Technical Memorandum No. 1

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South East Kelowna Irrigation District

Water Supply and Treatment Cost/Benefit Review

Source Review and Water Treatability

November 2007

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1 Objective

The objective of this Technical Memorandum is to review the feasibility of various alternative supply sources and to develop water treatment solutions based on the sources being carried forward for system options development.

2 Existing Supply Sources

The SEKID system is presently supplied via two supply sources as described below.

2.1 Hydraulic Creek

Hydraulic Creek is SEKID's current primary supply source and is known to have the capacity to supply both domestic and agricultural demands projected over the next ten years. Water in Hydraulic Creek originates from McCulloch Reservoir, an uplands lake controlled by SEKID. Based on a review of information contained in a SEKID Water Quality data spreadsheet covering the period 1992 to 2006, the water quality as measured at the intake site varies seasonally with colour and turbidity peaking during the spring freshet. The colour is due both to iron and organics originating from decaying vegetation in its watershed. Colour typically ranges from 30 TCU to 100 TCU with a high value of 152 TCU (April 1993) over the period 1993 to 2006. Turbidity typically ranges from 2 NTU to 6 NTU with a high value of 14.5 NTU (April 1997) over the period 1993 to 2006. Colour and turbidity peaks typically occur in April each year with a corresponding water temperature in the range of 2º C to 4º C. These would be expected to be the most challenging conditions to treat the water. Water temperature can drop to 0º C in the period between November and February.

Supply capacity is being increased in a project involving expansion of the Turtle Lake Reservoir.

2.2 Groundwater

SEKID presently operates three wells which draw water from the Rutland Aquifer. The O'Reilly Road well is dedicated to supplying water to 172 lots in the O'Reilly Road area. There are also two wells located on East Kelowna Road which supply significantly higher quality water to 110 domestic connections in the area and supplement the water supply in the East Kelowna area during drought years. Water quality records covering the period 1997 to 2006 were reviewed. Groundwater pH typically ranges from 7.4 to 7.6. Total hardness ranges from 200 to 230. Turbidity ranges from 0.1 to 0.4. Temperature typically ranges from 9º C to 10.5º C.

3 Potential Supply Sources

The following is a review of potential supply sources.

3.1 Canyon Lake/KLO Creek

Canyon Lake is an uplands lake source that would have the capability of augmenting SEKID's existing sources. It is the source of KLO Creek and may have adequate capacity to supply domestic demands. Water quality is unknown at present, but thought to be similar to Hydraulic Creek. It is expected that a similar level of treatment would be required for this source as for McCulloch Lake/Hydraulic Creek due to the fact that their watersheds have similar characteristics.

3.2 Okanagan Lake

A deep intake in Okanagan Lake might allow SEKID to avoid filtration by using a two stage disinfection process. Because of the distance of Okanagan Lake from the centroid of demand in SEKID, there would be a significant capital cost to build the pumping and pipeline infrastructure to convey water to SEKID. In addition to this capital cost, there would be a high energy cost to lift the water from Okanagan Lake (342 metres ASL) to Field Road Reservoir (620 metres ASL).

3.3 City of Kelowna

The City of Kelowna treated water distribution system extends to the west side of Mission Creek. Currently the City has installed treatment and pumping capacity of approximately 150 ML/d. This could be expanded to over 200 ML/d with the installation of additional pumping and treatment equipment at the Poplar Point intake. The City's largest pressure zone operates at an HGL of approximately 420 m. It is readily apparent that the City system would not be capable of supplying SEKID's full demands which exceed 150 ML/d. Even to supply the domestic demands (21 ML/d) would be extremely challenging without doing a major upgrade to the City's trunk feeder system. In addition to the cost of upgrading the City feeder system and extending a supply line to SEKID there would be the ongoing energy cost of lifting water from the City's HGL of 420 to SEKID's Field Reservoir HGL of 620. While the City of Kelowna does not appear to be a feasible alternative to supply the entire SEKID area, the Kelowna water system could be a partial solution to feed some of SEKID's customers along the boundary between SEKID and Kelowna should this be advantageous.

3.4 Wellfield Expansion

SEKID's existing wellfield draws water from the Rutland Aquifer. The Rutland Aquifer is considered to be a high productivity aquifer. The writer contacted SEKID's groundwater consultant, Remi Allard by telephone to determine the potential of increasing production from this aquifer. Mr. Allard indicated that expanding production from this aquifer to meet the full domestic demands of 21 ML/d is within the realm of possibilities, although a more detailed investigation would be required to confirm this. He noted that the City of Kelowna has some small systems extracting water from this aquifer and the impact on these systems would need to be considered. He also noted that there appears to be some interaction between the O'Reilly Road well and Mission Creek. Because of this additional volume of water that SEKID would be withdrawing from the aquifer, the additional wellfield development would trigger an environmental assessment. Based on this information, we have concluded that further development of the existing wellfield should be considered as part of the options review.

