLGs) and maximum residual disinfectant levels (MRDLs) for three disinfectants: chlorine, chloramines, and chlorine dioxide.

The maximum residual disinfectant level goal (MRDLGs) and maximum residual disinfectant level (MRDLs) for the three disinfectants are presented in Table 3.3. Compliance with the MRDLs is based on a running annual average (RAA) of samples collected in conjunction with the Total Coliform Rule sampling locations, computed quarterly. The regulation was established in recognition of the beneficial disinfection properties of chlorine, chloramines, and chlorine dioxide. The MRDLGs and MRDLs were determined as a balance to provide adequate control for public health effects while allowing the ability to control pathogens and other microbial waterborne contaminants under varying conditions. Basing compliance on an RAA allows CWSs the flexibility to increase disinfectant residual levels for short periods, as necessary to address specific issues within the water system and still maintain compliance.

Table 3.3 Stage 1 D/DBPR MRDLGs and MRDLs

Disinfectant	MRDLG (mg/L)	MRDL (mg/L)
Chlorine (measured as Free Cl_2)	4.0	4.0
Chloramines (measured as Total Cl_2)	4.0	4.0
Chlorine Dioxide (measured as ClO_2)	0.8	0.8

Brandon's wells contain ammonia concentrations in their raw water around 0.8 mg/L. The City has chosen to use breakpoint chlorination to maintain a free chlorine residual in the distribution system. As chlorine is added to the water, the chlorine oxidizes the ammonia in the water into mono, di, and trichloramines. When chlorine is added at a dosage greater 5 parts chlorine to one part ammonia (as nitrogen), the chlorine continues to oxidize the ammonia and di- and trichloramines comprise a larger portion of the total chlorine. Eventually, the additional chlorine will break down the ammonia into water and nitrogen gas. As chlorine dosage is increased a breakpoint, at around 7.6 parts chlorine to 1 part ammonia, will occur. At this point, all of the ammonia has been oxidized and additional chlorine added to water will create a free chlorine residual at a one-to-one ratio.

According to the Stage 1 D/DBPR, the City of Brandon is required to sample for free chlorine residuals at the same locations and frequency as outlined in the TCR. Based on a population of 8,785, 10 samples are required. The results of these monthly samples are averaged quarterly, and a running annual average of these quarterly samples must be less than the MRDL of 4 mg/L measured as free chlorine. Since Brandon typically maintains a free chlorine residual leaving the plant at around 0.6 mg/L, the distribution system chlorine residual has consistently been less than the MRDL .

The distribution system disinfectant residual must preserve and protect the microbiological quality of water as it is distributed to customers. Although Brandon experienced a single positive total coliform sample in 2017, the disinfectant residuals have maintained appropriate water quality relative to compliance with the RTCR.

Table 3.4 identifies the MCLs for the various DBPs regulated under the Stage 1 D/DBPR. Total trihalomethanes (TTHMs), haloacetic acids (HAA5s), chlorite, and bromate, are regulated under the Stage 1 D/DBPR. TTHMs are the sum of the following four trihalomethanes: chloroform, bromodichloromethane, dibromochloromethane, and bromoform. The Stage 1 TTHM MCL is 80 micrograms per liter (µg/L) based on an RAA from distribution system samples collected according to the sampling plan required by the Rule. HAA5 is the sum of the following five haloacetic acids: monochloracetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid. The HAA5 MCL of 60 µg/L, as an RAA of distribution system samples, has been established under Stage 1. Chlorite, a degradation product of chlorine dioxide, is regulated under Stage 1 at an MCL of 1.0 mg/L. Bromate, which is formed by the ozonation of water containing bromide ion, is regulated at 10 µg/L under the Stage 1 D/DBPR. Chlorite and bromate are not sampled for compliance with the D/DBPR in the Brandon system since chlorine dioxide and ozone are not part of treatment.

Table 3.4 Stage 1 D/DBPR MCLs

Regulated Disinfection By-Product	Stage 1 MCLs (µg/L)
Total Trihalomethanes (TTHM)	80
Haloacetic Acids (HAA5)	60
Chlorite	1,000 (1.0 mg/L)
Bromate	10

Sample results from Brandon's test results from 2010 through 2017 of compliance monitoring (under the Stage 1 D/DBPR) are summarized in Table 3.6. Based on these results the City was within compliance for the Stage 1 DBP MCLs for the running annual average for DPBs.

3.3.3 *Stage 2 Disinfectants/Disinfection By-Products Rule (Stage 2 D/DBPR)*

The USEPA published a Pre-Proposal Draft for the Stage 2 Disinfectants/Disinfection By-Products Rule (Stage 2 D/DBPR) on October 17, 2001, and officially proposed the Stage 2 D/DBPR on August 18, 2003. The rule was finalized and published on January 5, 2006. The Stage 2 D/DBPR is intended to reduce potential cancer and reproductive and developmental health risks from DBPs in drinking water. Under the Stage 2 D/DBPR, systems were required to conduct an evaluation of their distribution systems, known as an Initial Distribution System Evaluation (IDSE), to identify the locations that are more likely to have high DBP concentrations. Based on the results of the IDSE, Stage 2 D/DBPR compliance monitoring sites were chosen. Compliance with the MCLs for two groups of DBPs (TTHM and HAA5) would be calculated for each monitoring location in the distribution system. This approach, referred to as the locational running annual average (LRAA), differed from Stage 1 D/DBPR, which determined compliance by calculating the RAAs of samples from all monitoring locations across the system.

The Stage 2 DBPR also requires each system to determine if it has exceeded an operational evaluation level, which is identified using compliance monitoring results. The operational evaluation level provides an early warning of possible future MCL violations, which allows the system to take proactive steps to remain in compliance. A system that exceeds an operational evaluation level is required to review its operational practices and submit a report to the state primacy agency that identifies actions that may be taken to mitigate future high DBP concentrations, particularly those that may jeopardize compliance with the DBP MCLs.

PWSs regulated by the Stage 2 D/DBPR include community and non-transient non-community water systems that produce and/or deliver water that is treated with a primary or residual disinfectant other than UV light. Compliance deadlines are based on the population served by the PWSs. Wholesale and consecutive systems of any size must comply with the requirements of the Stage 2 D/DBPR on the same schedule as required for the largest system in the combined distribution system. A combined distribution system is defined as the interconnected distribution system consisting of wholesale systems that supply finished water to one or more other PWSs, and consecutive systems that receive some or all of its finished water from a wholesale system. Stage 2 D/DBPR compliance activities are outlined in Table 3.5 and are categorized by population and PWS type (community water systems or non-transient non-community water system (NTNCWS)). Two-year capital improvement extensions are possible for systems needing extra time to comply with Stage 2 D/DBPR.

Systems with low historical DBPs may have been granted a certificate in lieu of monitoring under the IDSE requirements. Stage 1 compliance data must have demonstrated that all TTHM and HAA5 results were less than 40 μg/L and 30 μg/L, respectively, for eight consecutive calendar quarters during a specified period to receive the 40/30 Certification.

Table 3.6 provides the LRAA results for the highest reported value for the City of Brandon from 2011 to 2017. Figure 3.1 and Figure 3.2 provide these data graphically as well as comparing these values to the MCLs for TTHMs and HAA5 concentrations. The highest recorded LRAA for both TTHM and HAA5 at the testing sites in Brandon were well below the MCLs for TTHM and HAA5, indicating the City of Brandon is in compliance with the Stage 2 DBPR.

Table 3.5 Stage 2 D/DBPR Compliance Activities and Deadlines

Public Water System	Actions			
	Submit IDSE monitoring plan, SSSP, or 40/30 certification	Complete an IDSE	Submit IDSE Report	Begin Stage 2 Compliance Monitoring
CWSs(1) and NTNCWSs(2) serving at least 100,000	October 1, 2006	September 30, 2008	January 1, 2009	April 1, 2012
CWSs and NTNCWSs serving 50,000 - 99,999	April 1, 2007	March 31, 2009	July 1, 2009	October 1, 2012
CWSs and NTNCWSs serving 10,000 - 49,999	October 1, 2007	September 30, 2009	January 1, 2010	October 1, 2013
CWSs serving fewer than 10,000	April 1, 2008	March 31, 2010	July 1, 2010	October 1, 2013
NTNCWSs serving fewer than 10,000	NA	NA	NA	October 1, 2013

(1) Community Water Systems,
(2) Non-Transient Non-Community Water System

Table 3.6 Stage 1 DBPR Compliance Results – City of Brandon

Testing Year	TTHM (μg/L)	Total HAA5 (μg/L)
2011	21.6	7.80
2014	15.7	5.62
2015	28.9	6.94
2016	34.0	9.15
2017	26.2	5.52

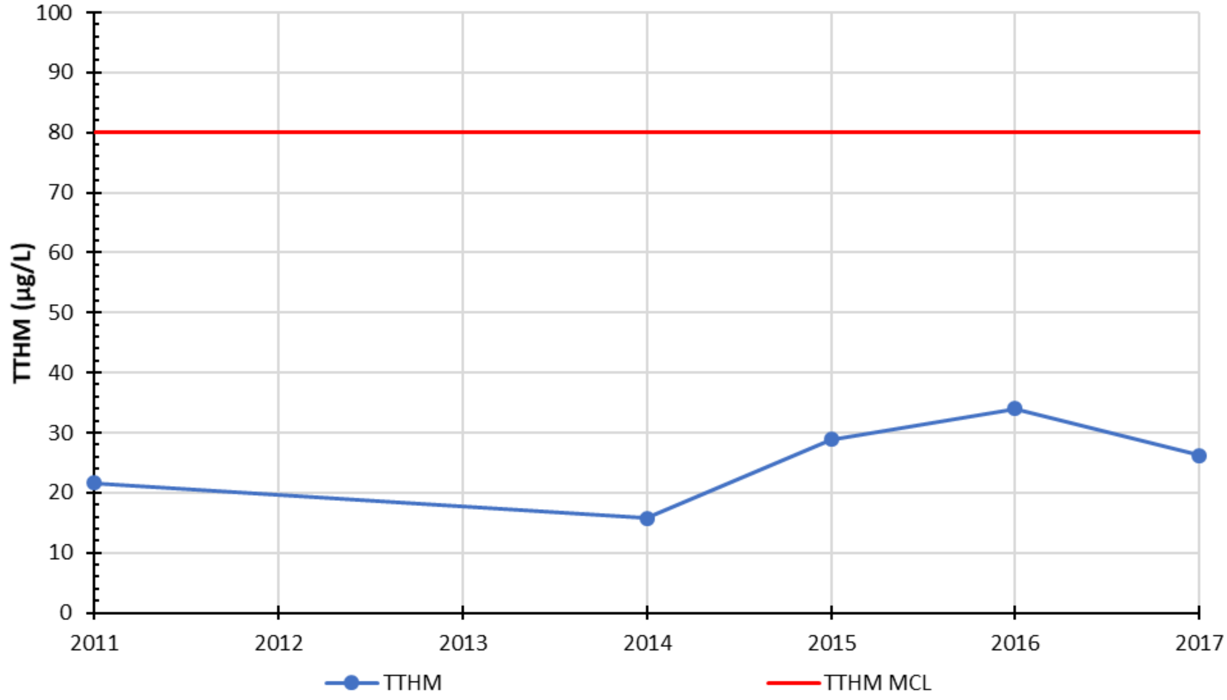


Figure 3.1 Brandon Stage 2 DBPR Highest Reported LRAA TTHM Compliance Trend

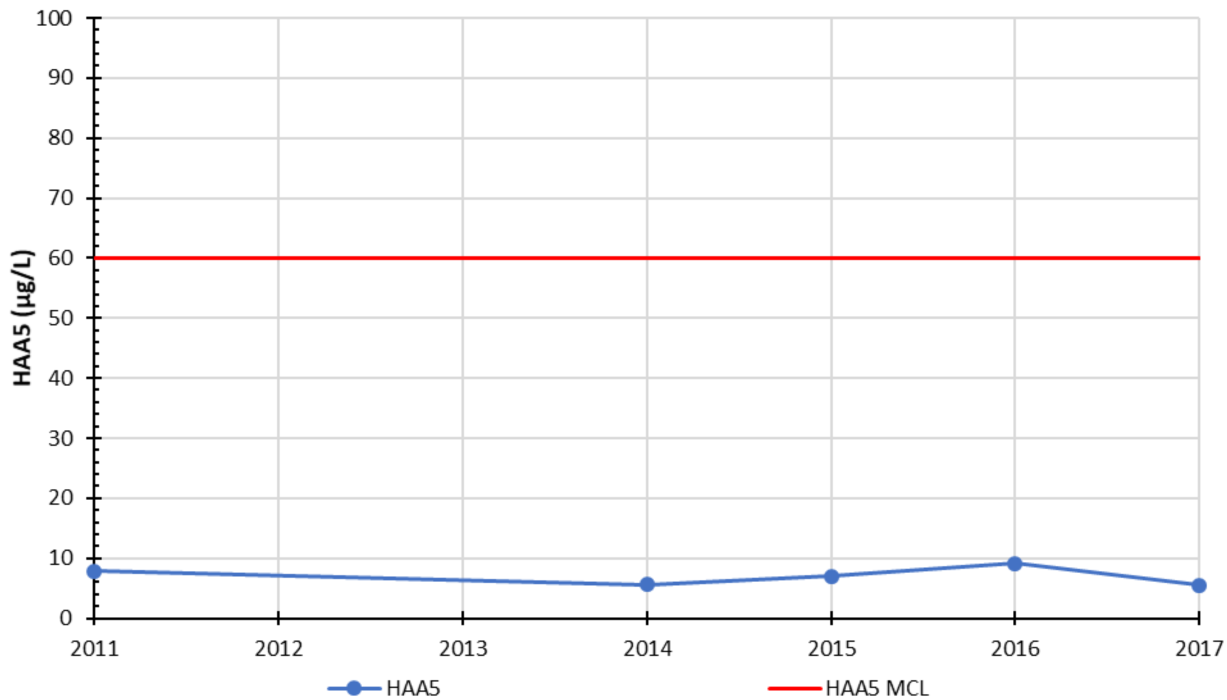


Figure 3.2 Brandon Stage 2 DBPR Highest Reported LRAA HAA5 Compliance Trend

3.3.4 *Phase II/IIb and Phase V Rules*

The Phase II and Phase IIb Rules became effective on July 1, 1991, and January 1, 1993, respectively. The Phase II/IIb Rules set standards for 38 synthetic organic chemicals (SOCs) and inorganic chemicals (IOCs). Thirty-six of the contaminants are regulated by MCLs and two, acrylamide and epichlorohydrin, are controlled by limiting their use of drinking water treatment chemicals.

Although a large number of Phase II/IIb chemicals result from human activity, others occur naturally in water. These contaminants have been shown to either be or are suspected to be, carcinogenic through ingestion. Some of the other effects of these contaminants include damage to numerous organs in the body, circulatory system damage, bone damage, nervous system damage and disorders, thyroid damage, and decreased body weight.

PWSs are required to ensure the water they supply meets the MCL for each Phase II/IIb chemical. A plan for synchronizing compliance monitoring across several existing and upcoming rules was introduced under Phase II/IIb. Monitoring frequencies for most source-related contaminants were coordinated with compliance periods of three years each. Phase II/IIb monitoring requirements also established: (1) sampling locations for surface and groundwater systems, (2) the initial sampling frequency that is specific to a contaminant or contaminant group, (3) lower repeat sampling frequencies for water systems that do not detect a specific contaminant or contaminant group during the initial monitoring, (4) increased monitoring frequencies for water systems that do detect initial contaminant, (5) monitoring waivers for reducing or eliminating the sampling frequencies, and (6) one-time monitoring requirements for 30 other unregulated contaminants.

The Phase V Rule, effective on January 17, 1994, set standards for 23 additional contaminants. Contaminants monitored under Phase V included four inorganic contaminants, cyanide, three volatile organics, and 15 pesticides or synthetic organics. The USEPA set different monitoring schedules for different contaminants, depending on the routes by which each contaminant enters the water supply. In general, surface water systems must take samples more frequently than groundwater systems because the source water is subject to more external influences. Systems that prove over several years that they are not susceptible to contamination can apply for a variance to reduce monitoring frequency.

The Inorganic Contaminants (IOCs) regulation under the Phase II Rule became effective in 1992. Some IOCs in finished water can alter consumer's acceptability by affecting the taste, color, and scale decomposition on pipes and fittings. In addition, IOCs such as arsenic and lead have demonstrated adverse consequences on human health. The purpose of IOCs is to protect public health and reduce the potential risk of cancer or other adverse health effects.

Data from recent IOC regulatory sample collections for Brandon were reviewed. As shown in Table 3.7, historical IOC data indicated the City of Brandon does not have issues complying with IOC regulations as all sample results were below the regulatory MCLs. Lead, copper, and arsenic are discussed individually since the USEPA has established the Lead and Copper Rule and the Arsenic Rule.

Table 3.7 MCLGs, MCLs, and City of Brandon Results for Inorganic Contaminants

Contaminant	MCLG (mg/L)	MCL (mg/L)	Brandon IOC Range (mg/L)
Antimony	0.006	0.006	< 0.0002
Arsenic	0	0.01	<0.001
Asbestos (fiber > 10 micrometers)	7 million fibers per liter (MFL)	7 MFL	-
Barium	2	2	0.028 – 0.034
Beryllium	0.004	0.004	< 0.0002
Cadmium	0.005	0.005	< 0.0002
Chromium (total)	0.1	0.1	0.002 – 0.006
Copper (90th percentile)	1.3	Action Level=1.3	0.62
Cyanide (as free cyanide)	0.2	0.2	-
Fluoride	4	4	0.52 – 1.23
Lead (90th percentile)	zero	Action Level=0.015	0.0027
Mercury (inorganic)	0.002	0.002	<0.0001
Nitrate (measured as Nitrogen)	10	10	0.5 – 0.7
Nitrite (measured as Nitrogen)	1	1	<0.02 mg/L
Selenium	0.05	0.05	< 0.0005 – 0.0007
Thallium	0.0005	0.002	< 0.0001

(1) Data were not available for Asbestos, and Cyanide.
(2) Lead and Cooper levels recorded as the 90th percentile of 80 samples taken.
(3) Nitrite levels represented the historical values from 2010 and 2017
(4) Nitrate levels represent the historical values between 2016 and 2017.

3.3.5 *Lead and Copper Rule (LCR)*

The 1986 Amendments to the SDWA required USEPA to promulgate drinking water standards for contaminants that impose potential adverse health risks. Lead and copper were specifically listed in the 1986 SDWA amendments for the mandatory development of a National Primary Drinking Water Regulation (NPDWR). USEPA responded to this mandate by promulgating the Lead and Copper Rule (LCR). The stated goal of the LCR is to “minimize lead and copper at users’ taps while ensuring that treatment does not cause the system to violate any NPDWR.” This goal is intended to be accomplished through the application of corrosion control strategies (i.e., varying pH levels, alkalinity levels, and inhibitor utilization). The LCR action levels for lead and copper are 0.015 mg/L and 1.30 mg/L, respectively, for the 90th percentile concentration of samples measured at customer taps.

The USEPA published proposed revisions to the LCR on July 18, 2006. The proposed revisions included changes in the health effects language, utility’s public education requirements in the event of a lead Action Level (AL) exceedance and reporting requirements of PWSs before adding a new water source or changing a treatment process. The National Drinking Water Advisory Council LCR Working Group began in March 2014 to develop recommendations for long-term LCR revisions.

The final report was released on August 24, 2015. To further address the corrosion-related issues, the USEPA published the Lead and Copper Rule Revisions White Paper in October 2016. The USEPA is considering different regulatory options to improve the existing rule. The options include lead service line replacement, improving optimal corrosion control treatment requirements and clarification or strengthening of sampling requirements.

The LCR requires systems to sample water from customer taps according to an approved sampling plan. The samples are 1-liter, first-draw samples, collected after the water has remained in the plumbing system undisturbed for 6 hours. The LCR action levels for lead and copper are 15 µg/L (0.015 mg/L) and 1,300 µg/L (1.3 mg/L), respectively, in the 90th percentile of samples measured at customer taps. According to the LCR and based on Brandon's 2010 Census population of 8,785, the system falls in the population range of 3,301 – 10,000, which requires at least 20 samples under the reduced monitoring schedule. In 2017, 20 lead and copper samples were collected from various locations throughout the City. Results of these samples ranged from 0.23 to 7.9 µg/L for lead and not detectable to 0.82 mg/L for copper. The 90th percentile values reported in Table 3.7 were 0.0027 mg/L (2.7 µg/L) and 0.62 mg/L for lead and copper, respectively. Based on historical records, the City of Brandon has been in compliance with the LCR.

3.3.6 *Nitrate and Nitrite*

Nitrate and nitrite are the only acute inorganic contaminants regulated under the Phase II/V Rules. The regulation for nitrate and nitrite became effective in 1992. Nitrite and nitrate from fertilizer, sewage, and wastes from humans and/or farm animals can enter the drinking water supply. Excessive concentrations of nitrate in drinking water have caused serious illness and sometimes death in infants under six months of age. The USEPA, under the authority of the SDWA, has set the MCLG and MCL for nitrate at 10.0 mg/L and for nitrite at 1.0 mg/L (measured as nitrogen, N) measured on samples at the entry point to the distribution system. The WHO has recommended guidelines for nitrate and nitrite in drinking water of 15 mg/L (as nitrogen) and 3 mg/L (as nitrogen), respectively.

Nitrite levels in Brandon's treated water were below the detection limits for samples collected between 2010 and 2017. Nitrate levels tested between 2010 and 2017 ranged from 0.5 mg/L to 0.7 mg/L. All nitrite and nitrate levels were within compliance of the Phase II/IIb and V Rules.

3.3.7 *Radionuclides Rule*

The USEPA proposed an NPDWR for six radionuclides in 1991, which included combined radium 226, radium 228, (adjusted) gross alpha, beta particle, and photon radioactivity, radon, and uranium. A revision to this rule, promulgating the final drinking water standards for (non-radon) radionuclides in drinking water, was published in December 2000. Systems had until early December 2003 to collect samples to use for grandfathering. The first three-year monitoring period ended in December 2006. This rule, which applies to all CWSs, changes the monitoring requirements to include sampling from all distribution system entry points. The adverse health effects associated with exposure to radionuclides include radiotoxicity, which affects human tissue, and chemotoxicity, which affects human organs. Extended radionuclide exposure has also been linked to cancer. The MCLGs and MCLs for regulated radionuclides are provided in Table 3.8.

Table 3.8 Primary Drinking Water Regulations for Radionuclides

Radionuclides(1)	MCLGs	MCLs
Radium 226/228	0	5 pCi/L
Beta and Photon Emitters	0	4 mrem/year
Gross Alpha Emitters	0	15 pCi/L
Uranium	0	30 µg/L

(1) Excludes Radon

The levels of radium and tested levels of alpha emissions in Brandon's wells that draw from the Split Rock Creek aquifer (Wells 3, 6 and pending Well 7) were reviewed. Radium 226/228 from operational Well 6 have been approximately 8 pCi/L, and treatment provided by the water treatment plant lowered the concentration to less than the 5 pCi/L MCL. The City installed a hydrous manganese oxide (HMO) system to enhance radionuclide removal. The system works by dosing the raw water with a controlled dosage of the HMO solution. Radium is then adsorbed onto the surface of the HMO particles which are then trapped by the plant's filters. The radium is then removed through backwashing the filters. When the HMO system in Brandon went online in October 2017, the radium concentrations were reduced by about 50 percent. Radionuclide data from the Split Rock Creek wells and treated water are summarized in Table 3.9.

Table 3.9 Brandon Well and Treated Water Radionuclide Data

Sample	Well #3	Well #6 Raw	Well #1,6 Treated	Well #7	Well #8 Test Hole
Sample Date	10/20/2017	4/15/2015	10/5/2017	10/21/2017	4/11/2017
Gross Alpha, pCi/L	4.49	6.92	10.2	53.1	20.7
Radium-226, pCi/L	1.88	6.58	2.42	12.9	3.8
Radium-228, pCi/L	1.06	1.01	<1	<1	<1
Total Radium	2.94	7.6	2.4-<3.4	12.9-<13.9	3.8-<4.8

While completely eliminating all radioactive sources from our air, food, and water is not possible, best practices can be implemented to reduce the concentration of radionuclides in drinking water to safe exposure levels. The EPA's MCL levels seek to provide guidance to utilities on how best to minimize the cost of water treatment while also providing safe water for their customers. Whichever water source the City chooses to use will need to, at a minimum, meet the EPA's MCLs for radionuclides. Various treatments such as lime softening, ion exchange, HMO, or reverse osmosis or a combination of these treatments exist to substantially reduce the concentration of radionuclides in the water.

3.3.8 *Arsenic Rule*

Based on a Public Health Standard that dated back to 1942, the USEPA enforced an arsenic standard of 50 µg/L from 1975 through 2006. A revised Arsenic Rule was proposed and finalized in June 2000 and January 2001, respectively. This revised rule applies to all CWSs and NTNCWSs and requires compliance with an MCL of 10 µg/L (0.01 mg/L), based on samples obtained from all entry points to the distribution system. In addition to the MCL, the rule also specifies a non-enforceable MCLG of zero. The compliance date for the revised Arsenic Rule was January 23, 2006. Exemptions could extend the compliance date by up to three years or up to nine years, depending on system size and its finished water arsenic concentration. Arsenic causes adverse health effects in humans at high exposure levels. High levels of arsenic typically lead to gastrointestinal irritation accompanied by difficulty in swallowing, thirst, hypertension, and convulsions. The lethal dosage for humans is estimated to range from 70 to 180 mg/L. According to the IOC, testing for arsenic revealed a concentration range of less than 0.001 to 0.002 mg/L. Thus, the City of Brandon has been in compliance with the Arsenic Rule.

3.3.9 *Synthetic Organic Compounds Rule (SOCs Rule)*

Synthetic Organic Contaminants (SOCs) are man-made compounds used for a variety of industrial and agricultural purposes. The USEPA has established MCLs for thirty-three SOCs, which include contaminants such as pesticides, PCBs, and dioxin. No regulated SOC has been detected in the City of Brandon's water samples collected in 2017.

3.3.10 *Volatile Organic Compounds Rule (VOCs Rule)*

The Volatile Organic Compounds (VOCs) Rule became effective under the SDWA Phase II/V Rules on January 9, 1989. The VOCs Rule established MCLs for twenty-one volatile organic compounds (VOCs) such as styrene, toluene, xylenes, etc. that are suspected human carcinogens through ingestion. During the last round of testing in 2017, all tested VOC concentrations were below detection limits except for toluene at a concentration of 0.0017 mg/L, which is below the MCL of 1 mg/L. No other VOC was detected in the previous sampling done in 1999, and 2004. Since the only detected VOC, toluene, was measured to be below its MCL, the City of Brandon is in compliance with the VOC rule.

3.4 Secondary Drinking Water Standards

Secondary drinking water regulations are established for contaminants that may adversely affect the finished water appearance, taste, and odor; promote adverse digestive effects; discolor human skin and teeth or have economic impacts (hard or corrosive water on plumbing fixtures and equipment). Established secondary maximum contamination levels (SMCLs) can be grouped into three general categories: aesthetic effects, cosmetic effects, and technical effects. The USEPA maintains that the SMCLs represent reasonable goals for non-health threatening contaminants. States may establish higher or lower levels as appropriate for the local conditions. SMCLs are not federally enforceable but can be adopted by individual primacy agencies as enforceable standards. Table 3.10 provides a list of the SMCLs compared to Brandon treated water quality. Specific water quality effects are discussed below.

Table 3.10 EPA SMCLs Compared to Brandon Treated Water

Contaminant	SMCL	Brandon Treated Water 2/8/2016
Aluminum	0.05 to 0.2 mg/L	
Chloride	250 mg/L	17 mg/L
Color	15 color units	
Foaming Agents	0.5 mg/L	
Iron	0.3 mg/L	0.09 mg/L
Manganese	0.05 mg/L	0.03 mg/L
Odor	3 TON (threshold odor number)	
Sulfate	250 mg/L	191 mg/L
Total Dissolved Solids (TDS)	500 mg/L	571 mg/L
Zinc	5.0 mg/L	
Silver	0.1 mg/L	
Fluoride	2.0 mg/L	
Corrosivity	Non-corrosive	
Copper	1.0 mg/L	
pH	6.5 to 8.5	7.31

3.4.1 *Aesthetic Effects*

Aesthetic objectives are water quality objectives that a water supply system strives to meet, although they do not have adverse effects on public health. These objectives include controlling color, taste, odor, and foaming.

Aluminum can impact color and adversely affects the aesthetic quality of the finished water. Since Brandon does not use any aluminum product in its water treatment, aluminum is not an immediate concern for the City. Potential treatment processes that use aluminum as a coagulant would be operated to minimize residual aluminum in the treated water.

Chloride has little effect at concentrations below the SMCL of 250 mg/L. At concentrations above 250 mg/L, chloride imparts a salty taste to the water. High concentrations of chloride can also have adverse effects on boiler operations, industrial cooling operation, and food processing operations. Chloride concentrations are not a concern for the City of Brandon as all tests for the last 25 years have shown chloride levels below the SMCL.

Color in potable water is not only aesthetically undesirable but may also stain clothes and plumbing fixtures. Color in water is measured with a colorimeter and graded on a scale from zero to 70, with zero being perfectly clear water. The test is somewhat subjective, requiring a visual comparison of the color of the water sample to a color wheel. The SMCL for color is 15 color units. Color may be indicative of aluminum, iron, manganese, dissolved organic material in the source water. The presence of color in finished water may indicate inadequate treatment, a high disinfectant demand, or high potential for the formation of DBPs. Direct color measurements of Brandon's water were not completed, but there has not been a substantive appearance of noticeable color in Brandon's finished water.

Detergents or similar substances in the water usually cause foaming when the water becomes aerated. The SMCL for foaming agents has been established as 0.5 mg/L. An oily, fishy, or perfume-like taste is often associated with foaming. No known detergents nor foaming agents are known in the water from Brandon's wells.

The presence of iron in water is recognized by its rusty color, metallic taste, and reddish or orange staining effects. Manganese in water is identified by its black or brown color, bitter metallic taste, and black staining effects. The SMCLs for iron and manganese are 0.3 mg/L and 0.05 mg/L, respectively. The iron in Brandon's wells tested between 0.06 to 1.88 mg/L, and the Manganese tested between 0.06 to 0.37 mg/L. Both of these tests showed iron and manganese concentrations higher than the desired SMCL values. The treatment plant uses oxidation, adsorption and filtration processes to remove much of the iron and manganese from the water – from Table 3.10, the treated water concentrations were 0.09 and 0.03 mg/L, respectively.

Taste and odor are typically measured by public acceptance rather than by scientific methods, with unacceptable taste and odor usually manifested as public complaints. Most organic and some inorganic compounds and dissolved gas contribute to the taste and odor of water. Odor tests can be performed to describe and quantify (subjectively) odor intensity. The threshold odor number (TON) is the standard unit measurement of odor intensity and is the ratio by which a water sample must be diluted with odor-free water for the odor to remain detectable. The SMCL for the odor in drinking water is 3 TON. Higher levels of iron and manganese may result in metallic tastes. Taste and odor are not a major concern for the City of Brandon.

Sulfate is an anion with high solubility that naturally exists in water sources primarily in the forms of sodium sulfate, calcium sulfate, and magnesium sulfate. The USEPA and SD-DENR have adopted an SMCL of 250 mg/L for sulfate in drinking water, as indicated in Table 3.10, based on taste impacts and the potential for laxative effects. The USEPA estimates indicate that only three percent of drinking water supplies in the country have provided water in excess of this 250 mg/L recommendation; however, elevated sulfate concentrations are quite common in South Dakota groundwater. The Brandon treated water sulfate concentration was 191 mg/L, meeting the SMCL.

Waters with high concentrations of salts, measured as total dissolved solids (TDS), may be less agreeable to consumers and, depending upon the specific salts present, may have an adverse digestive effect. The presence of TDS and specific metals such as iron, copper, manganese, and zinc may impart taste problems in finished water. According to the WHO, waters with TDS concentrations less than 1,200 mg/L are generally acceptable to customers. The SMCL for TDS is 500 mg/L. High TDS concentrations are also usually related to high ion concentrations that increase conductivity. This increased conductivity, in turn, increases the water's ability to complete the electrochemical circuit and to conduct a corrosive current. TDS levels for Brandon's wells ranged from 484 to 540 mg/L, with well 6 being slightly over the SMCL.

The LCR requires utilities to distribute "non-corrosive" water. Corrosion control strategies may include 1) pH and alkalinity adjustment, and 2) addition of corrosion inhibiting chemicals. The City of Brandon currently doses their finished water with a phosphate-based corrosion control chemical. Given the fact that the 90th percentile lead and copper results from the 2017 sampling were below the action level, the current approach to corrosion control has shown to be successful in Brandon.

The presence of zinc in a water source can contribute to taste and odor issues and corrosion. Zinc was not tested in Brandon's wells and is not known to be a concern for the City.

The corrosivity of water is dependent on the pipes in the distribution system and largely related to the Lead and Copper Rule. Compliance with the Lead and Copper Rule is a strong indication that the water distributed in the distribution system is a non-corrosive water since it is not found to dissolve lead and copper. Water with higher pH values above neutral and higher alkalinity concentrations have also been found to decrease the corrosive nature of water.

3.4.2 *Cosmetic Effects*

Cosmetic objectives address effects that do not damage the body but typically produce undesirable visual effects, such as skin and tooth discoloration. These objectives include controlling silver concentrations and controlling the fluoride residual in the distribution system.

Skin discoloration is related to the ingestion of silver in levels above the non-enforceable SMCL of 0.10 mg/L. Silver was not tested in Brandon's wells.

Fluoride has the unique distinction of having an adverse health impact at high concentrations and a health benefit at low concentrations. High concentrations of fluoride cause fluorosis (mottling of teeth) and bone disease. The SMCL for fluoride is 2.0 mg/L, and the MCL is 4.0 mg/L. Above 2.0 mg/L, fluorosis becomes more prominent. Low fluoride concentrations help prevent tooth decay. In 2015, the U.S. Department of Health and Human Services released the Public Health Service recommendation, updating the optimum concentration for fluoride in water from the old range of 0.7 to 1.2 mg/L, to a single value of 0.7 mg/L. At the same time, USEPA announced that it intends to consider tightening the MCL for fluoride. South Dakota DENR implemented the U.S. Department of Health and Human Services recommendation in January 2016, requiring public water systems serving more than 500 people to adjust fluoride levels between 0.5 and 0.9 mg/L, with an optimum level of 0.7 mg/L.

Fluoride is naturally occurring in Brandon's wells at a concentration range of 0.2 to 0.5 mg/L. Since the wells contain an average concentration of 0.44 mg/L, the City has received a waiver from the fluoride requirements and does not add any additional fluoride to their raw water before it is distributed.

3.4.3 *Technical Effects*

Adverse technical effects can cause damage to downstream water equipment processes and can sometimes reduce the effectiveness of treatment for other contaminants. In addition, damage can be done within the distribution system components and fixtures within homes. These adverse technical effects include corrosivity and scaling.

By-products formed by corrosion of piping and plumbing have health, aesthetic, and economic implications. The SMCL for corrosivity is non-corrosive water. Additionally, the LCR requires utilities to distribute "non-corrosive" water. Corrosion control strategies may include: 1) modifying the water quality so that it is less corrosive to the pipe material, 2) placing a protective barrier between the water and the pipe, and 3) use of pipe materials that do not corrode when in contact with water. Adjusting the alkalinity and pH is considered a passive mechanism to control corrosion by inducing the formation of less soluble compounds such as carbonates and phosphates to adhere to the pipe wall in the distribution system to minimize corrosion.

Copper can impact color and adversely affects the aesthetic quality of the finished water but is also a technical concern relating closely to the corrosivity of finished water. Corrosive water which remains in contact with copper plumbing or fixtures can result in water with an elevated copper concentration. Copper is not harmful below the SMCL of 1.0 mg/L as a small amount is needed for normal human metabolism.

The measure of the activity of hydrogen ions present in water is termed pH. The pH of the source water directly or indirectly impacts the effectiveness of many processes in water treatment including 1) corrosion control, 2) softening, 3) membrane treatment and 4) chlorine disinfection, to name a few. The pH of water also has an impact on DBP formation.

3.4.4 *Hardness*

Hardness in water does not have a regulatory limit; however, many utilities routinely include hardness removal as a treatment objective. Hardness in water originates predominantly from calcium and magnesium ions, but iron, manganese, and strontium contribute a minor hardness increment. Total hardness is typically defined as the sum of the calcium and magnesium hardness expressed in milligrams per liter as calcium carbonate ($CaCO_3$). Carbonate hardness is the portion of total hardness present associated with bicarbonate salts, while non-carbonate hardness is the portion of total hardness associated with non-carbonate salts.

The hardness of water may be classified as soft (below 75 mg/L as $CaCO_3$), moderate (75 to 150 mg/L as $CaCO_3$), hard (150 to 300 mg/L as $CaCO_3$), and very hard (above 300 mg/L as $CaCO_3$. The degrees of finished water hardness are shown in Table 3.11. Although higher values of hardness are not dangerous, public acceptance typically favors a water supply below 150 mg/L as $CaCO_3$. Hard water tends to leave scale in water heaters and precipitate on plumbing fixtures upon evaporation.

Table 3.11 Degree of Hardness

Hardness	Total Hardness (mg/L as $CaCO_3$)
Soft	0 to 75
Moderate	75 to 150
Hard	150 to 300
Very Hard	Above 300

Testing of the raw water from Brandon's wells revealed total hardness values between 379 and 412 mg/L as CaCO3. According to Table 3.11, Brandon's water would be considered "very hard." Currently, no treatment process in Brandon water treatment plant removes hardness from the water, although many homeowners in Brandon treat city water with ion exchange water softeners to obtain softened water for their personal use.

3.5 Potential Future Regulations

The Stage 2 D/DBPR and other drinking water regulations continue to focus on DBPs and microbial contaminants, and it is likely that future versions of these rules will result in increasingly stringent regulations. A major challenge for surface water systems is the concern that efforts to reduce the health risks presumed by DBPs could lead to increased health risks from microbiological contaminants, or conversely, that the increased concern over meeting the treatment technique requirements for the removal and/or inactivation of *Giardia*, viruses, *Cryptosporidium*, and other microbes could lead to increased health risks associated with DBPs. Microbial benchmarking will help balance actual health risks associated with microbial contaminants and perceived health risks associated with DBPs. At this time, Brandon is not considering surface water as a new water source, but if regulatory history is a precedent, groundwater systems will also be included in any new DBP rule.

3.5.1 *Contaminant Candidate List (CCL)*

The SDWA requires the USEPA to publish a Contaminant Candidate List (CCL) periodically. The CCL is an established list of priority contaminants identified for research regarding future regulation. The first CCL of 60 contaminants was published in March 1998, and the second list was published on February 2005. The second list carries forward 51 unregulated contaminants from the first list, including nine microbial contaminants and 42 chemical contaminants. Of the nine contaminants not carried forward (which included manganese, sodium, and sulfate), it was determined that there was sufficient data not to regulate the contaminants. In October 2009, the third Contaminant Candidate List (CCL3) was published using a new selection process and contained 116 contaminants composed of 104 chemical contaminants and 12 microbial contaminants.

One contaminant that was added to the CCL3 that relates to water treatment is N-nitrosodimethylamine (NDMA), which is an endocrine-disrupting compound (EDC) and a known by-product of chloramination. Although chloramination is considered a best available technology for minimizing regulated DBPs, an MCL for NDMA could be a potential concern for the PWSs. Initial research regarding NDMA indicates highest formation potentials in systems using coagulant polymers that have a DMA backbone. Controlling disinfection conditions also influences NDMA formation. Since free chlorine is used for disinfection in Brandon, NDMA formation is not likely occurring.

In addition to contaminants identified on the CCL3, there are other compounds that may also be regulated in the future after research on their health effects and routes of exposure are conducted and evaluated. One group of compounds of interest is iodine-containing DBPs, which are proving to be more toxic than TTHMs and HAA5s and could eventually be a treatment concern for PWSs.

The CCL4 was finalized on November 17, 2016 and includes 97 chemicals or chemical groups and 12 microbial contaminants. The EPA uses the UCMR 4 to collect data on selected contaminants from the CCL list to determine the prevalence and distribution of contaminants.

Of interest to Brandon, manganese was included as a parameter in UCMR 4. Currently, manganese is included in the Secondary Drinking Water Standards for its aesthetic effects (brown staining upon oxidation) as discussed in Section 4.2.2. Manganese data was collected during UCMR 1, but EPA determined not to regulate manganese with a Primary Drinking Water Standard at that time. However, in 2004, EPA issued a health advisory, recommending drinking water supply manganese concentration not exceed 0.3 m/L, based on lifetime exposure to manganese concentrations, and not exceed 1.0 mg/L for 1-day and 10-day exposures to infants. Preliminary health assessments indicate that excessive manganese concentrations cause adverse neurological impacts, especially in infants, although more research was needed to determine if the health impacts are sufficient to require regulation of manganese as a health-related (required) drinking water standard. The EPA will be gathering manganese concentration and occurrence data from public water supplies through UCMR 4, after which a regulatory decision will be made. In light of these recent developments and the potential for a manganese primary drinking water standard, Brandon should continue manganese removal as a treatment objective and optimize manganese removal to seek the best manganese removal achievable with the water treatment plant processes.

3.5.2 *Distribution System Rule*

There have been discussions about the implementation of a distribution system regulation in the future. The Distribution System Rule is intended to help maintain treated water quality as water is transported from the treatment facility to the tap. This regulation is in early development, and the issues of concern were published in white papers on the topics of water quality decay, biofilms, cross-connections, buried infrastructure, finished water storage, groundwater intrusion, leaching, nitrification, and water mains. The main issues of concern are if the water is not stabilized properly for corrosion control prior to entering the distribution system or if the disinfection residual concentrations are too low in areas of the distribution system.

3.5.3 *Emerging Contaminants*

Emerging contaminants such as EDCs, personal care products (PCPs), and pharmaceutically active compounds (PhACs) are becoming increasingly important with respect to drinking water treatment, as all three groups of compounds are being monitored and researched with respect to public health impacts. EDCs are chemicals, predominately man-made, that interfere with normal hormone functions in living organisms. Known EDCs include pesticides, dioxins, polychlorinated biphenyls (PCBs), and heavy metals. PCPs and PhACs include shampoos, pheromones, fragrances, herbal substances, over the counter medicines, and prescription medications. In response to a congressional mandate, the USEPA has developed the Endocrine Disruptor Screening Program to help identify endocrine disruptors from the estimated 87,000 chemicals used today. To a lesser extent, PCPs and PhACs are also under review by the USEPA. It is possible that any number of these compounds may become regulated or added to the CCL within the planning horizon for this report.

3.5.4 *PFAS*

Per- and polyfluoroalkyl substances can be found in food packaging, stain- and water-repellant fabrics, non-stick products, polishes, waxes, paints, cleaning products and fire-fighting foams. Fire-fighting foams are a major source of groundwater contamination at military bases and airports where firefighting training occurs. Groundwater contamination by PFAS has also occurred near industries where PFAS were manufactured or were used in the manufacturing process. In 2016, EPA issued a health advisory for PFOA and PFOS, two PFAS chemicals that have been most extensively studied and utilized. EPA established a health advisory level of 70 parts per trillion of the combined concentration of PFOA and PFOS and are currently engaging the regulatory process to further regulate PFAS. Brandon has not measured PFAS in their water sources but will likely need to do so in the future.

3.6 Groundwater Rule

Although groundwater has historically been thought to be free of microbial contamination, recent research indicates that some groundwaters are a source of waterborne disease. Most cases of waterborne disease are characterized by gastrointestinal symptoms such as diarrhea, vomiting, etc. These symptoms are much more serious and can be fatal for persons in sensitive subpopulations such as young children, the elderly, and persons with compromised immune systems. In addition, research indicates that some viral pathogens found in groundwater are linked to long-term health effects such as adult-onset diabetes and myocarditis (inflammation of the middle muscular layer of the heart wall).

The 1996 amendments to the SDWA required EPA to develop regulations that require disinfection of groundwater systems "as necessary" to protect the public health. The Ground Water Rule (GWR) establishes multiple barriers to protect against bacteria and viruses in drinking water from groundwater sources and establishes a targeted strategy to identify groundwater systems at high risk for fecal contamination. The GWR was issued as a final regulation in 2006. This rule applies to public groundwater systems (systems that have at least

15 service connections or regularly serve at least 25 individuals daily at least 60 days out of the year). Implementation of this rule began in January 2010. The requirements of this rule include:

- System sanitary surveys conducted by the State which are intended to identify significant deficiencies,
- Hydrogeologic sensitivity assessments for non-disinfected systems,
- Source water microbial monitoring by systems that do not disinfect and draw from hydrogeologically sensitive aquifers or have detected fecal indicators within the system's distribution system,
- Corrective action by any system with significant deficiencies or positive microbial samples indicating fecal contamination, and
- Compliance monitoring for systems which disinfect to ensure that they reliably achieve 4-log (99.99 percent) inactivation or removal of viruses.

A positive total coliform result from the TCR routine sampling triggers source water monitoring. Source water monitoring requires the system to collect a sample from the well(s) for further microbial analysis. If the sample is positive, then the system must take corrective action as directed by the state. A groundwater system's best action to maintain compliance with the Ground Water Rule is to maintain chlorine residuals in the distribution system sufficient to prevent positive coliform results in their TCR samples.

3.7 Development of Water Quality Goals/Objectives

Any new source of water distributed to the City of Brandon must meet the requirements outlined in the USEPA's SDWA primary drinking water standards. Secondary drinking water standards are not enforceable. Thus, communities can decide to set their own secondary standards for treatment.

During meetings between AE2S, the City of Brandon staff and the Brandon Water Committee, outcomes for future water supplies were discussed and proposed: (1) The City desires meet the MCLs for the primary drinking water standards and would prefer to remove radionuclides to concentrations lower than the MCL as is feasible by available technologies (2) remove iron and manganese to meet the Secondary MCLs and (3) if feasible, remove hardness and total dissolved solids to lower than current levels.

Table 3.12 provides a list of general water quality parameter concentrations in neighboring systems along with the treated water quality from Brandon. Brandon has higher levels of total dissolved solids (TDS) and hardness compared to other nearby regional systems. Sulfate levels are similar for all four systems and are all near or below the SCML. Brandon currently uses free chlorine as its residual disinfectant, while all three of the nearby systems use a combined chlorine disinfectant residual.

In order for the City to produce water that is comparable to other nearby systems, the hardness in Brandon's water would require treatment to remove approximately 50 percent of the raw water total hardness. Removing the hardness will also remove the TDS levels as well. Continued reduction of iron and manganese concentrations, using existing or other appropriate treatment technology, is also required.

Table 3.12 Comparison of Brandon and Nearby System Secondary Contaminants Levels

Parameter	L&C RWS	Sioux Falls	MCWC	Brandon	SMCL
pH	8.6	8.5	9.0	7.3	6.5 – 8.5
TDS, mg/L	490	376	350	570	500
Alkalinity, mg/L as $CaCO_3$	64	44	27	250	-
Total Hardness mg/L as $CaCO_3$	172	238	187	390	-
Ca Hardness, mg/L as $CaCO_3$	100	111	118	250	-
Sulfate, mg/L	273	200	180	191	250
Chlorine Residual Type	Chloramine	Chloramine	Chloramine	Free Chlorine	-

As described in Section 3.3.7, radionuclides have been a concern for the City of Brandon, particularly from the water obtained from the Split Rock Creek aquifer. The formerly utilized manganese greensand treatment process has historically removed radionuclides to levels below the SDWA MCLs, but Brandon added additional radionuclide treatment capability by installing an HMO system in 2017. Additionally, the greensand filter media was replaced by IMAR™ filtration media in early 2019. If the future water supply is obtained from the Split Rock Creek aquifer, treatment technologies must be applied to meet the primary drinking water MCLs. Fortunately, since hardness removal is one of the City's goals, the same treatment alternatives that are effective at removing hardness, (lime softening, ion exchange, and reverse osmosis) are also effective at reducing radionuclide concentrations. Additionally, radionuclide-specific treatment technology is available to treat high concentrations of radionuclides at the well. Other options to reduce radionuclides include blending water from the Split Rock Creek aquifer with water from other sources that do not contain radionuclides or abandoning the Split Creek aquifer and obtaining water from other sources that do not contain detectable amounts of radionuclides.

3.8 Water Quality Goals and Objectives Summary

In order to protect the public's health, multiple regulations have been implemented in the treatment of surface and ground waters. These enforceable regulations are known as the primary drinking water standards. The enforcement of these primary standards in South Dakota falls under the jurisdiction of the SD-DENR. In addition, secondary guidelines have been generated and are helpful for utilities to create treatment goals that cost-effectively meet their customers' desired water quality. The secondary guidelines are not enforceable but provide guidance for commonly acceptable ranges of other undesirable water constituents.

Completely eliminating all forms of contaminants from drinking water delivered to customers is not economically feasible. Therefore, the guidelines established in the Safe Drinking Water Act aid water utilities to make the best decisions to deliver safe water at an affordable rate to its customers. The City of Brandon desires to continue to provide safe and affordable water to its customers, with the primary goals of reducing radionuclides below their respective MCLs and provide water of similar secondary quality to nearby water systems.

Considering the above factors, the water quality goals for Brandon's future water supplies include:

- Meet the primary drinking water standards of the Safe Drinking Water Act
- If feasible, remove radionuclides to concentrations below those stipulated in the SDWA MCLs
- Remove iron and manganese to levels at or below the Secondary MCLs of 0.3 and 0.05 mg/L respectively
- If feasible, achieve hardness and TDS concentrations lower than the current concentrations.

Chapter 4 EVALUATION OF THE EXISTING WATER SYSTEM

The city of Brandon is served by a series of wells that pump to an iron and manganese removal water treatment plant. The characteristics of the existing wells and water treatment plant were examined to evaluate their roles and capabilities relative to meeting future water source and supply requirements. Known characteristics of two proposed wells were included in the evaluation since their design and implementation are moving forward. The locations of the existing and proposed wells and water treatment plant are shown in Figure 4.2, appended to this chapter.

4.1 Water Rights Summary

The existing water supply was reviewed previously to determine the adequacy of the water supplies from a quantity perspective, and water quality was reviewed in greater detail in Chapter 3. This section briefly summarizes the water rights the City currently has for water permitted by the State of South Dakota Department of Environment and Natural Resources (SD-DENR).

The SD-DENR Water Rights Program is responsible for managing the appropriation and use of the state's water resources. Table 4.1 summarizes the amount of water permitted for use by each well and its associated aquifer as well as reserved future use. Table 4.2 provides a summary of historical water rights activities for the City of Brandon's municipal water use.

