OPAL REGIONAL SYSTEM

LEVEL II STUDY

October 2000

EXECUTIVE SUMMARY

Prepared for:

WYOMING WATER DEVELOPMENT COMMISSION

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1.0 INTRODUCTION

This water facility planning study involves two communities. The first is the Town of Opal and the second is the Oakley Area. This study will review the Town of Opal’s water system and operation procedures with a focus on methods to reduce the high fluoride levels in the water. Secondly, the study will look at pipeline routes and costs to install a water line from the Kemmerer Diamondville Joint Powers Board water system to the Oakley Area. The Oakley Area and the Town of Opal are located in southwestern Wyoming in Lincoln County, approximately 2 and 15 miles respectively southeast of Kemmerer along State Highway 30.

In an effort to maintain continuity between the Level II Study and the Executive Summary of the Level II Study Sections 1-5 will focus on Opal’s water system. Section 6 will focus on the pipeline route, costs, and needs for the Oakley Area.

According to the Town’s records, there are 116 full-time residents living in Opal with no seasonal residents. Wyoming State Historical Census data indicates that the population of Opal has been up and down for the last 60 years, with a low of 55 and a high of 95.

The average growth rate over the past 60 years is 0.08% per year. However, the growth rate over the past 10 years has increased to 2.0%. For the 25-year planning period, a 2% growth appears to be optimistically too high. Thus, due to the low historical growth rates in the Town of Opal over the last 60 years this study will use a growth rate of 0.5% per year over the next 25 years. The following table charts the projected growth through 2025 based on a 0.5% growth rate.

<table>
<thead>
<tr>
<th>Population Projections for the Town of Opal</th>
</tr>
</thead>
<tbody>
<tr>
<td>------</td>
</tr>
<tr>
<td>Population</td>
</tr>
</tbody>
</table>

Growth Rate = 0.5%

According to Opal records, the existing total number of culinary water connections is 44. All of these connections are residential connections, no commercial or seasonal connections. As mentioned above, the current and the projected 2025 population are 116 and 131 people. By dividing the current population by the number of existing connections equals 2.64 people per connection. Thus, by dividing 2.64 people per connection into 131 connection, it is estimated that in the year 2025 there will be 6 new connections for a total of 50.
The following chart shows the water usage for the Town of Opal during September 1999 through August 2000.

<table>
<thead>
<tr>
<th>Season</th>
<th>Average Use (gals./day)</th>
<th>Peak Daily Use (gals./day)</th>
<th>Total Season Use (gals./season)</th>
<th>Average Use (gals./conn./day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>13,145.</td>
<td>16,775.</td>
<td>2,381,600.</td>
<td>300.</td>
</tr>
<tr>
<td>Overall Year</td>
<td>14,565.</td>
<td>19,500.</td>
<td>5,325,000</td>
<td>332.</td>
</tr>
</tbody>
</table>

The summer use data shown above is of particular interest, because the system must be capable of delivering these water flows. The average daily use will be discussed in later sections in regard to volume of water storage. The peak daily use is of particular importance in discussing the capacity of water sources. The peak daily summer use of 19,500 gallons equates to an average source delivery of 14 gallons per minute.

2.0 WATER SYSTEM ANALYSIS

According to the State of Wyoming, Opal owns five groundwater wells, three of which are in operation and have water rights appropriated to them. All five wells are located within the Town’s boundary. The five wells were drilled in 1985 and 1986. Knoll Well #3 was abandoned due to radionuclides. Knoll Well #5 was abandoned because the draw down exceeds the depth of the pump. Thus, the pump sucks air. Other than regular maintenance and repair, the other three wells have been working well for the Town of Opal.

Opal presently has two storage reservoirs, including a 250,000-gallon concrete tank and a 30,000-gallon steel tank, for a total capacity of 280,000 gallons. The 250,000-gallon storage reservoir is located on the top of the butte northeast of the community. The 30,000-gallon tank is located next to Knoll Well #1 and the Booster Pump/Chlorination Building. The 30,000-gallon tank is used as a chlorine contact chamber. The 250,000-gallon tank floats online through a single inlet/outlet pipeline.