3.5 Mission Creek

Mission Creek would have the capacity to supply all of SEKID's demands. Hydraulic Creek discharges into Mission Creek. Water quality in Mission Creek would be similar, but lower quality than Hydraulic Creek. Because its elevation is lower than Hydraulic Creek, additional pumping would be required to deliver water into the SEKID system. Based on our review, we don't consider Mission Creek to be a preferential alternative to Hydraulic Creek as a supply source. It could, however, possibly be suitable as a future source to augment the supply from Hydraulic Creek.

3.6 Other Creeks

There are other creeks which either traverse or are located near the SEKID sources area including Rumohr Creek, Priest Creek, and Bellevue Creek. None of these creeks are considered to have any advantage over Hydraulic Creek in terms of water quality, i.e. similar levels of treatment would be required for all of them.

4 Sources to be Considered for Options Review

As a result of our review of SEKID's existing sources and other potential sources, we don't believe that any of the potential other supply sources, other than wellfield expansion, offer advantages over SEKID's existing developed supply sources. The advantages of the existing supply sources over the other options are summarized as follows:

- The elevation of the Hydraulic Creek intake allows SEKID to deliver its high demand agricultural supply to its entire service envelope by gravity. This is a significant advantage in terms of energy costs and environmental sustainability when compared to options requiring pumping.
- The water quality in the existing wellfield is significantly better than any of the other sources under consideration. This makes this source attractive as a domestic supply source due to the reduced capital our initial assessment suggests would be required to provide treatment infrastructure and the reduced ongoing operation and maintenance costs involved in treating it.

- All of SEKID's existing water supply and distribution infrastructure is already connected to these sources therefore there is virtually no further investment required to use them as SEKID's water supply.

For the above reasons water treatability assessment and development of water treatment concepts will be based on utilizing/expanding SEKID's existing supply sources.

5 Treatment Requirements – Hydraulic Creek Source Water

The objective of water treatment for the Hydraulic Creek source would be to meet the Interior Health Authority's (IHA) 4-3-2-1-0 protocol and to meet the Guidelines for Canadian Drinking Water Quality (GCDWQ). The 4-3-2-1-0 treatment objectives recommended 4-log (99.99 percent) inactivation and/or removal of viruses, 3-log (99.9 percent) inactivation and/or removal of Giardia and Cryptosporidium, dual treatment (e.g. filtration and disinfection), <1 NTU turbidity, and 0 total or fecal coliforms. As noted, the most challenging treatment conditions occur in the spring, with high levels of organics (TOC/ DOC) and colour , along with low water temperatures. The raw water conditions in the spring will dictate the process selection.

5.1 Clarification

Water treatment utilizing clarification and filtration as primary unit processes would be a logical process selection based on the treatment objectives and the raw water conditions. Options for clarification processes include, but are not limited to, Dissolved Air Flotation (DAF), Actiflo® ballasted flocculation, and plate settlers. For the purposes of costing in Technical Memorandum No. 2, Actiflo® was the assumed clarification process. Actiflo® is a robust high-rate treatment process that results in a small plant footprint and can lead to a cost effective treatment solution. If an option is pursued that uses Hydraulic Creek water, Actiflo®, and other options such as DAF, should be piloted to determine their treatment effectiveness on the Hydraulic Creek water source. It is also important to pilot filtration downstream of the clarification processes in order to assess the filterability of the clarified water.

5.2 Coagulation

Coagulation upstream of the clarification process will be critical to removal of organics and colour in the clarification step. The objective for colour removal is to meet the GCDWQ aesthetic objective (AO) of 15 True Colour Units (TCU). With regards to organics, the treatment objective would be to remove organic carbon so as to mitigate disinfection by-product (DBP) formation. The GCDWQ have a Maximum Acceptable Concentration (MAC) of 100 ug/L for trihalomethanes, which would be one of the key DBPs of interest. By removing a portion of the organic carbon, the concentration of DBP precursors will be reduced and the formation of DBPs mitigated. Typical coagulants used in Western Canada include polyaluminum chloride (PACL), ferric chloride and alum. Different coagulants should be evaluated at the pilot stage to assess their suitability with the raw water and the other unit process.

5.3 Potassium Permanganate

In order to achieve greater removal of organics and colour, addition of potassium permanganate can be incorporated in the treatment process. In the costing of the treatment options in Technical Memorandum 2, a chemical feed system for potassium permanganate was included. Potassium permanganate is commonly used as an oxidant for removal of iron and manganese, colour, and taste and odour compounds. The concentration or iron in the Hydraulic Creek water source can exceed the GCDWQ AO of 0.3 mg/L. Addition of permanganate, along with coagulation, could be very effective in reducing the iron levels to below the AO. Although considered only a moderately strong oxidant, potassium permanganate does not produce any by-products currently of concern. It is expected that potassium permanganate would be required seasonally when TOC/DOC and colour levels spike.