Table 4.1 Current and Future Use Water Rights Allocated per well

Well	Permit/License Number (s)	Big Sioux Aquifer - South			Split Rock Creek Aquifer		
		Max Annual Draw (acre-ft/year)	Max Rate (ft^3/s)	Max Rate (gpm)	Max Annual Draw (acre-ft/year)	Max Rate (ft^3/s)	Max Rate (gpm)
1 & 2	License 5868-3	376	0.52	233	-	-	-
3	License 5868-3	-	-	-	1,006	1.39	624
4 & 5	License 5869-3	217	0.78[a]	350[a]	-	-	-
6 & Future 8	License 6156-3	-	-	-	968	4.44[a]	1,993[a]
Well 7	Permit 8151-3	-	-	-	1,451	3.34[a]	1,499[a]
Total Permitted		593	1.02	457	3,425	9.17[a]	4,116[a]
Future Use Remaining	BSA: 4002-3, 6696-3, SRCA: 6697-3	1,913	-	-	697	-	-

[a] Maximum withdraw rate higher than the yearly allocation

Table 4.2 City of Brandon Overall Water Rights Summary

Source	Aquifer	Permit #	Status	Priority Date	Well #	Permitted Amount (ac-ft/year)	Withdraw Rate (ft^3/s)[a]	Withdraw Rate (gpm)[a]	Withdraw Rate (MGD)[a]
GW	Big Sioux: South	4002-3	Future Use	9/12/1977	N/A	685	0.95	424	0.61
GW	Big Sioux: South	6696-3	Future Use	1/27/2006	N/A	1,227.7	1.69	760	1.09
GW	Split Rock Creek	6697-3	Future Use	1/27/2006	N/A	2,148.4 - reduced to 697.4 by 8151-3	0.96	432	0.62
GW	Big Sioux: South	1804-3	Incorporated into 5868-3	1/25/1971	1 & 2	376	0.52	233	0.34
GW	Split Rock Creek	1804-3	Incorporated into 5868-3	1/25/1971	3	405	0.56	251	0.36
GW	Split Rock Creek	5296-3	Incorporated into 5395-3	3/22/1989	3	239	0.33	148	0.21
GW	Split Rock Creek	5395-3	Incorporated into 5868-3	3/8/1990	3	311	0.43	193	0.28
GW	Big Sioux: South	5868-3	License	6/8/1995	1 & 2	376	0.52	233	0.34
GW	Split Rock Creek	5868-3	License	6/8/1995	3	51	0.07	31	0.05
GW	Split Rock Creek	5868-3	License	6/8/1995	3	956	1.32	592	0.85
GW	Big Sioux: South	4885-3	Incorporated into 5869-3	4/20/1982	5	203	0.28	126	0.18
GW	Big Sioux: South	5869-3	License	9/23/1977	4 & 5	217	0.5[b]	224[b]	0.32[b]
GW	Split Rock Creek	6027-3	Incorporated into 6156-3	12/1/1977	6	968	2.23[b]	1001[b]	1.44[b]
GW	Split Rock Creek	6156-3	License	11/4/1999	6 & 8	968	4.44[b]	1,993[b]	2.87[b]
GW	Split Rock Creek	8151-3	Permit	1/27/2006	7	1,451 (Reduce 6697-3 by 1,451)	3.34[b]	1499[b]	2.16[b]
GW	Multiple	7181-3	License	1/21/2010	N/A	0	0	0	0

[a] Withdraw rate assumed to be at a constant rate for the entire year unless otherwise noted.
[b] Maximum withdraw rate.

Table 4.2 summarizes historical permits and licenses that have been received by Brandon relative to operations of their municipal water supply system. A license is provided after a well has been completed and its production capacity is known. A permit reserves water, either for an anticipated well or for future use. Several permits/licenses have been updated to reflect changes in operations, construction of wells, and consolidation (incorporation) of permits/licenses.

Table 4.1 summarizes the current permits/licenses in effect for Brandon. License 5868-3 includes water sourced from both the Big Sioux Aquifer and the Split Rock Creek aquifer. Relative to Well 3 in the Split Rock Creek aquifer, 5869-3 authorizes a maximum withdrawal rate of 1.39 ft^3/s. The water right at the time of this permit did not limit the annual volume but rather listed the peak diversion rate. If the well was operated continuously, it would yield 1,006 acre-ft per year, which is essentially the maximum water withdrawal from Split Rock Creek allowed by this license. The same interpretation applies to the Big Sioux Aquifer wells (1&2) that were covered by License 5868-3. The remaining licenses and permits (not including future use permits) are written with a maximum annual withdrawal along with maximum diversion rate. These more recent permits recognize the well may operate at an instantaneous flow rate greater than the annual average flow rate. Future licenses will likely be structured with a maximum annual withdrawal and a maximum diversion rate. The future use permits reserve an additional volume of water that can be withdrawn from the aquifer.

4.2 Existing Raw Water Supply

The City of Brandon currently draws all of its raw water from 3 wells located within the city limits. The locations of the wells are noted in Figure 4.2 and the end of this chapter. Well 1 was constructed in 1971 and is located directly south of the water treatment plant and has an approximate production rate of between 160-190 gpm. Well 1 draws water from the Big Sioux Aquifer at an average depth of 48 ft pumps the water directly to the head of the water treatment plant (WTP). Well 3 was constructed in 1964 and is located just east of the Brandon Valley High School. Well 3 draws water from the Split Rock Creek aquifer at an average depth of 222 ft. Water from Well 3 is not pumped to the WTP; it is instead disinfected through on-site chlorine injection to form a free chlorine residual and is then pumped directly into the distribution system. No treatment for iron, manganese or radium is provided from this well. Therefore, Well 3 is used primarily as an emergency well and as an additional water source during peak day demands. Well 6, constructed in 1999, provides most of the City's water, with an average production of between 1,250 and 1,600 gpm. Well 6 draws from the Split Rock Creek aquifer at an average depth of 275 ft. Water from Well 6 is pumped directly to the head of the WTP for treatment. The City has also refurbished another well, Well 7. Well 7 is expected to produce about 1,200 gpm if or when it is placed on-line. Water from Well 7 is drawn from the Split Rock Creek aquifer at an average depth of 423 ft and can also be directed to the head of the WTP for treatment. Well 7 was tested and found to contain higher radium levels has delayed the adoption of this well into the City's well inventory.

There are currently plans to add new Wells 8 and 9 to the system to increase overall raw water capacity and redundancy. Well 8 has been drilled in the Split Rock Creek Aquifer approximately 500 ft north of Well 6 and has been pump tested. The well house and piping are in final stages of design. Well 6 and Well 8 will serve as redundant wells to each other since the yield from both wells is similar. Well 9 is currently in the initial phase of development. It is to be completed in the Big Sioux Aquifer north of the WTP. Well 9 is expected to be able to pump between 200 and 250 gpm to the WTP. The successful implementation of these additional wells will help the City maintain a reliable water source. The locations of Wells 8 and 9 are shown in Figure 4.2.

The characteristics of existing and pending wells are summarized in Table 4.3. Other wells 2, 4, and 5 are not in service as their production rates were too low to justify their continued use. The total current peak production rate from the existing wells is approximately 2,060 – 2,440 gpm, with a firm capacity (with the largest well out of service) of 810 – 840 gpm. Should Well 7 be placed online, and it reliably produces the estimated 1,200 gpm, the peak production rate would be increased to approximately 3,260 – 3,640 gpm with a firm capacity of 2,010 – 2,040 gpm.

Table 4.3 Summary of Existing and Pending Wells

Well Number	Aquifer	Year Built	Depth (ft)	Average Production (gpm)	Status
1	Big Sioux: South	1971	48	160 – 190	To WTP with Well 6
3	Split Rock Creek	1964	222	650	Treated at Well, Direct Discharge into System
6	Split Rock Creek	1999	275	1,250 – 1,600	To WTP with Well 1
7	Split Rock Creek	1995	423	1,200	Pending
8	Split Rock Creek	-	-	1,800 – 2,000[a]	Under Construction
9	Big Sioux: South	-	-	200 – 250[a]	Under Development

[a] Estimated production rate.

4.3 Water Treatment Plant Capacity & Capabilities

The current water treatment plant (WTP) was constructed in 1997 and has a rated production capacity of 2,000 gpm with all four filters in operation. The treatment train consists of aeration, chlorine injection, injection of hydrous manganese oxide (HMO), 30 minutes of detention at 2,000 gpm, filtration using four greensand filters, and a second addition of free chlorine. The water then flows to the clearwell where it stored until it is pumped into the distribution system. As the water is pumped from the clearwell, a corrosion inhibitor and an iron and manganese sequestering agent are added.

4.3.1 *WTP Process Description*

The system is currently capable of treating iron and manganese through oxidation by aeration and through the use of a greensand filter. The HMO system was placed online in the fall of 2017 and is used to reduce radium concentrations in the water as well as iron and manganese oxidation. Ammonia in the raw well water is removed through break-point chlorination. Currently, there is no treatment technology used to reduce raw water hardness levels. Figure 4.1 provides an illustration of the process schematic for the Brandon WTP.

Aeration

The WTP uses an induced-draft aerator. The aeration process is primarily used to remove dissolved iron through the oxidation process with oxygen present in the air. As air passes through the water, oxygen reacts with the dissolved iron and oxidizes it to a form that is less soluble in water. The detention process allows the newly formed particles of the insoluble iron to coagulate and to be better trapped by the filter. Aeration also reacts similarly with manganese, but to a lesser extent. The maximum flow capacity of the aerator has not been determined. For this study and with the absence of information on the aerators, the maximum flow rate through the aerators is assumed to be 2,000 gpm.

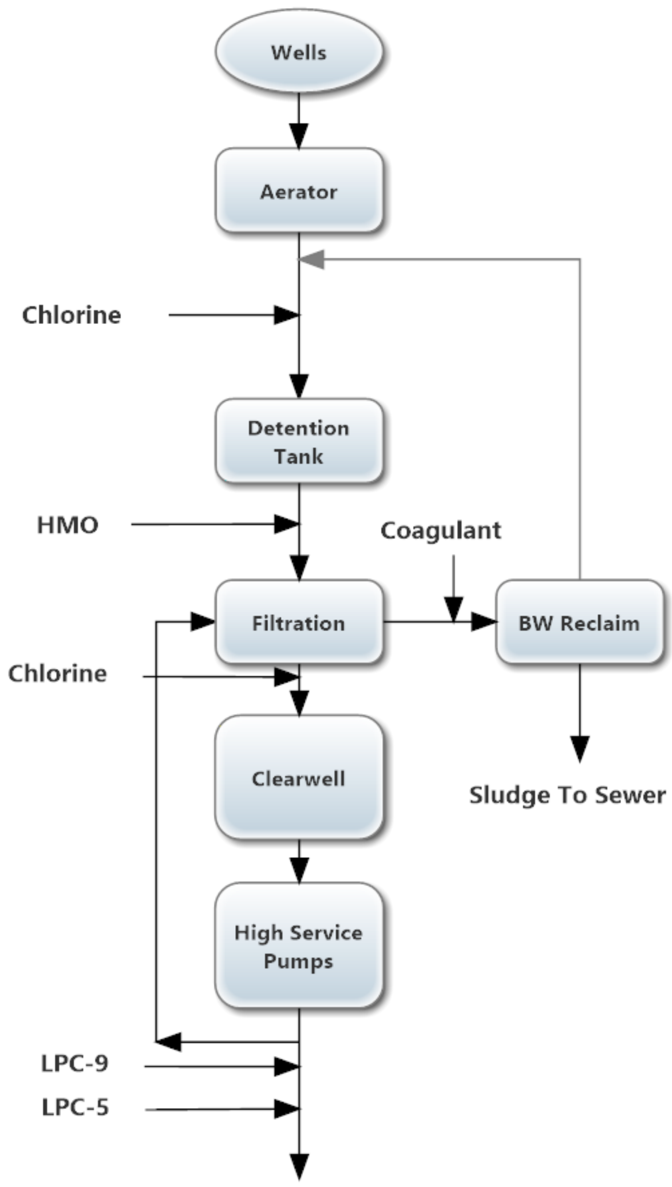


Figure 4.1 Brandon WTP Process Schematic

Detention Basin

The detention basin that follows the aerator was designed to provide 20 minutes of detention time at a flow rate of 2,000 gpm. According to 10 States Standards, 30 minutes is the recommended detention time to allow the oxidation reactions to progress. However, a detention time shorter than 30 minutes may be acceptable if the results of a pilot plant study indicate a reduction in detention time is possible. Without further analysis supporting a shorter detention time than the 20-minute design, the peak flow through the detention tank should be limited to 2,000 gpm.

The gravity flow channel connecting the detention basin with the filters has a design capacity of 2,000 gpm. However, during a site visit in the summer of 2018, it was noted that when the flow through the plant approaches 2,000 gpm, water tends to slosh over the sides into the first two filters. At their current average peak flow rate of about 1,800 gpm, the water level in the channel was near the rim, leaving little to no extra flow capacity through the channel. This channel is not likely to be able to convey the full design capacity of the plant. Although not ideal, because the water sloshes off into the first two filters, water is not lost in the production process which indicates the full 2,000 gpm can still be delivered to the filters and moved through the plant.

Filters and Backwashing

The WTP uses four filters arranged around a central flow-splitting system. The original filter media consisted of a gravel base, 12 inches of anthracite coal, and 18 inches of greensand filter media. According to the WTP plans, the four filters are all 12 ft x 14 ft giving a total surface area of 672 ft^2. If the plant is run at the design capacity of 2,000 gpm, a filter loading rate of 2.98 gpm/ft^2 will result. Should a single filter need to be taken offline, the filter loading rate at 2,000 gpm would increase to 3.97 gpm/ft^2. According to 10 States Standards Section 4.3.1.3, if more than two filters are provided, the filters should be able to meet the plant design [firm] capacity when one of the filters is offline. Section 4.3.1.2 in the 10 States Standards also states that the typical filtration loading rates of between 2 and 4 gpm/ft2 may be appropriate, with final approval from the engineer and reviewing authority. Therefore, per 10 States Standards evaluation, the firm capacity of the filters is 2,000 gpm. However, Brandon operators indicate the filters have not run at 2,000 gpm for an extended period of time, nor has the plant been operated at 2,000 gpm with one filter out of service for an extended period of time. So, while the design application rate of the filters could enable a firm capacity of 2,000 gpm, this firm capacity has not been tested.

The historically used greensand filter contains a coating that reacts with much of the remaining dissolved manganese and rapidly oxidizes the dissolved form of manganese to the insoluble form that can be adsorbed onto the filter media. The greensand filter is also capable of oxidizing much of the remaining dissolved iron as well. This media was successfully used for treatment since the water treatment plant was constructed, and the historical treated water quality data presented in this report reflect the water quality obtained from this treatment process

The greensand filter media was replaced during the winter of 2019 with a patented product provided by Tonka Water. The new filter media, known commercially as IMAR™, is a dual-media blend of sand and anthracite specifically designed to efficiently remove iron, manganese, arsenic, and radium from groundwater sources. According to pilot studies, the IMAR™ media was successful at reducing iron, manganese, and radium concentrations better than the existing greensand filter media. As of the completion of this report, operators are optimizing the operations of the IMAR™ media. Adjustments to optimize the media include ensuring a free residual chlorine is present in the filter influent water and adjusting the HMO dosage.

With the change to the HMO system, it was initially thought that the filters would need to be backwashed every 10 hours, meaning a single filter would need to be backwashed every 2.5 hours. However, the operators have steadily increased the filter run times to around 20 hours, meaning a single filter is backwashed on average every five hours. Filter breakthrough was the main driver for limiting the filter run length to 20 hours.

The backwash process involves seven minutes of simultaneous wash (air and water), four minutes of purge, and seven minutes of high-rate backwashing. The total backwash process keeps a filter offline for between 20 to 30 minutes. During the backwash process, the plant's effluent valve shuts about 20%. The additional head from this partial closure of the effluent valve is used to deliver water to the first two stages of the backwash. A high-service pump is used for the high-rate final stage flushing of the filters. The system has constraints on when a backwash process may occur. If all three high-service pumps are required, no backwashing can occur. Likewise, if the clearwell level is too low, backwashing is also prohibited.

The backwash system would allow a filter to be backwashed every 2 hours, providing 8-hour filter run times. At the current peak flow rate of about 1,800 gpm, filter run lengths averaged about 20 hours. With increased filter loading, more frequent backwashing may be necessary. However, considering its current capacity and other bottlenecks in the plant, the backwash system is not likely to be a bottleneck source in the WTP at a flow rate of 2,000 gpm.

A backwash system also supports the WTP filter operations. Four backwashes can be stored in the 87,200-gallon backwash tank. The backwash water is decanted at a rate no greater than 10 percent of the influent flow of the plant. At this decant rate, a backwash can be completed and decanted in less than two hours at the peak design flow rate, meaning a backwash can occur every two hours. Table 4.4 provides a summary of the filter and backwash characteristics.

Table 4.4 Characteristics of the Brandon WTP filters (each of 4 equivalent filter cells)

Parameter	Value
Number of Filter Cells	4
Cell Length x Width (ft)	14 x 12
Cell Area (ft2)	168
Loading Rate (at Max Flow, all filters), (gpm/ft2)	3.0
Loading Rate (at Max Flow, one filter out of service), (gpm/ft2)	4.0
Backwash Volume (gallons)	15,000 – 20,000
Anthracite depth (inches)	12
Greensand depth (inches)	18

Clearwell and High-Service Pumping

The filtered water then flows into the 0.5 MG clearwell north of the WTP underground. The WTP uses three high-service pumps that, combined, can produce approximately 3,100 gpm. The flow rate from two of the three high-service pumps exceeds the plant's current production capacity. With one of the largest pumps out of service, the high-service pumps are able to produce a firm capacity of 2,400 gpm. Table 4.5 summarizes the capabilities of the high-service pumps.

Table 4.5 High-Service Pump Capacities

Pump(s)	Flow rate (gpm)
1 (VFD)	1,450
2 (Soft-start)	1,660
3 (Soft-start)	1,660
1 + 2 or 3	2,400
2 + 3	2,600
1 + 2 + 3	3,100

4.3.2 *Chemical Feed Systems*

As indicated in the process descriptions, various chemicals are added throughout the treatment process. Chlorine and HMO are dosed ahead of the filters. Chlorine is also dosed after the filters as well. As the water is pumped from the clearwell to the distribution system, LPC-5, a polyphosphate, and LPC-9, zinc orthophosphate, are added for iron and manganese sequestration and corrosion control respectively. A coagulant is also added to the backwash waste to aid in sludge settling in the backwash reclaim tank. Table 4.6 summarizes the chemical feed, storage, and dosing capabilities.

Table 4.6 Chemical Feed and Storage Systems at the Brandon WTP

Chemical	Storage System Size	Number of pumps/feeders	Individual pump/feeder capacity
HMO	(2) 500-gallon tanks	2	N/A
Chlorine	150 lb cylinders	3	Raw (2) at 100lb/day; Effluent (1) at 50 lb/day
LPC-5	(1) 100-gallon tank	1	12 gpd
LPC-9	(1) 500-gallon tank	1	42 gpd

Chlorine System

The chlorine feed system provides gas feed to two injectors in the pipe between the aerator and the detention tank and to one injector at the filter effluent. Each injector is supplied by two Omni Hydro regulators mounted on 150 lb chlorine cylinders connected by a switchover to a valved rotameter that is manually adjusted by operators to control the chlorine feed rate. Prior to the installation of the IMAR™ media, the chlorine dosages were 5.6 mg/L to the raw water and

1.7 mg/l to the effluent. The post IMAR™ chlorine dosage approach increased the raw chlorine feed to achieve a free chlorine residual on the filter influent. During the high flow season, the current use of 150 lb cylinders requires frequent cylinder changeouts, and a one-ton cylinder chlorine feed system is envisioned to improve operations.

Hydrous Manganese Oxide (HMO) System

The HMO system installed in the Fall of 2017 was primarily installed to enhance radium removal from the drinking water. The HMO product is Tonkazorb 3%, a proprietary suspension of preformed manganese dioxide that is dosed prior to filtration. The current dosage rate is 0.72 mg/L. The radium in the water adsorbs to the HMO particles and is removed by the filters. The HMO system is also effective at reducing iron and manganese through adsorption and oxidation, so the City no longer adds permanganate for iron and manganese control.

4.3.3 *Water Quality Capabilities*

The current treatment objectives are iron, manganese and radium removal, ammonia removal by breakpoint chlorination, disinfection to maintain a chlorine residual in the distribution system, and corrosion control. The unit processes are appropriate to achieve removal of iron and manganese to meet their secondary MCL's of 0.3 mg/L and 0.05 mg/L, respectively. The chlorination system has been successfully applied to achieve ammonia removal by breakpoint chlorination and provide a disinfectant residual in the distribution system. The HMO system is an appropriate technology to enhance radium removal, and the existing system has historically removed radium to below the SDWA MCL's. However, the capacity of the HMO system, along with the recent IMAR™ filter replacement, must be optimized for radium removal, and has not been tested with the higher radium levels that exist in Well 7, although optimization of the HMO dosage may provide radium removal to meet the SDWA MCL's. The phosphate-based corrosion control chemicals have been applied to meet the requirements of the Lead and Copper Rule successfully.

4.4 Water Treatment System Capacity Summary

Table 4.7 summarizes the water treatment system production rates and firm capacities. Under the current setup of operating wells and defining the firm capacity as the largest pump being taken offline, the firm capacity is then slightly above 800 gpm, which is about half the required flow rate needed to meet the demands during the peak months. The treatment plant is not limited by any one treatment process and can continually produce its design capacity of 2,000 gpm with only one to two backwashes per day requiring a temporary slowdown in production. So while the design application rate of the filters could enable a firm capacity of 2,000 gpm, this firm capacity has not been tested.

Table 4.7 Water Treatment System Capacities Summary

Raw Water Production				Water Treatment Plant Production		
Item	Current Capacity (gpm)	Current Firm Capacity (gpm)	Future[1] Firm Capacity (gpm)	Item	Capacity (gpm)	Firm Capacity (gpm)
Well 1	160-190	160-190	160-190	Aerator	2,000	2,000
Well 3	650	650	650	Detention	2,000	2,000
Well 6	1,250-1,600	X	1,250-1,600	Plant Conveyance	2,000	2,000
Well 7	X	X	1,200	Filters	2,000[2]	2,000[2]
Well 8	X	X	X	HSPs	3,100	2,400
Well 9	X	X	200-250			
Total	2,060-2,440	810-840	3,460-3,890 (5.0-5.6 MGD)	Total Capacity	2,000	2,000

[1] Future firm capacity assumes wells 7, 8, and 9 are available for water production. Well 7 is currently not connected to the raw water line, wells 8 and 9 are planned for construction.
[2] This capacity has not been tested. Firm capacity may be impacted by IMAR™ media performance.

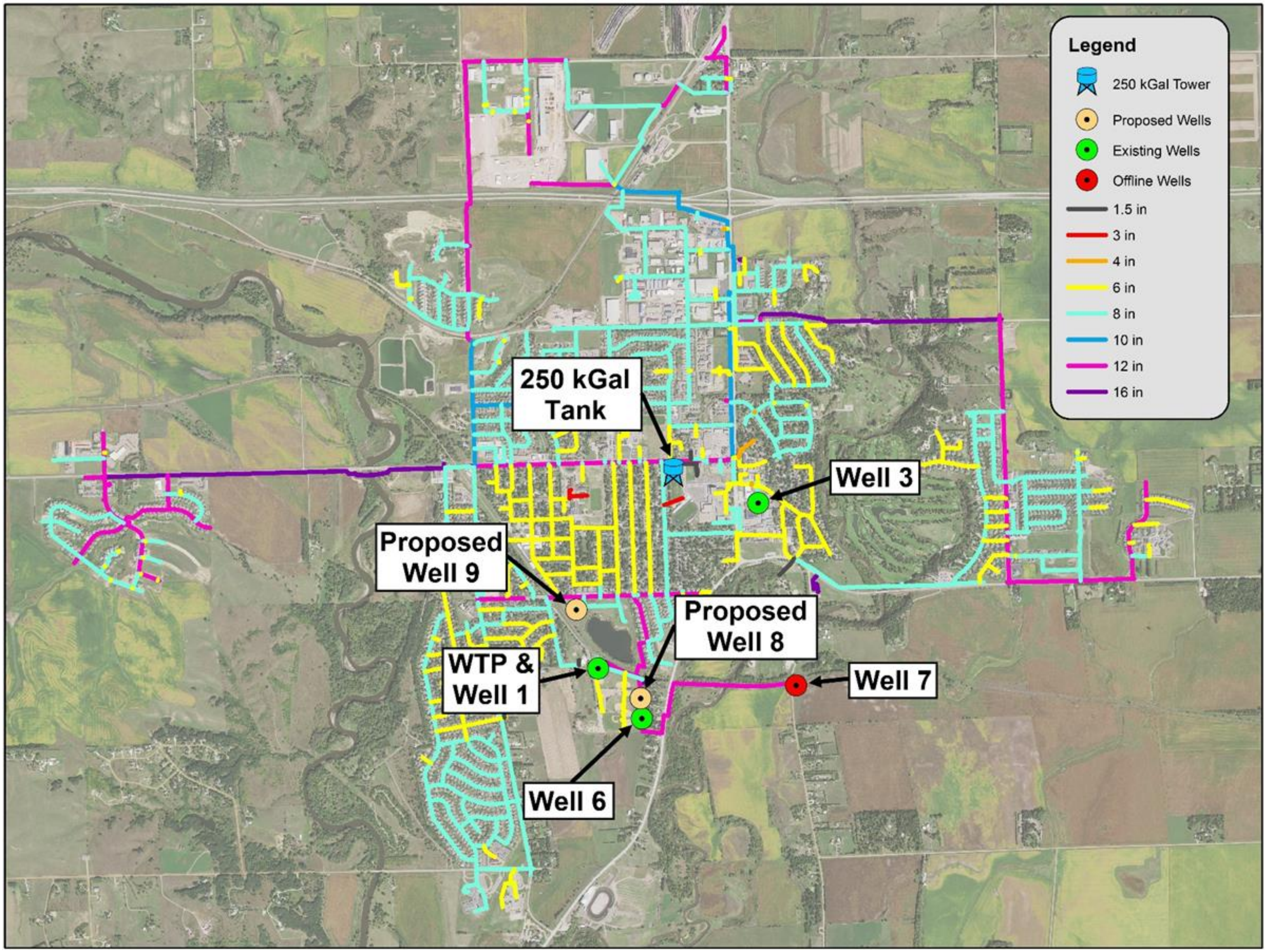


Figure 4.2 Overview of the City of Brandon Distribution System, Existing and Proposed Wells

Chapter 5 GROUNDWATER ASSESSMENT

The City of Brandon utilizes groundwater as their current water source. As the City continues to grow, additional water supply sources need to be identified for the anticipated increase in population. Groundwater is one possible supply source to meet this increasing demand. The availability of additional groundwater sources to meet future demands was investigated to understand the potential role of groundwater in meeting Brandon's future source water needs.

AE2S subcontracted with WSP USA, Inc. (WSP), to review groundwater resources within a 3-mile radius of Brandon. WSP developed hydrogeological conceptual models to provide information on the viability of the groundwater sources and prepared a report summarizing their findings. This report is titled City of Brandon Water Supply Evaluation Report (WSER), dated September 2018 and was submitted to the City of Brandon as a separate document. A summary of the WSER is provided below. Select tables and figures referenced in this Chapter extracted from WSP's WSER and are either included in this chapter or are attached to this document as Appendix A.

WSP accessed several data sources to compile the WSER. WSP (formerly operated as Leggette, Brashears & Graham, Inc (LBG)) has conducted several hydrogeological studies in the Brandon area and brought that experience to the study. Reports of geology and groundwater resource studies by the South Dakota Geologic Survey, the United States Geological Survey, and the US Army Corps of Engineers and other agencies were utilized as technical resources. The South Dakota Department of Environment and Natural Resources Water Rights Program well completion report database and the South Dakota Geological Survey lithologic log database were accessed by WSP, as well as information from the City of Brandon, including well logs, water quality information and well construction information.

5.1 Summary of Aquifers

The City of Brandon is geographically located above groundwater sources that are identified as the Quaternary Aquifer and the Split Rock Creek Aquifer. The Quaternary Aquifer is the shallower of the two aquifers while the Split Rock Creek Aquifer is deeper. Brandon has completed four wells in the Quaternary Aquifer (City Well 1 (CW-1), CW-2, CW-4, and CW-5), and three wells in the Split Rock Creek Aquifer (CW-3, CW-6, and CW-7). The Quaternary Aquifer well depths range from 48 feet to 56 feet (measured from the land surface to the bottom of the wells) while the Split Rock Creek Aquifer well depths ranging from 222 feet to 423 feet. Additional information on the aquifer parameters can be found in Table 1 of Appendix A.

These two aquifers vary in available water quantity and quality. The Quaternary Aquifer only has one City well (CW-1) currently in use, which is operated between 170 and 190 gallons per minute (gpm). The pumping rates of Brandon's three wells in the Split Rock Creek Aquifer are approximately 1,750 gpm (CW-6), 600 gpm (CW-3, and 1,200 gpm (CW-7). The City currently draws water from CW-1, CW-3, and CW-6. CW-1 and CW-6 provide raw water to the water treatment plant, and both wells operate when water treatment plant is running. CW-3 pumps water directly to the distribution system with disinfection and water stability treatment at the well house and is only used when Well 6 is not operational. CW-7 is available but is not currently utilized due until appropriate radionuclide removal treatment is proven.

The water quality of these two aquifers was reviewed in the WSER - tables of water quality data reviewed in the WSER are presented in Table 2 and Table 7 in Appendix A of this report. Ranges of key water quality parameters for the City of Brandon wells and additional monitoring wells historically sampled by DENR are summarized in Table 5.1.

Table 5.1 Water Quality

Parameter	Quaternary (Big Sioux) Aquifer		Split Rock Creek Aquifer	
	Brandon Wells	DENR MA Wells	Brandon Wells	DENR MA Wells
pH	7.6-7.8	7.04-7.15	7.6-7.9	6.6-8.4
Total Dissolved Solids, mg/L	450-500	416-668	450-540	482-1330
Iron, mg/L	0.05-0.3	<0.03-0.7	0.6-2.7	<0.05-1.13
Manganese, mg/L	0.3-0.5	<0.01-0.42	0.2-0.4	0.14-0.53
Alkalinity, mg/L as CaCO3	260-320	317-322	290-310	303-419
Sulfate, mg/L	35-40	66-156	95-150	85-640
Nitrate-Nitrite, mg/L as N	5-8	<0.01-5.9	<0.2	<0.04-0.08
Total Hardness, mg/L as CaCO3	360-390	340-547	350-420	235-923
Gross Alpha, pCi/L			2-28	9.6
Radium 226+228, pCi/L			1.5-20	2.7

When the Brandon Wells results from the two aquifers are compared, the water quality of the two aquifers are similar in total dissolved solids, alkalinity, and total hardness. The Quaternary Aquifer has elevated Nitrate-Nitrite relative to the Split Rock Creek Aquifer, and the Split Rock Creek Aquifer has elevated radionuclides relative to the Quaternary Aquifer. Constituents that exceed the Environmental Protection Agency's (EPA) Primary Maximum Contaminant Level (MCL) and Secondary MCL (SMCL) are the constituents that should be noted. Within the Quaternary Aquifer, these constituents include total dissolved solids (TDS), iron, and manganese. In the Split Rock Creek Aquifer; TDS, iron, manganese, Gross Alpha, Gross Alpha – adjusted, and Radium 226 + Radium 228 exceed the MCL and/or SMCL.

Radionuclide concentrations in the Split Rock Creek formation are a primary factor that influences well development and treatment process selection. WSP cited several studies regarding the source and location of radionuclides and surmised the source(s) of radionuclides is "a function of bedrock geology and mineral composition of the Split Rock Creek formation and the Sioux Quartzite. Additionally, well construction characteristics likely contribute to concentrations experienced at a given well, indicating higher radionuclide concentrations are likely at greater depth. WSP suggests that well-designed sampling and analysis plan carried out during well construction can enable screening a well at an appropriate depth to minimize radionuclide concentrations in a given well location.

As additional well locations are explored for Brandon, an initial investigation should include small diameter wells that could be sampled to examine the water quality at that location. The water quality of wells in the Quaternary Aquifer is known to vary widely over short distances. The radionuclide concentrations at a potential well location will determine the degree of radionuclide removal required to meet the MCL.

5.2 Aquifer Cross-Sections

Hydrogeological Conceptual Models (HCM) are intended to be a model of an aquifer to provide an understanding of its general physical characteristics, including hydrology, geology, geologic structure, and water quality. Data from many sources are gathered and incorporated into a HCM. WSP utilized information from well completion reports, water quality data, well pumping records, South Dakota Geologic Survey (SDGS) data, United States Geological Survey (USGS) data, and other sources as described in the WSER. The HCM considers several elements, including aquifer cross-sections, aquifer properties (including thickness, material, hydraulic properties such as storativity and transmissivity, potentiometric surface and hydrography, recharge and discharge to develop a view of aquifer productivity. WSP prepared HCMs for both the Quaternary Aquifer and the Split Rock Creek Aquifer.

The structure of these aquifers is graphically shown in Appendix A, WSER Figures 4 and 5. These figures show a cross-section of the various subsurface soil layers and geology. These cross-sections show the locations of wells, the logs of which were used to create the cross-sections. Within the geology, the approximate location and depth of sand and gravel deposits are also identified to show the aquifer locations.

5.3 Aquifer Characteristics

The WSER utilized available data to identify aquifer key characteristics of the Quaternary and Split Rock Creek Aquifers. These characteristics are summarized in Table 5.2.

Table 5.2 Quaternary and Split Rock Aquifer Characteristics

Characteristic	Quaternary Aquifer	Split Rock Creek Aquifer
Active Groundwater Permits	15	18
Total Groundwater Approp. (Project Area) BGY	1.33	4.15
Total Aquifer Volume (Project Area), Billion Gals	18.2	69.5
Brandon Permitted Withdrawals, BGY	0.48	3.5
Brandon Actual Withdrawals, BGY	0.073	0.284
Transmissivity, gpd/ft	5,250-25,350	11,968-88,000
Storativity, unitless (estimated)	0.15	0.00007-0.0053

The characteristics in Table 5.2 describe the total volume of water in the two aquifers in the project area, the amount of water appropriated, Brandon's appropriated water withdrawals (including current permits and future water rights), and Brandon's actual withdrawals. At first glance, it appears the appropriated water is a relatively small fraction of the total available water, and that Brandon's share is a fraction of the total permitted withdrawals. However, the long-term sustainability of the aquifer is better defined by the amount of recharge relative to withdrawal, since a sustainable aquifer recharges to satisfy the water withdrawn from the aquifer. The productivity and long term sustainability of an aquifer are related to the interplay between aquifer transmissivity, storativity, and recharge.

5.4 Aquifer Recharge

WSP assumed and postulated sources of aquifer recharge in the HCMs to assess the available water within each aquifer. The Quaternary Aquifer is the shallower of the two aquifers and is primarily recharged by precipitation with minor amounts from nearby adjoining subsurface features. The recharge for the Split Rock Creek Aquifer is likely from the adjacent subsoil features, specifically the Sioux Quartzite outcrops that allow water to move through the fractures in the Sioux Quartzite and into the Split Rock Creek Aquifer. Minimal recharge is believed to be through vertical infiltration of precipitation. WSP cited hydrographs of water levels in wells monitored by DENR to indicate aquifer recharge does occur in both the Quaternary and the Split Rock Creek Aquifer.

WSP indicated a significant data gap exists to enable confident knowledge of the sources and quantity of recharge to the Quaternary and Split Rock Creek Aquifers and recommended additional data collection and study to close the data gap. Additional data gaps include lack of aquifer characteristic (T&S) data, water usage data by permit holders, and aquifer stratigraphy information in certain locations of each aquifer.

5.5 Locations and Production of Potential Wells

WSP used the HCMs to determine the potential for groundwater source locations and the ability for groundwater to move through the aquifer. Based on this information, WSP estimated that the Quaternary Aquifer yield likely ranges from 195 gpm to 750 gpm and would require five additional wells (total of 6 wells) to access this water. The Split Rock Creek Aquifer yield is likely in the range of 940 gpm to 5,600 gpm utilizing the three existing City wells and two additional wells (total of 5 wells). Potential locations for the wells in the Quaternary Aquifer and the Split Rock Creek Aquifer are identified in the WSER Figures 21 and 36, respectively, included in Appendix A.

The WSER indicated that potential development of the Quaternary Aquifer could include exploration and development of withdrawal points along the Big Sioux River, utilizing infiltration galleries or horizontal collector wells to draw water from the River through the riverbank, utilizing the aquifer material as a filter to remove turbidity from the river. However, this option carries water quality risks, including designation of the groundwater as under the influence of surface water, and potential emerging contaminant and nitrate contamination of the aquifer by recharge from the Big Sioux River. Additional geological investigations would be required needed to determine the feasibility of this option.

The WSER suggested that additional investigation and study should be completed (especially regarding aquifer recharge) if developing additional groundwater resources from the Quaternary and Split Rock Creek Aquifers becomes a viable alternative for future Brandon water supply needs.

5.6 Summary of Findings

The WSER indicates that groundwater is available in both the Quaternary and Split Rock Aquifers. The Quaternary Aquifer has a limited quantity of groundwater and may potentially need up to five new wells to access this water. The Split Rock Creek Aquifer is reported to have a greater volume of water available and may be accessible with two new wells. The wells constructed for either of these aquifers will have different characteristics such as well depth, pump size, and cost, which will be further refined in subsequent chapters. These two aquifers also have water quality parameters that exceed the MCL or SMCL. Both aquifers exceed the MCL/SMCL for TDS, Iron, and Manganese. The Quaternary Aquifer also exceeds the Nitrate as N MCL/SMCL while the Split Rock Creek Aquifer exceeds the MCL/SMCL for Gross Alpha, Gross Alpha – adjusted, and Radium 226 + Radium 228. These constituents will need to be considered for treatment from the water should additional water from either of these two aquifers be proposed as an alternative water source for the City of Brandon.

Chapter 6 WATER SOURCES EVALUATION

As the City of Brandon continues to grow, additional water sources will need to be identified and procured. To meet that need, potential raw water sources and treated water sources were sought and evaluated. The raw water source alternatives included drilling additional wells in the Big Sioux and/or the Split Rock Creek (SRC) aquifers. Potential treated water source alternatives included purchasing treated water from the City of Sioux Falls, SD, or from Minnehaha Community Water Corporation (MCWC).

6.1 Local Aquifers

As described in Chapter 5, the City of Brandon can obtain water from the Big Sioux Aquifer and the SRC Aquifer. The two aquifers have similar water quality in terms of hardness, total dissolved solids, and alkalinity and both contain elevated iron and manganese concentrations. The primary drinking water quality standard parameters of concern are the elevated levels of nitrate found in the Big Sioux Aquifer and the elevated levels of radionuclides found in the SRC Aquifer. Relative to well productivity, wells drilled in the Big Sioux aquifer are anticipated to have around 10-20 percent of the yield rate compared to wells drilled in the SRC Aquifer.

6.1.1 *Big Sioux Aquifer*

The Big Sioux Aquifer alternatives (discussed in greater detail in Chapter 7) propose drilling up to five additional wells in the Big Sioux Aquifer. The City currently has one active well drawing water from the Big Sioux Aquifer (Well 1). As described previously in this report, the Big Sioux Aquifer has nitrate levels around 7 mg/L as nitrogen but has negligible levels of radionuclides. The yields of Brandon's wells 2, 4 and 5, constructed in the Big Sioux aquifer, declined over the years to yield around 100 gpm or less, causing Brandon to take these wells off-line, leaving Well 1 as the sole Big Sioux Aquifer well producing between 150 and 200 gpm. According to the groundwater study performed by WSP, five additional Big Sioux wells would likely have the ability to produce a combined yield range of between 195 and 750 gpm, or about 40 to 150 gpm average per well. In order to better predict the actual yield rates of the proposed wells, WSP recommended additional analysis if the aquifer before the installation of any new well.

As described previously in this report, the Big Sioux Aquifer has nitrate levels around 7 mg/L as nitrogen but has negligible levels of radionuclides relative to the levels in the Split Rock Creek Aquifer. Both aquifers contain similar concentrations of total dissolved solids and hardness, and both contain elevated concentrations of iron and manganese. Various treatment options are proposed to achieve the treated water objectives established in this report. These treatment options are outlined in Chapter 7.

The City would need to engage the South Dakota Department of Environment and Natural Resources (SD DENR) Water Rights permitting process for new well development. The City's current and future use water rights were introduced in Chapter 4. In the Big Sioux Aquifer, the City currently has 685 ac-ft/year of future use available under Future Use Water Permit 4002-3 and an additional 1227.7 ac-ft/year future use available under Future Use Water Permit 6696-3. The areas encompassing the water diversion locations for these future water permits are outlined in Figure 6.1.

The WSP WSER identified potential locations for the proposed Big Sioux Aquifer wells based on favorable aquifer characteristics. These locations were utilized for planning purposes and cost estimates, although the actual locations of potential wells would depend on land acquisition and site access. The proposed Big Sioux Wells would be located within the future water use areas bounded by the red squares in Figure 6.1 (Section 34, T102N-R48W and Section 3, T101N-R48W)The proposed wells are anticipated to have a yield rate of between 195 and 750 gpm to fully utilize the estimated range of production projected in the WSP WSER. Well 9, currently being explored by the City and shown in the lower red square, is included in the 5 wells proposed for the Big Sioux Aquifer.

Existing well permits and future use permits would likely be utilized in permitting the new wells in the Big Sioux Aquifer. Existing wells 4 and 5 have a separate associated water license of 217 acre-ft/year under Water License 5869-3. The permitting process would determine the approach of permitting the new wells as replacement wells for existing wells 2, 4, and 5 and/or permitting under the existing future use permits. Given the areas of water availability in the Big Sioux Aquifer projected by the WSP WSER, this project proposes no Big Sioux Wells be constructed in the quarter sections defined by Future Water Use Permit 6696-3 (green squares in Figure 6.1).

Depending on the future growth of the City and the treatment technologies chosen for the new WTP (discussed further in Chapter 7), the estimated 2070 average raw water demand ranges between 1.5 and 2.1 MGD and the estimated peak day raw water demand ranges between 5.2 and 6.2 MGD. If the combined yield rate of the five proposed Big Sioux wells and the existing SRC wells does not provide a firm capacity greater than the future raw water demands, an additional well would be constructed in the SRC aquifer to supplement the Big Sioux wells. To examine this possibility, Table 6.1 summarizes the anticipated pumping rates of existing wells and wells proposed by this alternative. The maximum anticipated pumping rates of the wells are shown, along with the operating pumping rate. The maximum pumping rate is either the maximum rate that can be pumped from an existing well or an assumed maximum rate for the proposed wells, considering the results of the WSP WSER. Although wells are equipped to pump at a maximum flow rate, they do not operate continuously at that rate. Conservatively, wells may be expected to operate 50% of the year, promoting sustainable aquifer management and well asset management. The operating pumping rate shown in Table 6.1 is the lower of 50% of the maximum pumping rate or pumping rate equivalent to the annual water production allowed by the existing permit.

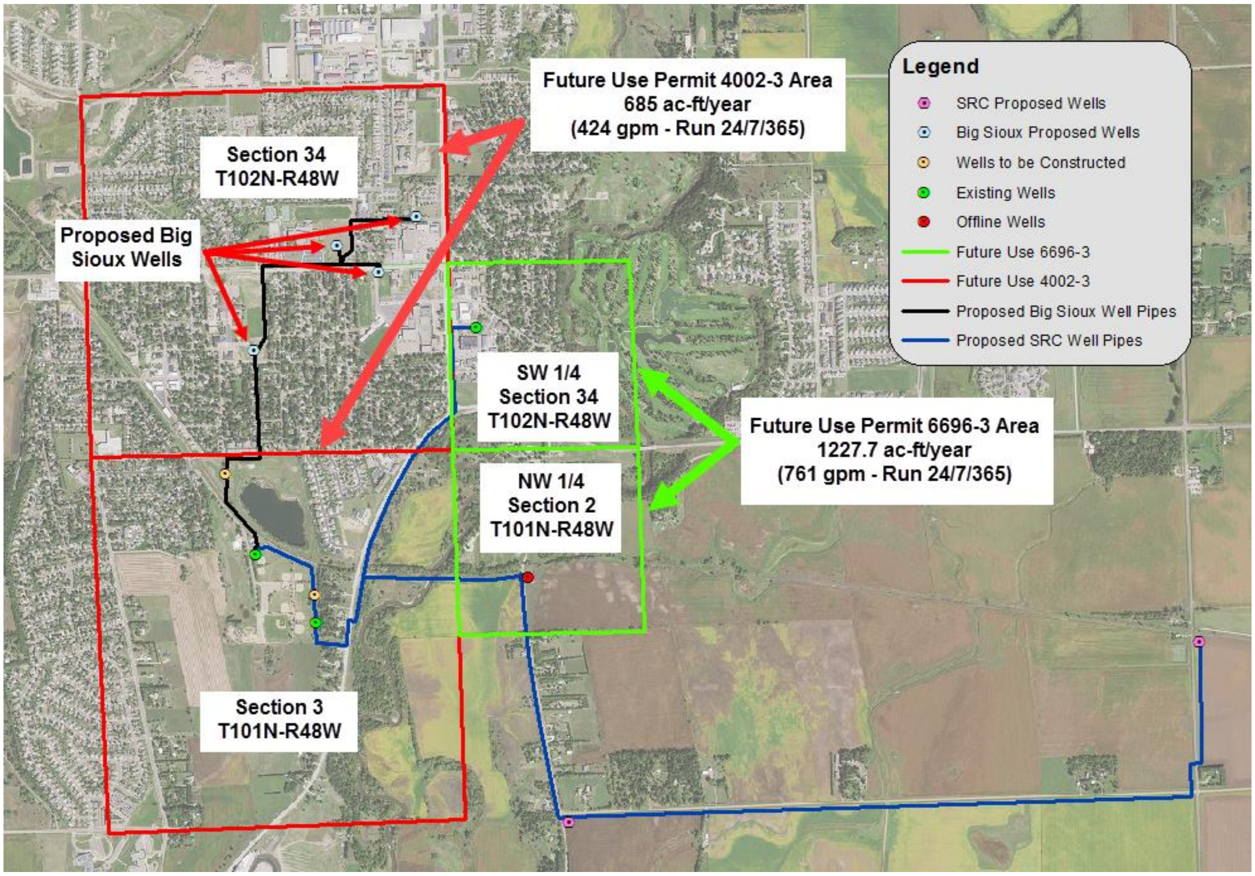


Figure 6.1 Locations and the maximum annual withdrawals from Big Sioux Aquifer Future Water Permits.

As noted in Table 6.1, the proposed well inventory includes 5 new wells in the Big Sioux Aquifer, the existing Wells 1, 3, 6, and 7, and a new well in the Split Rock Creek Aquifer. The total operating pump rate from the proposed wells inventory ranges from 3.3 to 3.7 MGD, more than required to meet the 2.5 MGD estimated average day demand in 2070. The maximum day production ranges between 7.2 and 8.0 MGD. However, the firm capacity of the well system must be capable of providing the maximum day demand with one well out of service. Given the largest capacity well is Well 6, and the proposed Well 8 will serve as a redundant pump for that well, the largest well out of service is considered to be either Well 7 or the new Split Rock Creek well, both of which are assumed to have a maximum pumping rate of 1.73 MGD. Reducing the total maximum day production by the 1.73 MGD pumping rate yields a firm capacity of the well inventory ranging between 5.5 and 6.3 MGD, which is sufficient to meet the 2070 estimated peak raw water demand. Considering the raw water requirements of the Big Sioux source alternative, the future peak day raw water demands govern the required future well inventory.

The SDDENR Water Rights permitting process must be engaged to fulfill the permitting requirements of this alternative. Well permits and licenses, as well as future water permits, will need to be acquired and adjusted to accommodate the proposed wells. These activities are summarized in the implementation section of this report.

Table 6.1 Water Production, Big Sioux Aquifer Alternative

	Maximum Pumping Rate		Sustainable Pumping Rate[a]		Licensed/Permitted Use			Operating Pump Rate	Operating Use
	gpm	MGD	gpm	MGD	Acre-ft/yr	MGD	gpm	MGD	Acre-ft/yr
New BSR Wells (incl. Well 9	194-750	0.28-1.08	97-375	0.14-0.54				0.14-0.54[b]	156-605
Well 1 (License 5868-3)	180	0.26	90	0.13	376	0.34	233	0.13[b]	145
Well 3 (License 5868-3)	625	0.90	313	0.45	1006	0.90	624	0.45[b]	504
Well 6 (License 6156-3)	1600	2.30	800	1.15	968	0.86	600	0.86[c]	968
Well 7 (Permit 8151-3)	1200	1.73	600	0.86	1451	1.30	900	0.86[b]	968
New SRC Well	1200	1.73	600	0.86				0.86[b]	968
Total		7.2-8.0			3801			3.3-3.7	3709-4158

[a]Sustainable Pumping Rate = 50% of Maximum Pump Rate
[b]Operating Rate = Sustainable Pumping Rate
[c]Operating Rate limited by permitted use

6.1.2 *Split Rock Creek*

The Split Rock Creek alternatives (discussed in greater detail in Chapter 7) assumes the future water source will focus on the Split Rock Creek Aquifer, proposing to install up to two additional wells in the SRC Aquifer. Previous wells constructed in the SRC Aquifer have produced significantly higher yield rates than wells constructed in the Big Sioux Aquifer, potentially providing a cost advantage as compared to the Big Sioux Aquifer wells. According to the groundwater study performed by WSP, two additional wells plus the three existing wells would likely have the ability to produce a combined yield range of between 940 – 5,600 gpm, or about 190-1,120 gpm average per well. In order to better predict the actual yield rates of the proposed wells, the WSP WSER recommended additional analysis on the aquifers be performed before the installation of any new well.

As described previously in this report, the SRC Aquifer has elevated levels of radium and radionuclides but contains negligible levels of nitrate compared to the Big Sioux Aquifer. The two aquifers provide water with similar hardness and dissolved solids concentrations, and both require iron and manganese removal. Various treatment options are available to achieve the treated water goals established in this study with an additional awareness regarding radionuclide removal from the water obtained from the Split Rock Creek wells proposed in this alternative. These treatment options are described in Chapter 7.

The current and future use water rights were introduced in Chapter 4. For the SRC Aquifer, the City currently has 697.4 acre-ft/year of future use under Future Use Water Permit 6697-3 and can withdraw up to 3,425 acre-ft/yr from current wells 3, 6 and 7. Figure 6.2 provides a map of the locations, and the maximum annual withdraws from each of the future use water permits the City has for appropriating water from the SRC Aquifer.

For planning purposes, WSP identified potential locations of future SRC wells. These locations were identified to enable cost estimates for the wells and associated infrastructure – the actual locations of the wells will depend on acquiring access to land and other site factors. As displayed in Figure 6.2, the proposed locations WSP recommended for new wells in the SRC aquifer are outside of the current area outlined by Future Use Water Permit 6697-3. Depending on the outcome of the recommended additional groundwater study, additional water right activities for the proposed wells in the SRC aquifer would include adjusting the area for future water rights, requesting additional future water rights, and permitting and licensing future wells. This activity may include transferring a portion of existing authorized water withdrawals from existing wells to proposed wells. These activities are outlined in the implementation plan.