The water distribution network consists of looped 6” and 8” lines. The pipes were not physically examined, however reports from Opal’s Public Works Director, Robert Taylor, indicate that the distribution system is in good working condition.

The three operating wells pump into an 8” transmission line, which then conveys water to the 30,000-gallon tank to be chlorinated. The transmission line is also in good working condition. Booster pumps then pump the chlorinated water into the distribution system.
At several times in the history of the water system, contamination has been detected in the system, resulting in the need for disinfection and re-testing of the water for bacterial contamination. Although the exact cause of the contamination is unknown, several items are often suspected. A concern in the community is that proper water sampling procedures had not been followed. Since the employment of Robert Taylor, about a year and a half ago, the Town has not tested positive for bacterial contamination. Mr. Robert Taylor is a certified water and wastewater operator. He has the following certificates; Level II Water Treatment, Level I Water Distribution, Level I Wastewater Treatment, and Level I Wastewater Collection.

According to WDEQ requirements, the physical elements of the water system are sized adequately and have ample capacity to meet the Town's needs for the next 25-years. These elements include the Town's water rights, sources, storage tanks, and distribution and transmission network. However, one of the key study objectives of this report is to analyze the possible methods to reduce the high fluoride content in the Opal water system. The following section is dedicated to this objective.

3.0 WATER TREATMENT ANALYSIS

The Town of Opal's existing water supply has routinely tested above the EPA allowable limit for fluoride concentration. The fluoride levels have ranged from 3.5 to 4.7 mg/L averaging over 4.0 mg/L. The EPA maximum contamination level for fluoride is 4.0 mg/L for the EPA Primary Drinking Water Standard. The primary standards establish maximum contaminant levels for materials that are known or suspected health hazards. The maximum contaminant level is the enforceable level that the water supplier must not exceed. The EPA also has Secondary Drinking Water Standards that are not designed to protect public health. Instead, they are intended to protect "public welfare". The EPA has set a standard maximum fluoride concentration of 2.0 mg/L in order to meet the requirements for secondary standards. J. M. Montgomery, Water Treatment Principles and Design, 1985, states adverse health affects begin to occur at concentrations exceeding 4.0 mg/L. The Town must lower its fluoride levels below 4.0 mg/L in order to meet the EPA primary drinking water standard. Reducing the fluoride concentration to below 4.0 mg/L is the primary goal of this project. The secondary goal is to reduce the fluoride to below 2.0 mg/L to meet the secondary drinking water standard.

The noted health affects from excessive fluoride ingestion include tooth mottling (dental fluorosis) and skeletal fluorosis and, at extreme concentrations, toxicity leading to gastrointestinal upset and death. Table 3.1, Affects of Fluoride Ingestion in Relation to System Levels shows the health affects associated with various levels of fluoride concentration in drinking water.
Table 3.1: Affects of Fluoride Ingestion in Relation to System Levels

<table>
<thead>
<tr>
<th>Concentration Range</th>
<th>Health Affects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mg/L</td>
<td>Reduction in Dental Decay</td>
</tr>
<tr>
<td>2.0 mg/L</td>
<td>EPA Secondary Drinking Water Standard</td>
</tr>
<tr>
<td>3.5 – 4.7 mg/L</td>
<td>Sampled Range of Town’s Water</td>
</tr>
<tr>
<td>4 mg/L</td>
<td>EPA Primary Drinking Water Standard</td>
</tr>
<tr>
<td>&gt;4 mg/L</td>
<td>Tooth Mottling</td>
</tr>
<tr>
<td>&gt;4 mg/L</td>
<td>Town’s Average Fluoride Level</td>
</tr>
<tr>
<td>10 mg/L</td>
<td>10% of Population Can Taste Fluoride</td>
</tr>
<tr>
<td>&gt;15 – 20 mg/L</td>
<td>Skeletal Fluorosis</td>
</tr>
<tr>
<td>250 – 450 mg</td>
<td>Toxic</td>
</tr>
<tr>
<td>4 – 5 g (Total Ingestion)</td>
<td>Fatal</td>
</tr>
</tbody>
</table>