5.4 Activated Carbon

Activated Carbon is an adsorbent material that provides a surface on which ions or molecules in the liquid or gaseous phase can concentrate. In drinking water treatment, activated carbon adsorption is used to remove natural organic compounds, taste and odour compounds, and synthetic organic chemicals from source water. Activated carbon is available in two different forms: granular and powdered. Granular activated carbon (GAC) is usually used either as a stand-alone step in the treatment or is used as part of the filter media. GAC has not been considered further for this application. Powdered activated carbon (PAC) is added to water, mixed for a short period of time, and removed. Adsorption of molecules occurs while the PAC is in contact with the water. PAC is usually added early in the treatment process and then either settles out with the floc in the clarification process or is removed from the filter beds during backwashing. A powder activated carbon (PAC) chemical feed system has been included in the costing for the treatment options in Technical Memorandum 2. It is expected that PAC would be required seasonally when TOC/DOC and colour levels spike.

5.5 Filtration

Filtration downstream of clarification would ensure effluent turbidity meets the IHA standard of 1 NTU. Also, the filtration process can be designed to ensure effluent turbidity is below the future anticipated standard of 0.3 NTU. It is expected that filtration, along with clarification, would meet the IHA's requirement for dual treatment and 3 log inactivation of Giardia/ Cryptosporidium. Granular media filtration was included in the costs in the Technical Memorandum 2. Membrane filtration is also an option for the Hydraulic Creek water source. However, membrane filters may not be cost effective. Membrane filtration for purposes of turbidity removal or protozoa reduction would not require clarification upstream. However, for the removal of colour and organics, addition of a coagulant and or an adsorbent (PAC) upstream of the membrane filters would be required, further increasing the cost for this option.

5.6 Disinfection

For all the treatment options in Technical Memorandum No. 2 for the Hydraulic Creek source, chlorination using free chlorine is proposed. Filtered water would be chlorinated before entering the Field Road Reservoir. Disinfection through the use of free chlorine would meet the 4 log virus inactivation/ removal requirement and would provide a residual in the distribution system to control microbial re-growth. Chlorination at the Hydraulic Creek intake site is discontinued for all of the treatment options for the Hydraulic Creek source as chlorination of the raw water at the Hydraulic Creek site forms high levels of DBPs,

Ultraviolet (UV) disinfection is included for the treatment Option 2 which is outlined in Technical Memorandum No. 2. For this option, a portion of the summer demand is clarified, but not filtered. To compensate for the lack of filtration, UV disinfection is provided where filtration is not provided. UV disinfection will provide 3 log Giardia/ Cryptosporidium removal and will provide the second level of treatment required by IHA. The side stream not filtered will be of a lower effluent quality, i.e., the colour and turbidity will be higher than for the other options. However, UV disinfection along with chlorination for virus inactivation will ensure the treated water is thoroughly disinfected.

5.7 Residuals Management

For all of the treatment options discussed in Technical Memorandum No. 2, it is proposed to recycle a majority of the waste streams and to minimize discharge to the local watercourses. Filter to Waste (FTW) will be recycled directly to the front of the treatment plant, i.e., upstream of the clarification process. Filter backwash waste and clarifier waste will be thickened, with the thickener supernatant recycled to the front of the treatment plant and the thickened sludge discharged to natural freeze/ thaw and/or evaporation lagoons. The freezing process in the lagoons will dehydrate the sludge particles by freezing the water that is closely associated with them. After a freeze/ thaw cycle, a sludge layer will form on the bottom of the lagoon with a water layer on top. The sludge will be dry enough to allow for landfill disposal. The water will be decanted from the top of the lagoon. Once the water is decanted, the sludge on the bottom off the lagoon can be removed with loading equipment and trucked to landfill.

5.8 Alternative Processes

There are a number of other processes that could be utilized for the treatment of Hydraulic Creek source. The options proposed above are identified as cost effective options to meet the regulatory requirements and provide safe and aesthetically pleasing drinking water. There are other treatment processes, or different combinations of the processes identified above, that could be effective alternatives to the treatment train described above. Ozone with biologically active carbon (BAC) filters could be an effective primary treatment process, in lieu of the clarification/ filtration process described above. Oxidation with ozone would remove a high percentage of the colour and organic carbon, while the BAC filters would remove the turbidity and the assimilable organic carbon (AOC) produced from the oxidation of organic carbon. Also, as mentioned above, there are other clarification processes that deserve consideration. Membrane filtration should also be reviewed further as well. The alternative processes were not included in the costs estimates included in Technical Memorandum No. 2, however the feasibility of these options could be evaluated as the Study progresses.