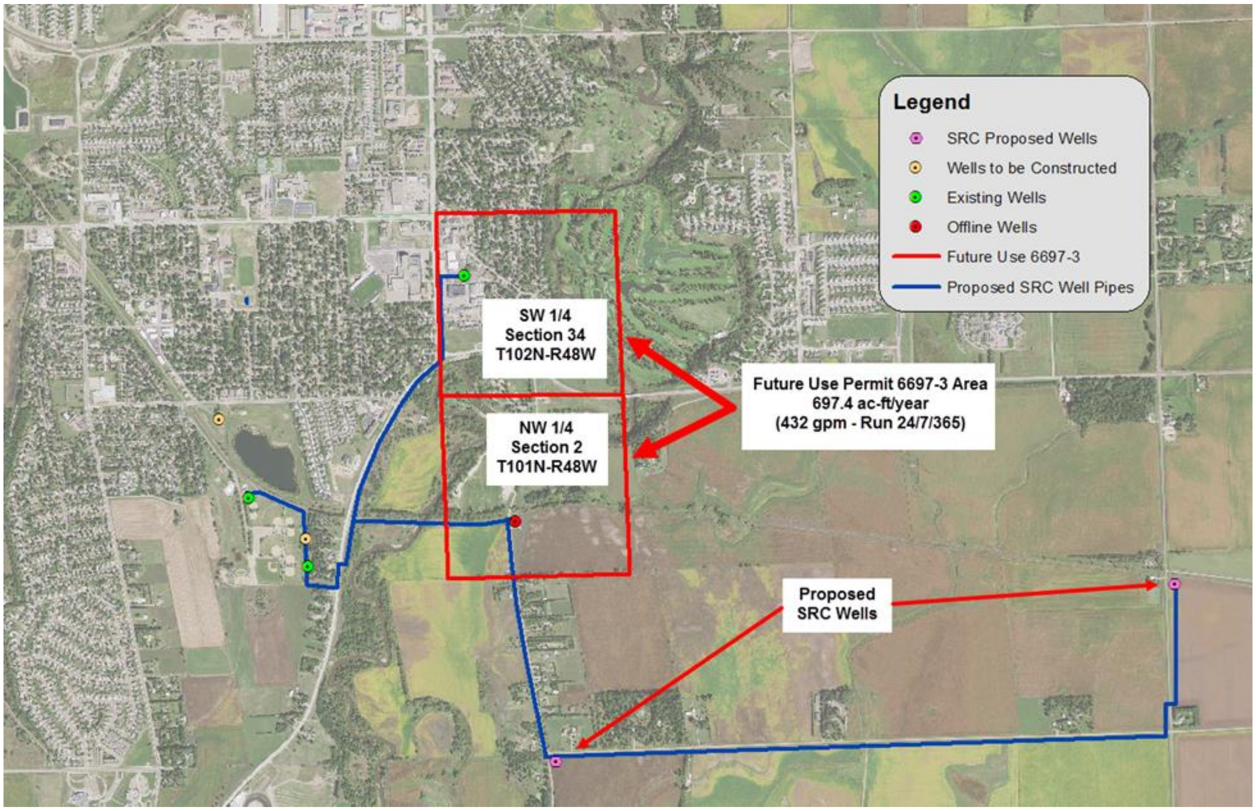


Figure 6.2 Current SRC Future Water Use Permit Amounts and Locations

Table 6.2 summarizes the potential water flow and production characteristic requirements of the Split Rock Creek source alternative. These characteristics were developed using assumptions similar to those for developing the Big Sioux Aquifer well characteristics. The flow characteristics of the two new wells are proposed in the Split Rock Creek Aquifer were assumed to be similar to those of Well 7, with a maximum flow rate of 1200 gpm and a sustainable pumping rate of 600 gpm. The annual water withdrawal from each of the proposed wells was assumed to be similar to Well 6, yielding 968 acre-ft/year. Using these assumptions, the well inventory could provide an average day demand of 4 MGD, and a peak flow (all wells operating) of 8.65 MGD. Assuming the firm capacity is defined as the total production capacity when one of the 1,200 gpm wells is out of service, the firm capacity would be approximately 6.9 MGD, which exceeds the estimated 2070 maximum day raw water need of 6.2 MGD. This proposed plan provides source capacity governed by maximum day water consumption.

Table 6.2 Available Well Pumping Rates Vs. Water Rights for the SRC Well Alternative

	Maximum Pumping Rate		Sustainable Pumping Rate[a]		Licensed/Permitted Use			Operating Pump Rate	Operating Use
	gpm	MGD	gpm	MGD	Acre-ft/yr	MGD	gpm	MGD	Acre-ft/yr
Well 1	180	0.26	90	0.13	376	0.34	233	0.13[b]	145
Well 3	625	0.90	313	0.45	1006	0.90	624	0.45[b]	504
Well 6	1600	2.30	800	1.15	968	0.86	600	0.86[c]	968
Well 7	1200	1.73	600	0.86	1451	1.30	900	0.86[b]	968
New SRC Well A	1200	1.73	600	0.86				0.86[b]	968
New SRC Well B	1200	1.73	600	0.86				0.86[b]	968
Total		8.65			3801			4.04	4521

[a]Sustainable Pumping Rate = 50% of Maximum Pump Rate
[b]Operating Rate = Sustainable Pumping Rate
[c]Operating Rate limited by permitted use

6.2 Purchase Water from Sioux Falls

An option to purchase water from the City of Sioux Falls was explored. The City staff from Sioux Falls and Brandon and staff from AE2S met on February 11th, 2019 at the Sioux Falls Administration Building to discuss possible delivery options. Two approaches to delivering water to Brandon were discussed, (1) Subdivision delivery, and (2) Water Treatment Plant (WTP) delivery. Subdivision delivery would deliver Sioux Falls water to a section of Brandon's service area that would be hydraulically separated from the remaining service area, causing the customers to receive different water quality depending on location. WTP delivery would deliver the Sioux Falls water to the Brandon WTP where it would be blended with Brandon WTP finished water and then distributed to the customers. Since Sioux Falls and Brandon use a different disinfection approach and also provide water with a substantial difference in water hardness and dissolved solids concentrations, it was determined the WTP deliver would be the best approach for delivering Sioux Falls water to Brandon. Sioux Falls currently distributes water with a chloramine residual whereas Brandon provides a free chlorine residual. The blended water would be delivered with the appropriate chlorine residual type chloramine or free chlorine, considering costs, required infrastructure, and implementation of a potential change in disinfection type.

At the February 11 meeting, Sioux Falls stated that they are not able to provide water to Brandon. Sioux Falls indicated that they have limited water available to service new customers outside their planned service area and provided the following justification:

- Sioux Falls Wellfield Contamination – Wells in the airport area, providing approximately 30 percent of the groundwater appropriation, have been off-line due to the presence a contaminant in the wells. It will likely take some time to explore and implement alternatives to recover or replace the production from these wells, and until that .
- Sioux Falls currently has identified additional Big Sioux Aquifer wells in their CIP but is waiting on the USGS report to be completed to locate and install the wells in the best

locations. The study is anticipated to be completed sometime during the second half of 2019.

- A study was also performed on the wellfield piping from the wells to the WTP. It was found that the current wellfield piping creates a bottleneck and restricts the overall capacity to 50 percent if all of the wells are operating at the same time.
- Sioux Falls' current facilities are planned and capable of meeting Sioux Falls water needs through 2045, beyond 2045 additional improvements will be needed.

Although Sioux Falls would not provide water in the near term, Sioux Falls encouraged further communication and dialog with Brandon to explore potential long term water supply options, including participating in regional water supply planning beyond 2045.

As a result of this interaction, Sioux Falls water delivery to Brandon was not considered a viable option for near term (current through 2045) water supply.

6.3 Purchase Water from Minnehaha Community Water Corporation

The City of Brandon, representatives from Minnehaha Community Water Corporation (MCWC), and AE2S staff met several times to discuss the potential for MCWC providing water to the City of Brandon on a short-term or long-term basis. In developing this option, MCWC considered the current and future water demands of their customers, availability of water resources, and infrastructure requirements to deliver water to Brandon. MCWC concluded they could deliver to Brandon a maximum of 250,000 gallons of treated water per day for a period of up to 5 years after delivery infrastructure was constructed. Water would be delivered through the existing MCWC tower located near the intersection of 481st Avenue and 260th Street on the northwest corner of the Brandon industrial park north of Interstate 90. Water would flow south along Sioux Avenue through an existing 8-inch MCWC pipe. A new pipe would be installed to deliver water from this MCWC pipe to the Brandon WTP where the MCWC water would be blended with Brandon WTP finished water. Additional chlorine would be added at the Brandon WTP to achieve a free chlorine residual in the finished water, matching the disinfection approach used by the City of Brandon. MCWC provide cost estimates for infrastructure needed to accomplish this approach.

The following elements characterize the infrastructure needs and costs associated with the MCWC potential source:

- The rough estimated cost of about $500,000 was provided for the infrastructure necessary to deliver 250,000 gallons per day over a maximum period 5 years to provide some relief to Brandon while they develop their own long-term water sources and additional treatment capacity.
- The $500,000 cost includes Brandon's cost share of a meter building, control valve, and approximately 1,000 feet of 8-inch PVC pipeline. This cost doesn't include the connecting pipe from Sioux Ave to the WTP.
    - The control valve cost is proposed to be a shared cost between MCWC and the City of Brandon.

- Water would be delivered to Brandon from MCWC's infrastructure north and west of Brandon. The water would primarily be sourced from the Lewis and Clark water, supported by water produced from the MCWC water treatment facilities south of Dell Rapids.
    - The water quality provided to Brandon would be similar to the Lewis and Clark water.
- Approximately 1,000 ft of 8-inch diameter pipe, is needed to serve existing MCWC customers, enabling the MCWC infrastructure to be re-configured to serve Brandon.
- The Brandon WTP supply pipe would tee off the 8-inch pipeline on Sioux Blvd and pipe directly to the WTP clearwell. The mixed water (Brandon and MCWC) would need to be break-point chlorinated from Brandon's existing chlorination system. A control valve would be required to control the flow of water into the WTP clearwell.
- Flow to the clearwell would be delivered in an on/off function based on the operation of the Brandon WTP.
- Water could be withdrawn from MCWC faster than 173 gpm (0.25 MGD), assuming that the existing MCWC water tower north of the Interstate would be used as storage and buffer the withdrawal variability.
- A control valve will be needed to allow supplemental flow from the north MCWC area to areas in the south-east part of the MCWC system.

This MCWC alternative could increase the water delivery to Brandon by approximately 10 percent of the current maximum production capacity. It is further developed and evaluated as a short-term alternative in the following chapters.

6.4 Lewis and Clark Regional Water System

The Lewis and Clark Regional Water System provides treated water to its member systems in southeast South Dakota, southwest Minnesota and northwest Iowa. The system has been built in phases and can be expanded as needed to meet the reserved capacity of the members.

Project staff met with Troy Larson, executive director of Lewis and Clark, to discuss future plans for regional water supply. Following are highlights of that discussion.

- The current delivery capacity is 24 MGD.
    - The system is designed to expand to 60 MGD in the future – the capacity of this expansion is already allocated.
    - The intent for the expansion to 60 MGD is to remain as a groundwater system.
- Lewis and Clark is exploring what happens beyond 60 MGD.
    - The Lewis and Clark board recently began discussing "Lewis and Clark II" (beyond 60 MGD).
    - The current concept is they will not add new "members," but existing members could add new "customers."
    - New customers would be added within the framework of existing member service area frameworks.

- Troy Larson will invite Brandon to future meetings where Lewis and Clark II would be discussed.
    - Early effort will be to determine how much water is needed
    - Interested members/customers would likely contribute to any future water study

Although not available as an immediate solution to Brandon's water source needs, Lewis and Clark II represents a potential long-term water supply alternative for Brandon, and Brandon is encouraged to participate in discussions of this concept.

6.5 Summary

Based on review of future water sources examined in this study, it appears the immediate viable long-term solution for additional water sources for the City of Brandon is to develop and procure additional groundwater wells in the Big Sioux Aquifer and/or the Split Rock Creek Aquifer and treat the additional water through the expansion of their existing WTP.

The City of Sioux Falls is unable to provide water to the City of Brandon as they are facing their own water needs issues as well. Even though Sioux Falls is not offering water to Brandon in the near-term, they have indicated a desire to join a long-term regional water supply planning effort to supply water after 2045.

MCWC has indicated that they are able to provide up to 250,000 gallons per day over a maximum period of five years. This option is evaluated as a short-term alternative for Brandon. As with Sioux Falls, MCWC would like to be a partner in long-term regional planning for providing water to customers in the City of Brandon as well as rural customers in southeastern Minnehaha County.

Both MCWC and the City of Sioux Falls are members of, and receive water from, the Lewis and Clark Regional Water System, which is in the early stages of planning for long-term water needs of their members. Brandon is encouraged to participate in this planning effort.

Chapter 7 PROPOSED ALTERNATIVES

As the City of Brandon continues to grow, so do the demands for additional water. The design instantaneous capacity of the existing WTP is around 2,000 gpm (2.88 MGD), however, the current maximum output from Wells 1 and 6 (the wells connected to the WTP when this report was written) average around 1,600 to 1,800 gpm (2.3 – 2.6 MGD) limiting the total treated water output to less than the plant design capacity.

This section summarizes the development of future water source alternatives as well as alternative methods for treating the water. Potential sources of additional water included purchasing water from nearby water suppliers such as the City of Sioux Falls, Minnehaha Community Water Corporation (MCWC), or from Lewis and Clark Regional Water System (L&C), drawing water from the Big Sioux River, or obtaining water from the development of additional wells in the Big Sioux and or Split Rock Creek (SRC) Aquifers.

Since the community is growing rapidly, an additional short-term supply of water is needed to take full advantage of Brandon's current water treatment plant (WTP) capacity until a new or expanded WTP can be constructed in the coming years. Many of the short-term water solutions can be a part of the City's longer-term water needs.

The long-term alternatives both for source water and treatment methods are evaluated in this chapter. Long-term source water options include the development of the Big Sioux and or Split Rock Creek aquifers. Long-term treatment options include A) the existing treatment approach using HMO and IMAR™ media filtration to remove iron, manganese, and radium, B) using the existing treatment with the addition of reverse osmosis (RO) for hardness removal and C) a radionuclide removal technology for pretreating high-radionuclide level water prior to subsequent treatment at the water treatment plant. Planning for the long-term alternatives was completed for 25 and 50-year time frames (2045 and 2070).

The final portion of this chapter summarizes the Kepner-Tregoe® (K-T) decision-making process that was used to facilitate discussion among the City staff, AE2S project personnel and the community (represented by members from the Brandon Water Development Committee and the City Council) regarding the non-economic characteristics of each alternative. The long-term alternatives were then ranked based on non-economic factors. Chapter 8 describes the anticipated costs of each alternative.

7.1 Nonviable Alternatives

Various source water alternatives for the City of Brandon are not considered viable at the present time. This section describes these alternatives.

7.1.1 *Purchase Water from the City of Sioux Falls*

The City of Brandon staff and the City of Sioux Falls staff, as well as staff from AE2S, met to discuss potential options of Sioux Falls providing water to Brandon. Sioux Falls communicated that they are not able to provide water to Brandon in the foreseeable future as all of their allocations are needed for future development within their customer service area. The City also cited the loss of 30% of its groundwater capacity due to contamination as a contributing factor for their inability to sell additional water to Brandon. Despite the inability to provide water to Brandon in the near term, Sioux Falls is interested in participating in discussion of water provision for the future water needs of the metro area.

7.1.2 *Purchase Water from Minnehaha Community Water Corporation – Long-Term*

The City of Brandon also met with representatives from Minnehaha Community Water Corporation (MCWC) to discuss the City's needs and the potential for MCWC to meet the City's growing water requirements. As a result of these meetings in early 2019, it was determined that MCWC would be able to provide Brandon with up to 0.25 MGD for five years after infrastructure modifications were completed to deliver treated water to the Brandon water treatment plant. MCWC made no guarantee they could provide water to the City after the five years. At this time, purchasing of water from MCWC past a five-year time period is not considered a viable long-term alternative, although the short-term offer to provide treated water is evaluated in Section 7.2. MCWC is also interested in continuing discussions of long-term provision of water in its service area.

7.1.3 *Purchase Water from Lewis and Clark Regional Water System*

There is currently no option to directly connect Brandon to Lewis and Clark Regional Water System (L&C) as all of the allocations L&C provide are reserved for their current members. L&C recently indicated that planning for a long-term phase of L&C has just begun and would invite Brandon to the discussions. Pending these discussions, L&C may become a potential long-term regional source provider to Brandon through one of its members, but as of the date this report was written, purchasing water from L&C is not a current viable alternative.

7.2 Short-Term Alternatives

Since the firm capacity of the City's primary wells is less than both the maximum day demand and the firm production capacity of the existing WTP, a number of short-term water source alternatives have been proposed in this section. With the exception of purchasing water from MCWC, which has a 5-year duration, all of the short-term alternatives can be phased into the long-term planning phases.

7.2.1 *Short-Term Alternative 1 - Purchase Water from MCWC*

MCWC can provide up to 0.25 MGD treated water to the City of Brandon for a period of five years. MCWC would likely use their old tower just north of Brandon at the intersection of 260th St and 481st Ave. to stage water for Brandon and pipe the water into Brandon through an existing

8-inch pipe along Sioux Boulevard. Given the five-year duration of MCWC supply, this alternative could be implemented to supply water while the City is developing and constructing longer-term water source and treatment capacity.

In order for the City to purchase water from MCWC, Brandon would invest in infrastructure to enable delivery from MCWC to Brandon's WTP, including:

- A meter building
- Approximately 1,000 ft of 8-inch pipe to facilitate MCWC water delivery north of the industrial park
- A control valve (shared cost between MCWC & Brandon)
- Piping from the 8-inch main under Sioux Blvd to the WTP
- Site piping and valve/controls at the WTP to allow the water to flow into the clearwell.

Figure 7.1 provides the potential location of the proposed pipe from the existing 8-inch MCWC line that runs north/south to the WTP.

Brandon's existing post filter chlorine feed would be increased to provide free chlorine to breakpoint chlorinate the chloramine residual present in the MCWC water. Brandon's distributed water would retain the free chlorine residual currently supplied to the community. The MCWC treated water would blend with the Brandon WTP treated water in the Brandon WTP clearwell. The blend would be in a constant proportion of approximately 10 volumes of Brandon treated water to 1 volume of MCWC water, creating a consistent distributed water quality. Brandon would utilize the full allocation of MCWC water (250,000 gallons per day), during peak water demands, and during other times, the MCWC usage would be approximately 10 percent of the Brandon water production.

MCWC indicated the likely delivered water quality would be similar to the Lewis and Clark Regional System water since the Lewis and Clark water is currently distributed in the Brandon area. The softer MCWC water (approximately 170 mg/L as $CaCO_3$) and the harder Brandon finished water (approximately 390 mg/L as $CaCO_3$) would blend to achieve a hardness of approximately 370 mg/L as CaCO3. Given the relatively high alkalinity of the Brandon water compared to the MCWC water, the pH would be similar to Brandon's current pH, and the water stability relative to calcium carbonate would be minimally affected.

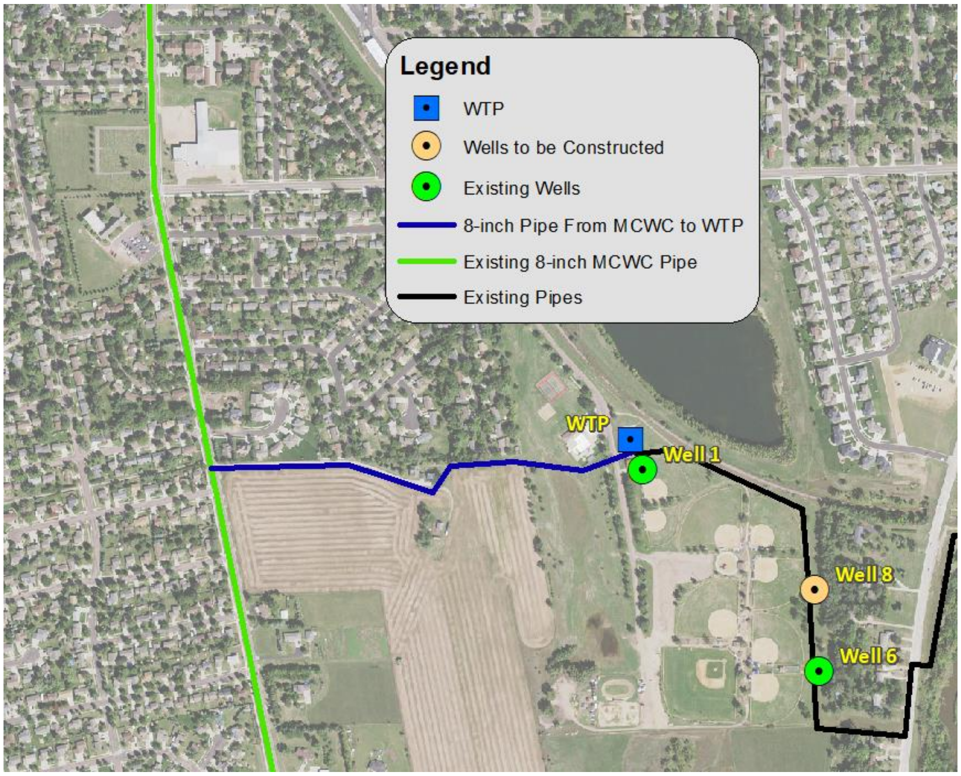


Figure 7.1 Location of the Proposed MCWC line from the Existing 8-inch MCWC to the Brandon WTP

7.2.2 Short-Term Alternative 2 - Pipe Well 3 to the Well 7 Header

An alternative source of additional supply to the WTP is piping Well 3 to the existing Well 7 header so that all of the water from Well 3 can be treated at the WTP. Well 3 draws water from the SRC Aquifer yet has low levels of radionuclides and has production rates of around 650 gpm, making it a favorable well to keep in operation. As with Well 6, Well 3 has high concentrations of iron and manganese, well above the secondary maximum contaminant level (SMCL) which would largely be removed at the WTP. Well 3 also has total hardness concentrations greater than 400 mg/L as $CaCO_3$. Figure 7.2 shows the proposed location of the pipe connecting Well 3 to the existing Well 7 header pipe.

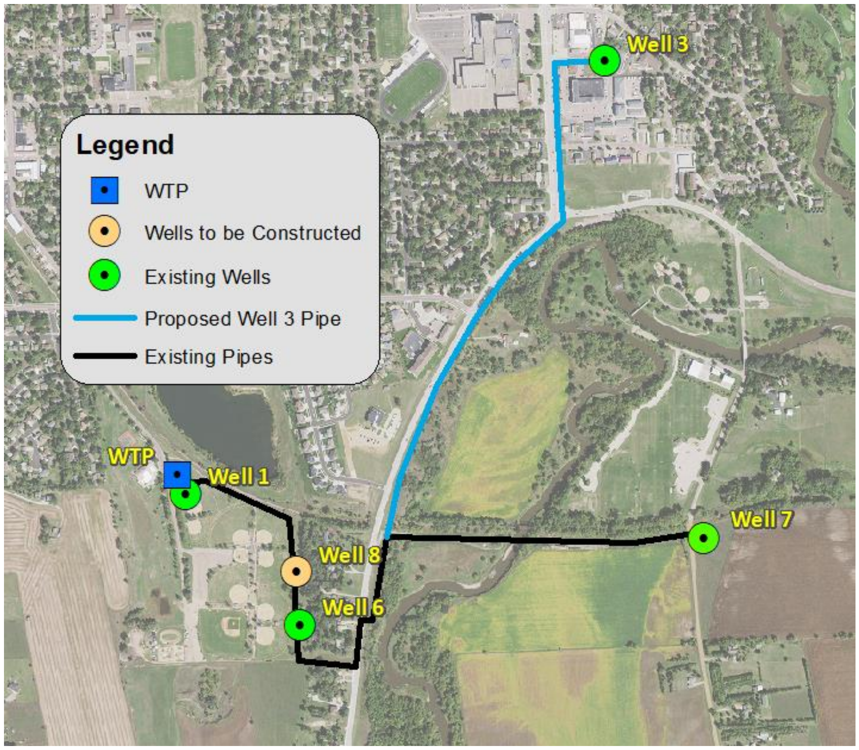


Figure 7.2 Location of the Proposed pipe Connecting Well 3 to the Well 7 Header Pipe

Currently, Well 3 is not often used due to its lack of treatment and to its elevated iron and manganese concentrations. It is typically only used during times of high demand, or to provide a redundant backup to wells 1 and 6. Piping Well 3 to the WTP would provide operators added flexibility in operating the City's wells by allowing a reliable source of water with low radionuclides concentrations and nitrate concentrations below detection limits to be better utilized.

Since Well 3 previously discharged into the distribution system at a higher head than would be required to pump to the WTP, a PRV or alternative pressure regulating valve would be recommended to be installed downstream from the pump to manage pump discharge flows and pressures. Additionally, the option to pump Well 3 directly into the distribution system could still exist. If this connection is considered a long-term installation, a reduced head pump is recommended to be installed in Well 3, and the PRV/headloss device could be removed to conserve energy.

7.2.3 Short-Term Alternative 3 - Provide Radium Removal at Well 7

Well 7 has already been constructed and draws water from the SRC aquifer. It is an operational well with an anticipated yield rate of around 1,200 gpm and can provide water to the Brandon WTP. However, Well 7 has not been utilized as a raw water well due to its elevated radionuclide concentrations relative to Well 6. Brandon has switched to an HMO/IMAR™ treatment process with the plan to enhance the treatment plant's radionuclide removal capacity and enable the use of Well 7. However, a pre-treatment technology that provides another barrier to radionuclides would enhance the usage of Well 7

The Water Remediation Technology (WRT) radium removal process utilizes a radionuclide-specific adsorptive media to radium and other radionuclides from the Well 7 water. WRT's Z-88® radium removal process has been effective at removing radium at other utilities. The process removes radium by allowing the water from the well to come in contact with the fluidized bed of a proprietary adsorptive media that is contained in a steel pressure vessel similar to a pressure filter. Treated water radionuclide concentrations are substantively below the MCL. When the media is spent (the adsorptive capacity is used up) WRT replaces it with fresh media and the spent media is disposed of in a licensed disposal facility.

WRT states system has many advantages, including:

- Reducing radium to levels less than the MCL (5 pCi/L)
- No backwash or regeneration cycle required
- Zero-liquid discharge eliminates waste stream disposal concerns
- Iron and Manganese pre-treatment are not required
- Minimal maintenance and operation consist of routine monitoring and sampling
- No handling of radioactive materials, media or chemicals by utility staff
- Disposal to a licensed facility
- Z-88® is NSF Standard 61 certified for use in drinking water
- A complete package of services can be provided on a long-term contract basis

Enabling the water to be treated directly at Well 7 allows a viable water source to be used as needed with low levels of radionuclides delivered to the plant. Additionally, removing the radium at the well decreases the amount of radium is accumulated in the filter backwash waste. Figure 7.3 provides a conceptual view of the WRT radium removal process equipment. Brandon would purchase the equipment from WRT and enter into a long-term agreement with WRT for media maintenance/disposal. The equipment would be housed in a heated structure to protect the pipes from freezing. For conceptual design, the WRT equipment building would be located at Well 7 – although an alternate location might be at the water treatment plant. The VFD on the well pump would be used, along with a control valve, to regulate the flow through the WRT equipment. The resulting flow would be controlled to enable the WTP to run at maximum hydraulic capacity.

7.2.4 *Short-Term Alternative 4 – Use Well 7 and Remove Radium Using Existing HMO/IMAR System*

Another option for providing water for Brandon is to utilize Well 7 and remove radionuclides to concentrations below the EPA MCL using the existing HMO/IMAR™ process. The HMO/IMAR™ process replaced the permanganate/greensand process and is currently in operation at the water treatment plant.

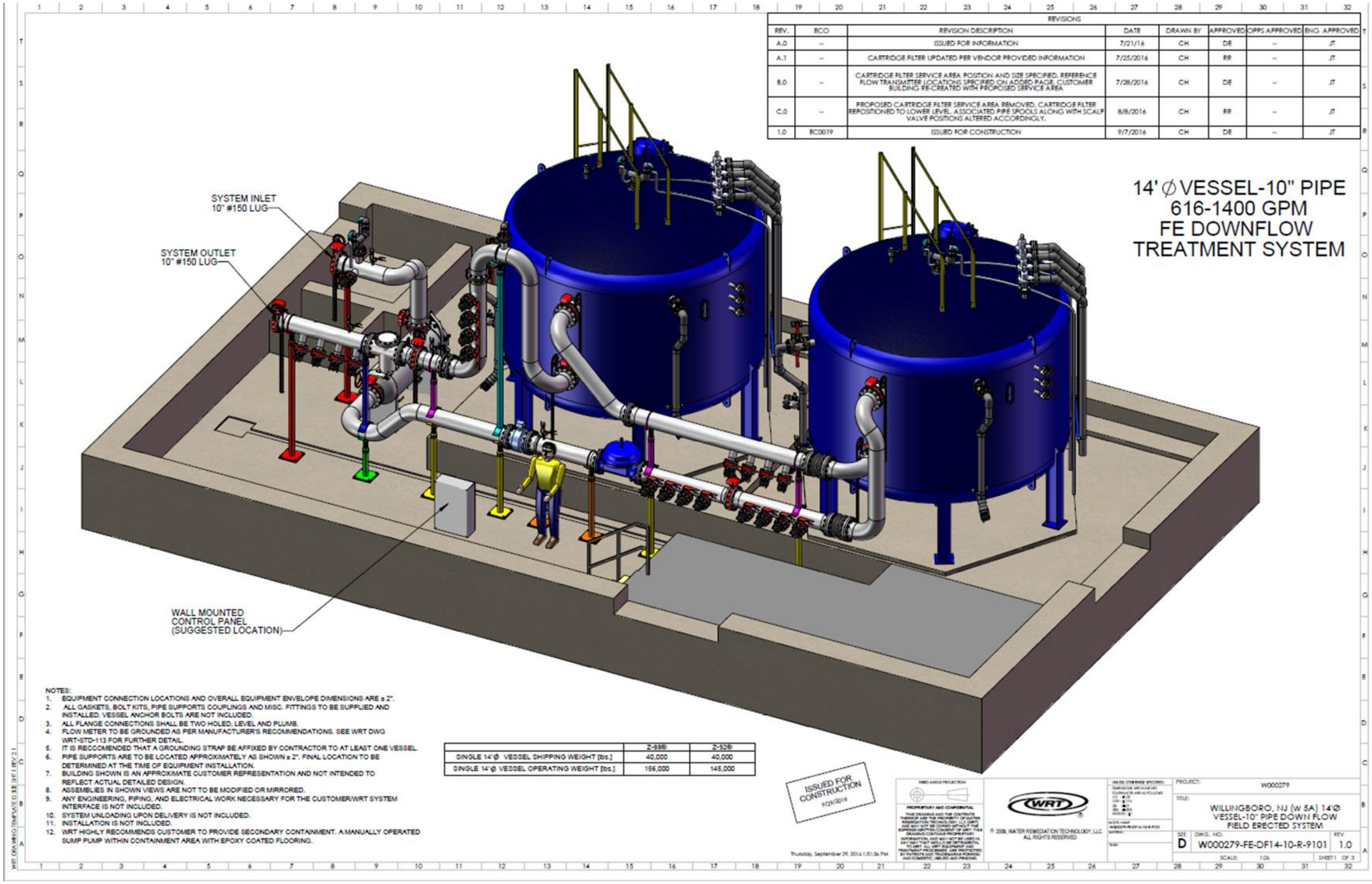


Figure 7.3 Conceptual View of the WRT Radium Removal Process Equipment

Before the HMO/IMAR™ process was installed, a pilot study was conducted on water from Well 7 comparing the removal efficiencies of the greensand filters versus the HMO/IMAR™ system. Under the water conditions and operating procedures employed during the pilot study, the results indicated that the HMO/IMAR™ process was potentially more effective at removing radium and other radionuclides than the greensand filtration process. It is worth noting that when the pilot test was run, the radium concentrations in the raw water were about half what was measured from Well 7 under previous pumping tests. The results from the pilot showed that the concentration of radionuclides from Well 7 was still removed to concentrations below the MCL. However, at this time it has not been proven that the IMAR™ filter and HMO combination would be successful in decreasing the higher concentrations of radionuclides from Well 7 that were recorded during the April 15th, 2015 pump test to levels below the MCL. Further testing would be required to validate this alternative. This alternative would not involve the construction of any additional infrastructure, only careful testing of radionuclides in the raw and filtered effluent to determine the removal efficiencies. It is assumed the dosage rate of the HMO would at least match the 1.5 mg/L concentration as tested in the pilot study, and the HMO/IMAR™ process also requires a free chlorine residual at the filter influent.

For the short-term alternative, it is assumed the flow rate from Well 7 is regulated to supplement the flows from Wells 1 and 6 to achieve the design flow of the WTP. Under this condition, the Well 7 radionuclide concentrations would be diluted by the other wells to achieve a raw water radionuclide that is lower than the Well 7 radionuclide concentration, further increasing the probability of successful treatment.

7.2.5 *Construct and Pipe Well 9 to the Head of the WTP*

Another short-term alternative that can be a part of the long-term water supply plan is to complete the construction of Well 9 and its transmission pipe to the WTP. Well 9 is in the early stages of a phased approach to construction. Well 9 would draw water from the Big Sioux Aquifer and is anticipated to produce similar yield rates to Well 1 of around 150 gpm. Figure 7.4 provides the location of Well 9 and its pipe connection to the WTP.

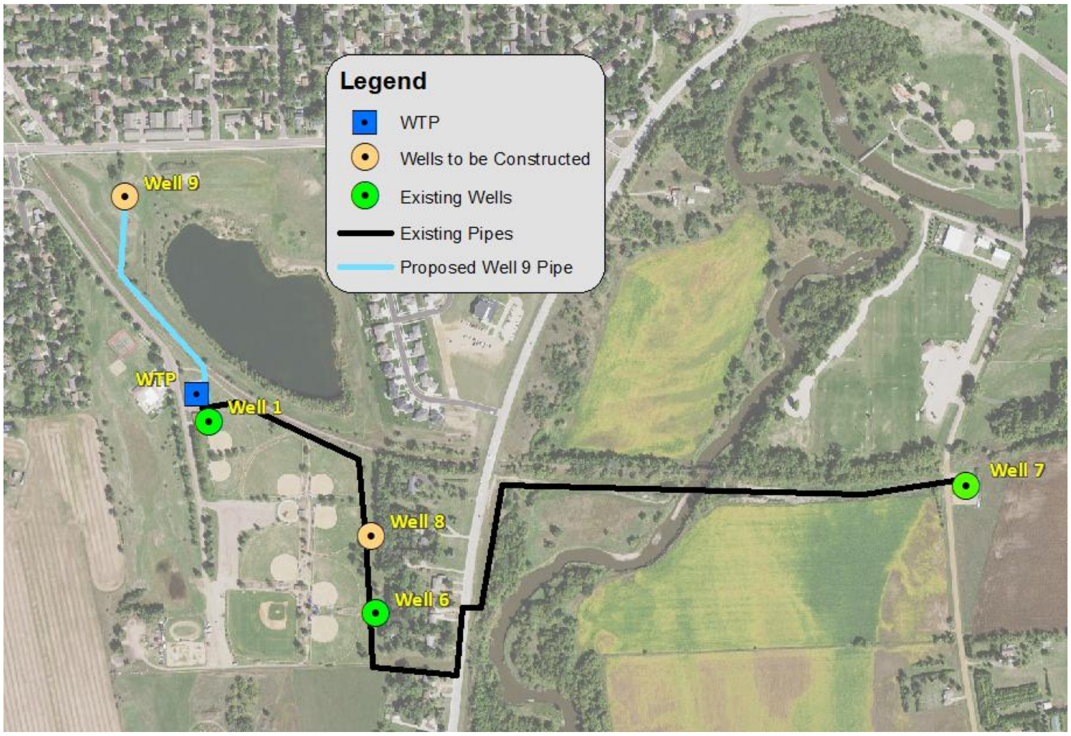


Figure 7.4 Location of the Proposed pipe Connecting Well 9 to the Head of the WTP

7.3 Long-Term Alternatives Assumptions

In order to describe and evaluate the costs (Chapter 8) of the long-term alternatives, a few assumptions were made regarding system phasing, construction, and operations through 2070. The following is a list of the assumptions:

- Existing WTP will be capable of running at the design 2,000 gpm (2.88 MGD) capacity.
- The existing plant can be expanded in phases to meet the demands of the system – the initial expansion would be as soon as design and construction can be completed, meeting the 2045 firm capacity of 3.8 MGD, and the second phase would produce the 2070 firm capacity of 5.0 MGD. The designed and constructed capacity of each phase may be adjusted to achieve cost efficiency.
- Firm capacity is defined as having one filter out of service while not exceeding 3 gpm/ft^2 in any one filter.
- Firm capacity from wells is defined as having an SRC well with a 1,200 gpm flow rate out of service – using the approach outlined in Chapter 6.
- The production rate for new Big Sioux wells was assumed to be 150 gpm per well
- The production rate for new SRC wells was assumed to be 1,200 gpm per well.
- Water quality from the wells assumed to remain constant over time.

- Well 3 will be piped directly into the Well 7 header and flow directly to the WTP for treatment (see Section 7.2.2)
- Well 8 will be redundant to Well 6 and vice versa. Well 6 and Well 8 will not run simultaneously, but Well 6 or Well 8 is always assumed available for production.
- Well 9 will be constructed with an average maximum production rate of 150 gpm.
- Well 7 will be operational, and radium will either be removed directly at the well using the WRT process or at the WTP to levels below the MCL.
- RO Concentrate water can be discharged to the Big Sioux River.
- Demand is assumed to increase linearly to 5.2 MGD by 2070.

7.4 Long-Term Alternatives Treatment Technologies

The current WTP design capacity is 2,000 gpm (2.88 MGD), and the City's current maximum day demands are approaching 2.5 MGD. With the continued growth of the City and the correlated growth in water demand, the design capacity of the existing plant is anticipated to be reached by 2026 if the water demand increases linearly with time. Figure 7.5 provides a graph with the future anticipated maximum day demand curve (blue line) compared to the existing well production capacity (red line) and design (black line) capacity of the existing WTP. The blue line also represents the raw water and WTP production needs to meet the future maximum day demands without RO treatment, while the green line represents the anticipated future maximum day raw water and pre-RO water treatment needs.

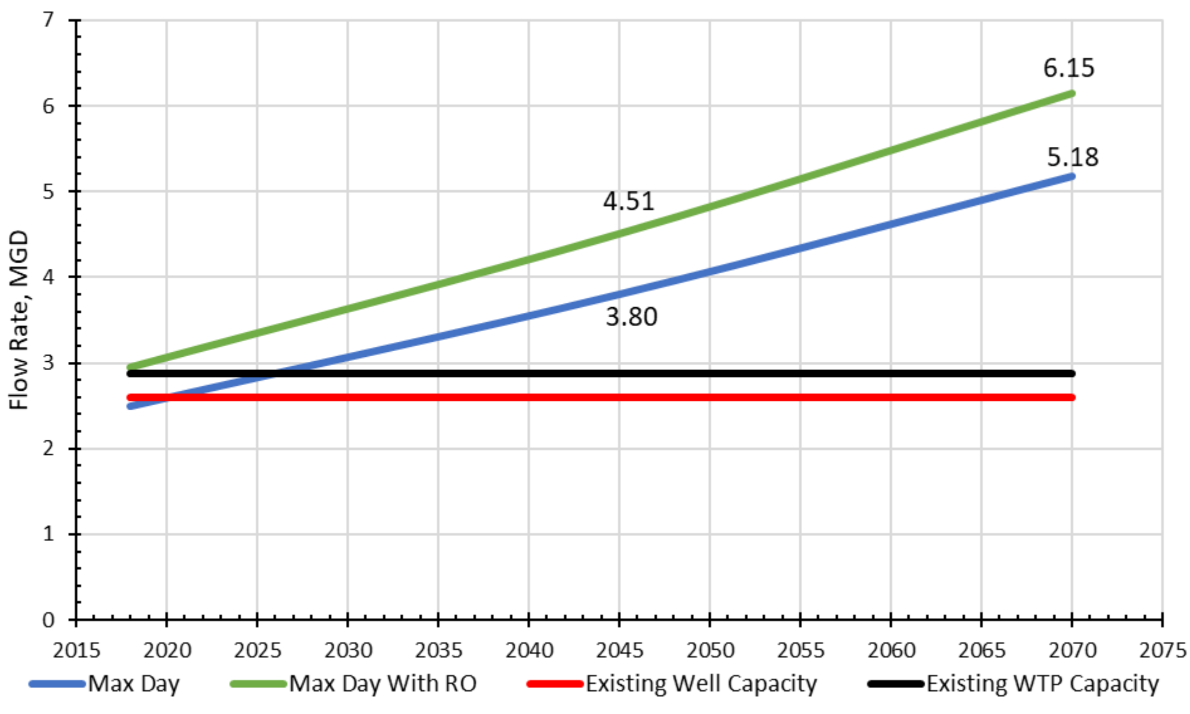


Figure 7.5 Future demands with current WTP capacity

7.4.1 *Existing Treatment Technology*

All of the long-term alternatives will use the HMO/IMAR™ process to decrease iron, manganese, and radium concentrations. The HMO is injected into the water before the filters, and in combination with a free chlorine residual, the iron and manganese are oxidized to their less soluble forms. The HMO adsorbs any un-oxidized manganese, and the resulting oxidized particulate matter and HMO particles are removed by the IMAR™ media in the filters. Radium is then removed from the water when the HMO particles with the adsorbed radium are trapped by the filter media. Previous pilot testing indicated the combination HMO/IMAR™ system might remove radium up to a 90 percent removal efficiency. Given the recent (early 2019) installation of the IMAR™ media in Brandon's filters, optimization of the HMO/IMAR™ process is ongoing, and is assumed to achieve full-scale iron, manganese and radium removal efficiencies that were demonstrated in the pilot study.

7.4.2 *Radium Removal at Well 7*

This treatment technology was previously described in detail as a short-term alternative (See section 7.2.3) and included installing equipment at Well 7 containing proprietary media that specifically adsorbs radium, enabling the treated water Radium concentrations below the MCL. The treated water would be piped to the WTP for further treatment in the existing treatment process for iron and manganese removal. Once the media is spent, the vendor (Water Remediation Technologies) replaces the media and disposes the spent media to a licensed disposal facility.

7.4.3 *Water Softening – RO*

RO is a potential option for the City of Brandon to soften their finished water. The RO system would also be very effective at decreasing radium concentrations as well. The added benefit to RO over other softening techniques is that RO can remove up to 99% of total dissolved solids (TDS) whereas ion exchange removes no TDS and lime softening only removes TDS associated with the alkalinity and hardness that remove in the softening process. The RO plant does require additional raw water as the dissolved solids to be removed are concentrated in a liquid stream that must be discharged. Typical RO systems reject up to 25% of the influent water they receive. This waste stream from the RO process often has high concentrations of TDS, hardness and other dissolved ions. For the alternatives using RO, the RO concentrate can likely be discharged to the Big Sioux River.

7.4.4 *Water Softening – Lime Softening*

Lime softening is another potential softening option which involves the addition of lime and a detention period to allow non-soluble calcium carbonate that forms during this process time to precipitate. The solid precipitates are then dried in large ponds or dewatered using filter presses. The team determined that lime softening would not be the best fit for Brandon for a number of reasons including (1) Brandon has limited space for drying beds near their current WTP, (2) the higher costs to construct and the additional size requirements for the contact basins make lime softening less feasible, and (3) Brandon has access to a receiving stream to discharge the RO concentrate, a feature many other communities do not have.

7.4.5 *Water Softening – Ion Exchange*

Another alternative to remove hardness and decrease radium concentrations is to use ion exchange. The ion exchange process functions as the name implies, divalent cations (calcium, magnesium, and radium) are exchanged with monovalent cations, typically sodium. As the water enters the ion exchange resin, the calcium, magnesium, and radium ions, are attracted to the ion exchange resin and displace the sodium ions. The sodium ions then leave the ion exchange unit and are blended with filtered water. Once the ion exchange resin has become saturated with calcium, magnesium, and radium ions, the unit must be regenerated. This process involves backwashing the resin and treating the resin with a brine (sodium chloride) solution to allow the sodium ions to reattach to the resin to be later exchanged with calcium, magnesium, or radium. The brine solution used to regenerate the resin also contains all of the cations removed from the resin as well. The brine solution may be disposed to the sewer or receiving steam, however regulations or restrictions may exist on this discharge.

The construction costs between ion exchange and RO are similar. Ion exchange units work well for smaller communities, but on larger growing municipal systems, the amount of salt consumed can be problematic from an environmental and regulatory standpoint. The ion exchange system also does not remove TDS and but rather simply exchanges an equivalent amount of sodium for the hardness that was removed. The treated water contains relatively high sodium concentrations that might affect drinkability, especially for the person on a low-sodium diet. Even though the energy costs would be higher using RO, the team determined that ion exchange was also not a good fit for the City of Brandon to decrease hardness and radium concentrations.

7.5 Long-Term Alternative Water Sources

Since purchasing the water from regional sources is not a viable long-term alternative at this point, additional water will need to be procured from one or more of the three primary sources of water close to Brandon, the Big Sioux River, the Big Sioux Aquifer, and or the SRC Aquifer.

7.5.1 *Water from the Big Sioux River*

A potential option for the City of Brandon is to treat water from the Big Sioux River and utilize it as a sole source or blend it with existing groundwater sources to meet current and future demands. However, treating surface water, particularly one that is susceptible to taste and odor events, turbidity excursions, upstream wastewater discharges and is subject to surface water treatment rules, is typically more costly than treating groundwater since surface water has more stringent treatment requirements and has variable water quality. Additionally, the closest point where the City would likely draw river water from is directly downstream from the Sioux Falls Water Reclamation Plant (WRP) and is also downstream of the Smithfield wastewater treatment plant discharge. During low flow conditions, the nitrate concentrations in these discharges will cause elevated nitrate levels in the Big Sioux River, escalating the costs of treatment.

An alternative to a direct intake from the river is to install a collector well or infiltration gallery in an appropriate geological setting near the river to obtain relatively high flow rates and utilize the river bank soil formation as a filter. However, one must assume the water is influenced by surface water, and treatment process design must consider the groundwater to be under the influence of surface water, requiring elements of surface water treatment design. While the raw water is likely to have low turbidity, it will still be relatively hard, likely contain iron and manganese, ammonia and nitrate, as well as being influenced by upstream wastewater discharges.

Either of these intake alternatives may result in reclassifying the Big Sioux River as a domestic water supply, potentially resulting in significant impacts on potential wastewater discharge regulations upstream of the intake.

Given these considerations, the Big Sioux River was not further pursued as a viable water source.

7.5.2 *Develop Additional Wells in the Big Sioux & SRC Aquifers*

Another option for growing the City's raw water inventory is to develop additional wells in the Big Sioux Aquifer. As discussed in previous chapters, the Big Sioux aquifer is a shallower aquifer than the SRC aquifer. The Big Sioux Aquifer is not known to contain detectable levels of radium, but it does contain nitrate concentrations around 7 mg/L, as tested from Well 1.

Figure 7.6 provides a map of the hypothetical locations of the four new big Sioux wells as approximated by the WSP groundwater study. These locations are preliminary and serve to mark the general area favorable to the development of additional Big Sioux Wells and provide a basis for well and raw water piping cost estimates. Further study would be required to determine the best possible final location for the wells. The construction of well infrastructure piping could be completed at the same time road construction projects are completed, which would save cost over what has been estimated in this study. Well 9 has been planned to be constructed and is also located in the Big Sioux Aquifer.

Figure 7.6 Hypothetical Locations of additional Big Sioux Wells

Figure 7.7 and Figure 7.8 propose a phasing schedule for the addition of new wells with and without RO respectively at the proposed future WTP for the alternatives that further develop the Big Sioux Aquifer supplemented by water from the SRC Aquifer. The black trend lines on each Figure 7.7 and Figure 7.8 represent the maximum day, firm raw water flow requirement of the WTP with and without RO, while the bars represent the combined capacity of the wellfield from the various existing and proposed wells. The firm well capacity is evaluated with the largest well out of service. New wells are brought online when 80 percent of the firm capacity of the wells approaches the maximum day raw water demand. Although an approach to well phasing is suggested, the phasing of the wells must be revisited periodically in response to the realized water demand of Brandon.