Three approaches have been identified to resolve high fluoride concentrations in water:

1. Treat water from the existing sources to remove fluoride
2. Blend the water from the existing source with low fluoride water of alternative source
3. Locate and use a new source of water that contains lower fluoride concentration

1.0 Fluoride Removal through Treatment

The EPA has identified a variety of methods as treatment alternatives to reduce the amount of fluoride in the water. Five (5) of the effective methods will be analyzed.

1. Ion Adsorption with Activated Alumina
2. Bone Char Precipitation
3. Activated Carbon
4. Softening with Excessive Lime & Magnesium
5. Reverse Osmosis

An explanation of each effective method will follow.

Softening with Excessive Lime and Magnesium

Water softening with excessive lime and the introduction of magnesium allows the fluoride to cosettle with the additional magnesium in the water. This method requires mixing and settling
facilities for treatment. The disadvantage of this method is a large amount of settled sludge will have to be removed. If insufficient magnesium is present, additional magnesium must be added.

**Reverse Osmosis**
Reverse Osmosis (RO) is a highly efficient removal process for inorganic ions. Water is naturally drawn to salts and minerals by a process called osmosis. Osmosis can be reversed by pressurizing the water. Reverse osmosis is the process of applying high pressure to contaminated water causing the water to be driven away from the salts and minerals. Water is forced through a non-porous membrane. Since the membrane is non-porous, the water dissolves into the membrane and diffuses across. Fluoride as well as many other inorganic contaminants cannot dissolve through the membrane. These are then discharged in the concentrate. This process is usually not cost effective for the treatment of the entire water supply as it wastes up to 25% of the water in the process. However, this process could be used to treat a portion of the water and then blend the contaminant free water with the untreated water in order to comply with EPA requirements.

**Activated Carbon**
Activated Carbon treatment uses two types of carbon, granular and powdered. Both methods treat contaminants through the physical and chemical process of absorption, by which the contaminants accumulate at the carbon surface as they pass through the carbon bed. Removal efficiencies are considered below average at best. Over time, the surface of the carbon will collect all of the contaminants it can hold. Once this happens, fluoride is no longer removed from the water and the carbon must be regenerated. Frequent backwashing and regeneration or replacement of the carbon is required which generates waste that must be removed.

**Bone Char Precipitation**
This method works by precipitating fluoride crystals from the water due to the introduction of phosphoric acid and bone char. Similar to the activated alumina, the bone char attracts the fluoride and bonds to it. As the bone char becomes saturated with fluoride, it settles out of the water as a precipitate. This method requires mixing and settling facilities for treatment. The precipitant is removed, dewatered, and disposed of or regenerated off-site.

**Ion Adsorption with Activated Alumina**
Ion Adsorption is the process by which ions within a solution are removed by adhering them to the surface of another activated material. In this case, alumina is activated by placing it in a pH range of 5-8. Within this range, the alumina attracts and binds the fluoride and other chemicals to its surface.

**Comparison of Treatment Alternatives**
Table 3.2 shows a comparison of each method of fluoride reduction for effectiveness, cost, operation/maintenance costs, waste generation, and other considerations.
**Table 3.2 – COMPARISON OF FLUORIDE TREATMENT METHODS**