5.9 Point of Entry Devices

For treatment Option 3, Point of Entry (POE) devices are proposed as a treatment option for the residents outside of the McCulloch Road/ Gallagher's corridor. In order to meet the IHAs 4-3-2-1-0 protocol, ultrafiltration membrane filters, with GAC pre-filtration and post-membrane UV disinfection are proposed. Ultrafiltration would provide turbidity removal and along with UV disinfection, would provide a dual barrier to pathogens. GAC filters would reduce the organic carbon and colour. The cost estimates assume that these three stage units would be installed in the resident's homes in order to treat all of the water entering the homes. Chlorination would be discontinued at the Hydraulic Creek in take site, so raw water would be fed directly into the POE devices. Chlorination would not be required for disinfection and by discontinuing chlorination of the raw water at the Hydraulic Creek intake site, DBPs can be eliminated. We have assumed that chlorination would not be required downstream of the POE devices in the individual house plumbing systems. This assumption should be reviewed and confirmed with IHA.

6 Treatment Requirements – Rutland Aquifer Source Water

As the Rutland Aquifer is a groundwater source, it is not subject to the IHA's 4-3-2-1-0 protocol. The only parameter of concern is the hardness, which averages approx. 220 mg/L (as CaCO3). This is considered hard water and is considerably harder than the water from Hydraulic Creek. Raw Water from Hydraulic Creek never exceeds 100 mg/L hardness. Because hardness is an aesthetic parameter, Options 6 and 7 base cost estimates provided in Technical Memorandum No. 2 assumed the provision of chlorination only without any other treatment. The incremental costs involved in providing optional softening to 100 mg/L were therefore shown as optional costs.

6.1 Disinfection

Chlorination using free chlorine is proposed for disinfecting the groundwater extracted from the Rutland Aquifer. Disinfection through the use of free chlorine would provide a residual in the distribution system to control microbial re-growth. For the purpose of this study we have assumed that sodium hypochlorite generation technology would be utilized at a central treatment facility and would include the following components.

- Salt delivery and storage system.
- Brine tank.
- NaOCl generation equipment including water softener, heater, rectifier, controller, electrolytic cells, and brine proportioning pump.
- 0.8% NaOCl storage tanks.
- Solution metering pumps.

6.2 Optional Membrane Softening

The optional softening costs included in Technical Memorandum No. 2 are based on softening using membrane filtration, Reverse Osmosis (RO) membranes to be specific. The concept for this application would be to treat a side stream, which then can be blended with untreated groundwater to produce the water quality desired. In this case, 100 mg/L hardness was the target selected. Following softening the blended water would be chlorinated before entering the distribution system. Either nanofiltration or RO membranes can be used in this application to remove the hardness from the feed water. RO membranes utilize a smaller pore size than nanofiltration, and that would lead to a smaller membrane treatment plant. However, the unit cost for RO membranes would be higher. If an option is pursued that uses Rutland Aquifer source water, the economics of RO versus nanofiltration should be investigated further.

The waste stream from the membrane softening plant would be approx. 15% of the feed water flow. The waste flow when the plant is at capacity would be 3.4 ML/d. The concerns with this waste stream would be the quantity and the calcium carbonate formation potential, and the impact on the wastewater collection system and wastewater treatment process. There isn't a nearby connection to the sanitary sewer at the proposed plant site, so a new sanitary sewer main would need to be built. The waste stream could be concentrated further using a second pass membrane filtration system to reduce the waste flow, however, the calcium carbonate potential in the waste flow would increase accordingly. The impact on the wastewater collection and treatment process would need to be evaluated further.

6.3 Other Softening Processes

Other alternatives for softening include lime softening and sodium cycle ion exchange softeners. Lime softening has been the traditional approach for softening in North America. Lime is added to the water to convert convert bicarbonate to carbonate alkalinity and to precipitate calcium carbonate and magnesium hydroxide. Recarbonation is required after the softening process to stabilize the water and reduce the pH. This process creates significant quantities of sludge and the sludge handling/ processing can be cost-prohibitive. In addition, handling of the lime itself is quite operator and maintenance intensive. Due to the sludge and lime handling challenges, lime softening has not been considered further for this application.

Ion exchange is a process where an insoluble substance removes ions from solution and releases other ions of like charge into solution. The sodium cycle ion exchange process uses ion exchange resins to remove calcium ions from the feed water and replaces/ exchanges them with sodium ions. There, however, are few municipal ion-exchange softening plants, partly for economic reasons and partly because of problems associated with disposing of the waste flow. Also, this process will increase concentrations of sodium in the treated water. As with lime softening, sodium cycle ion exchange has not been considered further for this application.

Prepared by:

Tom Reinders, P.Eng.
Senior Process Engineer

Reviewed by:

Ian P.D. Wright, P.Eng.
Vice President, Water Treatment

WJH/cb