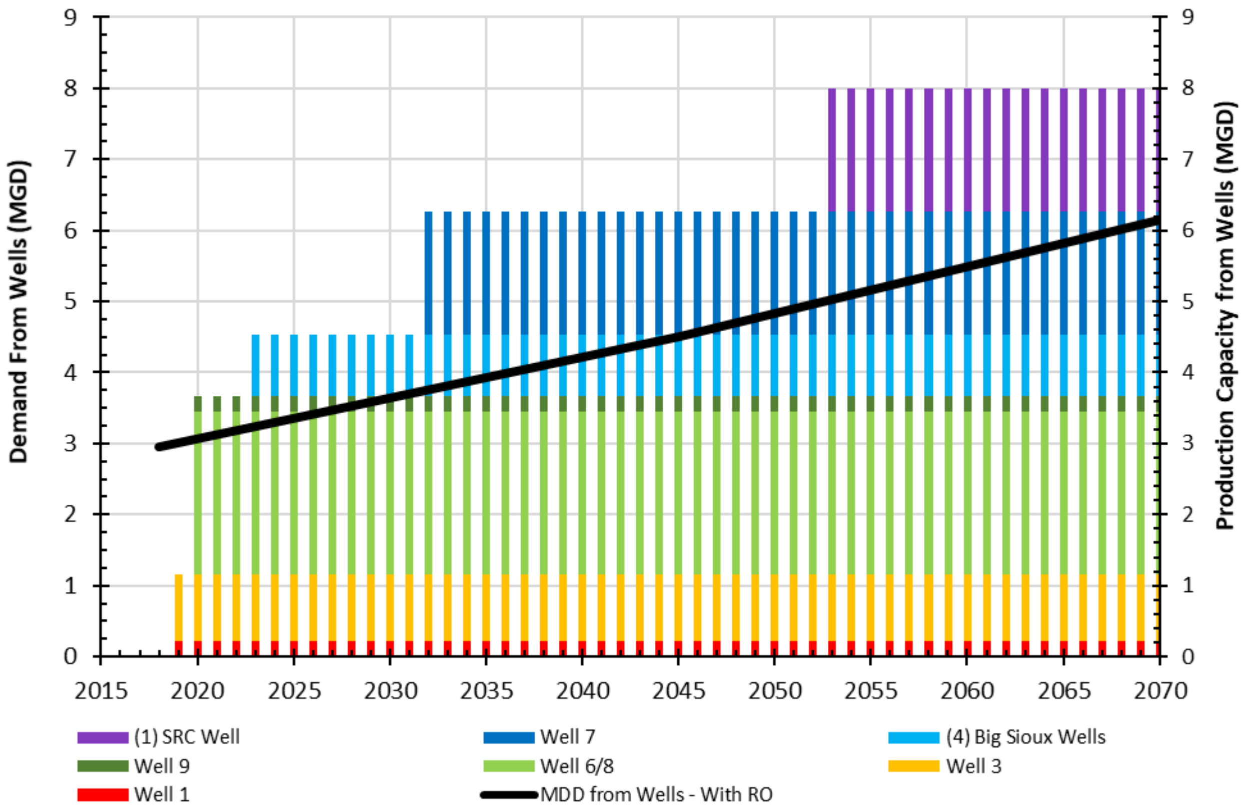


Figure 7.7 Proposed Well Phasing for Developing the Big Sioux Aquifer *with* WTP RO

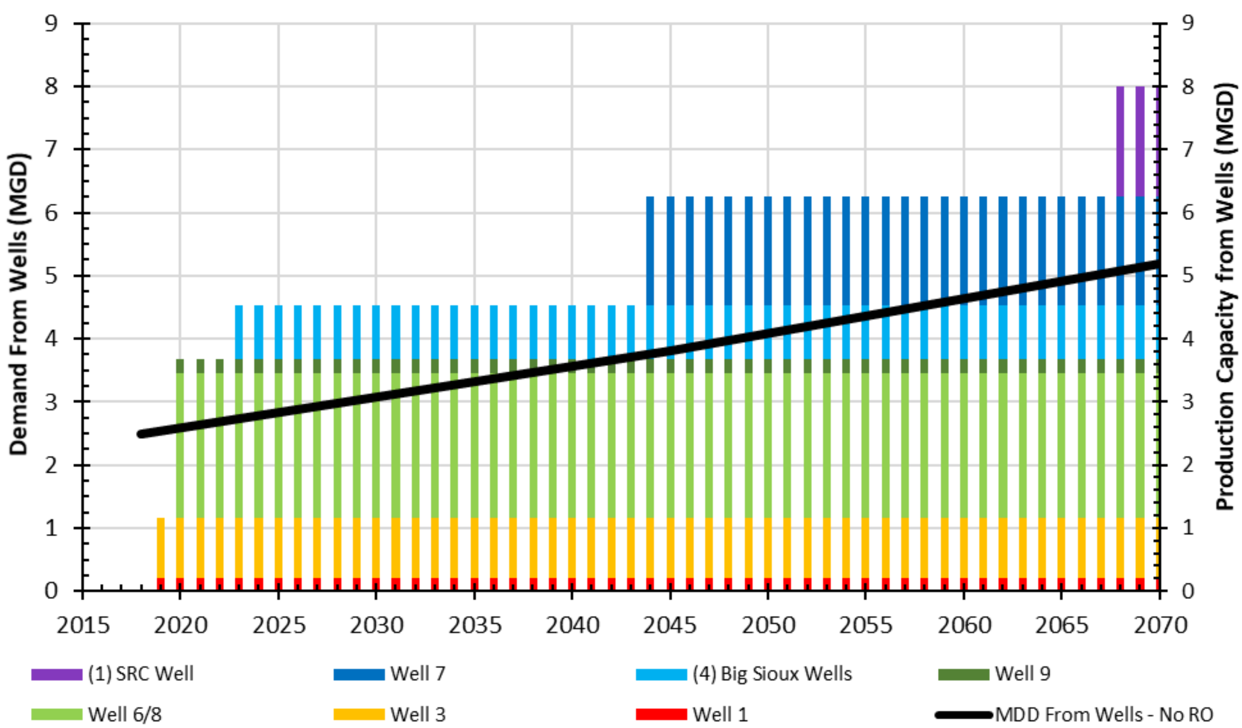


Figure 7.8 Proposed Well Phasing for Developing the Big Sioux Aquifer *without* WTP RO

7.5.3 *Develop Additional Wells in the SRC Reservoir*

The groundwater report completed by WSP in 2018 highlighted two additional potential locations for new wells to be developed in the SPC Aquifer. Figure 7.9 provides the hypothetical locations WSP estimated to produce the most water from the aquifer. As with the recommendation of the Big Sioux Aquifer wells, an additional study would also be needed to determine the best locations in the SRC aquifer for additional wells.

The City currently has three wells in the SRC aquifer, Wells 3, 6 and 7. Well 3 can produce up to 650 gpm, while Well 6 can produce up to 1,600 gpm and Well 7 is estimated to produce up to 1,200 gpm. According to the WSP, the combination of the three existing wells (Well 3, 6 and 7) and two additional wells are likely to produce between 940 to 5,600 gpm. For the purpose of this study, additional wells in the SRC aquifer were assumed to be able to produce an additional 1,200 gpm each.

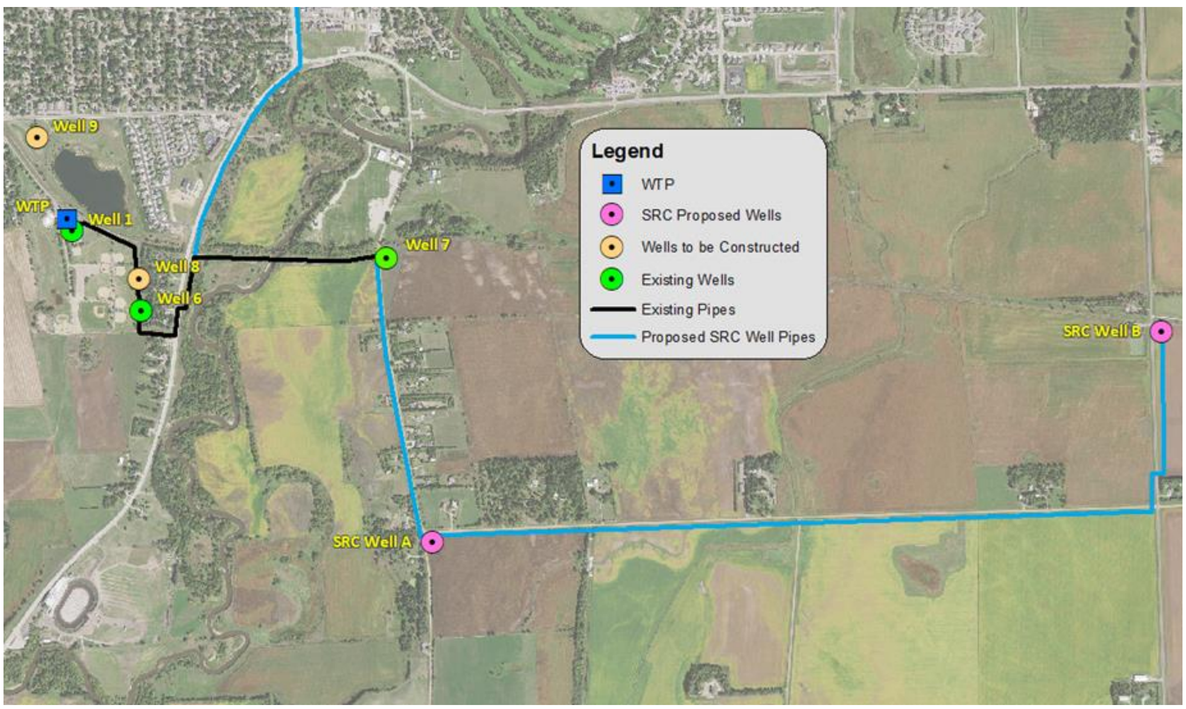


Figure 7.9 Hypothetical Locations of additional SRC Wells

Figure 7.10 and Figure 7.11 propose a phasing schedule for the addition of new wells with and without RO respectively at the proposed future WTP for the alternatives that further develop the SRC aquifer. The black lines represent the raw water needs of the WTP with and without RO, while the bars represent the combined capacity of the well field from the various wells in the system. New wells are brought online when 80 percent of the firm capacity of the wells approaches the maximum day raw water demand from the wells. Well 7 is initially not included since it is currently offline but may be brought online at a later date after optimization of the existing treatment process or with the construction of the expanded water treatment facilities. These proposed phasing schedules illustrate the phasing concept – the exact dates for additional wells would be fine-tuned as the implementation of the source water improvements moves forward.

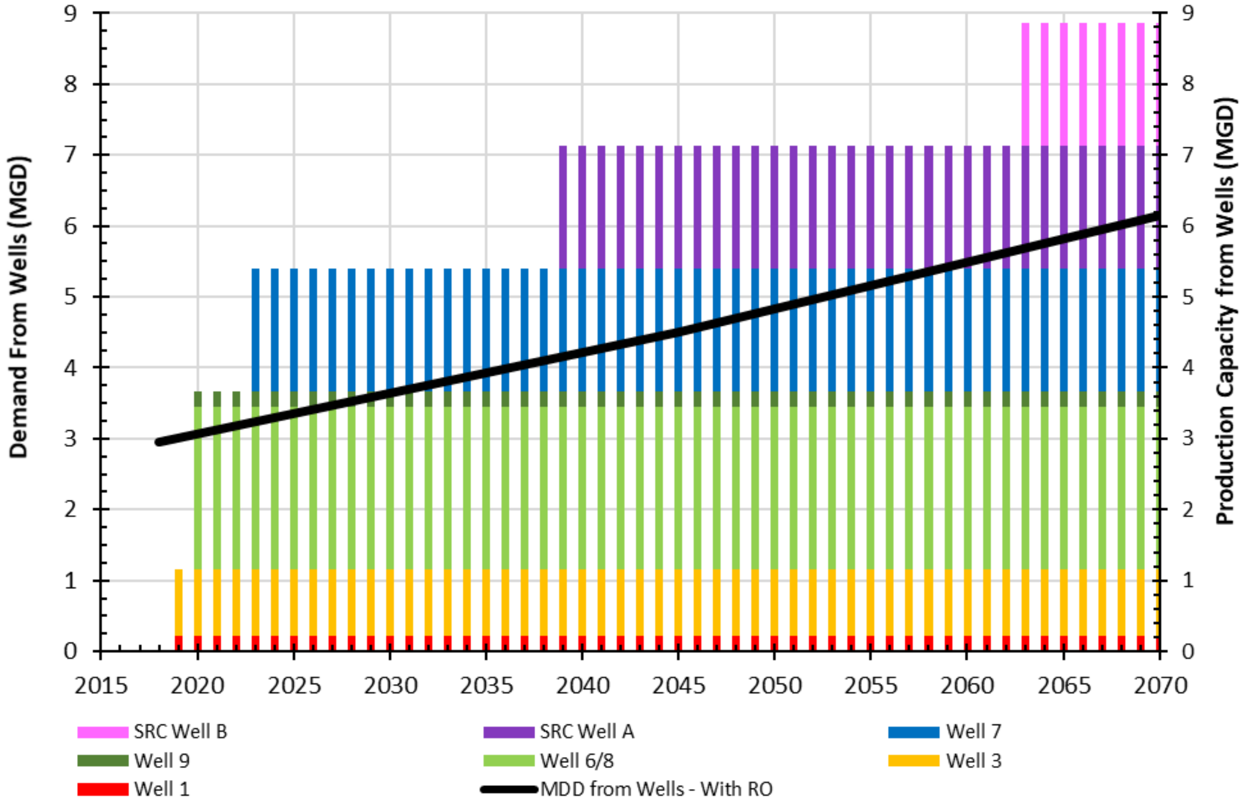


Figure 7.10 Proposed Well Phasing for Developing the SRC Aquifer *with* WTP RO

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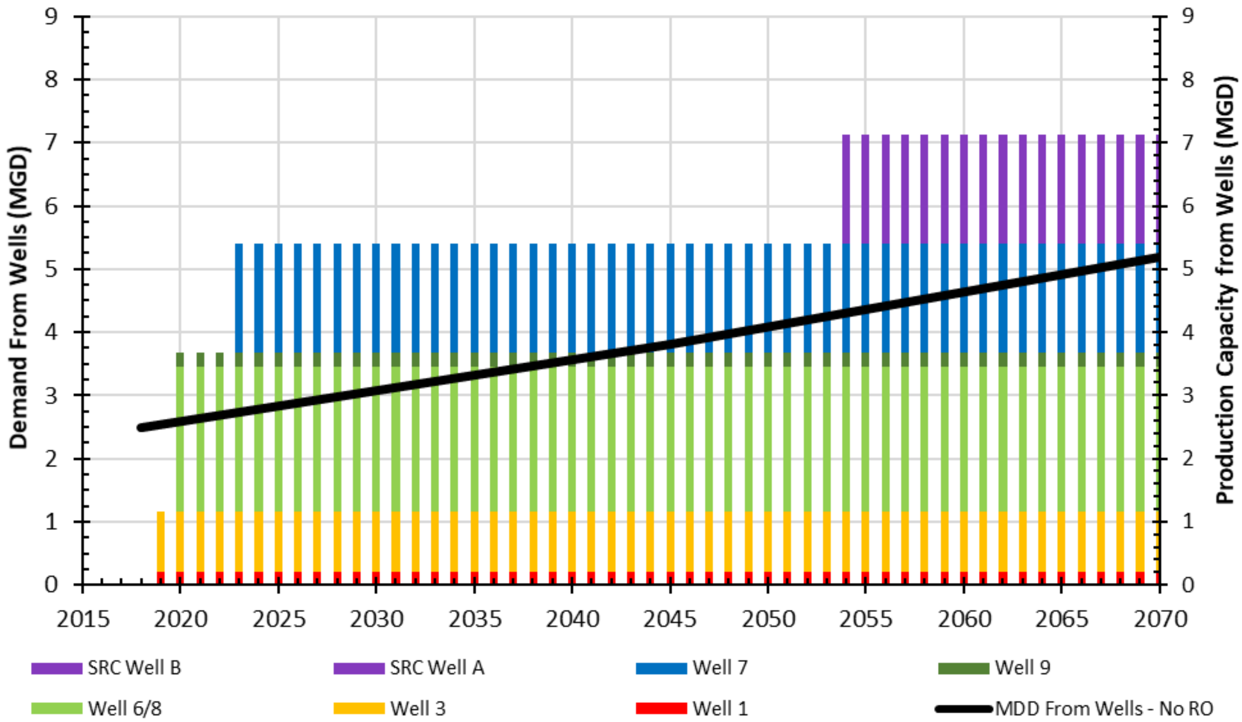


Figure 7.11 Proposed Well Phasing for Developing the SRC Aquifer *without* WTP RO

7.6 Residuals Management

The current WTP treatment process generates residuals from the filter backwash process. During the filter backwash, finished water from the clearwell is pumped in reverse through the filters at various staged flow rates to accomplish the objectives of the backwash process. All of this water is collected in the filter backwash troughs and flows into the backwash reclaim tank. After a backwash, the water in the filter backwash reclaim tank settles for approximately 30 minutes. After 30 minutes, water begins to be decanted from the filter backwash tank and is pumped to the head of the treatment plant (as long as the plant is running) at a flow rate no greater than 10-percent of the influent flow of the plant. Once the water level in the backwash reclaim tank has been drawn down to about 2.5 ft above the tank floor, the remaining water is discharged to the sewer, which ultimately travels to the Sioux Falls WRP.

AE2S, the City of Brandon staff and City of Sioux Falls staff met to discuss the future treatment processes at the new Brandon WTP. Sioux Falls views the Brandon Water Treatment plant as an industrial discharger, which is subject to the Sioux Falls Industrial Pretreatment Program. Correspondence from the Sioux Falls Industrial Pretreatment Program encouraged Brandon to consider backwash sludge disposal alternatives that do not discharge to the sanitary sewer system. The pretreatment ordinance prohibits the discharges of sludges, screenings or other residues from pretreatment of industrial wastes, and the discharges from the filter backwash disposal process may exceed future local limits for heavy metals.

7.6.1 *Filter Backwash Residuals*

As the City continues to grow, additional treatment capacity will be needed to meet future demands. With the addition of a new WTP, an opportunity exists to add or change some of the existing treatment. To address concerns with disposing solids to the Sioux Falls WRP, a solids processing step, including dewatering with a filter press, has been proposed for the expanded WTP. The filter press would remove the majority of the water that would normally be discharged to the sewer from the filter backwash recovery system. The filter press would also allow Brandon to conserve more of the backwash water, which would increase their water use efficiency. After the majority of the water is removed from the solids, a cake-like material remains. According to correspondence with the Sioux Falls Regional Landfill, as long as the dewatered cake passes the paint filter test, this material would be disposed of at the Sioux Falls Landfill, at a cost ranging from $18-39 per ton.

The costs associated with this sludge disposal technique were included in all treatment options considered for Brandon's long term water source alternatives. As the project moves forward to the design of any chosen alternative, Brandon should continue communications with Sioux Falls to verify the applicability of this proposed approach, or any alternative approach that might safely dispose of the filter backwash wastewater residuals.

7.6.2 *Reverse Osmosis (RO) Residuals*

Another potential treatment option considered in this study is RO. RO would be used primarily to soften the water. Only a portion of the flow after the filters would be diverted through the RO system, the rest of the water would bypass the RO system and would be blended with the processed water leaving the RO membrane. Some portion of the water that enters the RO membranes must be rejected. This rejected water has elevated total dissolved solids (TDS) that were concentrated during the RO process. A balance between energy costs and lost water is desired, which, along with considerations for receiving stream discharge requirements, typically results in disposal of approximately 25 percent of the water that enters the RO system.

This rejected water, also known as RO concentrate, has three options for discharge, (1) A zero liquid discharge process where the residual water is concentrated and potentially evaporated to dryness, (2) discharge the concentrate to the sanitary sewer, or (3) discharge the concentrate to a receiving stream, which in Brandon's case, is likely the Big Sioux River.

1. A zero liquid discharge is advantageous since it does not discharge any liquid stream, and more water is conserved. However, even with the water savings, it is a highly energy-intensive process and would not be cost-effective as there are other much cheaper disposal options available.
2. Discharging the RO concentrate to the sanitary sewer is another option. The RO concentrate would only contain elevated dissolved solids, and not suspended solids that are found in current filter backwash water wasted to the sewer. However, the volume would be much greater than the WTP is currently discharging to the City, so additional infrastructure would be required to accommodate the higher flows and the costs of discharge disposal to Sioux Falls would be encountered.

3. Finally, the RO concentrate could be discharged to the Big Sioux River, requiring a discharge permit. Given the beneficial uses of the Big Sioux River, and relative flows of the River and discharge, discharge is feasible considering the expected dissolved solids characteristics of the RO concentrate. Communications between the AE2S staff and the South Dakota Department of Environment and Natural Resources (SD-DENR) revealed that the state requires the radium concentration in the discharged RO concentrate meet a 5 piC/L limit. The SD-DENR interprets the 5 piC/L concentration to be met at the end of the pipe discharging into the river and does not provide credit for mixing or dilution from the river.

Given some of the unknowns in the treatment process efficiency and final treatment technologies used upstream, the RO concentrate may or may not exceed the 5 piC/L set by the SD-DENR. If the City of Brandon decides to use RO and discharge the RO concentrate to the Big Sioux River, the City has a few options to address the potential that it may exceed the 5 piC/L regulatory limit on the end on the pipe discharge. The City could:

- Ask for a change or review of the basis of the regulation,
- Ask for an alternate interpretation of the rule by the SD-DENR
- Request a deviation/waiver to enable discharge

The radium concentration of the discharge will depend on the raw water radium concentration, the radium removal achieved by WRT process and/or the HMO/IMAR™ process, and ultimately the concentration of the radium in the RO concentrate. If Brandon chooses to proceed with RO treatment, RO pilot studies should be conducted to determine the feasibility of RO discharge.

7.7 Alternatives Summary

The alternatives were broken into two alternative groups. The difference between the alternative groups is the development of the Big Sioux Aquifer and the SRC Aquifer (alternative group 1) versus the development of only the SRC Aquifer (alternative group 2). Each of the two alternative groups has four subgroups (A, B, C, and D) that differ based on water treatment technologies for the proposed WTP and additional radium removal treatment at Well 7.

7.7.1 *Alternative 1A – Develop Big Sioux and SRC Aquifers / Existing Treatment Approach*

Alternative 1A involves the development of the Big Sioux and SRC Aquifers with an expanded WTP utilizing the same treatment technology currently used (iron and manganese removal through the use of HMO and IMAR™). The wells may be staged as illustrated in Figure 7.8, where new wells are added when the raw water maximum day demand reaches 80 percent of the firm capacity of the wells.

Water treatment under this alternative would expand the current treatment plant using the existing treatment process. Figure 7.12 provides a conceptual process flow diagram for Alternative 1A. Water would be blended from all well sources. The blended water would enter the aerators, followed by the addition of chlorine. From there, the water would flow into a 30-

minute detention tank to allow oxidation of iron as well as begin the manganese oxidation process. The water then leaves the detention tank and is dosed with HMO, and travels to the gravity filters utilizing Tonka's IMAR™ filter media. The water then leaves the filters from both plants and travels to the existing clearwell. From there, the water is pumped into the distribution system after an iron and manganese sequestering chemical and a corrosion control chemical are added.

The filtration process requires the backwash process to keep the filter material clean. The filter backwash residuals management approach is the same for all alternatives (with or without RO) and were described in detail in Section 7.6. A summary of the chemicals used, and their dosages for Alternatives 1A, which are also the same for Alternatives 1B, 2A, and 2B, are summarized in Table 7.1.

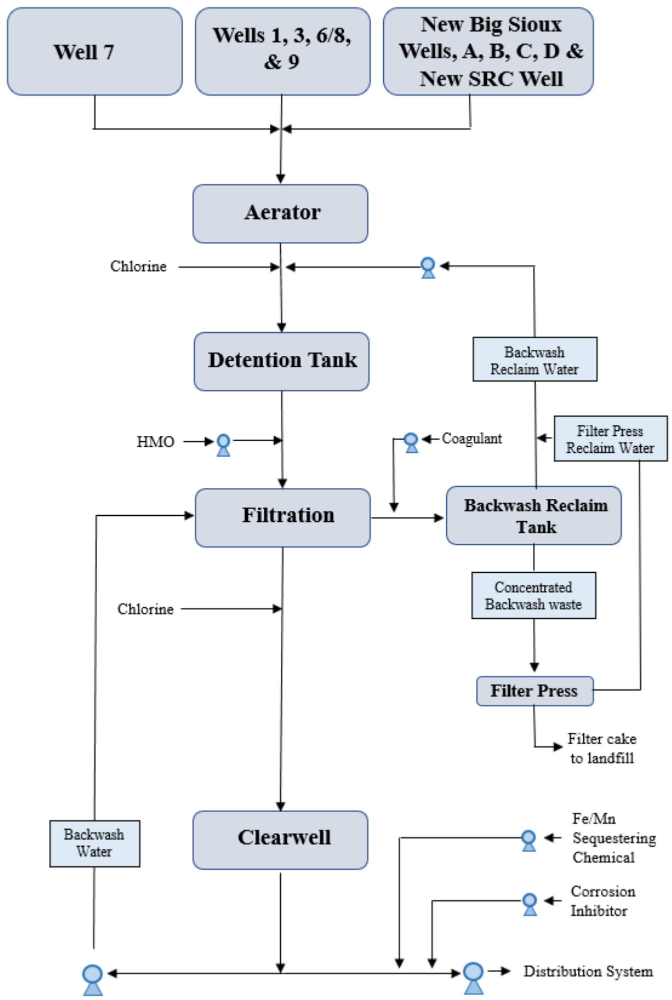


Figure 7.12 Alternative 1A Conceptual Process Flow Diagram

Table 7.1 Alternatives 1A, 1B, 2A, & 2B Treatment Chemicals and Dosages

Chemical	Purpose	Estimated Dosage (mg/L)
Chlorine	Break-point Chlorination & Disinfection	6.5 - 6.6
HMO	Corrosion control	0.6 - 1.5
Aqua Hawk 957	Backwash Coagulant	0.002 gal/MG
Calgon C5 (or equivalent)	Fe/Mn Sequestration	1.9
Calgon C9 (or equivalent)	Corrosion Inhibitor	4.4

7.7.2 Alternative 1B - Develop Big Sioux and SRC Aquifers / Existing Treatment Approach with WRT at Well 7

Alternative 1B is identical to Alternative 1A with the exception of the addition of the WRT onsite radium removal treatment system at Well 7. This treatment technology was further described in Section 7.2.3. Figure 7.13 provides a conceptual process flow diagram for Alternative 1B. Residuals management for this alternative is discussed in Section 7.6 and would consist of the disposal of filtration backwash solids. The WRT radium removal media would be removed and disposed of by WRT when the media has reached its useful life. WRT would then be responsible for replenishing the contact vessels with new media.

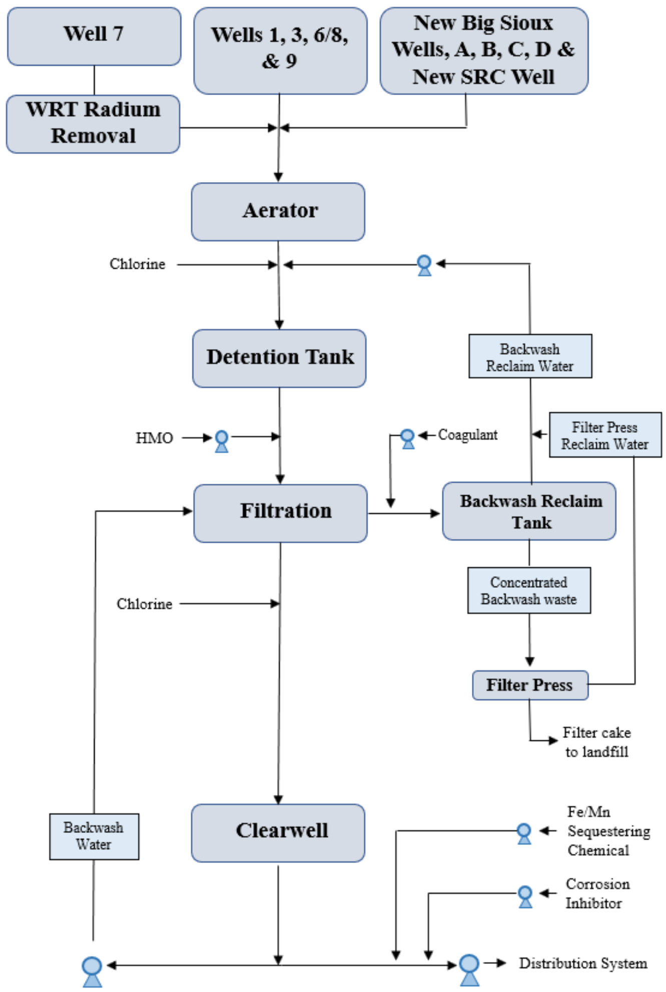


Figure 7.13 Alternative 1B Conceptual Process Flow Diagram

7.7.3 Develop Big Sioux and SRC Aquifers / Existing Treatment Approach with RO

Alternative 1C involves the development of the Big Sioux and SRC Aquifers with an expanded WTP utilizing the same treatment technology currently used (iron and manganese removal through the use of HMO and IMAR™) with the addition of RO for water softening. The wells may be staged similar to those illustrated in Figure 7.7, where new wells are added when the raw water MDD reaches 80 percent of the firm capacity of the wells.

Treatment in Alternative 1C combines the existing treatment with the addition of RO for water softening. Figure 7.14 provides a conceptual process flow diagram for Alternative 1C, which is similar to Alternative 1A, except with the addition of the RO system. After treatment using the HMO/IMAR™ process, a portion of the filter effluent water is diverted to the RO system, while the other portion bypasses the RO system. The RO system removes 98-99% of the dissolved solids and produces a water similar in quality to distilled water. This water processed by RO is then blended with the remaining water filtered water that bypassed the RO system to produce the desired hardness in the finished water leaving the plant. The expected total hardness of this finished water is approximately 200 mg/L as $CaCO_3$, approximately one half the raw water hardness. The blended water from the RO bypass and the RO effluent flow into the existing clearwell. Chemicals would be added to the water to adjust water stability and corrosiveness, and chlorine would be adjusted to provide a disinfecting residual. The water is pumped from the clearwell into the distribution system.

The filtration process requires the backwash process to keep the filter material clean. The filter backwash process as well as the residuals management is the same for all alternatives with and without RO and is described in greater detail in Section 7.6. The RO concentrate residual stream disposal is also discussed in greater detail in Section 7.6.2. A summary of the chemicals in the treatment process and their dosages for assumed for Alternatives 1C, 1D, 2C, and 2D are summarized in Table 7.2.

The RO membranes would be maintained using a periodic clean in place procedure and be replaced on a maintenance interval to maintain the productivity of the system. The costs of these maintenance requirements are included in the O&M costs of all options utilizing RO.

Table 7.2 Alternatives 1C, 1D, 2C, & 2D Treatment Chemicals and Dosages

Chemical	Purpose	Estimated Dosage (mg/L)
Chlorine	Break-point Chlorination & Disinfection	6.5 - 6.6
HMO	Corrosion control	0.6 - 1.5
Aqua Hawk 957	Backwash Coagulant	0.002 gal/MG
Calgon C5 (or equivalent)	Fe/Mn Sequestration	1.9
Calgon C9 (or equivalent)	Corrosion Inhibitor	4.4
Antiscalant	RO Scale inhibitor	4
Bisulfate	Dechlorination	5
Caustic – 50%	pH & Alkalinity Rise	6

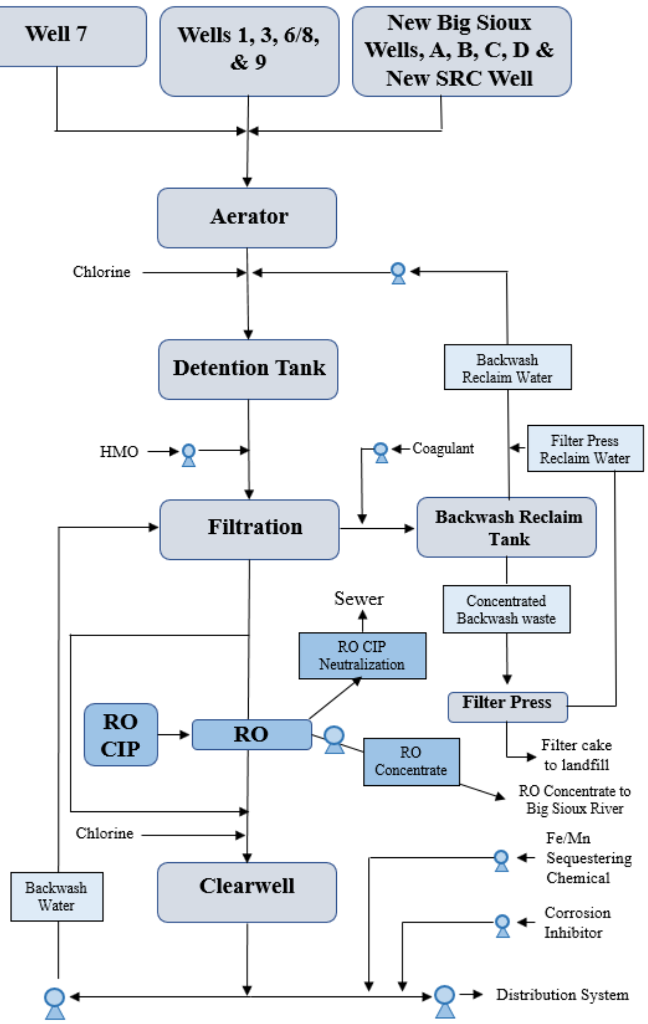


Figure 7.14 Alternative 1C Conceptual Process Flow Diagram

7.7.4 *Develop Big Sioux and SRC Aquifers / Existing Treatment Approach with RO & WRT at Well 7*

Alternative 1D is identical to Alternative 1C with the exception of additional onsite radium removal treatment at Well 7. This treatment technology would be provided by WRT and as further described in Section 7.2.3. Figure 7.15 provides a conceptual process flow diagram for Alternative 1D. Residuals management for this alternative is discussed in Section 7.6 and would consist of the disposal of filtration backwash solids and the RO concentrate water. The WRT radium removal media would be removed and disposed of by WRT when the media has been spent. WRT would then be responsible for replenishing the contact vessels with new media.

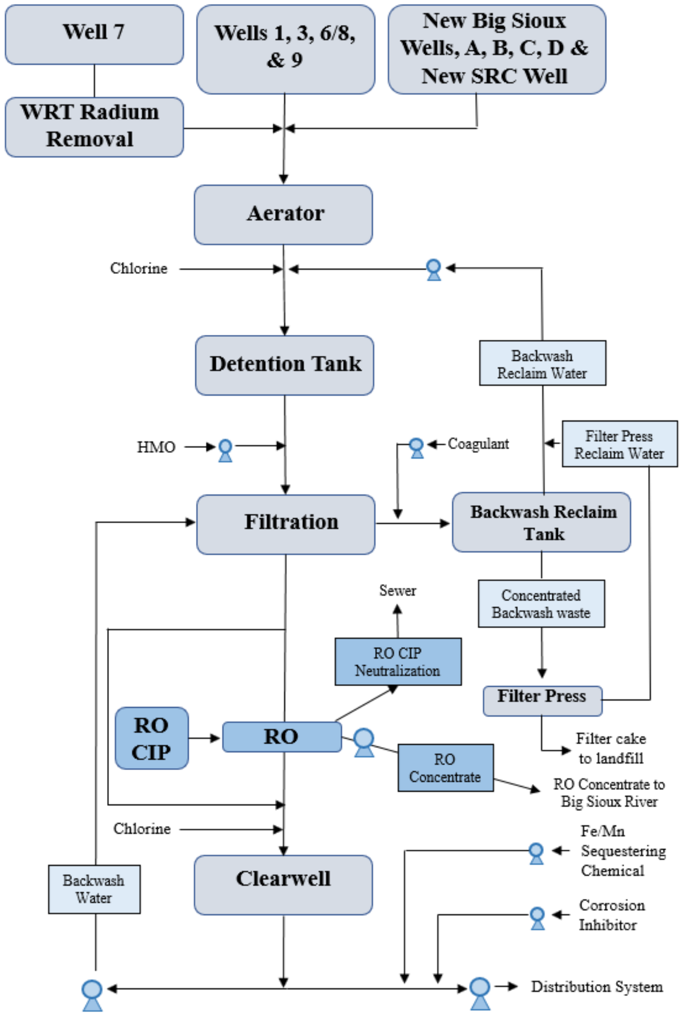


Figure 7.15 Alternative 1D Conceptual Process Flow Diagram

7.7.5 *Alternative 2A – Develop SRC Aquifer / Existing Treatment Approach*

Alternative 2A is identical to Alternative 1A, except Alternative 2A involves the development of wells in the SRC Aquifer only. The wells may be staged as illustrated in Figure 7.11, where new wells are added when the raw water MDD reaches 80 percent of the firm capacity of the wells. The treatment process for Alternative 2A is identical to Alternative 1A and is described in greater detail in Section 7.7.1. The conceptual flow process diagram for Alternative 2A is shown in Figure 7.16.

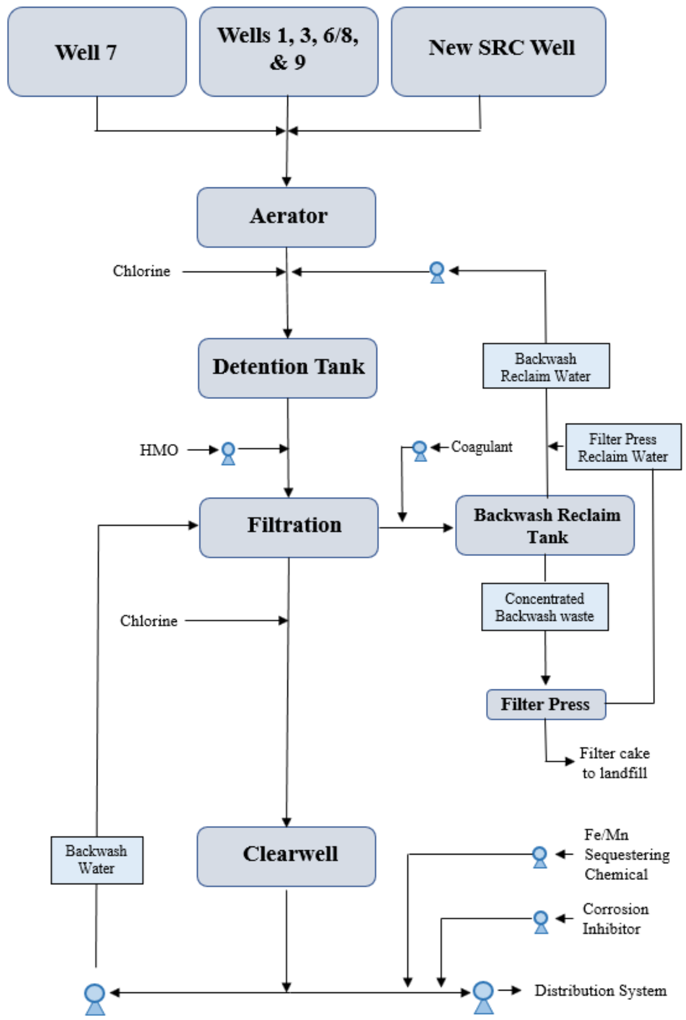


Figure 7.16 Alternative 2A Conceptual Process Flow Diagram

7.7.6 *Alternative 2B – Develop SRC Aquifer / Existing Treatment Approach with WRT at Well 7*

Alternative 2B is identical to Alternative 2A with the exception of additional onsite radium removal treatment at Well 7. This treatment technology would be provided by WRT and as further described in Section 7.2.3. Figure 7.17 provides a conceptual process flow diagram for Alternative 2B. Residuals management for this alternative is discussed in Section 7.6 and would only consist of the disposal of filtration backwash solids. The WRT radium removal media would be removed and disposed of by WRT when the media has been spent. WRT would then be responsible for replenishing the contact vessels with new media.

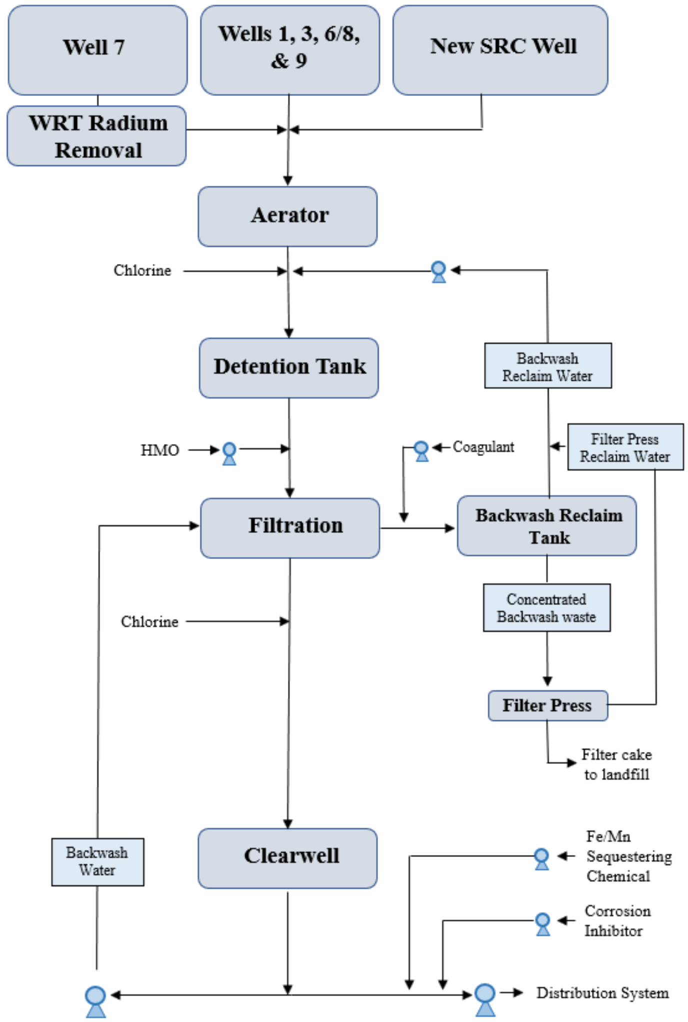


Figure 7.17 Alternative 2B Conceptual Process Flow Diagram

7.7.7 Alternative 2C – Develop SRC Aquifer / Existing Treatment Approach with RO

Alternative 2C is identical to Alternative 1C, except Alternative 2C involves the development of the SRC Aquifer only. The wells may be staged as illustrated in Figure 7.10, where new wells are added when the raw water MDD reaches 80 percent of the firm capacity of the wells. The treatment process for Alternative 2C is identical to Alternative 1C and is described in greater detail in Section 7.7.3. The conceptual flow process diagram for Alternative 2C is shown in Figure 7.18.

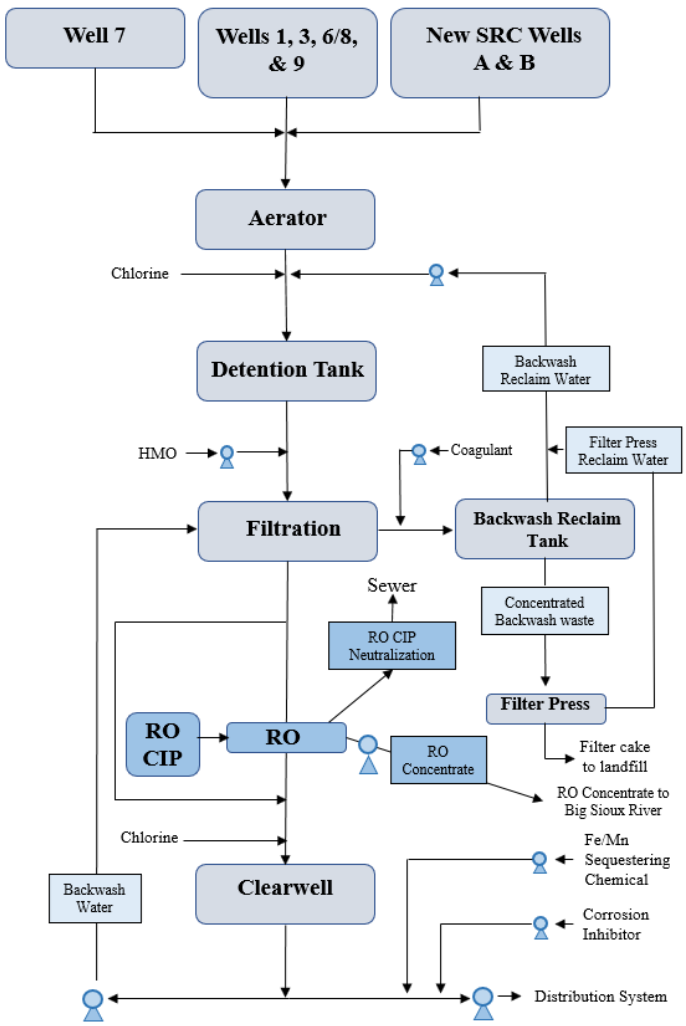


Figure 7.18 Alternative 2C Conceptual Process Flow Diagram

7.7.8 Alternative 2D – Develop SRC Aquifer / Existing Treatment Approach with RO and & WRT at Well 7

Alternative 2D is identical to Alternative 2C with the exception of additional onsite radium removal treatment at Well 7. This treatment technology would be provided by WRT and as further described in Section 7.2.3. Figure 7.19 provides a conceptual process flow diagram for Alternative 1D. Residuals management for this alternative is discussed in Section 7.6 and would consist of the disposal of filtration backwash solids and the RO concentrate water. The WRT radium removal media would be removed and disposed of by WRT when the media has been spent. WRT would then be responsible for replenishing the contact vessels with new media.

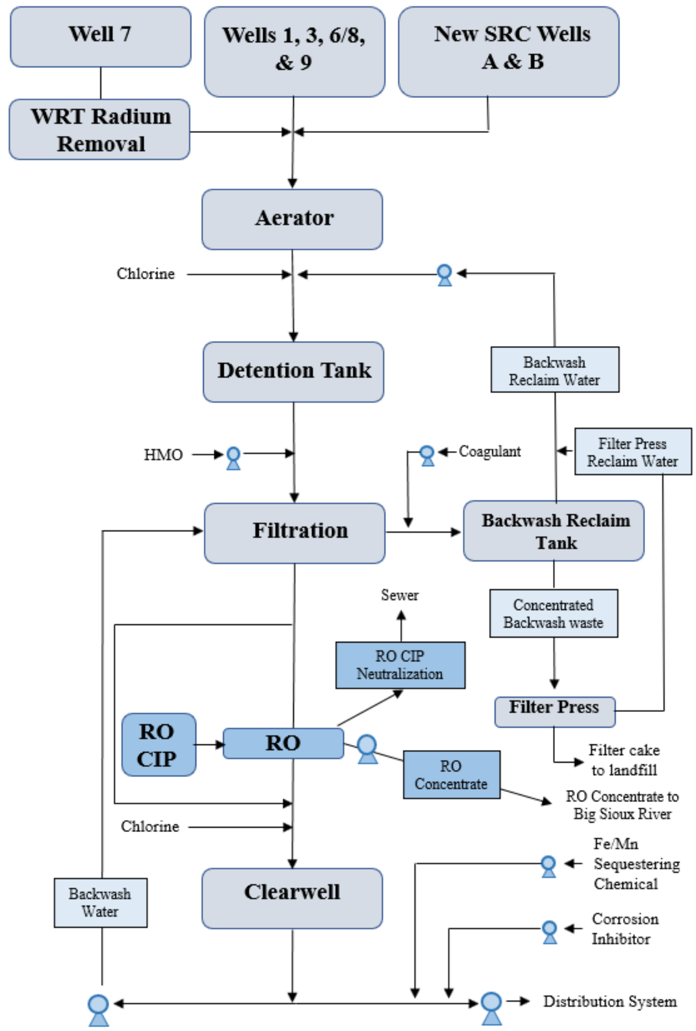


Figure 7.19 Alternative 2D Conceptual Process Flow Diagram

7.8 Non-Economic Comparison of Alternatives

The relative performance of these alternatives was evaluated using the Kepner-Tregoe® (K-T®) Decision Analysis procedure with the goal of comparing the alternatives without regards to cost. The K-T® Decision Analysis is a systematic procedure that encompasses the fundamental thought pattern people use to make choices. The specific techniques that define the systematic procedure used in K-T® Decision Analysis are developed around the following concepts:

- We appreciate that there is a choice to be made.
- We consider the specific factors that should be satisfied for the choice to succeed.
- We decide what course of action best satisfies these factors.
- We consider the risks associated with the chosen course of action that could jeopardize its success.

Selection criteria in K-T® Decision Analysis are classified either as MUST criteria that each candidate alternative solution must absolutely satisfy in order to be included in the decision process or WANT criteria that are desirable but not mandatory for each candidate problem solution to satisfy. The Project Team developed selection criteria to form the basis of a fair and balanced evaluation of Facility Plan Alternatives. Process selection criteria were classified as MUSTs or WANTs, as described in the following sections.

7.8.1 *Mandatory MUST Criteria*

Three MUST selection criteria were established based on regulatory compliance, system capacity, and finished water quality. The three MUST criteria are as follows:

- Regulatory Compliance – Each Facility Plan alternative must be capable of continuously meeting all enforceable U.S Environmental Protection Agency (USEPA) and South Dakota Department of Environment and Natural Resources (SD-DENR) drinking water regulations and standards.
- System Capacity – The ultimate capacity provided by each alternative must be at least 3.8 MGD by 2045 and 5.2 MGD by 2070. This capacity may be provided using a phased approach.
- Finished Water Quality – Each facility plan alternative must be capable of producing finished water with iron and manganese concentrations that are below the EPA's secondary drinking water standards of 0.3 and 0.05 mg/L respectively

All eight of the source and treatment alternatives met the mandatory MUST criteria. Thus, all eight alternatives were carried forward for scoring under the desirable WANT criteria.

7.8.2 *Desirable WANT Criteria*

Desirable WANT selection criteria were developed in four categories, including (1) Stakeholder Impacts, (2) Treatment Operations, (3) System Operations, and (4) Implementation. The relative importance of each category in the selection process, as well as individual criteria within each category, was established by assigning weighting factors as follows:

- The relative importance of each category of criteria was established by assigning a weighting factor between 1 and 10 to each.
- A weighting factor of 10 was assigned to the category of criteria considered most important. Remaining categories were assigned weighting factors relative to the most important category.
- Relative weighting factors were assigned using the following scale:
  - Critically Important 10
  - Very Important 7 to 9
  - Moderately Important 5 to 7

- Somewhat Important 3 to 5
- Minimally Important 1 to 3

- The preceding three steps were repeated to determine weighting factors for criteria within each category.

The criteria for the K-T® Decision Analysis were determined by the project team, consisting of representatives from the City of Brandon, staff from AE2S and representatives from the Brandon Water Development Committee and are shown in Figure 7.20. The factors considered when comparing the extent to which each alternative satisfies each criterion are listed in Table 7.3.