<table>
<thead>
<tr>
<th>METHOD</th>
<th>REMOVAL</th>
<th>COST</th>
<th>O&amp;M COST</th>
<th>WASTES BY-PRODUCTS</th>
<th>OTHER REQUIREMENTS/COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime Softening &amp; Magnesium</td>
<td>20 – 80%</td>
<td>L-M</td>
<td>M</td>
<td>Settled Sludge</td>
<td>-Possible interference with other ions -For small systems softening chemistry may be too complex</td>
</tr>
<tr>
<td>Reverse Osmosis</td>
<td>&gt;90%</td>
<td>M</td>
<td>M</td>
<td>Wastewater</td>
<td>-High percentage of rejection</td>
</tr>
<tr>
<td>Adjusted Alumina</td>
<td>&gt;80%</td>
<td>L</td>
<td>H</td>
<td>Backwash Regeneration Waste</td>
<td>-High Maintenance -Waste may be hazardous -Required Chemicals and pH adjustment may be difficult for small systems</td>
</tr>
<tr>
<td>Bone-Char Precipitation</td>
<td>&gt;80%</td>
<td>L-M</td>
<td>L - M</td>
<td>Settled Bone Char Precipitant</td>
<td>-Experimental -Considerable Bone Char Used</td>
</tr>
<tr>
<td>Activated Carbon</td>
<td>&lt;20%</td>
<td>L-M</td>
<td>L - M</td>
<td>Backwash Regeneration Waste</td>
<td>-Regeneration off site</td>
</tr>
</tbody>
</table>

**Selection of a Treatment Alternative**

After careful consideration of all of the treatment alternatives and a comparison of the costs, effectiveness, and maintenance of each, Reverse Osmosis appears to be the only viable option to remove fluoride from the Opal Water System. This method is only feasible if a portion of the water supply were treated and then blended with untreated water. By treating approximately 60% of the supplied water, the amount wasted will be significantly reduced and the Opal System will still be able to comply with the EPA Secondary Drinking Water Standard with levels of fluoride at 2.0 mg/L or below. Reverse Osmosis (RO) is the recommended treatment option.

**2.0 Blending of Water From Another Source**

With the limited funding available a preliminary desktop ground water study was conducted in the Opal area for the purpose of finding a source with low amounts of fluoride.

The study identified that the existing Opal wells are most probably drilled into the Laney Member of the Green River Formation. Because the Laney Member may be as thick as 3,000 feet, it is not possible to deepen the wells to obtain good quality water. Actually, in the study area, water in the permeable aquifers near the surface are more likely to produce better quality water than in the less permeable and deeply buried aquifers. The possibilities of developing a shallower well that produced lower levels of fluoride appear to be favorable. However, further investigations and the drilling of test wells would be required to completely determine the possibility and feasibility of diluting the existing source through blending.
**Recommended Treatment Method**

Based on the information provided in the previous sections, it is difficult to determine the best alternative for the Opal Water System without further information on the probability of a new source. Without additional research and information regarding a new source, treatment of the existing source water is the recommended alternative. As was discussed above, the recommended treatment alternative is the installation and operation of a Reverse Osmosis (RO) unit to reduce the fluoride content in the Opal Drinking Water to acceptable EPA standards.

### 4.0 COST ESTIMATES AND FUNDING

As was indicated previously in Section 3, the Reverse Osmosis (RO) unit is the recommended treatment alternative to reduce the fluoride levels in the Opal drinking water to meet the EPA Secondary Drinking Water Standards. The costs associated with the purchase of a 15-gallon per minute RO unit, RO unit building, evaporation pond, and telemetry are $212,000. These costs include engineering, design, construction inspection and a contingency for the proposed improvements.

The funding for the water system treatment improvements discussed above will most likely be available through the Wyoming State Land Investment Board (SLIB) and the Drinking Water State Revolving Fund (DWSRF). The DWSRF offers loans at a 4.00% interest rate. Based on initial indications, Opal has a high eligibility ranking and it is considered likely that funds will be available to Opal in the coming year through the DWSRF.

Opal should qualify for a 50/50 grant-to-loan ratio. This means Opal will be required to borrow $106,000 at a 4.00% interest rate for twenty (20) years. This equates to an annual payment of $7,800.00 per year. Operation and maintenance costs also need to be considered and are not grant eligible. The operation and maintenance of an RO unit is fairly expensive and has been estimated to be $3,200.00 per year. The total payments are summarized below.