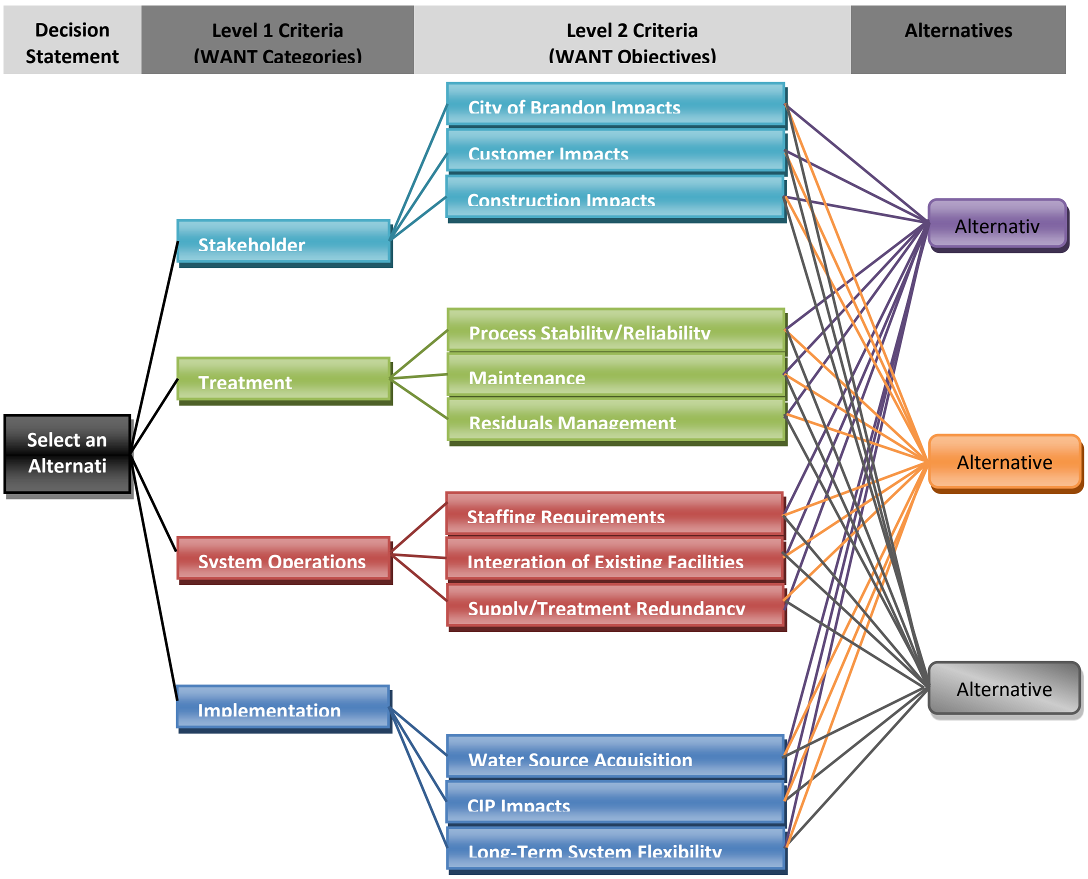


Figure 7.20 K-T® Decision Analysis Criteria for the City of Brandon Source & WTP Alternatives

Table 7.3 Factors for WANT Criteria Consideration

Stakeholder Acceptance	
City of Brandon Impacts	
•	To what degree will improved water quality promote development?
•	To what degree will the water be a source of pride to the community?
•	To what degree will the alternative provide water quality (hardness/TDS) that is similar to surrounding systems?
Customer Impacts	
•	To what extent will the alternative improve customer confidence in drinking water quality?
•	To what extent will the alternative promote appropriate customer water use (within the framework of conservation)?
•	To what extent will the alternative reduce radionuclides in the tap water?
•	To what extent will the salt consumption for ion exchange softening be decreased?
•	To what degree will the alternative provide value for the cost of water?
Construction Impacts	
•	To what degree does this alternative minimize impacts on public works horizontal infrastructure?
•	To what extent will the alternative create public impacts during construction of buried infrastructure?
•	How will this alternative limit water service disruptions during construction?
Public Safety	
•	To what degree will this alternative minimize the treatment chemical exposure hazards?
•	How will this alternative minimize the potential contamination of the water system during construction?
Treatment Operations	
Process Stability/Reliability	
•	What is the maturity and robustness of treatment technologies?
•	To what extent are multiple treatment barriers put in place for radionuclides?
•	Does the alternative enable staff confidence in treatment technologies/approach?
Maintenance	
•	What amount of maintenance will require outside contracts or can all maintenance be performed by WTP staff?
•	Does the alternative simplify maintenance of water source and treatment systems?
•	To what extent are the staff confident/experienced in the maintenance of the system?
Residuals Management	
•	Does the alternative provide confidence in a long-term approach to the disposal of treatment residuals?
•	To what degree does this alternative reduce disposal to the sanitary sewer?
System Operations	
Staffing Requirements	
•	To what degree does the alternative minimize additional staff requirements?
•	What levels of training, experience, and certification will be required?
Integration of Existing Facilities	
•	To what extent does this alternative integrate with existing raw water infrastructure?
•	To what extent does this alternative integrate with existing water treatment infrastructure?
Supply/Treatment Redundancy	
•	To what extent does this alternative enable the use of redundant water sources?
•	To what degree is the source resistant to drought impacts?
•	To what degree are treatment systems redundant?

Table 7.3 Continued

Implementation
Accommodating Additional Contaminants
• To what degree does this alternative provide the capability for accommodating changes in water quality?
• To what degree does this alternative provide the ability to blend water to accommodate additional contaminates?
Water Source Acquisition
• To what degree are source water permitting characteristics known and achievable?
• To what degree does the alternative enable the City to "lock-in" the source (own water rights)?
• To what extent will there be difficulty in acquiring additional land for source/treatment?
• To what degree will this alternative limit the number of additional wells needed?
CIP Impacts
• To what extent can the source improvements be phased to accommodate growth as it occurs?
• To what degree can the treatment improvements be phased to accommodate growth as it occurs?
Long-Term System Flexibility and Security
• To what degree will this alternative optimize the utilization of the water sources (minimize wasted water in treatment)?
• To what extent will the City gain long-term water source flexibility and security?
• To what extent are there possibilities for an additional source beyond the planning horizon?

The stakeholder groups independently determined how they felt the categories and criteria should be weighted. The weights from each of the three groups, (City of Brandon Staff, AE2S Staff and the Brandon Water Development Committee) were evenly split, meaning one-third of the weight of the responses was given to the rankings from the City of Brandon staff, one-third to AE2S staff and the final third was given to the Brandon Water Development Committee members' rankings. The combinations of everyone's rankings were used to determine the final relative weighting for the WANT categories and criteria, as shown in Table 7.4 and Table 7.5, respectively. These averages were normalized, assuming a maximum value of 10, for the City of Brandon, AE2S and the Brandon Water Development Committee (WDC) weightings.

The criteria that received a weight of 10 were considered most important in the decision process. System Operations category was ranked as the most important category by the City of Brandon staff, and the Stakeholder Acceptance category was ranked as the most important category by the AE2S and WDC teams. Combining the ranking results of the three groups, the Stakeholder Acceptance category was ranked as the most important, followed by the Treatment Operations, Implementation, and the lowest-ranked category, System Operations. The weights of the major categories are summarized in Table 7.4. Criteria under each category were weighed between 1 and 10 in a similar manner. Customer Impacts, Process Stability/Reliability, Supply Reliability, and Water Source Acquisition received the highest weight of 10. Criteria weights are summarized in Table 7.5.

Table 7.4 Category Weighting

Category	Relative Weight (1 to 10)					Criteria
	Brandon Team	AE2S Team	WDC Team	Ave	Normalized	
Stakeholder Acceptance	7.9	10.0	10.0	9.3	10.0	City of Brandon Impacts Customer Impacts Construction Impacts Public Safety
Treatment Operations	9.7	8.0	8.7	8.8	9.4	Process Stability/Reliability Maintenance Residuals Management
System Operations	10.0	7.7	7.8	8.5	9.1	Staffing Requirements Integration of Existing Facilities Supply & Treatment Redundancy
Implemen-tation	9.1	8.3	8.4	8.6	9.3	Accommodating Additional Contaminants Water Source Acquisition CIP Impacts Long-Term System Security and Flexibility

Table 7.5 Criteria Weighting

Category	Criteria	Relative Weight (1 to 10)				
		Brandon Team	AE2S Team	WDC Team	Average Weight	Normalized Weight
Stakeholder Acceptance	City of Brandon Impacts	9.7	8.3	9.0	9.0	9.0
	Customer Impacts	10.0	10.0	10.0	10.0	10.0
	Construction Impacts	9.3	5.3	6.5	7.1	7.1
	Public Safety	8.6	6.3	7.5	7.5	7.5
Treatment Operations	Process Stability/Reliability	9.7	10.0	10.0	9.9	10.0
	Maintenance	10.0	6.6	6.9	7.8	7.9
	Residuals Managements	9.7	9.7	6.9	8.7	8.8
System Operations	Staffing Requirements	7.3	5.3	5.6	6.1	6.1
	Integration of Existing Facilities	9.7	7.3	9.0	8.7	8.7
	Supply & Treatment Reliability	10.0	10.0	10.0	10.0	10.0
Implementation	Accommodating Additional Contaminants	8.3	9.0	7.4	8.2	8.2
	Water Source Acquisition	9.1	7.6	9.3	8.7	8.7
	CIP Impacts	9.1	9.0	7.4	8.5	8.5
	Long-Term System Security and Flexibility	10.0	10.0	10.0	10.0	10.0

7.8.3 *Non-Economic Alternative Scoring*

Each of the eight water treatment and supply alternatives that met the MUST criteria was scored based on its relative performance within each of the criteria following a 1 to 10 scale. The scoring was conducted by a focus group made up of Brandon city staff, Brandon Water Development Committee delegates, Brandon City council delegates and AE2S staff. The alternatives were scored a 10 if the alternative best met the criteria and a ranking of 1 if the alternative did not meet any portion of the criteria. It is important to note that assigning a score of 10 to an alternative for any given criterion does not imply that the alternative satisfies the given criterion perfectly, but rather that it most closely satisfies the intent of the criterion. Remaining alternatives in each group were assigned equal or lower scores based on their ability to satisfy the criterion relative to the alternative that best satisfies that criterion. This scoring was completed by the focus group in a workshop setting, enabling review and discussion of technical merits as needed to arrive at a score. The scorings for the long-term source water alternatives are presented in Table 7.6.

Table 7.6 Alternatives Scoring

Category	Criteria	Alternative Scoring							
		Alt. 1A	Alt. 1B	Alt. 1C	Alt. 1D	Alt. 2A	Alt. 2B	Alt. 2C	Alt. 2D
Stakeholder Acceptance	City of Brandon Impacts	5	7	9	10	5	7	9	10
	Customer Impacts	6	8	9	10	5	7	9	10
	Construction Impacts	6	6	5	5	9	9	8	8
	Public Safety	8	9	7	7	8	9	7	7
Treatment Operations	Process Stability/Reliability	6	8	9	10	6	8	9	10
	Maintenance	9	8	6	5	10	9	7	6
	Residuals Managements	9	10	7	7	9	10	7	7
System Operations	Staffing Requirements	9	9	7	7	9	9	7	7
	Integration of Existing Facilities	8	7	6	5	10	9	7	6
	Supply/Treatment Redundancy	7	7	7	7	8	8	8	8
Phasing Considerations	Accommodating Additional Contaminants	7	8	9	10	7	8	9	10
	Water Source Acquisition	7	7	6	6	8	8	7	7
	CIP Impacts	6	6	6	6	7	7	7	7
	Long-Term System Security and Flexibility	9	9	6	6	9	9	6	6

The following briefly describes discussions from the Alternatives Review Workshop conducted on June 12th, 2019, about how each of the criteria scores for the alternatives was determined:

City of Brandon Impacts:

Alternatives 1D and 2D scored the highest as these alternatives provided the most water treatment and barriers to radionuclides. Alternatives 1C and 2C ranked second as they also provided higher levels of treatment including RO softening, but lacked the WRT radium removal at Well 7. Alternatives 1B and 2B came in third place as they both had radium removal at Well 7 but no RO. Alternatives 1A and 2A had the least amount of treatment and would not provide water of a better quality than what is currently produced. The source of water from either the Big Sioux or SRC aquifers was not considered significant for this category.

Customer Impacts:

Similar to the City of Brandon Impacts, customer impacts were highly dependent on the level of treatment provided. Alternatives 1D and 2D (existing treatment approach, RO and the WRT radium removal system) scored the highest, followed by Alternatives 1C and 2C (existing treatment approach, RO and no WRT). The third highest score went to Alternatives 1B and 2B, (existing treatment with WRT radium removal treatment used at Well 7). The least favorable alternatives were Alternatives 1A and 2A (existing treatment). Alternatives in group 1 (water sources developed in the Big Sioux Aquifer & SRC) scored slightly higher than Alternative group 2 (water sourced primarily from the SRC aquifer) since water from the Big Sioux Aquifer does not contain detectable levels of radium.

Construction Impacts:

Alternatives in group 1 scored lower as the development of additional wells would be within the city of Brandon, and more wells would need to be constructed since the wells likely would not be as productive as wells developed in the SRC aquifer (Alternative group 2). Alternatives with RO (1C, 1D, 2C, and 2D) scored slightly lower as additional wells would be required, increasing the construction impacts from additional wells and underground piping. The team did not feel the difference in WTP building size (RO vs. no RO), nor the addition of the WRT radium removal system would have significant construction impacts due to the locations of these facilities.

Public Safety:

Public safety was viewed primarily in terms of handling treatment chemicals and residuals. The alternatives with WRT radium removal and existing treatment (1B and 2B) scored the highest as City staff would not be exposed to residuals with elevated radium concentrations or additional chemicals present in the RO system. Alternatives with RO (1C, 1D, 2C, and 2D) all scored the lowest as the RO membranes require additional, potentially strong, chemicals to maintain their performance and prevent scale buildup. Alternatives 1A and 2A (existing treatment without WRT radium removal) scored in the middle as higher levels of radium would be coming to the plant which may require a higher dosage of HMO, which would necessitate refilling the HMO tanks more frequently.

Process Stability/Reliability

Alternatives with RO and WRT radium removal (1D and 2D) scored the highest as they provided the greatest number of barriers to radionuclides. Alternatives with RO and no WRT radium removal (1C and 2C) scored just below 1D and 2D, followed by the alternatives without RO but with WRT radium removal (1B and 2B). The existing treatment (1A and 2A) scored the lowest as it provided the least number of barriers to radionuclides. All alternatives utilize mature and proven technologies.

Maintenance:

Alternatives in group 1 (development of Big Sioux and SRC Aquifers) scored slightly lower than alternatives in group 2 (development of only the SRC Aquifer) since the additional number of wells may require additional maintenance activities. The alternatives utilizing the existing treatment approach (1A and 2A) scored the highest as these alternatives would require the least additional maintenance. Alternatives with WRT (1B, 1D, 2B, and 2D) scored slightly lower as the replacement of media and inspection of the WRT equipment may require some additional attention from operators. Alternatives with RO (1C, 1D, 2C, and 2D) all scored the lowest as the RO membranes and supporting equipment will require additional attention from operations staff.

Residuals Management:

Relative to each other, the alternatives with the existing treatment at the WTP with WRT radium removal (1B and 2B) scored the highest as the residuals from the WRT vessels would be removed and replaced by WRT. Additionally, solids disposal from the WTP would contain less radium than alternatives without the WRT system (1A, 1C, 2A, and 2C); thus, they scored slightly lower. Alternatives with RO (1C, 1D, 2C, and 2D) all scored the lowest as the RO system produces a liquid concentrate stream that must be disposed of. The disposal of the RO concentrate may come with additional regulations or requirements.

Staffing Requirement:

Staffing requirements were assumed to be the least rigorous for the existing treatment alternatives (1A, 1B, 2A, and 2B). The team did not think the addition of the WRT radium removal system warranted additional training that may cause difficulty in finding qualified personnel. Alternatives with RO (1C, 1D, 2C, and 2D) scored lower due to the possibility of additional certification requirements or difficulty finding qualified operators with the necessary certification to fill any open positions.

Integration of Existing Facilities:

Alternatives in group 2 (development of the SRC Aquifer only) scored higher than those in alternative group 1 (development of Big Sioux and SRC Aquifers) since development in the Big Sioux Aquifer would require more wells as the production rate per well would be anticipated to be less in the Big Sioux Wells. The existing treatment (1A and 2A) scored the highest in their groups with the scores dropping with increasing levels of technology. The alternatives with RO scored the lowest as they would require additional wells and would be more difficult to integrate with the existing facilities.

Supply/Treatment Redundancy:

Alternative group 2 (development of SRC Aquifer only) was ranked slightly higher than alternative group 1 (development of the Big Sioux and SRC aquifers) as wells in the SRC aquifer have historically produced greater flow rates than those in the Big Sioux Aquifer. Additionally, the SRC Aquifer is deeper than the Big Sioux aquifer, and the team thought it might be less susceptible to drought or contamination. Between the treatment technologies, the team did not think there was any significant difference as all of the treatment processes would have redundancy.

Accommodating Additional Contaminates:

The alternatives with RO and WRT radium removal (1D and 2D) scored the highest as the bypass can be adjusted to move more water through the RO membranes to reduce a newly discovered contaminant. The WRT radium removal system allows the flexibility to remove additional radium should the radium concentration in Well 7 increase over time. Alternatives without RO or the WRT radium removal system (1A and 2A) have a limited ability to address additional contaminants without potentially making changes to the treatment process, thus they alternatives 1A and 2A scored the least.

Water Source Acquisition:

Alternatives without RO (1A, 1B, 2A, and 2B) scored the highest as additional wells would not be needed to offset the RO concentrate discharge volume. Alternatives in group 1 (development of new Big Sioux and SRC wells) scored slightly lower than those in group 2 (development of new SRC wells only) since constructing new wells in the middle of town may be more difficult particularly since more wells would likely be needed in the Big Sioux Aquifer than would be in the SRC aquifer for the same amount of produced water.

CIP Impacts:

Alternatives in group 2 (development of wells in the SRC Aquifer only) was viewed slightly more favorable that alternatives in group 1 (development of wells in the Big Sioux and SRC Aquifers) since expansion in the SRC aquifer may be easier to phase than the addition of wells in the middle of the town.

Long-Term System Security and Flexibility:

Alternatives without RO (1A, 1B, 2A, and 2B) were ranked the highest as these alternatives most efficiently utilized water. The team did not identify any significant differences between the alternative groups (Big Sioux versus SRC Aquifer development).

7.8.4 *Non-Economic Comparison Results*

The results of the K-T® Decision Analysis for non-economic comparison of the Facility Plan alternatives are shown in Table 7.7. The criteria performance score for each of the eight alternatives was determined by multiplying the category weight by the criteria weight and then by the alternatives score for the criteria. The criteria performance scores were totaled to determine each alternative's performance score for each category and to determine each alternative's overall performance score, as shown in Table 7.7.

Alternative 2B (development of the SRC aquifer only with WRT radium removal at Well 7 with the existing treatment approach) received the highest overall performance score in the non-economic comparison. The results for each category are briefly discussed below:

Alternative 2B (development of the SRC aquifer only with WRT radium removal at Well 7 with the existing treatment approach) was ranked the highest in the Treatment Operations and Implementation and categories, which were weighted as the second and third most important categories respectively. Alternative 2B also did well in the other two categories, coming in fourth in the Stakeholder Acceptance category, and second in the System Operations Category. Alternative 2B likely scored the highest for several reasons, including:

- Radium from Well 7 is removed before it ever reaches the WTP
- The least number of new wells are required
- Water in the treatment plant is used as efficiently as possible
- Operators are familiar with the existing treatment technology
- Well 7 can be more effectively utilized
- Less construction disruption in the middle of town
- The least impact from residuals disposal

Table 7.7 Non-Economic Comparison Results

Category	Weight [A]	Criteria	Weight [B]	Alternative Score [C]								Performance Score [D] = [A] x [B] x [C]							
				1A	1B	1C	1D	2A	2B	2C	2D	1A	1B	1C	1D	2A	2B	2C	2D
Stakeholder Acceptance	10.0	City of Brandon Impacts	9.0	5	7	9	10	5	7	9	10	450	630	810	900	450	630	810	900
		Customer Impacts	10.0	6	8	9	10	5	7	9	10	600	800	900	1,000	500	700	900	1,000
		Construction Impacts	7.1	6	6	5	5	9	9	8	8	424	424	353	353	636	636	565	565
		Public Safety	7.5	8	9	7	7	8	9	7	7	600	675	525	525	600	675	525	525
											Subtotal	*2,073*	*2,528*	*2,588*	*2,778*	*2,185*	*2,640*	*2,800*	*2,990*
Treatment Operations	9.4	Process Stability/ Reliability	10.0	6	8	9	10	6	8	9	10	566	755	850	944	566	755	850	944
		Maintenance	7.9	9	8	6	5	10	9	7	6	671	596	447	373	745	671	522	447
		Residuals Management	8.8	9	10	7	7	9	10	7	7	751	835	584	584	751	835	584	584
											Subtotal	*1,988*	*2,186*	*1,881*	*1,901*	*2,063*	*2,261*	*1,956*	*1,976*
System Operations	9.1	Staffing Requirements	6.1	9	9	7	7	9	9	7	7	499	499	388	388	499	499	388	388
		Integration of Existing Facilities	8.7	8	7	6	5	10	9	7	6	633	554	475	396	791	712	554	475
		Supply/ Treatment Redundancy	10.0	7	7	7	7	8	8	8	8	639	639	639	639	730	730	730	730
											Subtotal	*1,770*	*1,691*	*1,501*	*1,422*	*2,020*	*1,941*	*1,672*	*1,593*
Implementation	9.3	Accommodating Additional Contaminants	8.2	7	8	9	10	7	8	9	10	533	609	685	761	533	609	685	761
		Water Source Acquisition	8.7	7	7	6	6	8	8	7	7	562	562	482	482	642	642	562	562
		CIP Impacts	8.5	6	6	6	6	7	7	7	7	473	473	473	473	552	552	552	552
		Long-Term System Security and Flexibility	10.0	9	9	6	6	9	9	6	6	834	834	556	556	834	834	556	556
											Subtotal	*2,401*	*2,477*	*2,195*	*2,272*	*2,560*	*2,636*	*2,354*	*2,431*
Overall Performance Score (Total)												*8,234*	*8,883*	*8,166*	*8,373*	*8,829*	*9,478*	*8,782*	*8,989*
Performance Score												*1.01*	*1.09*	*1.00*	*1.03*	*1.08*	*1.16*	*1.08*	*1.10*

Alternative 2D (development of the SRC aquifer only with WRT radium removal at Well 7 and RO) ranked second overall and first in the Stakeholder Acceptance category. Alternative 2D has the added benefit of providing an additional barrier to radionuclides and other contaminants as well as providing softer water comparable to surrounding communities. However, Alternative 2D requires additional raw water, and the RO treatment process creates a residual waste stream that needs to be disposed of.

Chapter 8 COST EVALUATION OF ALTERNATIVES

8.1 Opinion of Probable Project Costs for the Proposed Alternatives

Opinions of probable project construction costs (OPPCC) were developed for each of the six alternatives. Unit costs were based on recent bids obtained for similar work, quotes from suppliers, and prior experience and engineering judgment. Capital costs are in 2019 dollars, and operations and maintenance (O&M) costs are the present worth in 2019 dollars of the operating period from 2020 through 2045.

The opinions of probable project cost provided within this Chapter are based on conceptual designs and not detailed designs. Furthermore, the opinions of probable project cost are made on the basis of the experience, qualifications, and best judgment of the project team as experienced and qualified professionals generally familiar with the water treatment industry. However, because the designs may change, and the project team has no control over the cost of labor, materials, equipment, contractor's methods of determining prices, or over competitive bidding market conditions, the opinions of probable project cost presented in this Chapter are considered planning level by nature. The estimated costs are subject to refinement as the facilities are developed in greater detail during the preliminary and final design phases.

The opinion of probable project costs for each short-term and long-term alternative is summarized in the following sections. These costs include the total project cost for additional raw or treated water supply sources from wells or regional water providers, water treatment facilities, and residuals management. Each proposed improvement includes the anticipated construction costs, engineering costs, and contingencies.

Multiplier percentages were used to estimate the installation, which includes contractor overhead and profit. The percentages utilized varied based on the nature, scope, and complexity of the work to be performed. The installed cost of infrastructure was summed to determine the value to construct the infrastructure. A multiplier of 10 percent of the installed construction costs was used to estimate the contractor's mobilization costs. For the WTP buildings, an additional 11 and 20 percent (of the installed construction cost) multipliers were used to approximate the building's mechanical, electrical installed costs respectively. The sum of these categories is the total cost to construct the infrastructure. An additional 16 percent and 4 percent multipliers were used on the total construction costs to estimate engineering, legal and administrative fees respectively. An additional 30 percent multiplier of the total construction costs was used as a contingency to account for the many unknowns at the planning level. The sum of the total construction costs, engineering, legal and administrative, and contingency costs form the OPPCC.

The cost estimates for this report were broken up into two planning sections. The first section compiles the capital, O&M, and salvage costs for five short-term alternatives compared against the existing system. The short-term alternatives were compiled to compare the costs of purchasing water from MCWC for the next 5 years versus other water acquisition alternatives.

The second section in this chapter compares the needed capital, O&M, and depreciation costs for the eight long-term alternatives for providing water through 2045. Chemical costs, dosage rates, electrical rates, and assumptions are supplied in Appendix B.

8.2 Short-Term Alternatives

The Brandon WTP has a current production capacity of 2,000 gpm; however, the current wells that are online and pump to directly to the WTP, (Wells 1, and 6) can only produce a combined flow rate of around 1,800 gpm. The City knows that a new WTP will be needed in the near future; however, until a new WTP is constructed, additional water can be treated at the current WTP in order to maximize the plant's full capacity. The short-term alternatives were developed to compare the costs associated with purchasing water from MCWC for the next five years versus constructing City-owned infrastructure to produce additional water until the new WTP can be constructed and into the future. The five short-term alternatives were all compared against the costs to produce the same amount of water using the existing infrastructure (Wells 1, 6 – treated at the WTP, and Well 3 – pumped directly into the distribution system). Figure 8.1 represents the maximum total water production that is projected to occur between 2020 and 2024, given past peak usage combined with anticipated future water demand growth.

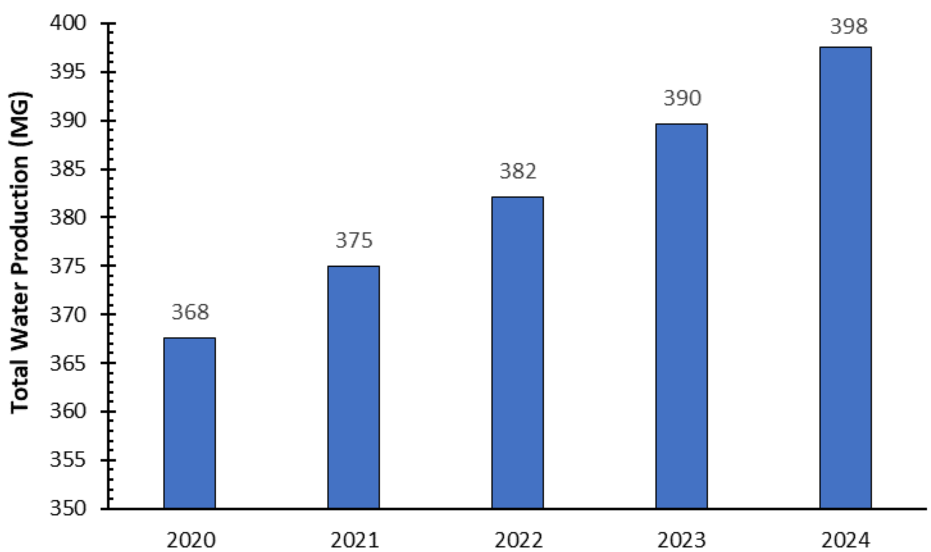


Figure 8.1 Total Projected Water Produced per Year (2020-2024)

8.2.1 *Existing System*

Under the existing system, the future maximum projected water demands presented in Figure 8.1, are met using the existing wells while keeping the usage from each well within the current water rights assigned to each well. Under the existing case, approximately 10 percent of the total water produced would come from Well 3; another 8 percent would come from Well 1 and the remainder would come from Well 6. Figure 8.2 provides a chart detailing the estimated total percentage of water produced from each well from 2020 through 2024.

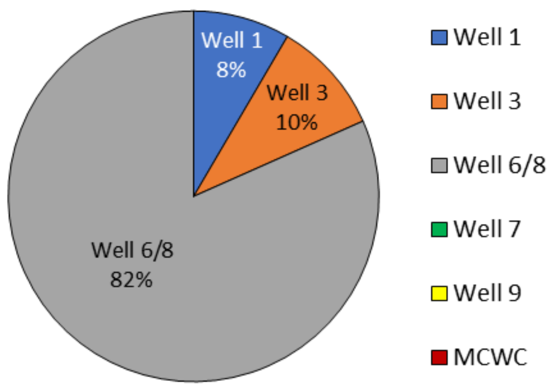


Figure 8.2 Potential Water Usage from the Existing Wells (2020-2024).

Table 8.1 and Table 8.2 provide the estimated costs to operate the existing system to meet the water demands between 2020 and 2024. The cost to produce water between 2020 and 2024 is approximately $2.76 per 1,000 gallons of treated water.

Table 8.1 Existing System O&M Projected Costs (2020-2024)

	2020	**2021**	**2022**	**2023**	**2024**	**NPV (2020-2024)**
Maintenance & Labor Costs	***$552,000***	***$566,000***	***$581,000***	***$597,000***	***$613,000***	***$2,700,000***
Purchased Water/Water Service Fees	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***
Chemical Costs						
Chlorine	$8,000	$8,200	$8,100	$8,500	$8,800	$38,600
Tonkazorb	$31,000	$32,000	$31,000	$33,000	$34,000	$150,000
Calgon C5 (LPC-5)	$6,400	$6,600	$6,500	$6,800	$7,100	$31,000
Calgon C9 (LPC-9)	$17,600	$18,000	$17,900	$18,600	$19,400	$85,000
Aqua Hawk 957	$13	$13	$13	$13	$14	$61
Chemicals Total	***$63,000***	***$65,000***	***$64,000***	***$67,000***	***$69,000***	***$304,000***
Electrical Costs						
Well 1	$1,000	$1,100	$1,100	$1,100	$1,100	$5,000
Well 3	$6,900	$7,700	$15,600	$16,000	$16,500	$58,000
Well 6	$17,500	$17,900	$18,100	$18,700	$19,300	$85,000
Well 7	$2,500	$2,500	$2,600	$2,600	$2,700	$11,000
Wells Other Usage (Heat, lights, etc.)	$2,000	$2,100	$2,100	$2,200	$2,200	$9,800
Wells Total	*$30,000*	*$31,000*	*$40,000*	*$41,000*	*$42,000*	*$170,000*
Water Tower Total	*$1,100*	*$1,100*	*$1,200*	*$1,200*	*$1,200*	*$5,400*
WTP Total	*$48,000*	*$49,000*	*$49,000*	*$51,000*	*$52,000*	*$231,000*
Electrical Total	***$79,000***	***$81,000***	***$90,000***	***$93,000***	***$95,000***	***$406,000***
Wastewater Discharge Fee (Volumetric @ $4.78/1,000 gal)	***$12,100***	***$12,300***	***$12,300***	***$12,800***	***$13,300***	***$58,000***
Total Water Produced (MG)	***368***	***375***	***383***	***390***	***398***	***1,914***
Total O&M Costs	**$710,000**	**$720,000**	**$750,000**	**$770,000**	**$790,000**	**$3,470,000**

Table 8.2 Existing System Projected Costs Summary (2020-2024)

Capital Costs	
Capital Costs (Watermain Improvements & Contributions to Capital Reserves) (NPV, 2020 – 2024)	$1,800,000
Estimated Salvage Value (2019 Dollars)	$0
Total Capital Costs	*$1,800,000*
O&M Costs	
Maintenance & Labor Costs (NPV, 2020 – 2024)	$2,700,000
Purchased Water Cost (NPV, 2020-2024)	$0
Chemicals Costs (NPV, 2020 – 2024)	$304,000
Electrical Costs (NPV, 2020 – 2024)	$413,000
Wastewater Discharge Fees (NPV, 2020 – 2024)	$58,000
Total O&M Costs	*$3,475,000*
Total Capital and O&M Costs	***$5,275,000***
Total Water Pumped (MG, 2020-2024)	***1,914***
Water Cost ($/1,000 gallons)	***$2.76***

8.2.1 *Short-Term Alternative 1 – Purchase Water from MCWC*

If the City were to purchase water from MCWC, Figure 8.3 provides a chart detailing the estimated total percentage of water from each well and from MCWC between 2020 and 2024. In order to maintain a consistent blend of water quality, the MCWC water delivery would be a consistent fraction of water production each day. MCWC's water delivery would be about 11 percent of the total water needs during this five year period. Assuming Well 8 provides redundancy to Well 6, Well 3 would likely not be needed during this time due to the supplemental flow from MCWC.

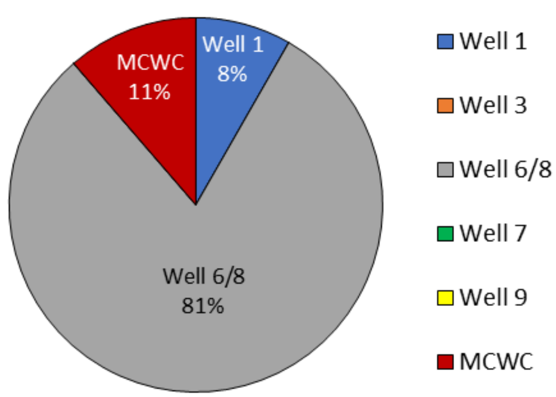


Figure 8.3 Short-Term Alternative 1 Potential Water Usage from Existing Wells and MCWC (2020-2024).

Table 8.3 and Table 8.4 provide the estimated costs to produce water between 2020 and 2024 with up to 250,000 gallons of water a day being purchased from MCWC. Purchasing water from MCWC does decrease the chemical and electrical costs slightly since the water being delivered is already treated and does not need to be pumped to the WTP. However, since this alternative cannot be guaranteed to provide the City with water after five years, the utilization of the added infrastructure is low, meaning the full life of the added infrastructure is not used. Additionally, every gallon purchased from MCWC would cost $2 per 1,000 gallons. These factors combine to give this short-term alternative a cost of approximately $3.24 per 1,000 gallons of treated water.

Table 8.3 Short-Term Alternative 1 System O&M Projected Costs (2020-2024)

	2020	2021	2022	2023	2024	NPV (2020-2024)
Maintenance & Labor Costs	***$555,000***	***$570,000***	***$585,000***	***$601,000***	***$617,000***	***$2,700,000***
Purchased Water/Water Service Fees	***$84,000***	***$88,000***	***$92,000***	***$95,000***	***$99,000***	***$425,000***
Chemical Costs						
Chlorine	$7,000	$7,300	$7,600	$8,000	$8,300	$35,000
Tonkazorb	$29,000	$30,000	$32,000	$33,000	$34,000	$146,500
Calgon C5 (LPC-5)	$6,000	$6,300	$6,600	$6,900	$7,200	$30,500
Calgon C9 (LPC-9)	$17,000	$17,000	$18,000	$19,000	$20,000	$84,000
Aqua Hawk 957	$12	$12	$13	$14	$14	$60
Chemicals Total	***$59,000***	***$61,000***	***$64,000***	***$67,000***	***$70,000***	***$296,000***
Electrical Costs						
Well 1	$1,000	$1,100	$1,100	$1,100	$1,100	$5,000
Well 3	$1,300	$1,400	$1,400	$1,400	$1,500	$6,500
Well 6	$17,000	$18,000	$18,000	$19,000	$19,000	$84,500
Well 7	$2,400	$2,500	$2,500	$2,600	$2,700	$12,000
Wells Other Usage (Heat, lights, etc.)	$2,000	$2,100	$2,100	$2,200	$2,200	$9,800
Wells Total	*$24,000*	*$25,000*	*$25,000*	*$26,000*	*$27,000*	*$118,000*
Water Tower Total	*$1,100*	*$1,100*	*$1,200*	*$1,200*	*$1,200*	*$5,400*
WTP Total	*$47,000*	*$48,000*	*$50,000*	*$51,000*	*$52,000*	*$230,000*
Electrical Total	***$72,000***	***$74,000***	***$76,000***	***$78,000***	***$80,000***	***$353,000***
Wastewater Discharge Fee (Volumetric @ $4.78/1,000 gal)	***$11,400***	***$11,800***	***$12,400***	***$12,900***	***$13,500***	***$58,000***
Total Water Produced (MG)	***368***	***375***	***383***	***390***	***398***	***1,914***
Total O&M Costs	**$781,000**	**$804,000**	**$829,000**	**$854,000**	**$880,000**	**$3,800,000**

Table 8.4 Short-Term Alternative 1 Projected Costs Summary (2020-2024)

Capital Costs	
Capital Costs (Watermain Improvements & Contributions to Capital Reserves) (NPV, 2020 – 2024)	$1,800,000
Capital – Brandon Piping Infrastructure	$240,000
Capital – MCWC Infrastructure Upgrades	$500,000
Estimated Salvage Value (2019 Dollars)	$140,000
Total Capital Costs	*$2,400,000*
O&M Costs	
Maintenance & Labor Costs (NPV, 2020 – 2024)	$2,700,000
Purchased Water Cost (NPV, 2020-2024)	$425,000
Chemicals Costs (NPV, 2020 – 2024)	$296,000
Electrical Costs (NPV, 2020 – 2024)	$353,000
Wastewater Discharge Fees (NPV, 2020 – 2024)	$58,000
Total O&M Costs	*$3,800,000*
Total Capital and O&M Costs	*$6,200,000*
Total Water Pumped (MG, 2020-2024)	*1,914*
Water Cost ($/1,000 gallons)	***$3.24***

8.2.1 *Short-Term Alternative 2 – Connect Well 3 to the Existing Well 7 Header*

Should the City pipe Well 3 to the existing Well 7 header, which would allow Well 3 to pump directly to the WTP, Figure 8.4 provides a chart detailing the estimated total percentage of water from each well between 2020 and 2024 for this alternative. Approximately 20 percent would come from Wells 1 and 3 while the rest would come from Wells 6 or 8.

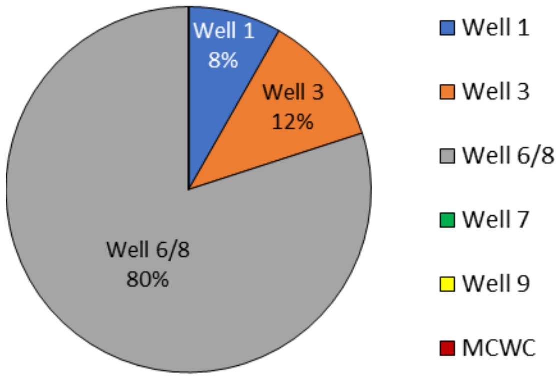


Figure 8.4 Short-Term Alternative 2 Potential Water Usage from Existing Wells (2020-2024).

Table 8.5 and Table 8.6 provide the costs to produce water between 2020 and 2024 by pumping water from Well 3 directly to the WTP for further treatment. The costs to treat water from Well 3 will increase the chemical costs over the existing system as the water from Well 3 is now being treated for iron and manganese removal. The estimated cost is $2.98 per 1,000 gallons of treated water.

Table 8.5 Short-Term Alternative 2 System O&M Projected Costs (2020-2024)

	2020	2021	2022	2023	2024	NPV (2020-2024)
Maintenance & Labor Costs	***$557,000***	***$572,000***	***$587,000***	***$603,000***	***$619,000***	***$2,700,000***
Purchased Water/Water Service Fees	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***
Chemical Costs						
Chlorine	$8,400	$8,800	$9,200	$9,600	$10,100	$43,000
Tonkazorb	$33,000	$34,000	$36,000	$37,000	$39,000	$166,000
Calgon C5 (LPC-5)	$6,800	$7,100	$7,400	$7,700	$8,100	$34,000
Calgon C9 (LPC-9)	$19,000	$19,000	$20,000	$21,000	$22,000	$94,000
Aqua Hawk 957	$13	$14	$15	$15	$16	$70
Chemicals Total	***$67,000***	***$69,000***	***$73,000***	***$75,000***	***$79,000***	***$337,000***
Electrical Costs						
Well 1	$1,000	$1,000	$1,100	$1,100	$1,100	$4,900
Well 3	$14,600	$15,100	$15,500	$15,900	$16,300	$72,000
Well 6	$17,000	$18,000	$18,000	$19,000	$19,000	$84,000
Well 7	$2,400	$2,500	$2,500	$2,600	$2,700	$12,000
Wells Other Usage (Heat, lights, etc.)	$2,000	$2,100	$2,100	$2,200	$2,200	$10,000
Wells Total	*$37,000*	*$39,000*	*$39,000*	*$41,000*	*$41,000*	*$183,000*
Water Tower Total	*$1,100*	*$1,100*	*$1,200*	*$1,200*	*$1,200*	*$5,400*
WTP Total	*$48,000*	*$50,000*	*$51,000*	*$53,000*	*$54,000*	*$237,000*
Electrical Total	***$86,000***	***$90,000***	***$91,000***	***$95,000***	***$96,000***	***$425,000***
Wastewater Discharge Fee (Volumetric @ $4.78/1,000 gal)	***$12,700***	***$13,400***	***$13,900***	***$14,500***	***$15,200***	***$65,0000***
Total Water Produced (MG)	***368***	***375***	***383***	***390***	***398***	***1,914***
Total O&M Costs	**$720,000**	**$740,000**	**$760,000**	**$790,000**	**$810,000**	**$3,500,000**

Table 8.6 Short-Term Alternative 2 Projected Costs Summary (2020-2024)

Capital Costs	
Capital Costs (Watermain Improvements & Contributions to Capital Reserves) (NPV, 2020 – 2024)	$1,800,000
Capital – Connect Well 3 to Existing Well 7 Header	$1,100,000
Estimated Salvage Value (2019 Dollars)	$720,000
Total Capital Costs	*$2,200,000*
O&M Costs	
Maintenance & Labor Costs (NPV, 2020 – 2024)	$2,700,000
Purchased Water Cost (NPV, 2020-2024)	$0
Chemicals Costs (NPV, 2020 – 2024)	$337,000
Electrical Costs (NPV, 2020 – 2024)	$425,000
Wastewater Discharge Fees (NPV, 2020 – 2024)	$65,000
Total O&M Costs	*$3,500,000*
Total Capital and O&M Costs	*$5,700,000*
Total Water Pumped (MG, 2020-2024)	*1,914*
Water Cost ($/1,000 gallons)	***$2.98***

8.2.1 *Short-Term Alternative 3 – Utilize Well 7 / No Radium Removal at Well 7*

Another potential option the City has that does not require any additional infrastructure is to use Well 7 and treat the water at the WTP to remove the elevated levels of radionuclides. Figure 8.5 provides a chart detailing the total percentage of water that may come from each well between 2020 and 2024 for this alternative.

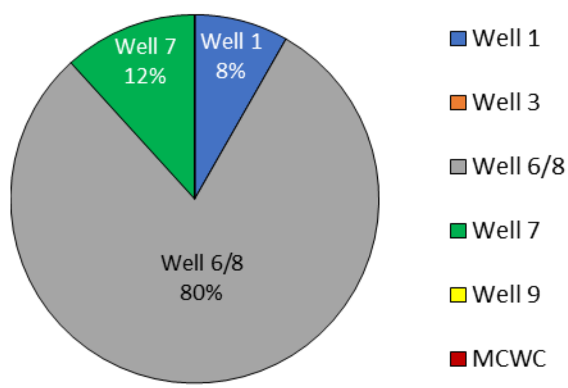


Figure 8.5 Short-Term Alternative 3 Potential Water Usage from Existing Wells (2020-2024).

Table 8.7 and Table 8.8 provide the estimated costs to produce water between 2020 and 2024 by utilizing Well 7 and treating for radionuclides at the WTP. The chemical costs are elevated for this short-term alternative since the higher levels of radionuclides in the blended raw water (blend of Wells 1, 6/8 and 7) may require a higher dosage of HMO. As discussed in Chapter 7, a pilot study was performed on the effectiveness of the IMAR^{TM} filter combined with the addition of HMO to remove radionuclides. The pilot study recommended using a dosage of 1.5 mg/L of HMO to directly treat the water from Well 7. The current dosage is about half of what was used in the pilot study. These factors contributed to give this alternative an estimated cost of $2.93 per 1,000 gallons of treated water.

Table 8.7 Short-Term Alternative 3 System O&M Projected Costs (2020-2024)

	2020	2021	2022	2023	2024	NPV (2020-2024)
Maintenance & Labor Costs	***$552,000***	***$566,000***	***$581,000***	***$597,000***	***$613,000***	***$2,700,000***
Purchased Water/Water Service Fees	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***
Chemical Costs						
Chlorine	$7,800	$8,200	$8,600	$9,000	$9,400	$40,000
Tonkazorb	$73,000	$76,000	$80,000	$83,000	$87,000	$370,000
Calgon C5 (LPC-5)	$6,800	$7,100	$7,400	$7,700	$8,100	$34,000
Calgon C9 (LPC-9)	$19,000	$19,000	$20,000	$21,000	$22,000	$94,000
Aqua Hawk 957	$13	$14	$15	$15	$16	$70
Chemicals Total	***$107,000***	***$110,000***	***$116,000***	***$121,000***	***$127,000***	***$538,000***
Electrical Costs						
Well 1	$1,000	$1,000	$1,100	$1,100	$1,100	$4,900
Well 3	$1,300	$1,400	$1,400	$1,400	$1,500	$6,000
Well 6	$17,000	$18,000	$18,000	$19,000	$19,000	$84,000
Well 7	$25,100	$25,800	$26,400	$27,100	$27,800	$123,000
Wells Other Usage (Heat, lights, etc.)	$2,000	$2,100	$2,100	$2,200	$2,200	$10,000
Wells Total	*$46,000*	*$48,000*	*$49,000*	*$51,000*	*$52,000*	*$228,000*
Water Tower Total	*$1,100*	*$1,100*	*$1,200*	*$1,200*	*$1,200*	*$5,400*
WTP Total	*$48,000*	*$50,000*	*$51,000*	*$53,000*	*$54,000*	*$237,000*
Electrical Total	***$95,000***	***$99,000***	***$101,000***	***$105,000***	***$107,000***	***$470,000***
Wastewater Discharge Fee (Volumetric @ $4.78/1,000 gal)	***$12,700***	***$13,400***	***$13,900***	***$14,500***	***$15,200***	***$65,0000***
Total Water Produced (MG)	***368***	***375***	***383***	***390***	***398***	***1,914***
Total O&M Costs	**$770,000**	**$790,000**	**$810,000**	**$840,000**	**$860,000**	**$3,800,000**

Table 8.8 Short-Term Alternative 3 Projected Costs Summary (2020-2024)

Capital Costs	
Capital Costs (Watermain Improvements & Contributions to Capital Reserves) (NPV, 2020 – 2024)	$1,800,000
Estimated Salvage Value (2019 Dollars)	$0
Total Capital Costs	*$1,800,000*
O&M Costs	
Maintenance & Labor Costs (NPV, 2020 – 2024)	$2,700,000
Purchased Water Cost (NPV, 2020-2024)	$0
WRT Service Fee (NPV, 2020-2024)	$0
Chemicals Costs (NPV, 2020 – 2024)	$538,000
Electrical Costs (NPV, 2020 – 2024)	$470,000
Wastewater Discharge Fees (NPV, 2020 – 2024)	$65,000
Total O&M Costs	*$3,800,000*
Total Capital and O&M Costs	*$5,600,000*
Total Water Pumped (MG, 2020-2024)	*1,914*
Water Cost ($/1,000 gallons)	***$2.93***

8.2.1 *Short-Term Alternative 4 – Utilize Well 7 / WRT Radium Removal at Well 7*

Similar to Short-Term Alternative 3, this alternative also utilizes Well 7. Instead of treating the water from Well 7 at the WTP, a radium removal treatment system provided by WRT and building would be constructed at Well 7. Well 7 water would be treated by the WRT system which would decrease radionuclides to levels below the maximum contaminant level (MCL), prior to delivery to the WTP where the Well 7 water would be blended with raw water from the other well sources and treated with the existing treatment process at the WTP. Figure 8.6 provides a chart detailing the estimated total percentage of water derived from each well between 2020 and 2024 for this alternative.

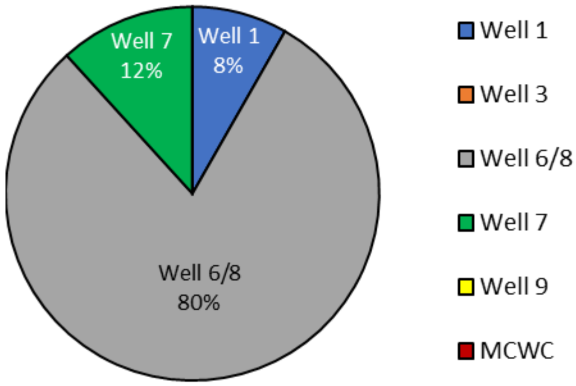


Figure 8.6 Short-Term Alternative 4 Potential Water Usage from Existing Wells (2020-2024)

Table 8.9 and Table 8.10 provide an estimate of the costs to produce water under this alternative between 2020 and 2024. The installation cost of the WRT system and the service fee of $1.20 per 1,000 gallons of water treated from Well 7 contribute to an estimated cost of $3.55 per 1,000 gallons of treated water.

Table 8.9 Short-Term Alternative 4 System O&M Projected Costs (2020-2024)

	2020	2021	2022	2023	2024	NPV (2020-2024)
Maintenance & Labor Costs	***$564,000***	***$578,000***	***$594,000***	***$610,000***	***$627,000***	***$2,700,000***
Purchased Water/Water Service Fees	***$52,000***	***$54,000***	***$57,000***	***$59,000***	***$62,000***	***$263,000***
Chemical Costs						
Chlorine	$7,800	$8,200	$8,600	$9,000	$9,400	$40,000
Tonkazorb	$33,000	$34,000	$36,000	$37,000	$39,000	$166,000
Calgon C5 (LPC-5)	$6,800	$7,100	$7,400	$7,700	$8,100	$34,000
Calgon C9 (LPC-9)	$19,000	$19,000	$20,000	$21,000	$22,000	$94,000
Aqua Hawk 957	$13	$14	$15	$15	$16	$70
Chemicals Total	***$67,000***	***$68,000***	***$72,000***	***$74,000***	***$79,000***	***$334,000***
Electrical Costs						
Well 1	$1,000	$1,000	$1,100	$1,100	$1,100	$4,900
Well 3	$1,300	$1,400	$1,400	$1,400	$1,500	$6,000
Well 6	$17,000	$18,000	$18,000	$19,000	$19,000	$84,000
Well 7	$25,100	$25,800	$26,400	$27,100	$27,800	$123,000
Wells Other Usage (Heat, lights, etc.)	$2,000	$2,100	$2,100	$2,200	$2,200	$10,000
Wells Total	*$46,000*	*$48,000*	*$49,000*	*$51,000*	*$52,000*	*$228,000*
Water Tower Total	*$1,100*	*$1,100*	*$1,200*	*$1,200*	*$1,200*	*$5,400*
WTP Total	*$48,000*	*$50,000*	*$51,000*	*$53,000*	*$54,000*	*$237,000*
Electrical Total	***$95,000***	***$99,000***	***$101,000***	***$105,000***	***$107,000***	***$470,000***
Wastewater Discharge Fee (Volumetric @ $4.78/1,000 gal)	***$12,700***	***$13,400***	***$13,900***	***$14,500***	***$15,200***	***$65,0000***
Total Water Produced (MG)	***368***	***375***	***383***	***390***	***398***	***1,914***
Total O&M Costs	**$790,000**	**$810,000**	**$840,000**	**$860,000**	**$890,000**	**$3,900,000**

Table 8.10 Short-Term Alternative 4 Projected Costs Summary (2020-2024)

Capital Costs	
Capital Costs (Watermain Improvements & Contributions to Capital Reserves) (NPV, 2020 – 2024)	$1,800,000
Capital – WRT Treatment Equipment & Building	*$2,700,000*
Estimated Salvage Value (2019 Dollars)	*$1,600,000*
Total Capital Costs	*$2,900,000*
O&M Costs	
Maintenance & Labor Costs (NPV, 2020 – 2024)	$2,800,000
Purchased Water Cost (NPV, 2020-2024)	$0
WRT Service Fee (NPV, 2020-2024)	$263,000
Chemicals Costs (NPV, 2020 – 2024)	$334,000
Electrical Costs (NPV, 2020 – 2024)	$470,000
Wastewater Discharge Fees (NPV, 2020 – 2024)	$65,000
Total O&M Costs	*$3,900,000*
Total Capital and O&M Costs	*$6,800,000*
Total Water Pumped (MG, 2020-2024)	*1,914*
Water Cost ($/1,000 gallons)	***$3.55***

8.2.1 *Short-Term Alternative 5 – Construct and Connect Well 9 to the WTP*

The City is currently in the process of developing Well 9. Although this well may or may not be able to produce enough to fully utilize the design capacity of the WTP, the combination of Wells 1, 6/8 and 9 may be able to produce enough water to meet the demand needs through 2024. Figure 8.7 provides a chart detailing the total percentage of water that may come from each well between 2020 and 2024 for this alternative.

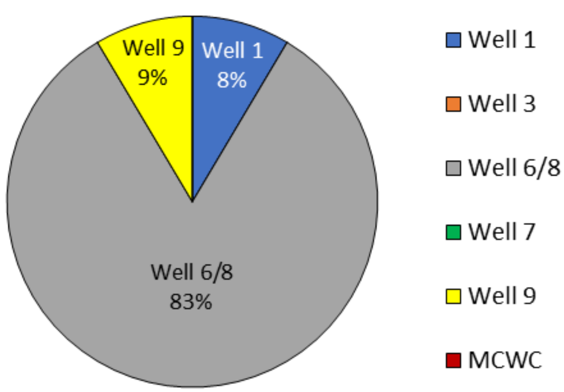


Figure 8.7 Short-Term Alternative 5 Potential Water Usage from Existing Wells (2020-2024)

Table 8.11 and Table 8.12 provide the estimated costs to produce water under Short-Term Alternative 5. The low cost of additional infrastructure and no purchase or service fees contribute to an estimated water cost of $2.93 per 1,000 gallons of treated water.

Table 8.11 Short-Term Alternative 5 System O&M Projected Costs (2020-2024)

	2020	2021	2022	2023	2024	NPV (2020-2024)
Maintenance & Labor Costs	***$555,000***	***$566,000***	***$581,000***	***$597,000***	***$613,000***	***$2,700,000***
Purchased Water/Water Service Fees	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***
Chemical Costs						
Chlorine	$7,900	$8,200	$8,600	$8,900	$9,000	$40,000
Tonkazorb	$33,000	$34,000	$36,000	$37,000	$38,000	$165,000
Calgon C5 (LPC-5)	$6,800	$7,100	$7,400	$7,700	$7,800	$34,000
Calgon C9 (LPC-9)	$18,600	$19,400	$20,400	$21,200	$21,400	$94,000
Aqua Hawk 957	$13	$14	$15	$15	$15	$70
Chemicals Total	***$66,000***	***$69,000***	***$72,000***	***$75,000***	***$76,000***	***$333,000***
Electrical Costs						
Well 1	$1,000	$1,100	$1,100	$1,100	$1,100	$5,000
Well 3	$1,300	$1,400	$1,400	$1,400	$1,500	$6,000
Well 6	$17,000	$18,000	$18,000	$19,000	$19,000	$84,000
Well 7	$2,400	$2,500	$2,500	$2,600	$2,700	$12,000
Well 9	$1,000	$1,000	$1,100	$1,100	$1,100	$5,000
Wells Other Usage (Heat, lights, etc.)	$2,000	$2,100	$2,100	$2,200	$2,200	$10,000
Wells Total	*$25,000*	*$26,000*	*$26,000*	*$27,000*	*$28,000*	*$122,000*
Water Tower Total	*$1,100*	*$1,100*	*$1,200*	*$1,200*	*$1,200*	*$5,400*
WTP Total	*$48,000*	*$50,000*	*$51,000*	*$53,000*	*$54,000*	*$237,000*
Electrical Total	***$74,000***	***$77,000***	***$78,000***	***$81,000***	***$83,000***	***$365,000***
Wastewater Discharge Fee (Volumetric @ $4.78/1,000 gal)	***$12,800***	***$13,300***	***$14,000***	***$14,500***	***$14,700***	***$64,0000***
Total Water Produced (MG)	***368***	***375***	***383***	***390***	***398***	***1,914***
Total O&M Costs	**$710,000**	**$730,000**	**$750,000**	**$770,000**	**$790,000**	**$3,500,000**

Table 8.12 Short-Term Alternative 4 Projected Costs Summary (2020-2024)

Capital Costs	
Capital Costs (Watermain Improvements & Contributions to Capital Reserves) (NPV, 2020 – 2024)	$1,800,000
Capital – New Well 9, Building, and Piping to WTP	*$600,000*
Estimated Salvage Value (2019 Dollars)	*$320,000*
Total Capital Costs	*$2,100,000*
O&M Costs	
Maintenance & Labor Costs (NPV, 2020 – 2024)	$2,700,000
Purchased Water Cost (NPV, 2020-2024)	$0
WRT Service Fee (NPV, 2020-2024)	$0
Chemicals Costs (NPV, 2020 – 2024)	$333,000
Electrical Costs (NPV, 2020 – 2024)	$365,000
Wastewater Discharge Fees (NPV, 2020 – 2024)	$64,000
Total O&M Costs	*$3,500,000*
Total Capital and O&M Costs	*$5,600,000*
Total Water Pumped (MG, 2020-2024)	*1,914*
Water Cost ($/1,000 gallons)	***$2.93***

8.2.1 *Summary of Short-Term Alternatives*

Figure 8.8 provides a comparison of the estimated costs per 1,000 gallons of treated water for all of the short-term alternatives. The "do nothing" option for the period between 2020 and 2024 provides the least expensive option at an estimated cost of $2.76 per 1,000 gallons of treated water. Although not a desirable option due to water discoloration from iron and manganese, the existing system option may require minimally treated water from Well 3 to be used to provide up to 10 percent of the total demand. Additionally, the full 2,000 gpm capacity of the WTP may not be fully utilized under the existing condition, unless Well 8 (when constructed) is operated at greater than 1,800 gpm.

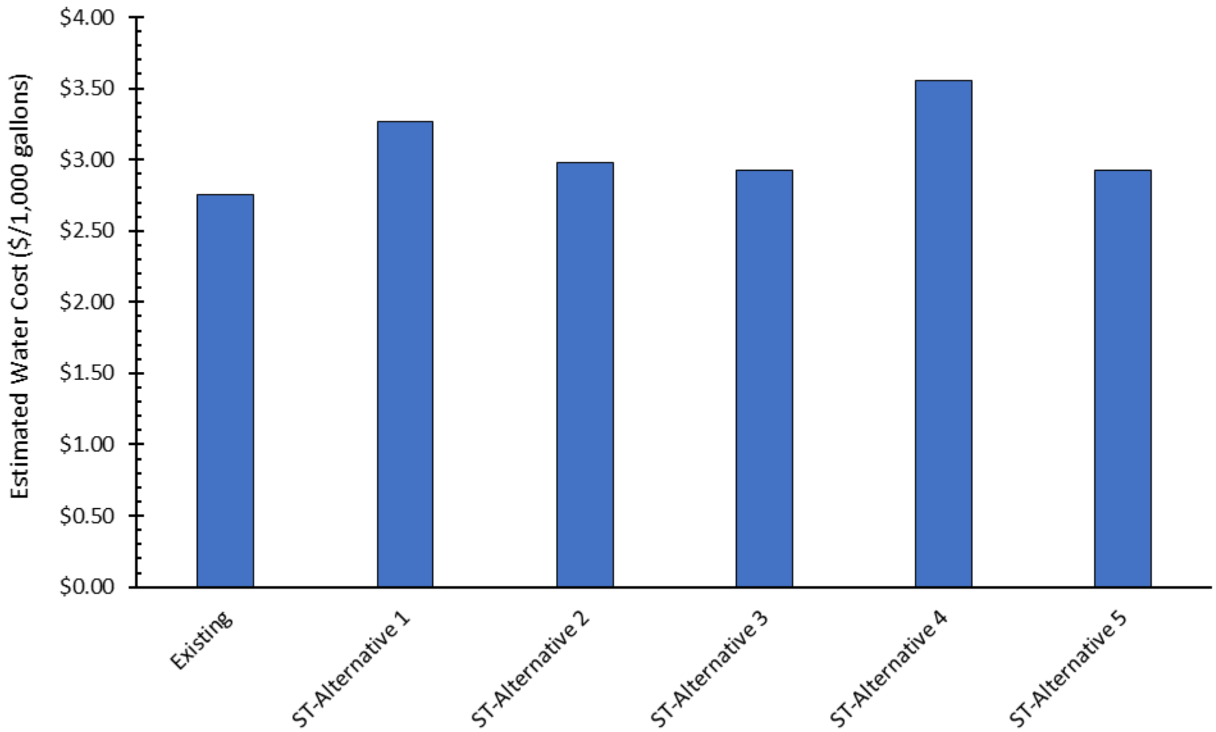


Figure 8.8 Cost Comparison between the Short-Term Alternatives

Short-Term Alternatives 3 and 5 (Well 7 no WRT, and Well 9) are the next most cost-effective options at approximately $2.93 per 1,000 gallons of treated water. Full-scale testing of the ability of the WTP to decrease the radionuclide concentrations from Well 7 (Short-Term Alternative 3) has not been attempted. Data from the pilot testing performed on Well 7 is available as a guide on how to dose HMO and the anticipated removal efficiencies that may result. The water from Well 7 would be blended with water from Wells 6 and 1, but there is still some uncertainty with the true radionuclide concentrations from Well 7. Short-Term Alternative 5 (construction of Well 9) would likely provide up to an additional 150 gpm with no detectable radionuclides which could further dilute any radionuclides concentrations coming from Wells 6/8. However, Well 9 may not have the ability to produce as much water as compared to Well 7, making Well 9 less able to provide overall source water redundancy.

Short-Term Alternative 2 (Treat water from Well 3 at the WTP) is estimated to cost $2.98 per 1,000 gallons of treated water. This alternative is attractive since Well 3 could provide added flexibility to operators as it can pump directly into the distribution system to meet higher demands than could flow through the WTP or to meet other emergencies should the plant be offline. Additionally, this well has radionuclide concentrations below the MCLs.

Short-Term Alternatives 1 and 4 both have a purchase or service fee associated with their use making these alternatives the least cost-effective. Short-Term Alternative 1 is estimated to cost $3.27 per 1,000 gallons of treated water, and Short-Term Alternative 4 is estimated to cost around $3.55 per 1,000 gallons of treated water. Although the cost is higher and the infrastructure would not be used after 5 years, Alternative 1 provides additional treated water that does not require treatment by the Brandon WTP, enabling a slightly better blended water quality, and an increased total treated water capacity, should other wells be constructed to utilize the capacity of the water treatment plant. The higher cost of Alternative 4 can be judged against its capability to remove radionuclides from Well 7, enabling usage of this well and avoid loss of capital that has been invested in this well.

Figure 8.9 summarizes how the addition of each new water source contributes to the amount of water that can be produced. Short-term Alternatives 2, 3, and 4 all have the ability to produce more water than the current treatment capacity of the WTP. Table 8.13 and Table 8.14 provides a summary of the costs for each of the short-term alternatives.

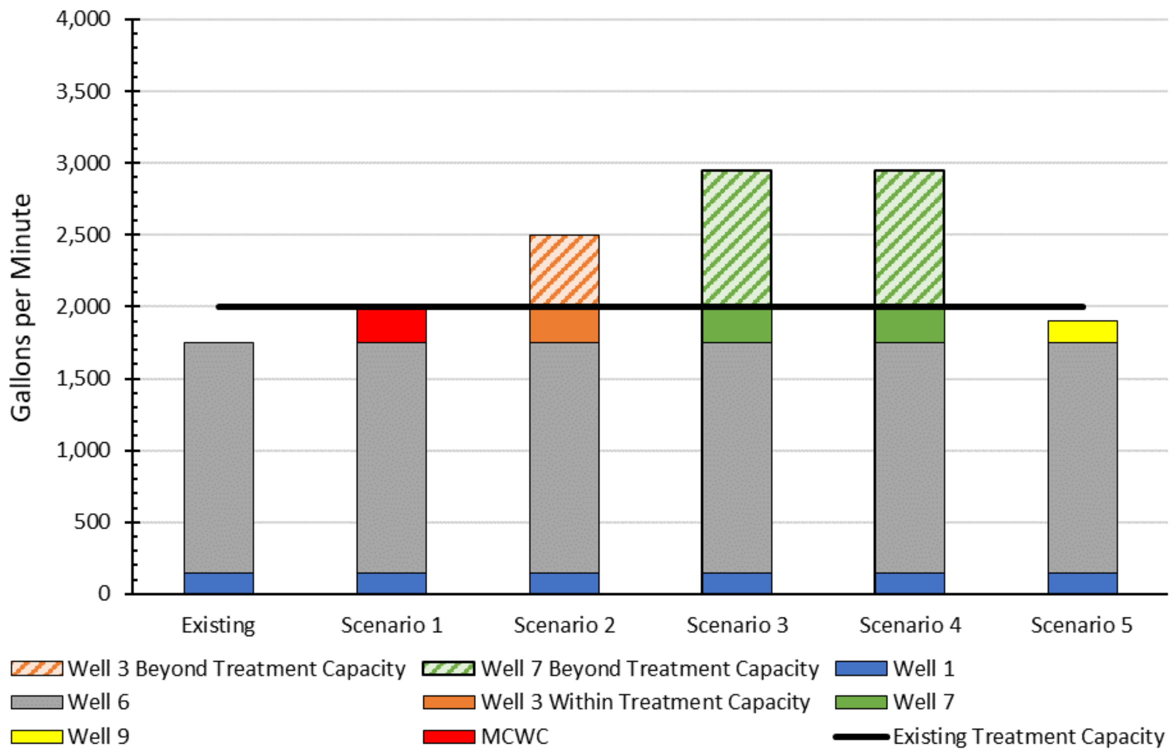


Figure 8.9 Summary of the Short-Term Alternative Well/MCWC Production Capacity versus Treatment Production Capacity

Table 8.13 Short-Term Alternatives Construction Costs Summary

Alternative	Estimated Capital Construction Costs	Estimated Salvage Value	Construction Costs minus Salvage Costs
Existing System	$0	$0	$0
Short-Term Alternative 1	$740,000	$140,000	$600,000
Short-Term Alternative 2	$1,100,000	$720,000	$380,000
Short-Term Alternative 3	$0	$0	$0
Short-Term Alternative 4	$2,700,000	$1,600,000	$1,100,000
Short-Term Alternative 5	$600,000	$320,000	$280,000

Table 8.14 Short-Term Alternatives Summary

Short-Term Alternatives Cost Summary	Purchase Water from MCWC	Pipe Well 3 to Well 7 Header	Utilizes Well 7	WRT Well 7 Treatment	Construct and Pipe Well 9 to the WTP	Construction Costs minus Salvage Costs	Rate Funded Capital	O&M Costs	Total Capital and O&M Costs	Total Water Pumped from WTP	Water Cost ($/1,000 gal)
Existing System	☒	☒	☒	☒	☒	$0	$1,800,000	$3,475,000	$5,275,000	1,914	*$2.76*
ST-Alternative 1	☑	☒	☒	☒	☒	$640,000	$1,800,000	$3,800,000	$6,200,000	1,914	*$3.24*
ST-Alternative 2	☒	☑	☒	☒	☒	$380,000	$1,800,000	$3,500,000	$5,700,000	1,914	*$2.98*
ST-Alternative 3	☒	☒	☑	☒	☒	$0	$1,800,000	$3,800,000	$5,600,000	1,914	*$2.93*
ST-Alternative 4	☒	☒	☑	☑	☒	$1,100,000	$1,800,000	$3,900,000	$6,800,000	1,914	*$3.55*
ST-Alternative 5	☒	☒	☒	☒	☑	$280,000	$1,800,000	$3,500,000	$5,600,000	1,914	*$2.93*

8.3 Long-Term Alternatives

In order to plan for the future water needs, eight long-term alternatives have been evaluated to provide water for the City of Brandon through 2045 with the ability to expand and provide water through 2070. The long-term alternatives utilize water from the Big Sioux and SRC aquifers and use the conventional treatment (HMO and IMAR^{TM} filter media) as well as alternatives that include Reverse Osmosis (RO), for hardness removal and to provide a redundant barrier to radionuclides, as well as an adsorptive radium removal system provided by WRT. Figure 8.10 provides the projected yearly water demands between 2020 and 2045.

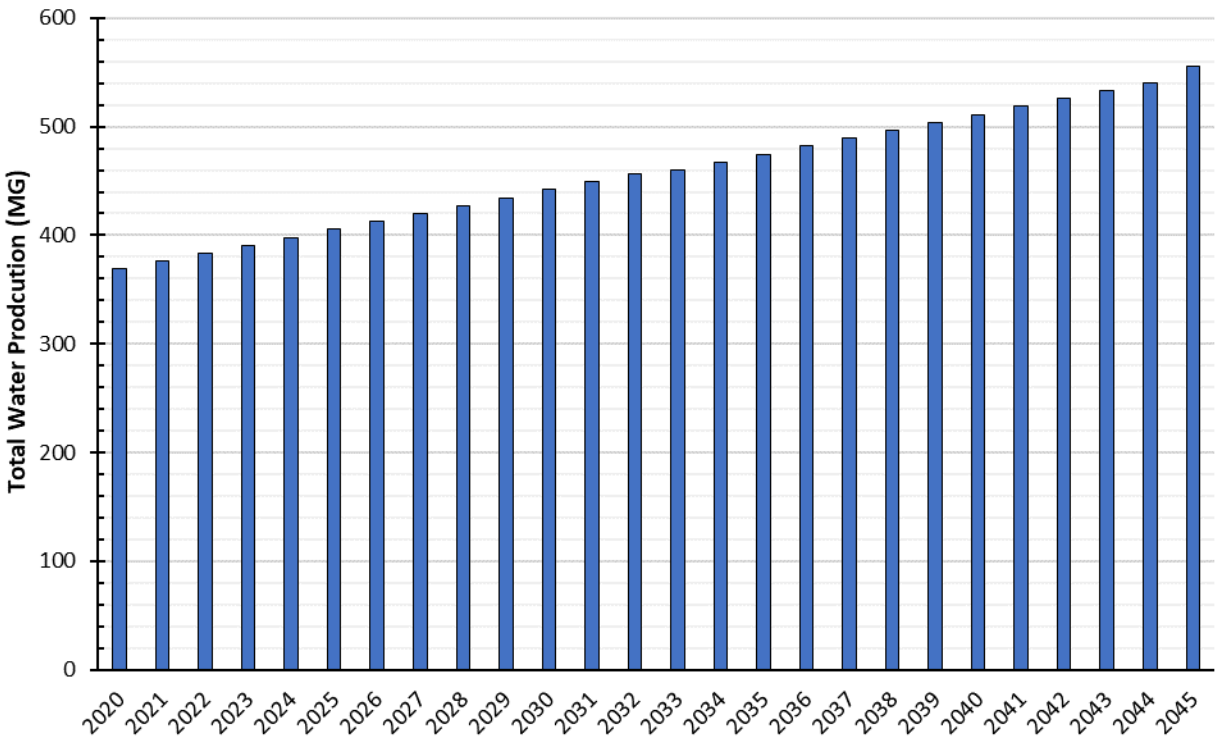


Figure 8.10 Total Projected Water Produced per Year (2020-2045)

The following sections provide the net present values of the opinions of probable construction costs for each alternative, as well as installation phasing of the improvements associated with each alternative. Supplemental information regarding operation and maintenance costs were obtained from City financial records and quotes from various vendors were used to support capital cost estimates. The following assumptions were made in the development of the capital costs, O&M costs, and rate impacts:

- Water source infrastructures (wells, raw water piping) were added when the anticipated maximum day demands reach 80 percent of the firm production capacity of the wells.
- All costs are assumed to increase with inflation, which is assumed to increase annually at a rate of 2.5 percent.

- Additional maintenance and labor costs are assumed to be 0.5 percent of the cost of all new infrastructure.
- Smaller capital improvements are paid from cash reserves when possible.
- Larger capital improvements are paid through SRF funding at a 3 percent annual percentage rate (APR) over 20 years.
- Debt coverage of 10 percent was used, meaning annual net revenue must be greater than 10 percent of the annual debt payments.
- Cash reserves must be sufficient to cover one years' debt payments at all times.
- Cash reserves must be greater than the 6-months' operating budget.
- Additional cash reserves beyond meeting the loan requirements are used to pay down the principal on outstanding loan balances.

The net present values of the total O&M costs for each year are also provided in the following sections. Chemical costs, dosage rates, electrical rates, and assumptions are supplied in Appendix B. Detailed financial analysis summaries are provided in separate supplemental document to this report.

8.3.1 *Long-Term Alternative 1A – Develop Big Sioux and SRC Aquifers / Existing Treatment Approach*

The opinion of probable project costs for Alternative 1A is summarized in Table 8.15. The total project cost between 2020 and 2045 would be approximately $38,300,000 for Alternative 1A.

Table 8.15 Opinion of Total Probable Project Costs for Alternative 1A

Operating Costs (NPV, 2020-2045)		Average Annual O&M
Electrical	$2,600,000	
Chemical	$2,100,000	
WRT Service Fee	$0	
Disposal Costs	$100,000	
Maintenance and Labor Costs	$17,900,000	
O&M Subtotal	*$22,700,000*	*$1,222,000*
Capital Costs (NPV, 2020-2045)	2019 Dollars	Average Annual Capital Improvement Costs*
CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - Installed 2019	$600,000	
CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - Installed 2023	$1,300,000	
CI-3 – Phase 2 Parallel Piping (Big Sioux Option) - Installed 2043	$300,000	
CI-4 – Well #8 and Connection - Installed 2019	$1,300,000	
CI-5 – (4) New Big Sioux Wells and related piping – Installed 2023	$2,800,000	
CI-6 – New WTP (Existing Approach) – Installed 2023	$9,300,000	
Capital Costs Subtotal	*$15,600,000*	*$529,000*
Total Capital and O&M Costs	**$38,300,000**	**$1,751,000**

*Average annual total debt and cash payments for improvements

8.3.2 *Long-Term Alternative 1B – Develop the Big Sioux Aquifer / Existing Treatment Approach / WRT Radium Removal at Well 7*

The opinion of probable project costs for Alternative 1B is summarized in Table 8.16. Since Alternative 1B uses a treatment technology at Well 7, which has a service fee associated with its use, two potential cost options exist. Alternative 1B assumes Well 7 is used minimally to only meet peak demands. Alternative 1B(2) assumes Well 7 will be utilized as a primary well. The present value of total project cost between 2020 and 2045 would be approximately $41,000,000 for Alternatives 1B and $46,200,000 for Alternative 1B(2).

Table 8.16 Opinion of Total Probable Project Costs for Alternatives 1B

Operating Costs (NPV, 2020-2045)	Alternative 1B	Average Yearly	Alternative 1B(2)	Average Yearly
Electrical	$2,600,000		$2,900,000	
Chemical	$2,000,000		$2,000,000	
WRT Service Fee	$100,000		$5,000,000	
Disposal Costs	$100,000		$100,000	
Maintenance and Labor Costs	$17,900,000		$17,900,000	
O&M Subtotal	*$22,700,000*	*$1,231,000*	*$27,900,000*	*$1,529,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Improvement Costs*		Average Annual Capital Improvement Costs*
CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - Installed 2019	$600,000		$600,000	
CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - Installed 2023	$1,300,000		$1,300,000	
CI-3 – Phase 2 Parallel Piping (Big Sioux Option) -Installed 2043	$300,000		$300,000	
CI-4 – Well #8 and Connection - Installed 2019	$1,300,000		$1,300,000	
CI-5 – (4) New Big Sioux Wells and related piping – Installed 2023	$2,800,000		$2,800,000	
CI-6 – New WTP (Existing Approach) – Installed 2023	$9,300,000		$9,300,000	
CI-7 – New WRT Radium Removal System at Well 7 – Installed 2023	2,700,000		2,700,000	
Capital Costs Subtotal	*$18,300,000*	*$948,000*	*$18,300,000*	*$948,000*
Total Capital and O&M Costs	**$41,000,000**	**$2,179,000**	**$46,200,000**	**$2,477,000**

*Average annual total debt and cash payments for improvements

8.3.1 *Long-Term Alternative 1C – Develop the Big Sioux and SRC Aquifers / Existing Treatment Approach Plus RO*

The opinion of probable project costs for Alternative 1C is summarized in Table 8.17. The present value of total project cost between 2020 and 2045 would be approximately $51,400,000 for Alternative 1C.

Table 8.17 Opinion of Total Probable Project Costs for Alternatives 1C

Operating Costs (NPV, 2020-2045)	NPV	Average Yearly
Electrical	$4,300,000	
Chemical	$3,700,000	
WRT Service Fee	$100,000	
Disposal Costs	$100,000	
Maintenance and Labor Costs	$19,700,000	
O&M Subtotal	*$27,900,000*	*$1,532,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Improvement Costs*
CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - Installed 2019	$600,000	
CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - Installed 2023	$1,300,000	
CI-3 – Phase 2 Parallel Piping (Big Sioux Option) - Installed 2043	$300,000	
CI-4 – Well #8 and Connection - Installed 2019	$1,300,000	
CI-5 – (4) New Big Sioux Wells and related piping – Installed 2023	$2,800,000	
CI-8 – New WTP (Existing Approach with RO) – Installed 2023	$17,200,000	
Capital Costs Subtotal	*$23,500,000*	*$1,242,000*
Total Capital and O&M Costs	**$51,400,000**	**$2,774,000**

*Average annual total debt and cash payments for improvements.

8.3.2 *Long-Term Alternative 1D – Develop the Big Sioux and SRC Aquifer*

The opinion of probable project costs for Alternative 1D is summarized in Table 8.18. Since Alternative 1D uses a treatment technology at Well 7, which has a service fee associated with its use, two potential cost options exist. Alternative 1D assumes Well 7 is used minimally to only meet peak demands. Alternative 1D(2) assumes Well 7 will be utilized as a primary well. The present value of total project cost between 2020 and 2045 would be approximately $53,900,000 for Alternatives 1D and $62,100,000 for Alternative 1D(2).

Table 8.18 Opinion of Total Probable Project Costs for Alternatives 1D

Operating Costs (NPV, 2020-2045)	Alternative 1D	Average Yearly	Alternative 1D(2)	Average Yearly
Electrical	$4,300,000		$4,800,000	
Chemical	$3,200,000		$3,200,000	
WRT Service Fee	$200,000		$7,900,000	
Disposal Costs	$100,000		$100,000	
Maintenance and Labor Costs	$19,900,000		$19,900,000	
O&M Subtotal	*$27,700,000*	*$1,521,000*	*$35,900,000*	*$1,988,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Imp. Costs*		Average Annual Capital Imp Costs*
CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - Installed 2019	$600,000		$600,000	
CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - Installed 2023	$1,300,000		$1,300,000	
CI-3 – Phase 2 Parallel Piping (Big Sioux Option) -Installed 2043	$300,000		$300,000	
CI-4 – Well #8 and Connection - Installed 2019	$1,300,000		$1,300,000	
CI-5 – (4) New Big Sioux Wells and related piping – Installed 2023	$2,800,000		$2,800,000	
CI-7 – New WRT Radium Removal System at Well 7 – Installed 2023	2,700,000		2,700,000	
CI-8 – New WTP (Existing Approach with RO) – Installed 2023	$17,200,000		$17,200,000	
Capital Costs Subtotal	*$26,200,000*	*$1,397,000*	*$26,200,000*	*$1,397,000*
Total Capital and O&M Costs	**$53,900,000**	**$2,918,000**	**$62,100,000**	**$3,385,000**

*Average annual total debt and cash payments for improvements.

8.3.1 *Long-Term Alternative 2A – Develop SRC Aquifer with Existing Treatment Approach*

The opinion of probable project costs for Alternative 2A is summarized in Table 8.19. The total project cost between 2020 and 2045 would be approximately $35,540,000 for Alternative 2A.

Table 8.19 Opinion of Total Probable Project Costs for Alternatives 2A

Operating Costs (NPV, 2020-2045)		Average Yearly
Electrical	$2,700,000	
Chemical	$2,500,000	
WRT Service Fee	$0	
Disposal Costs	$100,000	
Maintenance and Labor Costs	$17,500,000	
O&M Subtotal	*$22,800,000*	*$1,236,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Improvement Costs*
CI-4 – Well #8 and Connection – Installed 2019	$1,300,000	
CI-6 – New WTP (Existing Approach) – Installed 2023	$9,300,000	
CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) – Installed 2019	$540,000	
CI-10 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option) – Installed 2023	$1,600,000	
Capital Costs Subtotal	*$12,740,000*	*$646,000*
Total Capital and O&M Costs	**$35,540,000**	**$1,882,000**

*Average annual total debt and cash payments for improvements.

8.3.1 *Long-Term Alternative 2B – Develop the SRC Aquifer / Existing Treatment Approach / WRT Radium Removal at Well 7*

The opinion of probable project costs for Alternative 2B is summarized in Table 8.20. Since Alternative 2B uses a treatment technology at Well 7, which has a service fee associated with its use, two potential cost options exist. Alternative 2B assumes Well 7 is used minimally to only meet peak demands. Alternative 2B(2) assumes Well 7 will be utilized as a primary well. The present value of total project cost between 2020 and 2045 would be approximately $38,440,000 for Alternative 2B and $47,500,000 for Alternative 2B(2).

Table 8.20 Opinion of Total Probable Project Costs for Alternatives 2B

Operating Costs (NPV, 2020-2045)	Alternative 2B	Average Yearly	Alternative 2B(2)	Average Yearly
Electrical	$2,700,000		$2,900,000	
Chemical	$2,500,000		$3,100,000	
WRT Service Fee	$100,000		$8,500,000	
Disposal Costs	$100,000		$100,000	
Maintenance and Labor Costs	$17,500,000		$17,500,000	
O&M Subtotal	*$22,900,000*	*$1,238,000*	*$32,100,000*	*$1,770,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Imp. Costs*		Average Annual Capital Imp. Costs*
CI-4 – Well #8 and Connection – Installed 2019	$1,300,000		$1,300,000	
CI-6 – New WTP (Existing Approach) – Installed 2023	$9,300,000		$9,300,000	
CI-7 – New WRT Radium Removal System at Well 7 – Installed 2023	$2,700,000		$2,700,000	
CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) – Installed 2019	$540,000		$540,000	
CI-10 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option) – Installed 2023	$1,600,000		$1,600,000	
Capital Costs Subtotal	*$15,540,000*	*$801,000*	*$15,540,000*	*$801,000*
Total Capital and O&M Costs	**$38,440,000**	**$2,039,000**	**$47,500,000**	**$2,571,000**

*Average annual total debt and cash payments for improvements.

8.3.1 *Alternative 2C – Develop the SRC Aquifer / Existing Treatment Approach with RO.*

The opinion of probable project costs for Alternative 2C is summarized in Table 8.21. The present value of total project cost between 2020 and 2045 would be approximately $51,240,000 for Alternative 2C.

Table 8.21 Opinion of Total Probable Project Costs for Alternatives 2C

Operating Costs (NPV, 2020-2045)		Average Yearly
Electrical	$4,400,000	
Chemical	$3,900,000	
WRT Service Fee	$0	
Disposal Costs	$100,000	
Maintenance and Labor Costs	$19,700,000	
O&M Subtotal	*$28,100,000*	*$1,536,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Improvement Costs*
CI-4 – Well #8 and Connection – Installed 2019	$1,300,000	
CI-8 – New WTP (Existing Approach with RO) – Installed 2023	$17,200,000	
CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) – Installed 2019	$540,000	
CI-11 - (1) New SRC Well – Installed 2043	$1,500,000	
CI-12 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option with RO) – Installed 2023	$1,600,000	
CI-13 – Phase 2 Parallel Piping (SRC Option with RO) – Installed 2043	$1,000,000	
Capital Costs Subtotal	*$23,140,000*	*$1,105,000*
Total Capital and O&M Costs	**$51,240,000**	**$2,641,000**

*Average annual total debt and cash payments for improvements.

8.3.1 *Long-Term Alternative 2D – Alternative 2B – Develop the SRC Aquifer / Existing Treatment Approach / WRT Radium Removal at Well 7*

The opinion of probable project costs for Alternative 2D is summarized in Table 8.22. Since Alternative 2D uses a treatment technology at Well 7, which has a service fee associated with its use, two potential cost options exist. Alternative 2D assumes Well 7 is used minimally to only meet peak demands. Alternative 2D(2) assumes Well 7 will be utilized as a primary well. The present value of total project cost between 2020 and 2045 would be approximately $54,340,000 for Alternatives 2D and $63,240,000 for Alternative 2D(2).

Table 8.22 Opinion of Total Probable Project Costs for Alternatives 2D

Operating Costs (NPV, 2020-2045)	Alternative 2D	Average Yearly	Alternative 2D(2)	Average Yearly
Electrical	$4,400,000		$4,800,000	
Chemical	$3,900,000		$3,700,000	
WRT Service Fee	$200,000		$8,900,000	
Disposal Costs	$100,000		$100,000	
Maintenance and Labor Costs	$19,900,000		$19,900,000	
O&M Subtotal	*$28,500,000*	*$1,573,000*	*$37,400,000*	*$2,074,000*
Capital Costs (NPV, 2020-2045)		Average Annual Capital Improvement Costs*		Yearly Debt Payments*
CI-4 – Well #8 and Connection – Installed 2019	$1,300,000		$1,300,000	
CI-7 – New WRT Radium Removal System at Well 7 – Installed 2023	$2,700,000		$2,700,000	
CI-8 – New WTP (Existing Approach with RO) – Installed 2023	$17,200,000		$17,200,000	
CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) – Installed 2019	$540,000		$540,000	
CI-11 - (1) New SRC Well – Installed 2043	$1,500,000		$1,500,000	
CI-12 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option with RO) – Installed 2023	$1,600,000		$1,600,000	
CI-13 – Phase 2 Parallel Piping (SRC Option with RO) – Installed 2043	$1,000,000		$1,000,000	
Capital Costs Subtotal	*$25,840,000*	*$1,261,000*	*$25,840,000*	*$1,261,000*
Total Capital and O&M Costs	**$54,340,000**	**$2,834,000**	**$63,240,000**	**$3,335,000**

*Average annual total debt and cash payments for improvements.

8.3.1 *Summary of the Long-Term Alternatives*

The estimated present value costs of long-term alternatives were evaluated under a planning period between 2020 and 2045. As a part of this study, the estimated rate impacts were also evaluated.

Figure 8.11 summarizes the estimated yearly water rates for each of the long-term alternatives. The current cost in Brandon for a 6,000-gallon bill from a 1-inch or smaller meter would be $35, and all of the rate impact curves start at that rate. As a basis for comparison, the black line in Figure 8.11 provides a trend showing a 2.5% rate adjust for inflation. The remaining curves can be used to compare the rate impacts of each alternative assuming no other infrastructure improvements (such as tower construction, single pressure zone implementation costs, or core area distribution system improvements) are paid by the water bill. The combined rate impacts of these non-water source and treatment improvements are discussed in Chapter 10. Table 8.23 provides a summary of the long-term alternatives and their estimated rate impacts.

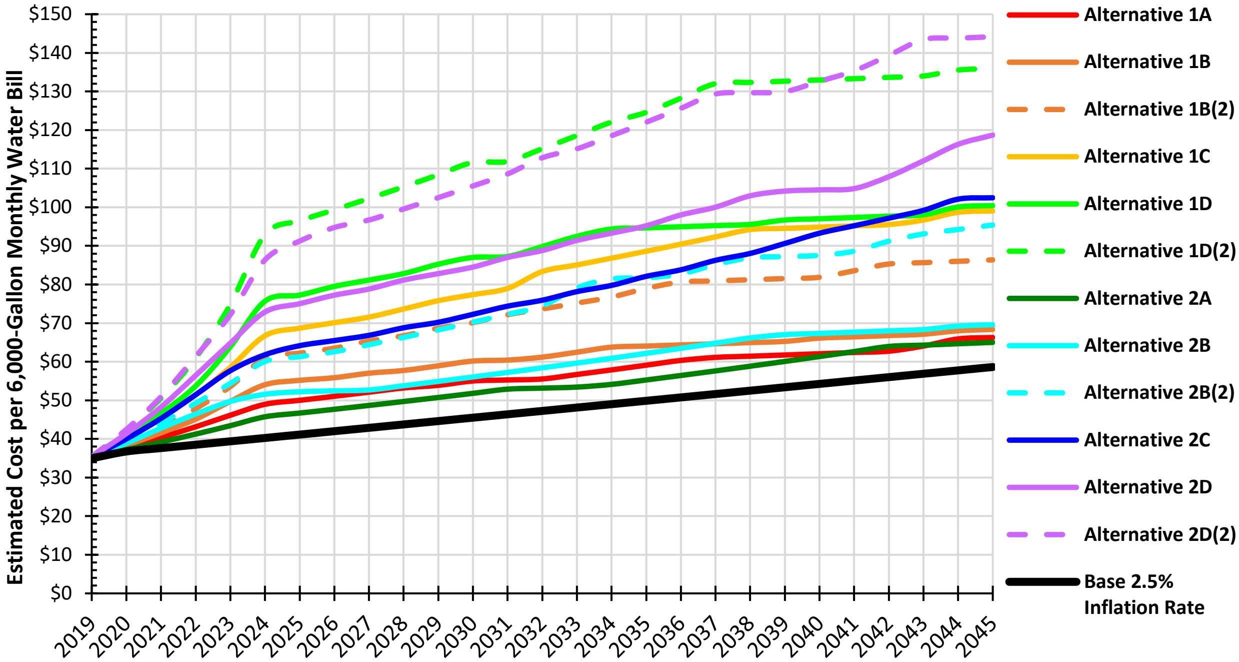


Figure 8.11 Estimated Rate Impacts for each of the Long-Term Alternatives without the (2) 1.25 MG Elevated Water Towers

Table 8.23 Long-Term Alternatives Estimated Costs and Rate Impacts Summary

Long-Term Alternatives Cost Summary	Wells		Treatment			Construction Costs ($ Million)	O&M Costs ($ Million)	Total Capital & O&M Costs (NPV, 2020-2045) ($ Million)	Estimated Average 6,000-gallon Water Bill
	Develop New Big Sioux & SRC Wells	Develop New SRC Wells Only	WRT Radium Removal at Well 7	Existing WTP Treatment Approach Only	Existing WTP Treatment Approach with RO				
LT-Alt 1A	☑	☒	☒	☑	☒	$15.6	$22.7	$38.3	*$54*
LT-Alt 1B	☑	☒	☑	☑	☒	$18.3	$22.7 - $29.1	$41.0- $47.4	*$60 - $69*
LT-Alt 1C	☑	☒	☒	☒	☑	$23.5	$27.9	$51.4	*$80*
LT-Alt 1D	☑	☒	☑	☒	☑	$26.2	$27.7 - $35.9	$53.9 - $62.1	*$88 - $111*
LT-Alt 2A	☒	☑	☒	☑	☒	$12.7	$22.8	$35.5	*$50*
LT-Alt 2B	☒	☑	☑	☑	☒	$15.5	$22.9 - $32.1	$38.4 - $47.6	*$55 - $72*
LT-Alt 2C	☒	☑	☒	☒	☑	$23.1	$28.1	$51.2	*$73*
LT-Alt 2D	☒	☑	☑	☒	☑	$25.8	$28.5 - $37.4	$54.4 - $63.3	*$82 - $105*

8.4 Overall Comparison and Recommended Alternative

Cost and non-cost factors may be considered when comparing alternatives and choosing a preferred alternative. In this study, the K-T tool was used to score the non-cost characteristics of each alternative (Chapter 7), and the cost characteristics were developed in Chapter 8.

The K-T scores that were summarized in Chapter 7 were combined with the present value of the estimated capital and O&M Costs for each of the eight alternatives to calculate composite alternative ranking scores. Since the alternatives that use the WRT radium removal treatment (Alternatives 1B, 1D, 2B, and 2D) have a service fee associated with the usage of Well 7 and can utilize Well 7 at different rates, two options of composite rankings exist. Table 8.24 provides the composite rankings for the lowest use of Well 7 for the WRT alternatives, while Table 8.25 provides the composite rankings for the highest use of Well 7 for the WRT alternatives.

Table 8.24 K-T Composite Rankings for Alternatives Assuming Low Well 7 WRT Usage

	1A	1B	1C	1D	2A	2B	2C	2D
KT Scoring Total	8,234	8,883	8,166	8,373	8,829	9,478	8,782	8,989
KT Performance Score	1.01	1.09	1.00	1.03	1.08	1.16	1.08	1.10
Present Value Cost ($ Million)	*$38.3*	*$41.0*	*$51.4*	*$53.9*	*$35.5*	*$38.4*	*$51.2*	*$54.4*
Cost Performance Score	0.70	0.75	0.94	0.99	0.65	0.71	0.94	1.00
Composite Rank	**1.43**	**1.44**	**1.06**	**1.03**	**1.66**	**1.64**	**1.14**	**1.10**

Table 8.25 K-T Composite Rankings for Alternatives Assuming Highest Well 7 WRT Usage

	1A	1B	1C	1D	2A	2B	2C	2D
KT Scoring Total	8,234	8,883	8,166	8,373	8,829	9,478	8,782	8,989
KT Performance Score	1.01	1.09	1.00	1.03	1.08	1.16	1.08	1.10
Present Value Cost ($ Million)	*$38.3*	*$47.4*	*$51.4*	*$62.1*	*$35.5*	*$47.6*	*$51.2*	*$63.3*
Cost Performance Score	0.61	0.75	0.81	0.98	0.56	0.75	0.81	1.00
Composite Rank	**1.67**	**1.45**	**1.23**	**1.05**	**1.93**	**1.54**	**1.33**	**1.10**

The cost performance score is calculated by dividing the present value cost of an alternative by the present value of the highest cost alternative. For example, in Table 8.24, the present value cost of the lowest cost, Alternative 2A, is 0.65 (65%) of the highest cost, Alternative 2D. The KT performance score is calculated by dividing the KT score total of an alternative by the lowest alternative KT score. For example, in Table 8.24, the KT score of the highest-ranking Alternative 2B was 1.16 (116%) of the KT score of the lowest scoring Alternative 1C. The composite score (rank) is calculated by dividing the KT performance score by the cost performance score. The composite score calculation approach gives equal weight to the non-cost (KT) performance score and the cost performance score. If there is a large cost difference between alternatives and a relatively small non-cost score difference, the costs will dominate the composite ranking.

The composite scores for Alternatives 2A through 2D (developing the Split Rock Creek Aquifer) earned higher composite scores than Alternatives 1A through 1D (developing the Big Sioux

Aquifer supplemented with Split Rock Creek). The higher composite scores were influenced by lower costs (for the 2A and 2B options) and by higher KT scores for the Split Rock Creek Aquifer alternatives.

The alternative with the highest composite ranking for both high and low usage of Well 7 was Alternative 2A, with a composite score of 1.66 for the low use and 1.93 for the high use scenarios. The alternative with the highest K-T performance score, Alternative 2B, ranked second for its composite score under the minimal use of Well 7 scenarios and Alternative 1A ranked second under the maximum Well 7 usage scenarios.

If Well 7 were to be utilized at a high rate, the present value costs are more similar to the SRC alternatives with RO (Alternative 2C). Alternative 2C also scored favorably on the K-T performance score since the RO system provides an added barrier to radium removal as well as softer water for the community.

Alternative 2A represents an expansion of the existing water treatment plant without any additional treatment barrier for radionuclide removal (WRT or RO) or softening (RO). Although the existing treatment process meets the requirements of the Safe Drinking Water Act, it does not improve the quality of water to the water customers in Brandon as does Alternatives B and C. Although the costs are greater than the lowest cost Alternative (2A) that utilizes the Split Rock Creek aquifer, it is recommended the City of Brandon pursue either Alternative 2B or 2C since both provide added treatment barriers for contaminants. The major difference is the 2C alternative provides softer water for the residents of Brandon and can provide a redundant barrier to other unknown or future contaminants.

Chapter 9 FINANCIAL EVALUATION

This study has allowed the City to evaluate its current water production capacity and plan for future water needs, as well as other infrastructure needs. The City current needs, at a minimum, additional water sources to provide redundant source supply as well as additional storage to provide adequate fire, emergency and equalization storage. In order for the City to continue to grow, the WTP will need to be expanded as well as other updates to the distribution system. This section summarized the estimated costs for all of the improvements the City needs to make as well as the potential impact the improvements may have on the current and future water rates.

9.1 Financial Parameters and Assumptions

Through meetings with the City staff, AE2S was able to compile a list of assumptions and financial parameters used to estimate the impacts the preferred alternatives may have on the future water rates. The following parameters were used:

- 6-months' operating budget is kept in a cash reserve at all times
- The total sum of debt payments is less than the cash reserve at all times
- Projects funded at 3 percent APR for 20 years when cash reserves are not sufficient to cover the costs of new projects.
- Rushmore and core improvement projects will be financed at 15 years at 3 percent APR.
- Additional 10% coverage applied to all loan balances, meaning revenue must be greater than 10 percent of the total debt payments.
- Non-operating revenue from cell towers will not be continued past 2020 with the install of the new tower(s).
- Well 8 paid for with cash
- Personnel services baseline equals $425,000 scaled up for inflation.
- Other Current Expenses = $216,677 base scaled up for inflation and with a 0.5% increase based on all new infrastructure.
- Smaller construction projects are paid for with cash if the previously mentioned financial requirements are met.
- Finances are allocated in such a way as to reduce the water rate as much as possible.
- Inflation assumed to be 2.5% annually, (2.469%) calculated from the average US inflation rate between 1990 and 2018.

Additional financial parameters for determining the other costs are covered in greater detail in Appendix B.

9.2 Estimated Projects Costs

Through discussions with the City staff and the WDC using the K-T® decision-making process and cost considerations, Long-Term alternatives 2B and 2C were viewed as favorable alternatives for expansion of source and treatment production capabilities. It is assumed that one of these alternatives will be chosen for implementation. The elements of these alternatives, including the estimated capital cost and year of installation, are shown in Table 9.1. In addition to the listed improvements, a new Split Rock Creek well and its associated piping would be constructed between 2040 and 2045. The estimated costs for these improvements are approximately $2,500,000 in 2019 dollars. These costs are not included in Table 9.1 due to negligible impacts on near-term rates.

Table 9.1 5-Year Capital Costs Summaries for Alternatives 2B and 2C

	Capital Improvement	Year Implemented	Cost (2019 Dollars)
Alternative 2B	CI-4 – Well #8 and Connection[1]	2019	$1,300,000
	CI-6 – New WTP (Existing Approach)	2023	$9,300,000
	CI-7 – New WRT Radium Removal System at Well 7	2020-2023	$2,700,000
	CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option)	2019	$540,000
	CI-10 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option)	2020-2023	$1,600,000
	Alternative 2B 5-Year Capital Costs Subtotal		$15,440,000
Alternative 2C	CI-4 – Well #8 and Connection[1]	2019	$1,300,000
	CI-8 – New WTP (Existing Approach with RO)	2023	$17,200,000
	CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option)	2019	$540,000
	CI-11 – (1) New SRC Well[2]	2040-2045	-
	CI-12 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option with RO)	2020-2023	$1,600,000
	CI-13 – Phase 2 Parallel Piping (SRC Option with RO)[2]	2040-2045	-
	Alternative 2B 5-Year Capital Costs Subtotal		$20,540,000

[1]Item not financed, paid for with cash.
[2]Item not constructed during the 5-year time period.

In addition to either Alternative 2B or 2C, the City has planned to make distribution system improvements to the core and Rushmore areas with a capital cost of approximately $5,000,000. These distribution system improvements are expected to be phased over a period of 5 years, incrementally adding approximately $85,000 of annual debt service per phase beginning in 2021, accumulating to a total annual debt service from the water fund of $425,000 per year by 2025. The City also plans to add two additional 1.25 MG water towers as well and are anticipating construction in 2020 and costing an estimated $9,700,000 and incurring an annual debt payment from the water fund of $653,000.

The City can choose how the major capital improvements are financed but likely would use either bonding or the South Dakota Drinking Water Program State Revolving Fund loans to fund the capital improvements. It is assumed the City would need to establish an income stream with excess funds equivalent to 10% of the loan amount as annual coverage to satisfy the requirements of the lending institutions. Table 9.2 summarizes the costs of the projects currently planned to be implemented by the City within the next five years. The annual debt payments stated in Table 9.2 for each project assumes the entire capital cost is funded by a single loan, and the interest rate and loan term shown in the corresponding columns in Table 9.2. The actual annual debt payment will depend on phasing and financing at the time each individual source/treatment alternative is implemented.

Table 9.2 Future 5-Year Financed Projects and Estimated Capital Costs

Project	Estimated Capital Cost ($ Million)	Year Installed	Loan Interest	Loan Term (Years)	Annual Debt Payment	Annual Coverage
Alternative 2B[3]	$15.5	2023	3%	20	$1,042,000[1]	$104,200
Alternative 2C[3]	$20.5	2023	3%	20	$1,378,000[1]	$137,800
Core & Rushmore Improvements	$5.0	2021-2025	3%	15	$425,000[2]	$42,500
(2) New 1.25 MG Water Towers	$9.7	2020	3%	20	$653,000[1]	65,300

[1]Annual debt payment at 3% APR and 20 years
[2]Annual debt payment at 3% APR and 15 years
[3]Only *one* treatment/source alternative will be selected.

9.3 Rate Impacts

Capital improvements and associated O&M costs may have a significant impact on Brandon's future water rates. Figure 9.1 provides a graph showing the potential water rate impacts of financing different amounts for 20 years at a 3-percent APR loan. The black line represents the current (2019) water rate, while the orange and blue lines represent the 2019 adjusted rate values required to meet the annual loan payments and the 10-percent loan coverage. The orange line represents a source/treatment alternative with a high O&M cost (RO, and high Well 7 with WRT utilization), while the blue line represents a source/treatment alternative with a low O&M cost (existing treatment approach). As shown by the intersection of the blue line and the black line in Figure 9.1, if the existing treatment approach is assumed for future water treatment improvements, the current water rate can support an additional $9 million dollars financed over 20 years at a 3 percent APR without requiring any rate adjustment. If a more O&M intensive approach is assumed (orange line), the current water rate can support an additional $2 million dollars of financed capital improvements.

Depending on the total capital improvements financed and the associated O&M that would be funded by the water rates, if the rate is above the orange line, a cash surplus would likely exist, while a cash deficit would likely occur if the rate were below the blue line.

Financing different capital improvements associated with each long-term alternative will have a range of impacts on Brandon's water rate required to fund the improvements. Using the assumptions outlined in Section 9.1, the water rate impact of each long-term source water alternative was estimated. The rate was estimated for each year for the time span from 2019 through 2045. The water rate impact included financing and paying for capital improvements as well as for operation and maintenance (O&M) costs of the water supply system, including the improvements.

Figure 9.2 shows the impact on the rates for the long-term alternatives without considering the other improvements that Brandon is anticipating (such as water towers and core reconstruction). The rate progression is compared to a water rate that is annually adjusted for inflation at 2.5% (black line in Figure 9.2). Note that Alternative 2A (constructing an addition to the water treatment plant with the existing treatment process and additional source water improvements) could be implemented with a minor rate increase (above an inflation-adjusted rate increase) – largely because the existing water rate has the surplus capacity to assume additional debt. Figure 9.3 shows the potential impact on the rates for all of the long-term alternatives, the Core and Rushmore improvements, and the (2) 1.25 MG elevated storage towers.