<table>
<thead>
<tr>
<th>Annual Payment</th>
<th>$7,800.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual O&amp;M</td>
<td>$3,200.00</td>
</tr>
<tr>
<td>Total</td>
<td>$11,000.00</td>
</tr>
</tbody>
</table>

There are currently 44 existing culinary water connections in Opal. Dividing the total payment by the number of users equates to $250.00 per year or $21.00 per month increase in user fees. Opal currently charges a base rate of $19.00 per month for the first 10,000 gallons with an overage rate of $2.00 per 1,000 gallons for water used over the base 10,000 gallons. With the construction of this project the base user fee would more than double to $40.00 per month. It is
recommended that the Town Council consider raising the overage rate to $4.00 per 1,000 gallons over the base of 10,000 gallons. The monthly user fee is summarized below.

| Existing Monthly Fee - | $19.00 per month |
| Increase in Monthly Fee - | $21.00 per month |
| Total Base Fee - | $40.00 per month |

After consideration of the end user costs the Town of Opal now has to decide if this project will be pursued.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon the analysis and evaluation of the preceding sections, the following conclusions are presented in regard to the Opal Water System:

If the Town of Opal is desirous of reducing the fluoride in their water system in the immediate future and is willing to pay the user fees outlined, they should make application to the respective funding agencies. The recommended mechanical means of reverse osmosis will accomplish the desired objective.

Obtaining a new source, which could be used to effectively dilute the water from the existing sources, appears to be a viable option. In order to verify that this a viable option, additional work must be done. This includes:

1. Conduct a groundwater resources/well siting study
2. Drill 4 test wells
3. Conduct pump tests
4. Water quality analysis
5. Economic analysis and project funding plan

An additional task that should be completed if this hydrologic approach is unsuccessful is the environmental assessment for the highly concentrated fluoride wastewater. Determination needs to be completed whether this wastewater can be discharged to the river or must it be placed in a total containment pond.

If WWDC feels it is a worthwhile investment, they would need to request from the State Appropriations Committee consideration for a Level II continuance. The budget we recommend to pursue the work tasks outlined above are as follows.

1. Groundwater resources/well siting study.................................$15,000
2. Drill 4 test wells........................................................................$26,200
3. Conduct pump tests ................................................................. $18,800
4. Water quality analysis .......................................................... $4,500
5. Economic analysis and project funding plan ....................... $3,500
6. Environmental Assessment ................................................... $8,000

TOTAL .......................................................... $76,000
6.0 OAKLEY AREA PIPELINE ANALYSIS

The goal of this section is to find the most economical means to convey water to the Oakley Area from the Kemmerer Diamondville Joint Powers Board (KDJPB) water system. The residents of the Oakley Area do not desire fire protection and are in the process of forming an improvement district, to obtain funding for the project.

The Oakley Area is located along State Highway 30 approximately 2.3 miles southeast of Kemmerer and Diamondville. The total number of lots in the Oakley Subdivision is 17. Three additional residential lots are adjacent to the subdivision and will be included in the study area, for a total of 20 lots. Currently, there are 16 residencies and no commercial users in the study area. Complete build-out for this area is 20 residencies.

As was mentioned earlier, the residents in the Oakley area are forming an improvement district. The preliminary boundaries of the district include 12 residencies. Throughout this study when discussing the benefits or costs associated with this project it is in reference to these 12 residencies.

Pipeline Route

At first, two pipeline routes were considered. Each route had the same construction obstacles, just in different locations. The preferred route parallels Highway 30 on the northeast side from the Oakley Subdivision to the KDJPB water tank. There are three physical obstacles between the Oakley Area and the KDJPB water system. The first obstacle is the large rock outcropping approximately 250 feet west of the Oakley Area. The rock outcropping is approximately 60-90 feet high, 200-300 feet long, and parallels the north right-of-way line of Highway 30. The second obstacle is the Hams Fork River. The Hams Fork River is approximately 70-100 feet wide and runs perpendicular to the pipeline route. The third major obstacle is the Union Pacific Railroad tracks. Throughout most of the study area, the tracks parallel the west bank of the Hams Fork River. However, just north of the Highway 30 bridge, which crosses the Hams Fork and the railroad tracks, the railroad tracks bridge over the river to the east side.