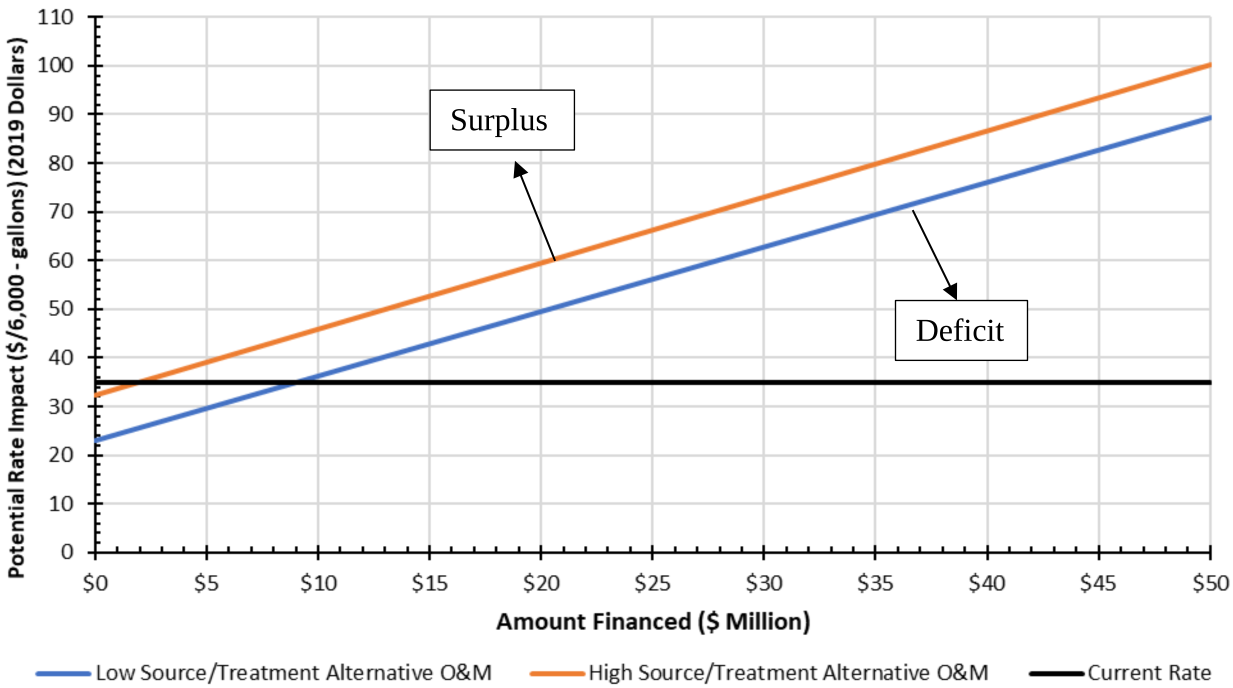


Figure 9.1 Potential Rate Impacts vs. Amount Financed (2019 Dollars)

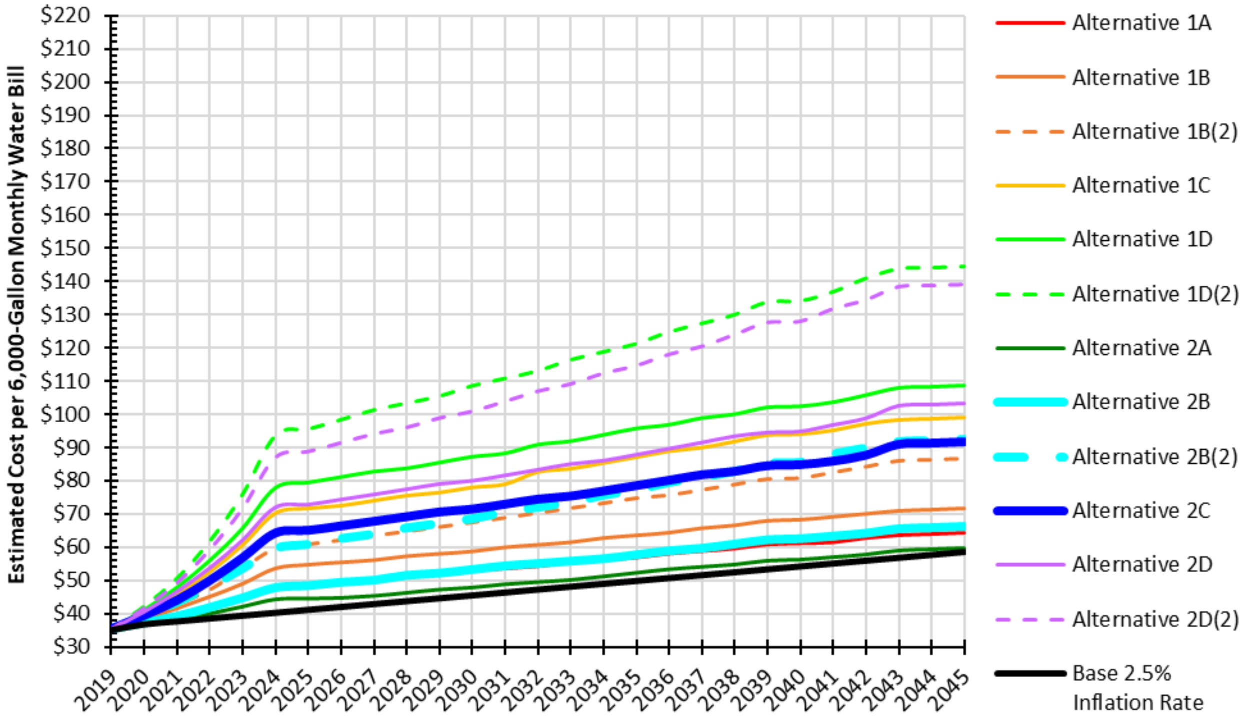


Figure 9.2 Potential Rate Impacts with only Source/Treatment Alternatives Considered

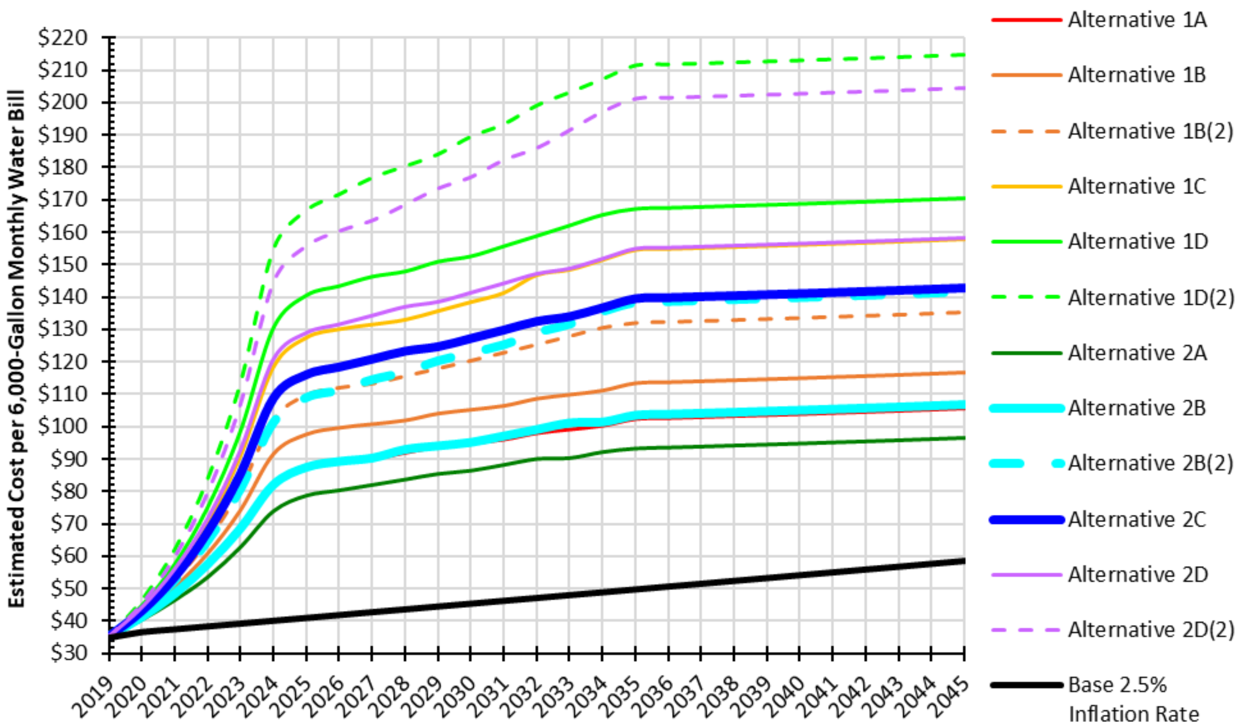


Figure 9.3 Potential Rate Impacts with Source/Treatment Alternatives, Core & Rushmore Improvements and (2) 1.25 MG Water Towers Included

The potential rate impact from implementing Alternative 2B, shown in Figure 9.2, and Figure 9.3 is represented by the light blue solid and dashed lines. Since Alternative 2B uses the WRT radium removal system at Well 7, which includes a volumetric service fee, two different O&M costs exist. The solid light-blue line in Figure 9.2 and Figure 9.3 represents the potential rate impacts for Alternative 2B with low well 7 usage, whereas the dashed light-blue line represents the potential rate impacts for Alternative 2B with high Well 7 usage. The difference between the solid and dashed light blue lines represents the range of potential water rates depending on the usage of Well 7. If only the treatment and source capacity alternatives are implemented (Figure 9.2), the anticipated rate would increase to about $48 to $60 by 2024 for a 6,000-gallon monthly water bill, and then parallel inflation after that. Should all of the proposed improvements (Alternative 2B water source and treatment improvements, water towers, and Core/Rushmore improvements) be implemented under the assumptions described in Section 9.1 (Figure 9.3), the anticipated rate would increase to about $82 to $101 by 2024 for a $6,000-gallon monthly water bill.

The potential rate impact from implementing Alternative 2C, shown in Figure 9.2 and Figure 9.3, is represented by the dark-blue lines. Alternative 2C has a higher initial capital cost, but its O&M costs are lower than Alternative 2B with high Well 7 usage. Should only Alternative 2C be implemented (Figure 9.2), the anticipated water rate would increase to about $64 by 2024 for a 6,000-gallon monthly water bill and then trend upward with inflation. If all of the proposed improvements (Alternative 2C water source and treatment improvements, water towers, and Core/Rushmore improvements) are implemented (Figure 9.3), the anticipated water rate for a 6,000-gallon monthly bill would be about $109 by 2024.

While the water rate impacts of source and treatment improvements might cause a substantive but reasonable increase in the water rate, implementing source/treatment improvements as well as the construction of two water towers and the proposed Core/Rushmore improvements in the anticipated time frame would cause an extreme rate increase. Clearly, the priority, phasing, and funding of each anticipated improvement must be considered to not place an undue burden on Brandon’s water rates.

Chapter 10 CONSIDERATIONS FOR IMPLEMENTATION

The Brandon Water Development Committee (WDC), the City of Brandon staff and AE2S participated in several meetings to discuss the alternatives presented in Chapter 8. A set of short-term alternatives that utilized existing wells (3 and 7) or planned well (9) were developed and compared against the option to purchase treated water from Minnehaha Community Water Company (MCWC). The short-term alternatives were considered in light of their costs, their capability to meet the Brandon water demands during the 5-year duration of the MCWC option, and the contribution to a long-term water supply. Long-term source water alternatives included developing additional wells from the Big Sioux and/or SRC Aquifers and expanding the water treatment plant with three treatment options that provided different levels of treatment. The outcomes of the Kepner-Tregoe analysis of non-economic factors and the estimated costs of each of the alternatives were compared, and two long-term alternatives were considered favorable, Alternative 2B (developing SRC wells and expanding the WTP using the existing treatment process with WRT radium removal at Well 7) or Alternative 2C (developing SRC wells and the expanding the WTP using existing treatment process plus RO for softening and added contaminant removal). The following sections discuss the considerations for implementing the short-term and long-term alternatives.

As this report was being prepared, the City of Brandon proceeded with the initial investigations to develop Well 9, including installation of a test well and observation wells to conduct a pump test. The pump test occurred during the final review of the draft report. The pump test revealed the production capacity of Well 9 would be approximately 75 gpm. The City of Brandon determined this capacity was too low to be viable, and halted construction Well 9. A production capacity of 150 gpm from Well 9 was assumed in the consideration of Well 9 for several alternatives in this study. The loss of Well 9 has the following impact on implementation of alternatives in this report:

- Short-term Alternative 5 (construction of Well 9 and associated infrastructure to connect to the water treatment plant) is no longer implementable.
- All long-term alternatives included Well 9's assumed capacity of 150 gpm in the source water inventory and also included the associated costs of construction ($600,000) in the capital costs of each alternative. Since the loss of this well would equally impact the capital costs of all alternatives, the relative cost comparison of the alternatives would not be changed and long-term alternative 2B or 2C remain the preferred alternatives.
- The assumed production capacity of Well 9 (150 gpm) must be accommodated in the design and implementation of future well additions – the likely consequence is that construction of the future wells in the Split Rock Creek aquifer will be phased earlier than anticipated (see Figures 7.10 and 7.11).

10.1 Short-Term Alternatives

A set of short-term alternatives were compared against the cost and benefit of purchasing water from MCWC. The alternatives are listed in Table 10.1, along with implementation features and water cost.

While the MCWC alternative does provide additional treated water to supplement the existing capacity of the WTP (adds approximately 11% of the plant capacity), the preferable approach is to implement one or more of the competing alternatives 2 through 4. Alternative 5, finish Well 9, is no longer viable due to low production from the Well 9 pump tests. Beyond five years, there is no certainty that water would be available from MCWC. The capital costs associated with connecting Brandon with MCWC may be lost after five years, whereas the other alternatives are all available to be used beyond five years, which makes them cost-effective when considered from a short-term perspective. Short-term Alternatives 2, 3, and 4 would enable the WTP to operate at its maximum capacity and meet the projected Brandon demands in the next 5 years. Short-term Alternatives 2, and 3, (which utilize water from Wells 3, and 7) are all assumed to be implemented in the long-term alternatives.

Whether or not the MCWC connection is chosen, Brandon should continue conversations with MCWC regarding long-term planning of water source/supply needs. Partnering with MCWC or the City of Sioux Falls for long-term water needs and adding a redundant source would broaden Brandon's water portfolio and increase resiliency and sustainability.

Table 10.1 Short Term Alternatives – Implementation Features and Cost

Alternatives	Implementation Features	Water Cost Including Capital Costs and O&M ($/1,000 gal)
Existing System	N/A	*$2.76*
ST-Alt. 1- Purchase MCWC Water	5-year duration provides treated water – adds 11% capacity, no assurance of long-term use of capital investment	*$3.24*
ST-Alt. 2 – Connect Well 3 to WTP	Year-round access to Well 3 – enables full WTP capacity – long term use	*$2.98*
ST-Alt. 3 - Utilize Well 7	Uses Well 7 - Requires optimization of HMO/IMAR™ system to high Ra water – long term use	*$2.93*
ST-Alt. 4 - WRT Well 7	Uses Well 7 – Provides Low Ra water from Well 7 – long term use	*$3.55*
ST-Alt. 5 - Finish Well 9	Provides additional raw water capacity (volume uncertain) – potential long term use	*$2.93*

10.2 Source Implementation

Potential regional water providers, including the City of Sioux Falls, MCWC and the Lewis and Clark Regional Water System, were contacted to determine long-term water availability. Other than the short-term offer of treated water from MCWC, the providers indicated their current water resource allocations prevented offers of long-term water supply to Brandon (covering the 2020-2045 planning period). However, the three providers expressed interest in exploring additional long-term sources (beyond 2045), and Brandon is encouraged to participate in discussions regarding long-term water source options.

The WSP study revealed that the Big Sioux aquifer has water available for development, but in the portion of the aquifer near Brandon, the aquifer characteristics require several relatively low yield wells to develop the aquifer (5 new wells would provide a total of 750 gpm). Comparatively, the SRC aquifer was found to have a much better probability of facilitating higher production wells (1,000 gpm per well) and could support two additional wells in addition to the 3 existing wells. Additionally, the City has stopped using three Big Sioux Aquifer wells due to low production rates, brining into question the long-term sustainability of the Big Sioux Aquifer wells.

Meetings were held with Brandon City staff and Water Development Committee regarding the development and characteristics of two aquifers, including presentation and discussion alternatives for source development, the advantages and disadvantages of each aquifer, concerns regarding long term recharge and water quality trends and included a ranking of non-cost considerations (KT analysis) and cost considerations. The outcome of this process favored developing the SRC aquifer wells (Alternative 2 option) as the primary future water source.

10.2.1 *Water Rights*

The City has current and future water rights in the SRC and Big Sioux Aquifers. The City should maintain enough current and future water rights to meet the average day demands through at least 2070 while considering redundancy should any one well be out of service for an extended period of time.

By 2070, the average day demand is expected to be around 2.5 MGD with an RO system used at the WTP and the associated maximum day raw water need at that time is expected to be around 6.2 MGD. In order to accommodate the future demands, the City should request additional future water rights in the SRC aquifer to facilitate additional production from new well(s) construction required a) to meet future water needs identified in this report, and b) to enable firm capacity required during maximum day flows. The City should also request that the future water right area be adjusted to encompass potential locations of additional wells highlighted in the WSP report.

10.2.2 *Additional Study*

The WSP report recommended additional study occur to verify the source of recharge to the Split Rock Creek Aquifer and estimate its response to additional withdrawals and to drought. The study would include additional data collection a numerical model of the aquifer. This additional study is recommended as part of the preliminary engineering of additional water supply from the Split Rock Creek Aquifer.

10.2.3 *Land Acquisition for Additional Wells*

Brandon should proceed with procuring land for additional well sites.

10.3 Treatment Implementation

All of the long-term alternatives considered expanding the existing WTP. Carrying over the existing treatment approach with and/or without RO for the proposed WTP were the two different treatment approaches considered at the expanded treatment plant. Additional radium removal was also considered to compliment the treatment efforts of either type of future WTP.

Brandon is encouraged to proceed with the process choice in a timely manner, so the design of the treatment plant expansion can move forward.

10.3.1 *Capacity of the Proposed WTP*

This study recommends the expansion of the WTP capacity, potentially in two phases. The firm capacity for each phase would be based on the maximum production rate the plant could produce while one filter is out of service with a maximum filter loading rate of 3 gpm/ft^2 on all of the filters. The proposed phasing provides production capacity enabling RO to be implemented as a future option. Figure 10.1 provides a graph of the anticipated capacity of the two treatment plant expansion phases. The solid black line represents the projected maximum day demands, while the solid lines represent firm WTP capacities for the current treatment plant (blue), the initial Phase 1 expansion (orange), and the 2045 Phase 2 expansion (green). The corresponding dashed lines represent the full (instantaneous) production capacity of the current plant (2.8 MGD) the Phase 1 expansion (5 MGD) and the 2045 Phase 2 expansion (6.8 MGD).

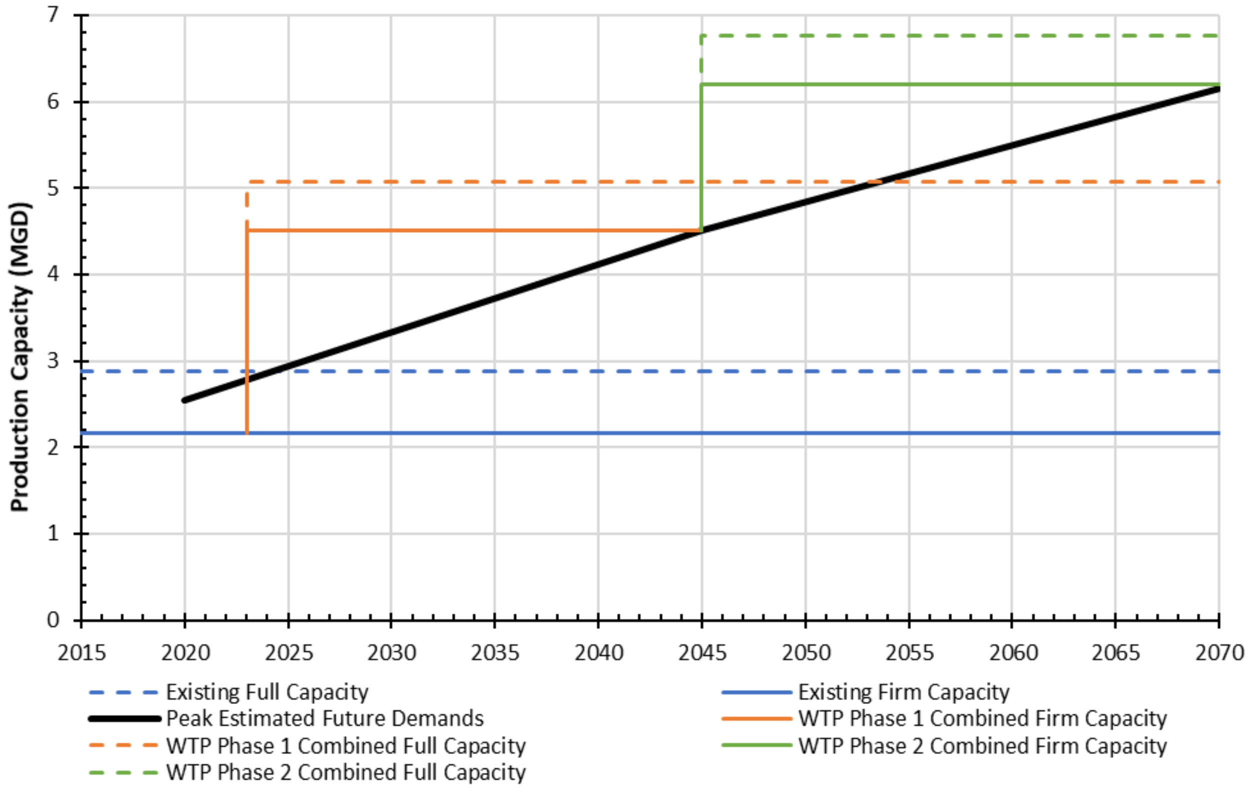


Figure 10.1 Estimated Capacities of the Existing and Proposed Treatment Plant Expansion Phases

The precise WTP capacities used for the design of each expansion phase should be revisited during design, and reflect cost-effectiveness of the phased addition, provisions to enable cost-effective expansion and the chosen treatment technologies (RO vs. no RO, etc.)

10.3.2 *Treatment Type*

The proposed WTP expansion will use the same treatment technologies (HMO/IMAR™) as the existing plant. Option B would include adding the WRT radium removal pre-treatment to Well 7, whereas Option C (RO) would utilize RO to soften the water to achieve a treated water hardness of approximately 200 mg/L as $CaCO_3$ and would reject roughly 50% of the radium entering the WTP (in addition to the 80-90 % removed from the HMO/IMAR™ system). The final selection of the added treatment options (WRT, RO) will inform the design of the treatment plant expansion.

After considering the costs and benefits of the various treatment options, the outcomes of KT analysis accomplished in this study, and impacts on water rates, the Brandon Water Development Committee favored treatment option B – expanding the water treatment plant utilizing the existing HMO/IMAR™ technology and implementing the WRT radium removal system at Well 7 – along with constructing the expansion hydraulically (capacity, piping accommodations and space) to accommodate RO in the future.

From discussions and meeting with the Water Development Committee and the City of Brandon staff, further Brandon community interaction can inform the decision of whether the City should keep the existing treatment approach, implement WRT radionuclide treatment, or implement RO in the new WTP.

10.3.3 *Special Requirements*

Implementation of the potential treatment alternatives will require discharging up to two different waste products. (1) The solids from the backwash process will be included in all alternatives, and (2) the concentrate from the RO process will be included with the alternatives that use RO, should Brandon choose these alternatives.

AE2S and the City staff have been communicating with the City of Sioux Falls regarding the future disposal of the WTP's backwash residual. The City of Sioux Falls Industrial Pretreatment has encouraged Brandon to consider an alternative approach to discharging the solids from the backwash process. The proposed WTP would modify the backwash solids disposal process by using a filter press to dewater the solids. The solids could then be hauled to the Sioux Falls Landfill. Additional conversations with representatives from the Sioux Falls Landfill indicated that the backwash solids could be disposed of in the landfill as long as the hauled residues pass the paint filter test. The solids that are generated from the filter press should be able to pass the paint filter test, making them eligible to be disposed of in the Sioux Falls Landfill. The Sioux Falls Landfill quoted a cost of $18-39 per ton to dispose of this filter backwash waste. As the design of the WTP expansion proceeds, Brandon should continue the discussion with Sioux Falls representatives to ensure the solids disposal process meets Sioux Falls requirements for disposal.

If RO is chosen as a treatment option, an additional waste stream for the RO treatment alternative that must be disposed of is the RO concentrate. Since the RO concentrate does not contain suspended solids, it could potentially be discharged to the sewer. However, this option was not pursued, and it not recommended at this time due to the added disposal costs, the added potential impacts on Brandon's sewer infrastructure, and the potential loss of the equalization credit the City of Brandon receives from using their old lagoons before discharging their wastewater to Sioux Falls.

The preferred option for discharging the RO concentrate is to obtain a discharge permit from the state and discharge the RO concentrate to the Big Sioux River. Although a preliminary review of the discharge permit requirements indicates the discharge is feasible, depending on the concentrations of radium in some of the Split Rock Creek wells and the radium removal efficiency of the HMO/IMAR™ system, the potential to exceed the current end of pipe discharge limit of 5 pCi/L of radium may exist. An additional study, potentially including an RO pilot plant, would confirm the Radium concentration in the concentrate discharge. If the concentrate does exceed 5 pCi/L, options to permit the discharge include:

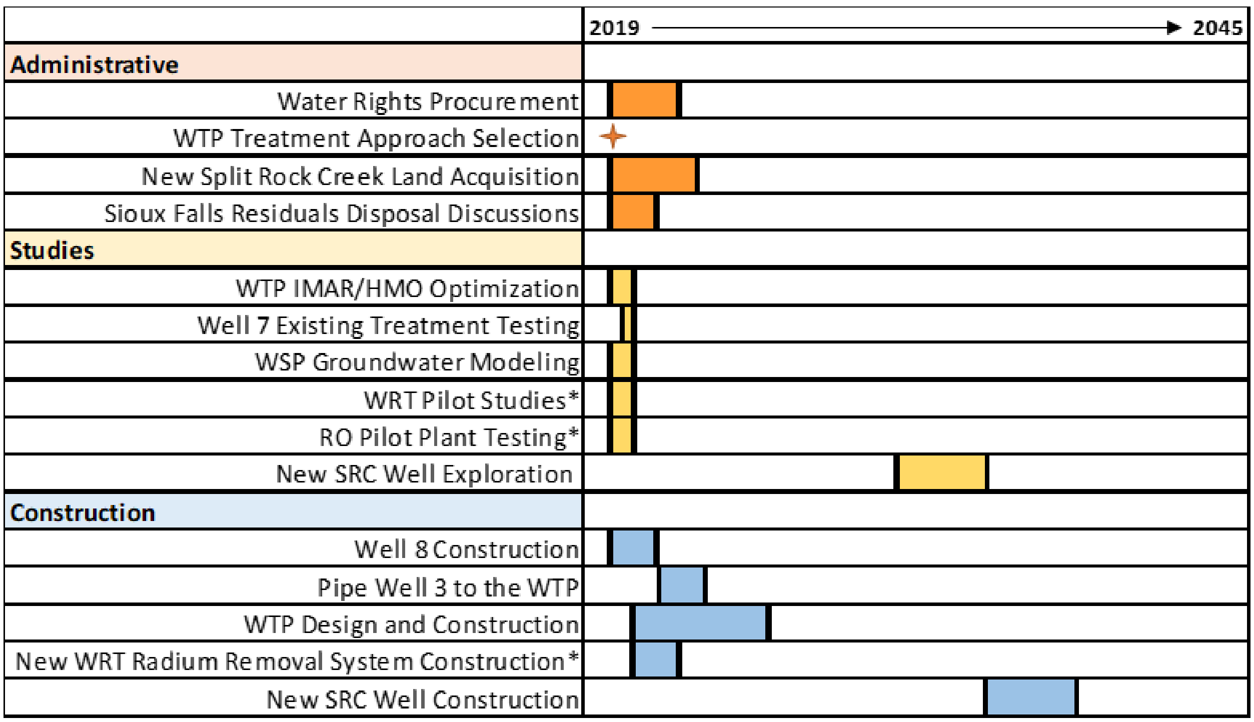
- Request a change or review of the basis of the regulation,
- Request an alternate interpretation of the rule by the SD-DENR
- Request a deviation/waiver to discharge

Section 7.6 discusses in greater detail the management and disposal of the waste residuals.

10.4 Treatment Implementation Timeline

Table 10.2 provides a potential implementation timeline for implementing the improvements for the treatment/source alternatives. One of the first implementation steps is to decide which treatment option the City would prefer to pursue – either the existing treatment approach with WRT radium removal at Well 7 or the existing treatment approach with RO. The specific pilot testing and certain construction elements are contingent upon the treatment technology(ies) chosen. The additional implementation steps are broken into three categories, Administrative, Additional Studies, and the Design/Construction phases.

Table 10.2 Potential Implementation Timeline



*Pending outcome of treatment selection

Items that should be initiated/completed in the next six months to a year include (1) Optimizing the HMO/IMAR™ system to reliably decrease radionuclide concentrations below their respective MCLs; (2) Test radionuclide removal efficiencies from water from Well 7 using the optimized HMO/IMAR™ system; (3) Procuring additional water rights in the SRC aquifer and re-allocating existing current and future use water rights/permits to better reflect anticipated well usage; (4) completing WSP groundwater modeling for better assurance in the aquifer's ability to recharge as well as providing better guidance for the best possible well locations and well installation methods to limit radionuclide concentrations; (5) Land acquisition for a new SRC well; (6) Communication with Sioux Falls regarding residuals disposal options; (7) Construct Well 8; and (8) Construction of the WRT radium removal system if chosen as future treatment alternative.

APPENDIX A – WSP WATER SUPPLY EVALUATION REPORT - TABLES AND FIGURES

Table 1

Brandon City Well Construction Summary

Water Supply Evaluation Report
Brandon, South Dakota

Well Name	UTMX (meters)	UTMY (meters)	Approximate Land Surface Elevation (feet) a	Static (ft bgs)	Total Well Depth (feet)	Well Diameter (inch)	Screen Slot (inch)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Top of Screen Elevation (feet)	Tested Yield (gpm)	Approximate Pumping Level (ft bgs)	Specific Capacity (gpm/ft)	Estimated T (gpd/ft) b	Date Drilled	Top of Aquifer (ft bgs)	Aquifer Thickness (feet)
CW-1	695115.0	4828456.0	1315.0	15.8	48	10	0.035	35	48	1280.0	310	45	10.6	15,925	4/16/1968	35	13
CW-2	695134.2	4828362.5	1314.8	14	50	8	0.070	38	50	1276.8	150	28	10.7	16,071	11/24/1970	14	28
CW-3	696099.6	4829451.7	1353.1	49	222	12	---	180	220	1173.1	400	58	44.4	88,889	1964	179	42
CW-4	695143.8	4828270.3	1314.9	22	52	10	---	28	52	1286.9	270	38	16.9	25,313	9/7/1976	20	32
CW-5	695160.3	4828180.4	1315.8	18	56	10	0.125 0.030 0.040	30	56	1285.8	350	36	19.4	29,167	7/15/1980	18	27
CW-6	695396.1	4828138.4	1319.2	22	275	12	0.030	161	275	1158.2	2210	111.65	24.7	49,303	10/1/1998	145	125
CW-7	696330.1	4828329.1	1323.9	28.7	423	10	0.020	343	423	980.9	1400	104.5	18.5	45,000	1/30/1995	188	142

Notes:

Signifies well is no longer being used (CW-2, CW-4, CW-5).
Signifies well is for standby/emergency sources (CW-3).
ft bgs = feet below ground surface
gpm = gallons per minute
gpm/ft = gallons per minute per foot of drawdown
gpd/ft = gallons per day per foot
a = Grade elevations from the ESRI Terrain basemap.
b = Empirical relationship from Driscoll (1986) used to estimate Transmissivity (T). Confined aquifer T = 2000 * specific capacity. Unconfined aquifer T = 1500 * specific capacity.

Table 2

Water Quality Analytical Results - Surface Water and Quaternary Aquifer

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	MW-2A	MW-3A	MW-4A	CW-1	CW-1	CW-1	CW-1	CW-1	CW-1	CW-1	CW-1
Sample Date				5/13/2014	5/13/2014	5/13/2014	7/2/2013	07/02/91	05/29/99	04/20/10	09/25/17	10/20/17	10/24/17	11/27/17
Sample Source				Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary
Origin				LBG	LBG	LBG	LBG	AE2S DENR file	AE2S DENR file	AE2S DENR file	AE2S	AE2S	AE2S	AE2S
PHYSICAL PROPERTIES														
Conductivity @ 25 $^{\circ}C$	umhos/cm			749	799	1050	818	746	649	780	---	---	---	---
Total Dissolved Solids	mg/L		500	458	**508**	**594**	484	486	396	441	**555**	---	---	---
INORGANICS														
Total Alkalinity	mg/L $CaCO_3$			274	319	303	261	---	---	---	---	---	---	---
Bicarbonate	mg/L $CaCO_3$			335	390	370	318	354	303	326	---	---	---	---
Carbonate	mg/L $CaCO_3$			<4	<4	<4	0	0	0	0	---	---	---	---
Chloride	mg/L		250	34	11	127	69	16.5	25.1	57.0	---	---	---	---
Sulfate	mg/L		250	82	107	23	39.4	81	44	40	---	---	---	---
Fluoride	mg/L	4	2	0.5	0.6	0.2	0.28	0.21	0.23	0.24	---	---	0.51	---
Total Hardness as $CaCO_3$	mg/L			347	361	390	379	409	304	37	---	---	---	---
AGGREGATE ORGANICS														
Total Organic Carbon	mg/L			0.8	1.1	0.8	---	---	---	---	---	---	---	---
NUTRIENTS														
Ammonia-Nitrogen as N	mg/L			0.2	1.21	<0.05	---	---	---	---	---	---	---	---
Nitrite as N	mg/L	1		<0.05 *	<0.05	0.11*	---	---	---	---	---	---	---	<0.02
Nitrate as N	mg/L	10		<0.05	<0.05	7.87	7.0	**10.9**	4.2	5.8	---	---	---	6.0
Nitrate-Nitrite as N	mg/L	10		<0.01	<0.01	7.98	---	---	---	---	---	---	---	---
METALS														
Arsenic	mg/L	0.01		<0.001	0.001	<0.001	---	---	---	---	---	---	<0.001	---
Barium	mg/L	2		0.10	0.07	0.29	---	---	---	---	---	---	0.0326	---
Calcium	mg/L			88	87	105	106	116.0	79.9	93.9	---	---	---	---
Chromium	mg/L	0.1		<0.005	<0.005	<0.005	---	---	---	---	---	---	0.0021	---
Iron	mg/L		0.3	0.11	**1.29**	<0.03	0.06	0.03	0.02	0.03	---	---	---	---
Magnesium	mg/L			31	35	31	27.7	29.1	25.5	27.4	---	---	---	---
Manganese	mg/L		0.05	**0.345**	**0.382**	**0.455**	**0.06**	**0.60**	0.02	0.02	---	---	---	---
Potassium	mg/L			4	8	6	3.9	---	---	---	---	---	---	---
Selenium	mg/L	0.05		<0.001	<0.001	0.002	---	---	---	---	---	---	<0.0005	---
Sodium	mg/L			24	31	59	26.1	11	13	24	---	---	---	---
RADIONUCLIDES														
Uranium	mg/L	0.03		---	<0.001	---	---	---	---	---	---	---	---	---
Gross Alpha	pCi/L	15		---	5.4	---	---	---	---	---	---	Pending	---	---
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---
Gross Beta	pCi/L			---	5.4	---	---	---	---	---	---	---	---	---
Radium 226	pCi/L			---	0.2	---	---	---	---	---	---	Pending	---	---
Radium 228	pCi/L			---	1.1	---	---	---	---	---	---	Pending	---	---
Radium 226 + Radium 228	pCi/L	5		---	1.3	---	---	---	---	---	---	---	---	---
FIELD PARAMETERS														
Dissolved Oxygen	mg/L			0.04	0.05	4.68	---	---	---	---	---	---	---	---
ORP				-74.8	-93.1	2.4	---	---	---	---	---	---	---	---
Temperature	$^{\circ}C$			11.24	9.82	11.83	---	---	---	---	---	---	---	---
Specific Conductance	umhos/cm			736	790	1,046	818 [1]	---	---	---	---	---	---	---
pH	S.U.		6.5 - 8.5	7.40	7.42	7.23	7.74 [1]	7.62	7.58	7.57	---	---	---	---

Notes:
BOLD = Exceeds MCL or Secondary MCL
BSR= Big Sioux River
mg/L = milligrams per liter
umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
DENR WQD = DENR Water Quality Database

Quaternary = Quaternary Aquifer
--- = no data
Pending = final laboratory analytical report was not received
[1] = laboratory measurement
[2] = Minimum, maximum, and average value statistics were calculated from the DENR WQD shapefile for all locations within the Project Area.
* = holding time exceeded

Table 2

Water Quality Analytical Results - Surface Water and Quaternary Aquifer

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	MA-80GA	MA-80GA	MA-80GA	MA-80FA	MA-80EA	MA-80Q	MA-80CA	MA-80CA	Summary Statistics of All Data from DENR WQD[2]			
Sample Date				8/27/1980	4/21/1993	3/6/2014	8/27/1980	8/26/1980	8/5/1980	6/5/1980	3/10/1982	Minimum	Maximum	Average	Number of Samples
Sample Source				Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary	Quaternary			
Origin				DENR WQD	DENR WQD	LBG	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD			
PHYSICAL PROPERTIES															
Conductivity @ 25 °C	umhos/cm			920	723	743	920	950	860	875	874	723	1730	981.7	56
Total Dissolved Solids	mg/L		500	**500**	430	433	**540**	**520**	416	**668**	**608**	380	**1330**	**637.8**	92
INORGANICS															
Total Alkalinity	mg/L $CaCO_3$			---	322	317	---	---	---	---	---	200	580	320	55
Bicarbonate	mg/L $CaCO_3$			---	393	387	---	---	---	---	707	244	707	417	85
Carbonate	mg/L $CaCO_3$			---		<4	---	---	---	---	ND	---	---	---	---
Chloride	mg/L		250	38	6.6	18	36	25	15	16	18	0.37	130	18.19	84
Sulfate	mg/L		250	120	74	66	100	125	90	140	156	20	**620**	148.26	92
Fluoride	mg/L	4	2	0.31	0.36	0.4	0.3	0.31	0.42	0.33	0.29	0.2	0.5	0.32	58
Total Hardness as $CaCO_3$	mg/L			340	350	353	416	473	377	547	523	152	1260	504.7	74
AGGREGATE ORGANICS															
Total Organic Carbon	mg/L			---	---	1.0	---	---	---	---	---	---	---	---	---
NUTRIENTS															
Ammonia-Nitrogen as N	mg/L			---	---	0.56	---	---	---	---	---	<0.02	0.45	0.17	47
Nitrite as N	mg/L	1		---	---	---	---	---	---	---	---	---	---	---	---
Nitrate as N	mg/L	10		---	---	---	---	---	---	---	---	---	---	---	---
Nitrate-Nitrite as N	mg/L	10		0.3	0.16	<0.01	5.6	< 0.10	< 0.10	5.6	5.9	<0.04	**28**	3.14	107
METALS															
Arsenic	mg/L	0.01		---	---	0.002	---	---	---	---	< 0.0005	<0.001	0.0068	0.0023	9
Barium	mg/L	2		---	---	0.08	---	---	---	---	---	0.0486	0.15	0.084	8
Calcium	mg/L			87	91	92	105	123	106	152	140	20	310	144	92
Chromium	mg/L	0.1		---	---	<0.005	---	---	---	---	0.02	0.0028	0.0267	0.014	9
Iron	mg/L		0.3	< 0.05	0.27	**0.7**	0.07	0.1	**0.3**	< 0.03	0.04	<0.03	**23.0**	**2.3**	92
Magnesium	mg/L			30	30	30	38	41	27	41	42	<10	120	36.1	92
Manganese	mg/L		0.05	**0.42**	**0.31**	**0.318**	< 0.05	**1.3**	**0.42**	**0.05**	< 0.01	<0.01	**1.30**	**0.46**	92
Potassium	mg/L			---	3.6	4	---	---	---	---	3.1	1.0	8	3.57	63
Selenium	mg/L	0.05		---	---	<0.001	---	---	---	---	< 0.002	<0.0005	<0.010	0.0032	9
Sodium	mg/L			54	22	21	30	20	32	18	22	8.8	200	36.49	92
RADIONUCLIDES															
Uranium	mg/L	0.03		---	---	---	---	---	---	---	---	0.0056	**0.0549**	0.0028	3
Gross Alpha	pCi/L	15		---	---	---	---	---	---	---	---	<0.3	**51.9**	9.83	16
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---	---
Gross Beta	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---
Radium 226	pCi/L			---	---	---	---	---	---	---	---	<0.3	<0.6	<0.43	7
Radium 228	pCi/L			---	---	---	---	---	---	---	---	0.9	0.9	0.9	2
Radium 226 + Radium 228	pCi/L	5		---	---	---	---	---	---	---	---	<1.4	<1.5	<1.45	2
FIELD PARAMETERS															
Dissolved Oxygen	mg/L			---	---	0.11	---	---	---	---	---	---	---	---	---
ORP				---	---	---	---	---	---	---	---	---	---	---	---
Temperature	°C			---	9	10.1	---	---	---	---	---	7.00	13.10	10.13	49
Specific Conductance	umhos/cm			---	575	677	---	---	---	---	---	400	1463	840.6	49
pH	S.U.		6.5 - 8.5	---	7.15	7.04	---	---	---	---	---	6.95	**8.67**	7.3	49

Notes:

BOLD = Exceeds MCL or Secondary MCL
BSR= Big Sioux River
mg/L = milligrams per liter
umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
DENR WQD = DENR Water Quality Database

Quaternary = Quaternary Aquifer
--- = no data
Pending = final laboratory analytical report was not received
[1] = laboratory measurement
[2] = Minimum, maximum, and average value statistics were calculated from the DENR WQD shapefile for all locations within the Project Area.
* = holding time exceeded

Table 2

Water Quality Analytical Results - Surface Water and Quaternary Aquifer

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	Big Sioux River at N. Cliff Ave. USGS #06482020				Big Sioux River NR Brandon (SD DENR Site WQM 31) USGS #06482100				SD DENR Site WQM BS29				SD DENR Site WQM 64			
Sample Date				Minimum	Maximum	Average	Number of Samples	Minimum	Maximum	Average	Number of Samples	Minimum	Maximum	Average	Number of Samples	Minimum	Maximum	Average	Number of Samples
Sample Source				Big Sioux River				Big Sioux River				Big Sioux River				Big Sioux River			
Origin				DENR WQD				DENR WQD				DENR WQD				DENR WQD			
PHYSICAL PROPERTIES																			
Conductivity @ 25 °C	umhos/cm			1140	3300	1688	11	52.6	2700	702	487	280	3350	1126	443	100	3072	1107	489
Total Dissolved Solids	mg/L		500	174	**1830**	**865**	48	131	**1747**	**748**	434	169	**2295**	**794**	405	223	**1938**	**834**	455
INORGANICS																			
Total Alkalinity	mg/L $CaCO_3$			---	---	---	---	102	360	215	130	114	380	257	---	110	395	259	166
Bicarbonate	mg/L $CaCO_3$			90	473	266	37	114	400	262	3	223	318	272	9	144	723	305	33
Carbonate	mg/L $CaCO_3$			0	11	0.371	35	0	0	0	22	---	---	---	---	---	---	---	---
Chloride	mg/L		250	8.7	**670**	186	46	7.5	**590**	182.3	82	7.9	**814**	228	15	7.9	170	43	37
Sulfate	mg/L		250	42	**400**	237	46	36	**393**	224	43	33	**316**	212	14	58	**660**	**260**	38
Fluoride	mg/L	4	2	0.3	1.4	0.63	17	0.1	0.5	0.3	8	---	---	---	---	---	---	---	---
Total Hardness as $CaCO_3$	mg/L			5	610	279	77	130	840	415	269	180	1180	509	---	179	1500	574	253
AGGREGATE ORGANICS																			
Total Organic Carbon	mg/L			0.0	94.0	17.01	117	12	21	15	12	---	---	---	---	---	---	---	---
NUTRIENTS																			
Ammonia-Nitrogen as N	mg/L			0.026	43.8	10.37	140	0.03	36	3.99	77	0.04	1.08	0.29	46	0.02	1.06	0.29	44
Nitrite as N	mg/L	1		0.0	0.4	0.101	16	0	**1.6**	0.2	79	0.01	0.87	0.12	42	0.01	0.1	0.02	31
Nitrate as N	mg/L	10		0.0	2.0	0.512	17	0	**24**	2	42	---	---	---	---	---	---	---	---
Nitrate-Nitrite as N	mg/L	10		0.01	7.3	1.446	132	0.2	**41**	4.0	446	0.1	**30.6**	3.2	403	0.1	**10.8**	1.1	354
METALS																			
Arsenic	mg/L	0.01		0.001	0.007	0.00288	51	0	0.0078	0.0021	5	0.002	0.0033	0.003	4	0.002	0.0028	0.002	3
Barium	mg/L	2		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Calcium	mg/L			32	150	88	46	10.4	138	92.8	34	41.9	142	96	150	41.6	270	109	181
Chromium	mg/L	0.1		---	---	---	---	0	0.004	0.002	5	0.0022	0.0232	0.0104	3	0.0052	0.0052	0.0052	1
Iron	mg/L		0.3	0.19	**7.9**	**1.02**	51	0.08	**3.78**	**0.43**	48	0.22	**4.36**	**0.83**	12	0.15	**4.03**	**0.78**	36
Magnesium	mg/L			11	60	41	46	16	94.9	46.9	34	16.5	86.4	51.7	149	15.6	116	57	179
Manganese	mg/L		0.05	**0.16**	**0.89**	**0.379**	55	**0.12**	**1.6**	**0.64**	53	**0.21**	**0.6**	**0.37**	12	**0.25**	**1.88**	**0.61**	37
Potassium	mg/L			7.7	29	13	46	7	23	14	8	8.6	20.1	14.8	9	5.8	12.2	7.8	34
Selenium	mg/L	0.05		0.001	0.004	0.00158	39	0.0009	0.0019	0.0014	2	0.0017	0.0017	0.0017	1	0.0011	0.0030	0.0020	2
Sodium	mg/L			7.7	460	144	46	6	403	81	11	7.1	326	51	162	6.4	122	36	186
RADIONUCLIDES																			
Uranium	mg/L	0.03		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gross Alpha	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gross Beta	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Radium 226	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Radium 228	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Radium 226 + Radium 228	pCi/L	5		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
FIELD PARAMETERS																			
Dissolved Oxygen	mg/L			1.00	23.20	10.79	275	1.8	20.5	9.5	507	4	21.1	11.8	462	4	20.6	11.2	491
ORP				---	---	---	---	---	---	---	0	---	---	---	---	---	---	---	---
Temperature	°C			-4.00	30.20	13.75	718	-0.56	33.9	12.0	578	0.0	34.4	12.69	476	-1.1	32.2	12.4	504
Specific Conductance	umhos/cm			1290	1290	1290	1	430	2270	1143	32	---	---	---	---	---	---	---	---
pH	S.U.		6.5 - 8.5	**5.5**	**8.9**	8.0	311	**5.9**	**10.1**	7.9	659	**4.5**	**9.25**	8.1	578	**4.9**	**9.57**	8.16	630

Notes:
BOLD = Exceeds MCL or Secondary MCL
BSR= Big Sioux River
mg/L = milligrams per liter
umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
DENR WQD = DENR Water Quality Database

Quaternary = Quaternary Aquifer
--- = no data
Pending = final laboratory analytical report was not received
[1] = laboratory measurement
[2] = Minimum, maximum, and average value statistics were calculated from the DENR WQD shapefile for all locations within the Project Area.
* = holding time exceeded

Table 7

Water Quality Analytical Results - Split Rock Creek Aquifer and Sioux Quartzite

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	McHardy Park Well	McHardy Park Well (McHardy Rd.)	CW-3	CW-3	CW-3	CW-3	CW-6	CW-6	CW-6	CW-6	CW-8 Test Well	CW-1 & CW-6 (#1 & #6)	Treatment Plant CW-6 (TREAT PLT Well #6)	CW-7 (1 Hour of Pumping)	CW-7 (23 Hours of Pumping)	CW-7 (32 Hours of Pumping)	CW-7	CW-7	CW-7
Sample Date				11/05/07	6/28/2004	3/23/1967	07/10/17	10/20/17	10/24/17	01/28/99	04/15/15	09/25/17	10/20/17	4/11/2017	10/31/17	12/06/99	4/14/2015	4/15/2015	4/15/2015	04/18/15	05/05/15	10/20/17
Sample Source				SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC
Origin				AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	AE2S	LBG	LBG	LBG	AE2S	AE2S	AE2S
PHYSICAL PROPERTIES																						
Conductivity @ 25 °C	umhos/cm			---	753	790	---	---	---	---	---	---	---	767	---	---	764	768	770	---	---	---
Total Dissolved Solids	mg/L		500	**870**	473	**559**	---	---	---	---	---	**555**	---	451	---	---	453	466	442	---	---	---
INORGANICS																						
Total Alkalinity	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	---	---	---	---	303	305	306	---	---	---
Bicarbonate	mg/L $CaCO_3$			380	375	390	---	---	---	---	---	---	---	377	---	---	370	372	373	---	---	---
Carbonate	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	---	---	---	---	0	0	0	---	---	---
Chloride	mg/L		250	163	4	2	---	---	---	---	---	---	---	7.57	---	---	2.72	3.46	3.45	---	---	---
Sulfate	mg/L		250	142	115	130	---	---	---	112	---	---	---	94.7	---	---	111	116	116	---	---	---
Fluoride	mg/L	4	2	---	---	---	---	---	0.51	0.52	---	---	0.52	---	---	---	0.456	0.483	0.487	---	---	0.52
Total Hardness as $CaCO_3$	mg/L			470	362	383	---	---	---	---	---	---	---	344	---	---	361	369	374	---	---	---
AGGREGATE ORGANICS																						
Total Organic Carbon	mg/L			18	---	---	---	---	---	---	---	---	---	---	---	---	1.02	1.01	0.939	---	---	---
NUTRIENTS																						
Ammonia-Nitrogen as N	mg/L				---	---	---	---	---	---	---	---	---	---	---	---	0.478	0.506	0.511	---	---	---
Nitrite as N	mg/L	1			---	---	<0.02	<0.02	---	<0.02	---	---	---	<0.05	<0.02	---	< 0.050	< 0.050	< 0.050	<0.05	---	---
Nitrate as N	mg/L	10		0.1	<0.1	0.25	<0.2	0.7	---	---	---	---	---	<0.05	0.7	<0.1	< 0.050	< 0.050	< 0.050	<0.05	---	---
Nitrate-Nitrite as N	mg/L	10			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
METALS																						
Arsenic	mg/L	0.01		---	**0.01**	---	---	---	<0.001	0.0	---	---	<0.001	---	---	---	0.008	0.008	0.008	---	---	<0.004
Barium	mg/L	2		---	0.021	---	---	---	0.0326	0.025	---	---	0.0336	---	---	---	0.025	0.024	0.025	---	---	0.0215
Calcium	mg/L			141	94.9	101.7	---	---	---	---	---	---	---	86.1	---	---	94	97.7	98.9	---	---	---
Chromium	mg/L	0.1		---	0.00132	---	---	---	0.0021	0.0062	---	---	0.0021	---	---	---	< 0.001	< 0.001	< 0.001	---	---	0.0017
Iron	mg/L		0.3	0.16	**1.21**	0.18	---	---	---	---	---	---	---	**0.562**	---	---	**0.732**	**0.61**	**0.63**	---	---	---
Magnesium	mg/L			29	30.4	31.1	---	---	---	---	---	---	---	31.3	---	---	30.5	30.3	30.8	---	---	---
Manganese	mg/L		0.05	0.02	**0.29**	**0.25**	---	---	---	---	---	---	---	**0.268**	---	---	**0.317**	**0.33**	**0.35**	---	---	---
Potassium	mg/L			---	3.8	6.8	---	---	---	---	---	---	---	12.1	---	---	3.77	3.87	3.84	---	---	---
Selenium	mg/L	0.05		---	<0.0005	---	---	---	<0.0005	<0.0005	---	---	0.00062	---	---	---	< 0.005	< 0.005	< 0.005	---	---	<0.0005
Sodium	mg/L			96	24.6	40.5	---	---	---	---	---	---	---	23	---	---	24.2	24.3	24.7	---	---	---
RADIONUCLIDES																						
Uranium	mg/L	0.03		---	0.0065	---	---	---	---	---	0.002	---	---	0.002	---	---	0.005	0.005	0.005	---	---	---
Gross Alpha	pCi/L	15		---	**25.2**	---	---	4.49	---	---	6.92	---	**20.60**	**20.7**	---	---	**23.3**	**27.5**	**26.7**	---	**26.7**	---
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	5.30	---	---	**19.4**	---	---	**20.2**	**24.2**	**23.2**	---	---	---
Gross Beta	pCi/L			---	---	---	---	---	---	---	3.35	---	---	---	---	---	4.03	3.27	3.35	---	---	---
Radium 226	pCi/L			ND	7.3	---	---	---	---	---	6.58	---	---	3.8	---	---	20.6	22.8	20.1	---	20.1	---
Radium 228	pCi/L			ND	<0.3	---	---	---	---	---	1.01	---	---	<1.0	---	---	0.944	0.568	0.539	---	0.539	---
Radium 226 + Radium 228	pCi/L	5		---	**7.3**	---	---	2.9	---	---	**7.59**	---	**5.2**	3.8	---	---	**21.544**	**23.368**	**20.639**	---	**20.639**	---
FIELD PARAMETERS																						
Dissolved Oxygen	mg/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ORP				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Temperature	°C			---	---	---	---	---	---	12.2	---	---	---	---	---	---	---	---	---	---	---	---
Specific Conductance	umhos/cm			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
pH	S.U.		6.5 - 8.5	---	---	---	---	---	---	7.5	---	---	---	---	---	---	---	---	---	---	---	---