Pipeline Route Permits

There are several permits or permission waivers to obtain prior to construction. Preliminary discussions concerning the conceptual design of the pipeline route has been completed with each of the following agencies or companies. During detailed design, applications and or legal documents will need to be submitted to each agency or company.

- Right-of Way: The Pittsburgh & Midway Coal Mining Co.
- Union Pacific Railroad: Railroad crossing
Economic Analysis

The costs to construct the pipeline from the KDJPB water tanks along Highway 30 through the Hams Fork River and under the Union Pacific Railroad bridge to the Oakley Area is estimated at $352,000. It should be noted that the costs of the individual service connections have been left out of the cost estimates. Each individual homeowner will be responsible for the construction of their service connection.

It is anticipated that there will not be a lot of maintenance costs for the pipeline. The design is simple and has minimal mechanical parts that are widely used and are reliable. However, there will be some operation costs associated with reading meters and producing billings. It is projected that a total of 6 hours each month will be required to operate the system. At $12 per hour a total of $72 a month will be accumulated for Operation and Maintenance costs. The KDJPB has indicated that they would not be interested in owning or maintaining the pipeline.

The KDJPB usage rates are currently set at $1.93 per 1000 gallons of water with an $8.31 base charge. Currently, the residents of the Oakley Area don’t use a lot of water for outside use. It is assumed that due to the high cost of water, the Oakley Area residents will be conservation minded. Therefore, the average residential use is estimated at 10,000 gallons per month. This equates to an average residential usage rate of $28 per month to be paid to the KDJPB. The District will need to finalize this rate with the KDJPB.

Construction Project Funding Options

There are four funding agencies that could participate with funding this project. They are WWDC, State Land and Investment Board (SLIB), and United States Department of Agriculture – Rural Development USDA-RD, and Drinking Water State Revolving Fund (DWSRF). Three possible funding scenarios are outline below.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Grant</th>
<th>Loan</th>
<th>Grant to Loan Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WWDC 50%</td>
<td>DWSRF 50%</td>
<td>50/50</td>
</tr>
<tr>
<td>2</td>
<td>SLIB 50%</td>
<td>DWSRF 50%</td>
<td>50/50</td>
</tr>
<tr>
<td>3</td>
<td>SLIB 50%, USDA-RD 25%</td>
<td>USDA-RD 25%</td>
<td>75/50</td>
</tr>
</tbody>
</table>

*A minimum of 20 connections is required for WWDC funding*
**The Median household income of the Oakley residents has to be below $26,148 in order to qualify for USDA-RD grant.**

The estimated total end user rate for each proposed funding scenario is shown below.

<table>
<thead>
<tr>
<th>Total End User Rates for Each Funding Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
</tr>
<tr>
<td>$54</td>
</tr>
<tr>
<td>Scenario 2</td>
</tr>
<tr>
<td>Scenario 3 (20-Year)</td>
</tr>
<tr>
<td>Scenario 3 (25-Year)</td>
</tr>
<tr>
<td>Scenario 3 (30-Year)</td>
</tr>
</tbody>
</table>

**Conclusions and Recommendations**

After further discussion with the Oakley Area residents it is evident that the MHI requirement, of $26,148 set by USDA-RD, will not be met. Therefore, the best funding scenario to pursue is Scenario 1 (WWDC 50% grant and DWSRF 50% loan). It is our recommendation that the residents of the Oakley Area complete the applications and/or legal details with the appropriate agencies as soon as possible to ensure that the project is not delayed. The following list outlines the recommended steps to be completed by the Oakley Area residents.

- Complete the formation of the Oakley Service and Improvement District
- Complete application with WWDC for Level III grant funding (50%)
- Complete application with DWSRF for Loan funding (50%)
- Complete negotiations with KDJPB for tap fee, water costs, and service agreement
- Pursue right-of-way agreements with property owners affected by pipeline