Notes:

BOLD = Exceeds MCL or Secondary MCL
SRC = Split Rock Creek Aquifer
DENR WQD = DENR Water Quality Database
NA = not analyzed
ND = non-detect
mg/L = milligrams per liter

umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
°C - degrees Celsius
--- = no data

Table 7

Water Quality Analytical Results - Split Rock Creek Aquifer and Sioux Quartzite

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	MA-80BA (SRC-10)	MA-80BA (SRC-10)	MA-80P (SRC-43)	MA-80P (SRC-43)	MA-80P (SRC-43)	MA-80Z (SRC-41)	MA-80Z (SRC-41)	MA-80Z (SRC-41)	MA-80Z (SRC-41)	MA-80Z (SRC-41)	MA-87C (SRC-17)	MA-87D (SRC-19)	MA-87D (SRC-19)	MA-87E (SRC-34)	MA-87F (SRC-24)	MA-87H (SRC-4A)	MA-87H (SRC-4A)
Sample Date				6/6/1980	6/6/1989	6/5/1980	6/25/1991	1/24/1995	7/2/1980	11/20/1980	6/26/1991	1/24/1995	3/6/2014	5/31/1989	6/13/1989	1/24/1995	6/13/1989	6/5/1989	5/23/1989	1/25/1995
Sample Source				SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC
Origin				DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	LBG	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD	DENR WQD
PHYSICAL PROPERTIES																				
Conductivity @ 25 °C	umhos/cm			1030	1320	1520	1576	1635	610	730	731	747	792	1070	1350	1349	859	747	843	825
Total Dissolved Solids	mg/L		500	**856**	**968**	**1260**	**1260**	**1330**	380	**510**	488	482	487	**674**	**1010**	**1050**	**570**	448	**526**	**540**
INORGANICS																				
Total Alkalinity	mg/L $CaCO_3$			0	327	0	373	372	---	---	306	303	310	419	368	363	335	311	314	308
Bicarbonate	mg/L $CaCO_3$			0	399	0	455	453	---	---	373	369	379	511	449	442	408	379	383	375
Carbonate	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	<4	---	---	---	---	---	---	---
Chloride	mg/L		250	3	3.9	8	7.5	7.2	< 2	< 2	2.5	2.4	3	4.9	6.7	7.1	4.6	2.3	3.6	3.6
Sulfate	mg/L		250	**388**	**430**	**613**	**640**	**560**	85	115	118	101	128	196	**420**	**400**	146	96	153	142
Fluoride	mg/L	4	2	0.44	0.64	0.53	0.51	0.49	0.39	0.46	0.44	0.42	0.4	0.36	0.69	0.56	0.48	0.54	0.58	0.52
Total Hardness as $CaCO_3$	mg/L			719	673	920	923	900	404	388	373	380	401	498	715	720	420	325	415	410
AGGREGATE ORGANICS																				
Total Organic Carbon	mg/L			---	---	---	---	---	---	---	---	---	0.8	---	---	---	---	---	---	---
NUTRIENTS																				
Ammonia-Nitrogen as N	mg/L			---	---	---	---	---	---	---	---	---	0.3	---	---	---	---	---	---	---
Nitrite as N	mg/L	1		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nitrate as N	mg/L	10		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nitrate-Nitrite as N	mg/L	10		< 0.05	0.08	< 0.05	< 0.04	<0.04	< 1.00	< 0.10	< 0.04	<0.04	0.01	< 0.04	< 0.04	<0.04	< 0.04	< 0.04	< 0.04	<0.04
METALS																				
Arsenic	mg/L	0.01		---	---	---	---	---	---	---	---	---	0.007	---	---	---	---	---	---	---
Barium	mg/L	2		---	---	---	---	---	---	---	---	---	<0.05	---	---	---	---	---	---	---
Calcium	mg/L			198	174	226	223	214	111	98	100	98	107.0	122	174	176	112	84	107	103
Chromium	mg/L	0.1		---	---	---	---	---	---	---	---	---	<0.005	---	---	---	---	---	---	---
Iron	mg/L		0.3	< 0.05	< 0.05	< 0.03	< 0.05	**1.13**	0.06	0.23	0.05	**0.43**	**0.60**	**0.47**	< 0.05	**1.43**	**0.77**	< 0.05	0.08	**1.11**
Magnesium	mg/L			55	58	87	89	88	31	35	30	32	32.0	47	68	68	34	28	36	37
Manganese	mg/L		0.05	**0.33**	**0.4**	**0.53**	**0.51**	**0.52**	**0.2**	**0.2**	**0.16**	**0.14**	**0.164**	**0.34**	**0.68**	**0.63**	**0.3**	**0.21**	**0.33**	**0.3**
Potassium	mg/L			---	7.9	---	5.8	5.9	---	---	3.2	3.2	3	4.7	6.2	6.1	3.2	7.4	3.4	3.6
Selenium	mg/L	0.05		---	---	---	---	---	---	---	---	---	<0.001	---	---	---	---	---	---	---
Sodium	mg/L			24	40	55	50	48	21	30	23	22	23.0	50	41	37	29	36	28	25
RADIONUCLIDES																				
Uranium	mg/L	0.03		---	---	---	---	---	---	---	---	---	0.002	---	---	---	---	---	---	---
Gross Alpha	pCi/L	15		---	---	---	---	---	---	---	---	---	9.6	---	---	---	---	---	---	---
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gross Beta	pCi/L			---	---	---	---	---	---	---	---	---	6.2	---	---	---	---	---	---	---
Radium 226	pCi/L			---	---	---	---	---	---	---	---	---	1.6	---	---	---	---	---	---	---
Radium 228	pCi/L			---	---	---	---	---	---	---	---	---	1.0	---	---	---	---	---	---	---
Radium 226 + Radium 228	pCi/L	5		---	---	---	---	---	---	---	---	---	2.7	---	---	---	---	---	---	---
FIELD PARAMETERS																				
Dissolved Oxygen	mg/L			---	---	---	---	---	---	---	---	---	0.07	---	---	---	---	---	---	---
ORP				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Temperature	°C			---	12.7	---	11	10.5	---	---	15	11	10.3	11.9	10.1	10.5	11.1	12.3	12.3	10
Specific Conductance	umhos/cm			---	1090	---	1450	1425	---	---	600	650	727	900	1140	1150	680	610	690	700
pH	S.U.		6.5 - 8.5	---	7.41	---	8.04	7.41	---	---	7.8	7.21	6.61	7.54	7.37	7.19	7.4	7.35	7.3	7.11

Notes:
BOLD = Exceeds MCL or Secondary MCL
SRC = Split Rock Creek Aquifer
DENR WQD = DENR Water Quality Database
NA = not analyzed
ND = non-detect
mg/L = milligrams per liter
umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
°C - degrees Celsius
--- = no data

Table 7

Water Quality Analytical Results - Split Rock Creek Aquifer and Sioux Quartzite

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	MA-87I (SRC-7A)	Summary Statistics of All Data from DENR WQD[1]				Watrec D	CW-3 (Brandon PW #3)	Watrec E	Watrec PW	Watrec PW	SRC-1	SRC-2	SRC-7	SRC-9	SRC-13	SRC-15	SRC-16	SRC-17	SRC-26
Sample Date				5/23/1989	Minimum	Maximum	Average	Number of Samples	4/27/1989	6/28/1989	8/8/1989	11/13/1989	11/16/1989	1/17/1991	1/17/1991	1/17/1991	1/17/1991	1/18/1991	1/17/1991	1/18/1991	1/18/1991	1/18/1991
Sample Source				SRC	SRC				SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC	SRC
Origin				DENR WQD	DENR WQD				Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995
PHYSICAL PROPERTIES																						
Conductivity @ 25 °C	umhos/cm			1050	610	1635	1042.1	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total Dissolved Solids	mg/L		500	**688**	380	**1330.0**	**743.6**	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
INORGANICS																						
Total Alkalinity	mg/L $CaCO_3$			336	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Bicarbonate	mg/L $CaCO_3$			410	168	511	398.2	48	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Carbonate	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Chloride	mg/L		250	6.6	<2	23	4.93	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Sulfate	mg/L		250	**250**	77	**640**	**277.5**	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Fluoride	mg/L	4	2	0.6	0.32	1.17	0.53	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total Hardness as $CaCO_3$	mg/L			489	310	923	533.5	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
AGGREGATE ORGANICS																						
Total Organic Carbon	mg/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
NUTRIENTS																						
Ammonia-Nitrogen as N	mg/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nitrite as N	mg/L	1		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nitrate as N	mg/L	10		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Nitrate-Nitrite as N	mg/L	10		< 0.04	<0.04	2.13	0.11	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
METALS																						
Arsenic	mg/L	0.01		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Barium	mg/L	2		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Calcium	mg/L			120	81	226	135.8	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Chromium	mg/L	0.1		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Iron	mg/L		0.3	0.16	<0.03	**1.77**	**0.54**	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Magnesium	mg/L			46	26	89	47.2	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Manganese	mg/L		0.05	**0.31**	**0.06**	**1.4**	**0.41**	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Potassium	mg/L			6.7	3.2	16	6.34	48	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Selenium	mg/L	0.05		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Sodium	mg/L			47	16	80	37.5	52	---	---	---	---	---	---	---	---	---	---	---	---	---	---
RADIONUCLIDES																						
Uranium	mg/L	0.03		---	---	---	---	---	0.018	---	**0.036**	0.0147	0.0147	---	---	---	---	---	0.00495	0.01005	---	0.02595
Gross Alpha	pCi/L	15		---	---	---	---	---	**19.1**	3.4	**29.2**	**27.5**	**30.9**	6.1	10.6	10.6	4.8	12.7	**26.9**	**40.4**	2.7	**17.9**
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gross Beta	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Radium 226	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Radium 228	pCi/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Radium 226 + Radium 228	pCi/L	5		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
FIELD PARAMETERS																						
Dissolved Oxygen	mg/L			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ORP				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Temperature	°C			12.7	9	17.1	11.7	45	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Specific Conductance	umhos/cm			900	525	1450	869.3	45	---	---	---	---	---	---	---	---	---	---	---	---	---	---
pH	S.U.		6.5 - 8.5	7.49	7.11	8.35	7.45	45	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Notes:
BOLD = Exceeds MCL or Secondary MCL
SRC = Split Rock Creek Aquifer
DENR WQD = DENR Water Quality Database
NA = not analyzed
ND = non-detect
mg/L = milligrams per liter

umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
°C - degrees Celsius
--- = no data

Table 7

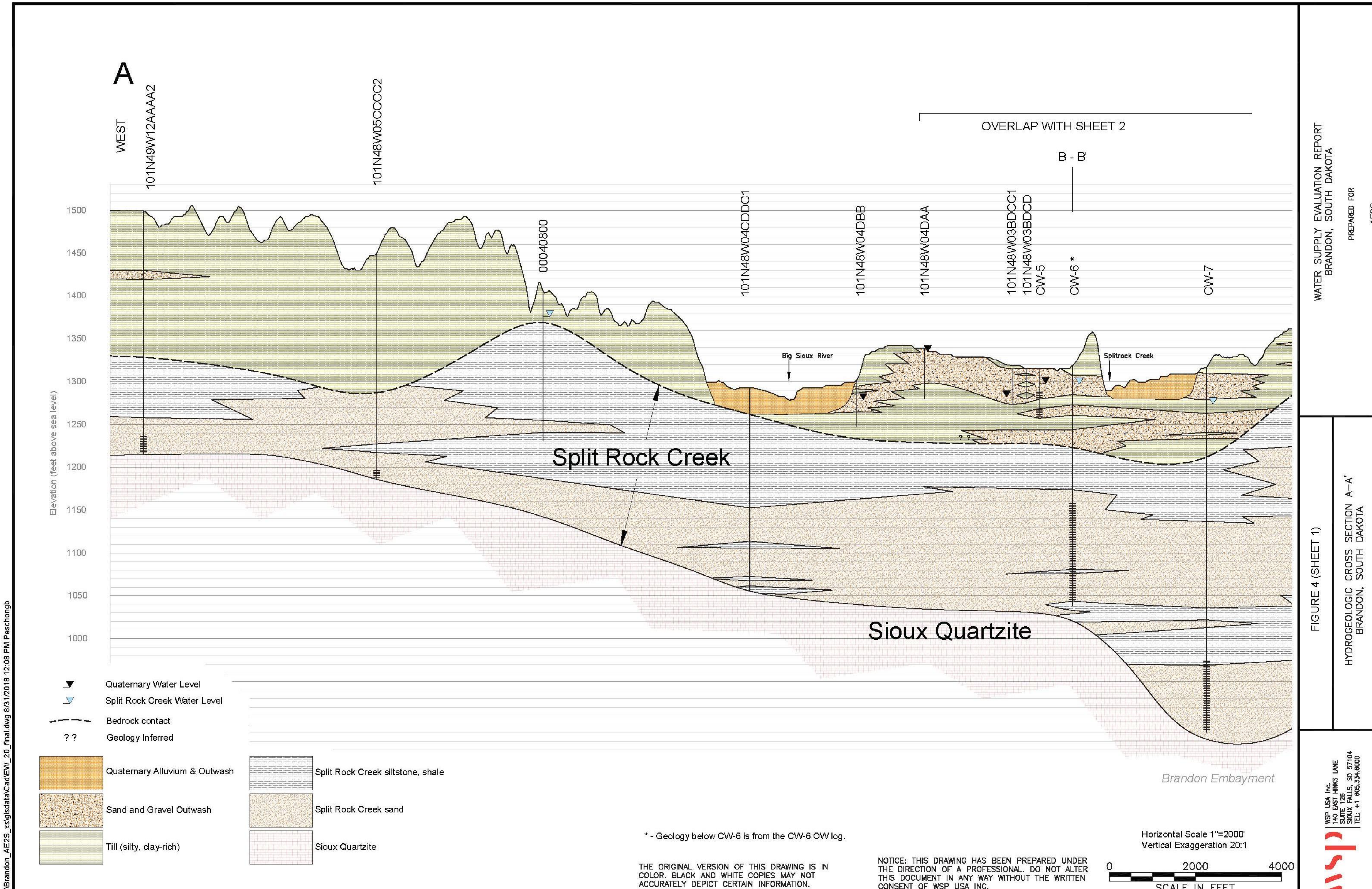
Water Quality Analytical Results - Split Rock Creek Aquifer and Sioux Quartzite

Water Supply Evaluation Report
Brandon, South Dakota

Detected Analyte	Units	Primary MCL	Secondary MCL	SRC-28	SRC-32	SRC-35	SRC-41	Q1	Q2 (b)	Q3	Q3 (Duplicate)	Q6	Q8	Q10
Sample Date				7/6/1989	7/6/1989	1/17/1991	6/22/1992	6/23/1992	6/23/1992	6/23/1992	6/23/1992	6/23/1992	6/23/1992	6/23/1992
Sample Source				SRC	SRC	SRC	SRC	Sioux Quartzite	Sioux Quartzite	Sioux Quartzite	Sioux Quartzite	Sioux Quartzite	Sioux Quartzite	Sioux Quartzite
Origin				Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995	Pence, 1995
PHYSICAL PROPERTIES														
Conductivity @ 25 °C	umhos/cm			---	---	---	---	---	---	---	---	---	---	---
Total Dissolved Solids	mg/L		500	---	---	---	---	---	---	---	---	---	---	---
INORGANICS														
Total Alkalinity	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	---	---
Bicarbonate	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	---	---
Carbonate	mg/L $CaCO_3$			---	---	---	---	---	---	---	---	---	---	---
Chloride	mg/L		250	---	---	---	---	---	---	---	---	---	---	---
Sulfate	mg/L		250	---	---	---	---	---	---	---	---	---	---	---
Fluoride	mg/L	4	2	---	---	---	---	---	---	---	---	---	---	---
Total Hardness as $CaCO_3$	mg/L			---	---	---	---	---	---	---	---	---	---	---
AGGREGATE ORGANICS														
Total Organic Carbon	mg/L			---	---	---	---	---	---	---	---	---	---	---
NUTRIENTS														
Ammonia-Nitrogen as N	mg/L			---	---	---	---	---	---	---	---	---	---	---
Nitrite as N	mg/L	1		---	---	---	---	---	---	---	---	---	---	---
Nitrate as N	mg/L	10		---	---	---	---	---	---	---	---	---	---	---
Nitrate-Nitrite as N	mg/L	10		---	---	---	---	---	---	---	---	---	---	---
METALS														
Arsenic	mg/L	0.01		---	---	---	---	---	---	---	---	---	---	---
Barium	mg/L	2		---	---	---	---	---	---	---	---	---	---	---
Calcium	mg/L			---	---	---	---	---	---	---	---	---	---	---
Chromium	mg/L	0.1		---	---	---	---	---	---	---	---	---	---	---
Iron	mg/L		0.3	---	---	---	---	---	---	---	---	---	---	---
Magnesium	mg/L			---	---	---	---	---	---	---	---	---	---	---
Manganese	mg/L		0.05	---	---	---	---	---	---	---	---	---	---	---
Potassium	mg/L			---	---	---	---	---	---	---	---	---	---	---
Selenium	mg/L	0.05		---	---	---	---	---	---	---	---	---	---	---
Sodium	mg/L			---	---	---	---	---	---	---	---	---	---	---
RADIONUCLIDES														
Uranium	mg/L	0.03		0.01005	0.00705	0.00705	---	0.01005	---	---	---	0.01005	---	0.01005
Gross Alpha	pCi/L	15		**40.0**	**17.3**	**18.1**	6.0	**17.9**	8.8	8.4	7.1	**20.6**	1.1	**32.9**
Gross Alpha - adjusted	pCi/L	15		---	---	---	---	---	---	---	---	---	---	---
Gross Beta	pCi/L			---	---	---	---	---	---	---	---	---	---	---
Radium 226	pCi/L			---	---	---	---	---	---	---	---	---	---	---
Radium 228	pCi/L			---	---	---	---	---	---	---	---	---	---	---
Radium 226 + Radium 228	pCi/L	5		---	---	---	---	---	---	---	---	---	---	---
FIELD PARAMETERS														
Dissolved Oxygen	mg/L			---	---	---	---	---	---	---	---	---	---	---
ORP				---	---	---	---	---	---	---	---	---	---	---
Temperature	°C			---	---	---	---	---	---	---	---	---	---	---
Specific Conductance	umhos/cm			---	---	---	---	---	---	---	---	---	---	---
pH	S.U.		6.5 - 8.5	---	---	---	---	---	---	---	---	---	---	---

Notes:
BOLD = Exceeds MCL or Secondary MCL
SRC = Split Rock Creek Aquifer
DENR WQD = DENR Water Quality Database
NA = not analyzed
ND = non-detect
mg/L = milligrams per liter

umhos/cm = micromhos per centimeter
pCi/L = picocuries per liter
S.U. = Standard Units
°C - degrees Celsius
--- = no data


A
WEST
101N49W12AAAA2
101N48W05CCCC2
00040800
101N48W04CDDC1
101N48W04DBB
101N48W04DAA
101N48W03BDCC1
101N48W03BDCD
CW-5
CW-6 *
CW-7
OVERLAP WITH SHEET 2
B - B'
Big Sioux River
Splitrock Creek
Elevation (feet above sea level)
1500
1450
1400
1350
1300
1250
1200
1150
1100
1050
1000
Split Rock Creek
Sioux Quartzite
Brandon Embayment
Quaternary Water Level
Split Rock Creek Water Level
Bedrock contact
? ? Geology Inferred
Quaternary Alluvium & Outwash
Sand and Gravel Outwash
Till (silty, clay-rich)
Split Rock Creek siltstone, shale
Split Rock Creek sand
Sioux Quartzite
* - Geology below CW-6 is from the CW-6 OW log.
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Horizontal Scale 1"=2000'
Vertical Exaggeration 20:1
0
2000
4000
SCALE IN FEET
WATER SUPPLY EVALUATION REPORT
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PREPARED FOR
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FIGURE 4 (SHEET 1)
HYDROGEOLOGIC CROSS SECTION A–A'
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WSP USA Inc.
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SIOUX FALLS, SD 57104
TEL: +1 605.334.6000
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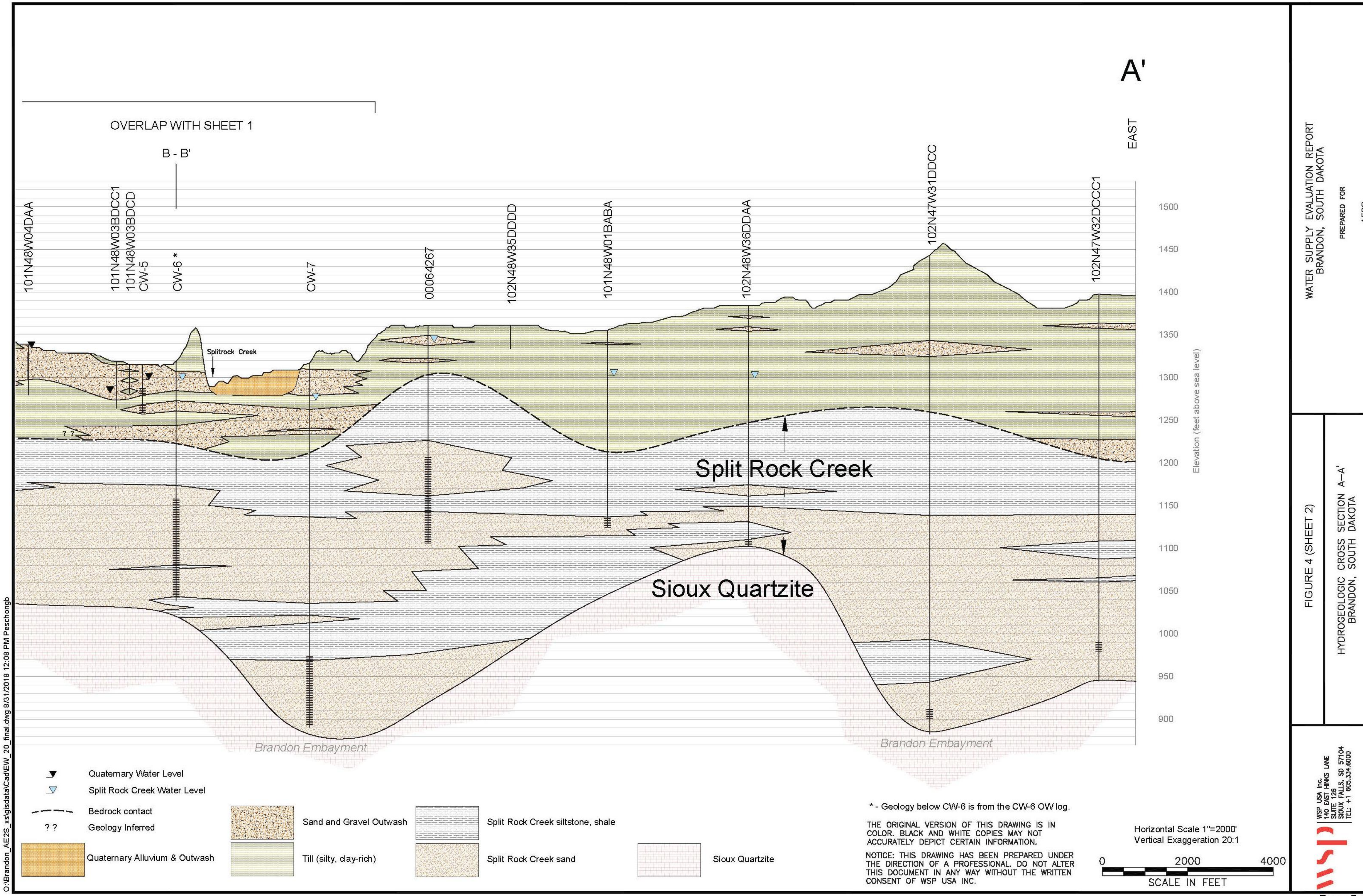
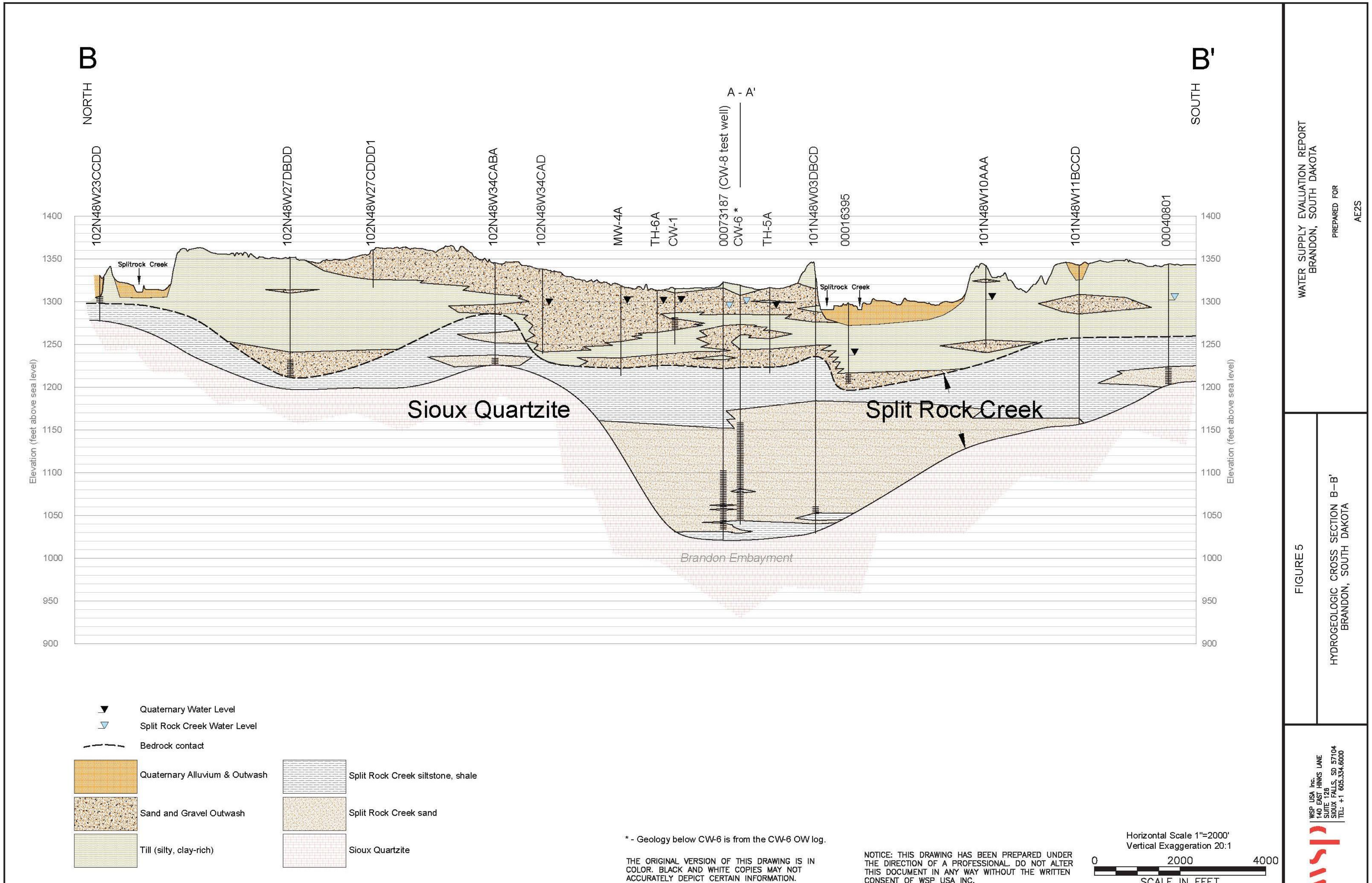


Page 5-12

Brandon SOUTH DAKOTA Building a Better Life

AE2S



B
NORTH
B'
SOUTH
A - A'
102N48W23CCDD
102N48W27DBDD
102N48W27CDDD1
102N48W34CABA
102N48W34CAD
MW-4A
TH-6A
CW-1
00073187 (CW-8 test well)
CW-6 *
TH-5A
101N48W03DBCD
00016395
101N48W10AAA
101N48W11BCCD
00040801
Splitrock Creek
Splitrock Creek
Elevation (feet above sea level)
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
Sioux Quartzite
Split Rock Creek
Brandon Embayment
Quaternary Water Level
Split Rock Creek Water Level
Bedrock contact
Quaternary Alluvium & Outwash
Sand and Gravel Outwash
Till (silty, clay-rich)
Split Rock Creek siltstone, shale
Split Rock Creek sand
Sioux Quartzite
* - Geology below CW-6 is from the CW-6 OW log.
THE ORIGINAL VERSION OF THIS DRAWING IS IN COLOR. BLACK AND WHITE COPIES MAY NOT ACCURATELY DEPICT CERTAIN INFORMATION.
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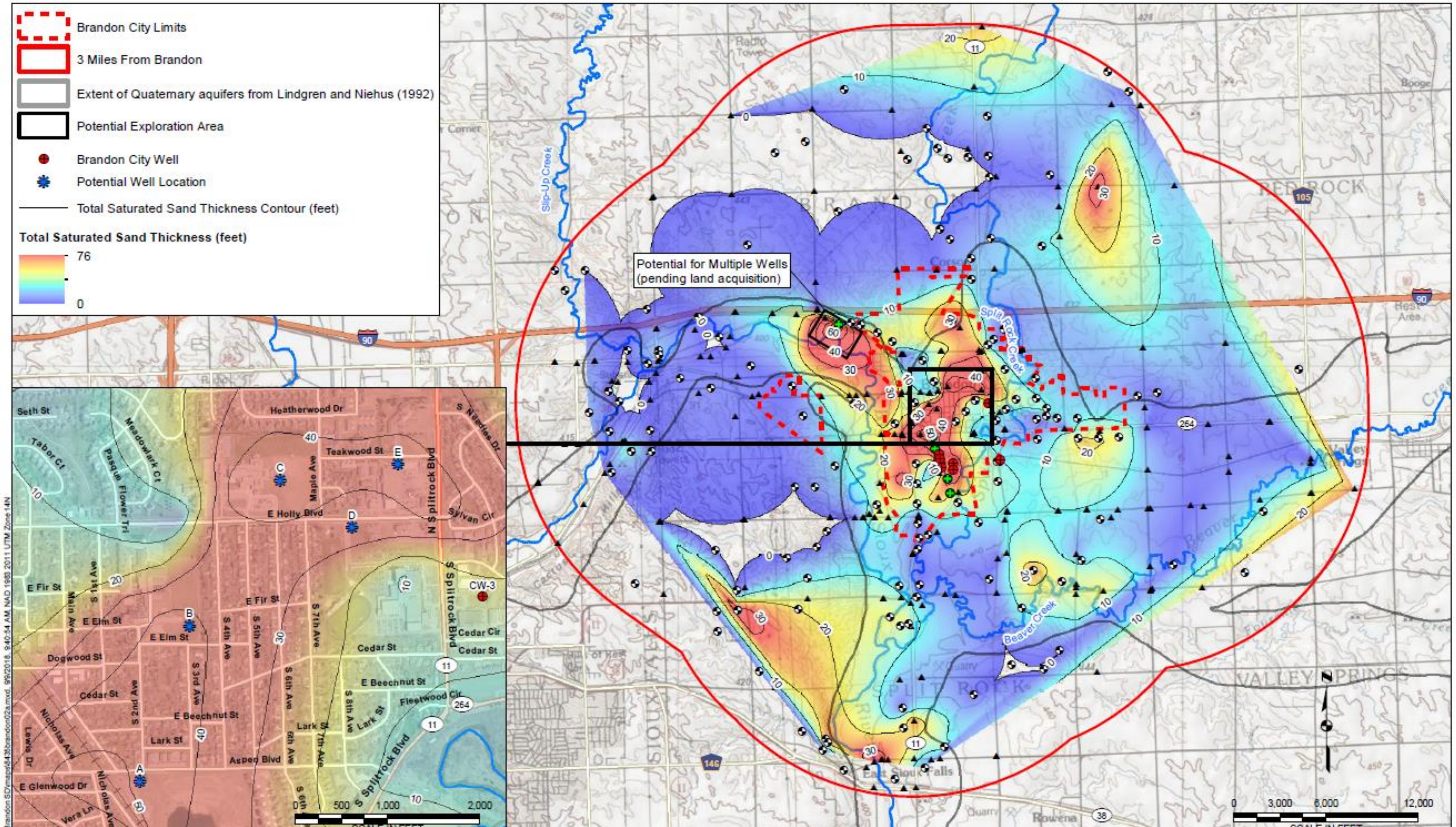
Horizontal Scale 1"=2000'
Vertical Exaggeration 20:1
0
2000
4000
SCALE IN FEET
WATER SUPPLY EVALUATION REPORT
BRANDON, SOUTH DAKOTA
PREPARED FOR
AE2S
FIGURE 5
HYDROGEOLOGIC CROSS SECTION B–B'
BRANDON, SOUTH DAKOTA
WSP USA Inc.
140 EAST HINKS LANE
SUITE 128
SIOUX FALLS, SD 57104
TEL: +1 605.334.6000



Note: This figure illustrates only the known saturated quaternary sand thickness.
Refer to map titled "Number of Sand Units Identified in Boring - Quaternary Aquifer" for information where the Quaternary Aquifer is likely absent.

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WATER SUPPLY EVALUATION REPORT
BRANDON, SOUTH DAKOTA

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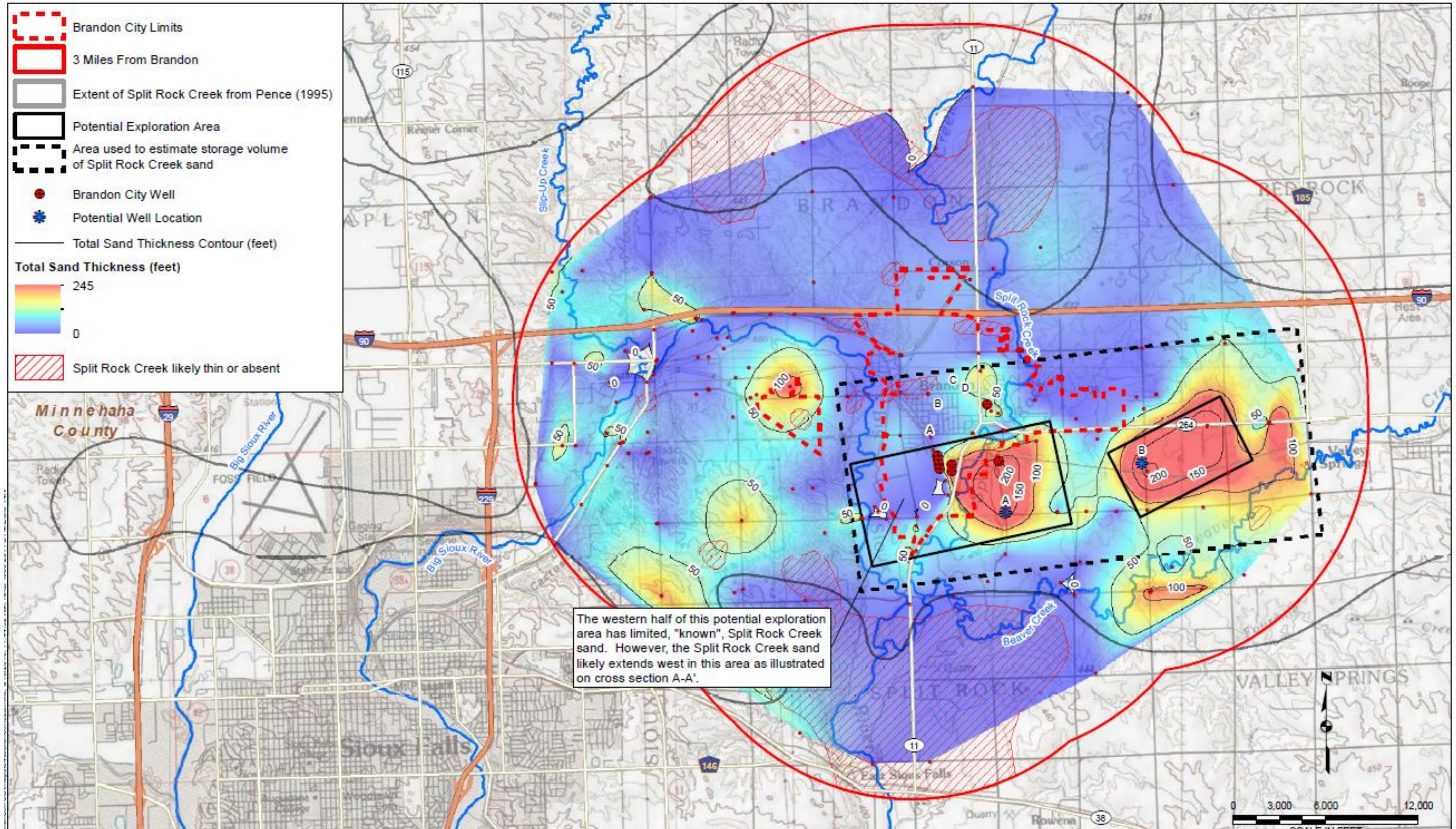
AE2S

FIGURE 21

POTENTIAL EXPLORATION AREAS
QUATERNARY AQUIFER

Building a Better Life



Note: This figure illustrates the thickness of one or more sand units in the Split Rock Creek.
Refer to map titled "Number of Sand Units Identified in Boring - Split Rock Creek Aquifer" for information on where Split Rock Creek Sand is likely absent.

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WATER SUPPLY EVALUATION REPORT
BRANDON, SOUTH DAKOTA

PREPARED FOR
AE2S

FIGURE 36

POTENTIAL EXPLORATION AREA
SPLIT ROCK CREEK AQUIFER

APPENDIX B – CAPITAL COST SUMMARIES AND RATE DEVELOPMENT ASSUMPTIONS

Funding Assumptions

- 6-months' operating budget is kept in a cash reserve at all times
- The total sum of debt payments is less than the cash reserve at all times
- Projects funded at 3% for 20 years when cash reserves are not sufficient
- Additional 10% coverage applied to all loan balances, meaning revenue must be greater than 10 percent of the total debt payments.
- Non-operating revenue from cell towers will not be continued past 2020 with the install of the new tower(s).
- Well 8 paid for with cash
- Personnel services baseline equals $425,000 scaled up for inflation.
- Other Current Expenses = $216,677 base scaled up for inflation and with a 0.5% increase based on all new infrastructure.
- Smaller construction projects are paid for with cash if the previously mentioned financial requirements are met.
- Finances are allocated in such a way as to reduce the water rate as much as possible.
- Inflation assumed to be 2.5% annually, (2.469%) calculated from the average US inflation rate between 1990 and 2018.
- 10-25% of additional revenue funds the water account; the rest goes toward routine or other system improvements.

Rate Development Assumptions and Basis for Values

Estimating the Non-Operating Revenue

This value appeared to bounce around from year to year in the previous annual financial reports. **$20,000 was chosen** and scaled for inflation as the basis for the non-operating revenue per year.

Determining the Electrical Costs

The electrical costs were based on the actual electrical bill provided to AE2S. Some assumptions were made where information was missing, such as transformer size, actual pump head, and flow characteristics from an energy standpoint, base-level energy for powering lights and heat in spaces. The amount of water used from each well was also estimated to determine the costs to pump from certain wells. Considerations were given to base electrical costs (transformer service fee), demand charges, as well as the actual usage rates. Sioux Valley energy appears to be very consistent in the pricing structure they provide to Brandon (i.e., similar hookup, demand, and usage charges). The following table summarizes the energy rates from obtained from the March 2019 electric bill.

	Usage		Demand Charge		Base Monthly Charge	
	Rate	Unit	Rate	Unit	Rate	Unit
Electrical	$0.0355	$/kWh	$14.75	kW	$1.20	$/kVA

Rates are the same all year for the WTP and the wells, according to Christina Smith (Brandon finance officer). I do not have an ability to estimate the costs for the pump stations as I am unaware of their flow rates or head/flow requirements. This was left out of all scenarios but is accounted for indirectly in the estimated maintenance and labor costs as it is a portion of the "other current expenses" under the "operating expense" category on the *2017 Annual Financial Report.*

Determining Chemical Costs

AE2S was provided a list of chemicals used in the WTP and their respective costs. The table below summarizes their dosage rates and costs.

Considerations were given to whether Well 7 was used with or without WRT, (Tonkazorb low and high doses respectively), chlorine costs with and without MCWC (MCWC water needs less chlorine to break-point chlorinate as compared to Brandon's raw water), and RO chemicals were fed only to the water estimated to be fed to the RO system.

Chemicals	Cost	Unit	Dose	Unit	Cost	Unit	Notes
Chlorine (without MCWC)	$0.42	lb	0.05477	lb/1,000 gal	$0.023	$/1,000 gal	
Chlorine (with MCWC)	$0.42	lb	0.05086	lb/1,000 gal	$0.021	$/1,000 gal	
Tonkasorb (low dose)	$4.29	gal	0.67	mg/L	$0.09	$/1,000 gal	
Tonkasorb (high dose)	$4.29	gal	1.5	mg/L	$0.20	$/1,000 gal	
Calgon C5 (LPC-5)	$9.70	gal	1.9	mg/L	$0.018	$/1,000 gal	
Calgon C9 (LPC-5)	$11.49	gal	4.4	mg/L	$0.051	$/1,000 gal	
Aqua Hawk 957	$22.00	gal	0.000002	gal/1,000 gal	$0.00004	$/1,000 gal	Backwash only
Antiscalant (RO Only)	$2.70	lb	4.0	mg/L	$0.090	$/1,000 gal	RO Only
Bisulfate (RO only)	$0.48	lb	5.0	mg/L	$0.020	$/1,000 gal	RO Only
Caustic - 50% (RO only)	$0.39	lb	6.0	mg/L	$0.019	$/1,000 gal	RO Only

Determining Discharge/Disposal Costs

For the existing WTP, the waste process discharges to Sioux Falls at a volumetric rate of $5.37 per 1,000 gallons with an equalization credit of $0.59/1,000 gallons making the total volumetric rate the City pays to discharge BW solids = **$4.78/1,000 gallons.**

For the new WTP which is expected to use a filter press, no water from the treatment processes are assumed to go to the sewer. Instead, a filter cake-like material will be disposed of in the Sioux Falls landfill at a rate of between $18-39/ton. For the purpose of this analysis, $39/ton was conservatively assumed to be the rate. Consideration was given to a round-trip haul from the Brandon WTP to the Sioux Falls landfill of 25 miles with a dump truck at the cost of $1.30 per mile.

Transportation cost = 25 * $1.30 = $32.50 per ton and $39.00 per ton to dispose of the filter cake.

Total cost estimated at = **$71.50/ton**.

Determining the Base Maintenance and Labor Cost

From the Communication with Christina Smith (City Finance Officer), use $425,000 for the personnel expense, and $216,667 (Average of previous 3 "Other Current Expense" costs for this category. Add 0.5% of all new infrastructure to this cost.

Estimating the Watermain Improvements & Contributions to Capital Reserve (Depreciation)

From the previous annual financial reports, the depreciation portion of the operating expenses ranged from around $300,000 to near $400,000. Without a better understanding of how this number was determined, a flat **$350,000 per year** was used and scaled for inflation in the rate calculator.

Elements missing from the Rate Calculator

- Core system improvements
- Booster station rehab/improvements
- Other miscellaneous larger improvements not covered in the Long-Term capital improvements summary.

Summary of the Capital Improvements recommended for each Long-Term Alternative

The following sections summarize the recommended cost estimates for each of the multiple capital improvements for each of the 8 long-term alternatives. Each capital improvement is given a unique number associated with it, as some improvements remain the same over different alternatives. All cost estimates are in 2019 dollars but are not all recommended to be constructed in 2019. The range each capital improvement is recommended to be constructed range between 2020 and 2045.

Alternative 1A – Develop Big Sioux and SRC Aquifers / Existing Treatment Approach

Capital Improvements:

CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - **$600,000** (2019 Dollars)

CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - **$1,300,000** (2019 Dollars)

CI-3 – Phase 2 Parallel Piping (Big Sioux Option) - **$300,000** (2019 Dollars)

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-5 – (4) New Big Sioux Wells and related piping - **$2,800,000** (2019 Dollars)

CI-6 – New WTP (Existing Approach) - **$9,300,000** (2019 Dollars)

Alternative 1B – Develop Big Sioux and SRC Aquifers / Existing Treatment Approach with WRT at Well 7

Capital Improvements:

CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - **$600,000** (2019 Dollars)

CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - **$1,300,000** (2019 Dollars)

CI-3 – Phase 2 Parallel Piping (Big Sioux Option) - **$300,000** (2019 Dollars)

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-5 – (4) New Big Sioux Wells and related piping - **$2,800,000** (2019 Dollars)

CI-6 – New WTP (Existing Approach) - **$9,300,000** (2019 Dollars)

CI-7 – New WRT Radium Removal System at Well 7 - **$2,700,000** (2019 Dollars)

Alternative 1C – Develop Big Sioux and SRC Aquifers / Existing Treatment Approach with RO

Capital Improvements:

CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - **$600,000** (2019 Dollars)

CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - **$1,300,000** (2019 Dollars)

CI-3 – Phase 2 Parallel Piping (Big Sioux Option) - **$300,000** (2019 Dollars)

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-5 – (4) New Big Sioux Wells and related piping - **$2,800,000** (2019 Dollars)

CI-8 – New WTP (Existing Approach with RO) - **$17,200,000** (2019 Dollars)

Alternative 1D – Develop Big Sioux and SRC Aquifers / Existing Treatment Approach with RO & WRT at Well 7

Capital Improvements:

CI-1 – Construct and Pipe Well 9 to the WTP (Big Sioux Option) - **$600,000** (2019 Dollars)

CI-2 – Well 3 Piping and Phase 1 Parallel Piping (Big Sioux Option) - **$1,300,000** (2019 Dollars)

CI-3 – Phase 2 Parallel Piping (Big Sioux Option) - **$300,000** (2019 Dollars)

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-5 – (4) New Big Sioux Wells and related piping - **$2,800,000** (2019 Dollars)

CI-7 – New WRT Radium Removal System at Well 7 - **$2,700,000** (2019 Dollars)

CI-8 – New WTP (Existing Approach with RO) - **$17,200,000** (2019 Dollars)

Alternative 2A – Develop SRC Aquifer / Existing Treatment Approach

Capital Improvements:

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-6 – New WTP (Existing Approach) - **$9,300,000** (2019 Dollars)

CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) - **$540,000** (2019 Dollars)

CI-10 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option) - **$1,600,000** (2019 Dollars)

Alternative 2B – Develop SRC Aquifer / Existing Treatment Approach with WRT at Well 7

Capital Improvements:

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-6 – New WTP (Existing Approach) - **$9,300,000** (2019 Dollars)

CI-7 – New WRT Radium Removal System at Well 7 - **$2,700,000** (2019 Dollars)

CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) - **$540,000** (2019 Dollars)

CI-10 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option) - **$1,600,000** (2019 Dollars)

Alternative 2C – Develop SRC Aquifer / Existing Treatment Approach with RO

Capital Improvements:

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-8 – New WTP (Existing Approach with RO) - **$17,200,000** (2019 Dollars)

CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) - **$540,000** (2019 Dollars)

CI-11 – (1) New SRC Well – **1,500,000** (2019 Dollars)

CI-12 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option with RO) - **$1,600,000** (2019 Dollars)

CI-13 – Phase 2 Parallel Piping (SRC Option with RO) - **$1,000,000** (2019 Dollars)

Alternative 2D – Develop SRC Aquifer / Existing Treatment Approach with RO and & WRT at Well 7

Capital Improvements:

CI-4 – Well #8 and Connection - **$1,300,000** (2019 Dollars)

CI-7 – New WRT Radium Removal System at Well 7 - **$2,700,000** (2019 Dollars)

CI-8 – New WTP (Existing Approach with RO) - **$17,200,000** (2019 Dollars)

CI-9 – Construct and Pipe Well 9 to the WTP (SRC Option) - **$540,000** (2019 Dollars)

CI-11 – (1) New SRC Well – **1,500,000** (2019 Dollars)

CI-12 – Well 3 Piping and Phase 1 Parallel Piping (SRC Option with RO) - **$1,600,000** (2019 Dollars)

CI-13 – Phase 2 Parallel Piping (SRC Option with RO) - **$1,000,000** (2019 Dollars)