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June 30, 2004  
File No.: 0402-01

Breakwater Enterprises Ltd.  
Box 855  
Parksville, B.C. V9P 2G9

**Attention: Mr. Robert Hill**  
**Manager**

Dear Sirs:

**Re: Breakwater Enterprises Ltd.**  
**Water Source and System Assessment.**

Koers & Associates Engineering Ltd. is pleased to submit two (2) copies of our water system assessment report entitled "Breakwater Enterprises Ltd. - Water Source and System Assessment", dated June 2004.

The water source and system assessment report is in general conformance with our Terms of Reference that we submitted on January 14, 2004, which were approved by the Vancouver Island Health Authority on January 30, 2004. We have identified both minor improvements and high priority improvements that should be considered in the Breakwater system.

We will be pleased to discuss the assessment recommendations in more detail, or provide any further assistance that may be needed.

Yours truly,

KOERS & ASSOCIATES ENGINEERING LTD.

D.A. Koers, P.Eng.  
Project Manager



Matt Palmer, P.Eng.  
Project Engineer



Enclosures



A Member of Consulting Engineers of British Columbia  
and Association of Consulting Engineers of Canada



# **BREAKWATER ENTERPRISES LTD.**

## **WATER SOURCE AND SYSTEM ASSESSMENT**

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- Appendix B EBA Report on Well R8-2
- Appendix C Certificates of Analyses from Water Quality Testing Program

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# 1 INTRODUCTION

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## 1.1 AUTHORIZATION

Breakwater Enterprises authorized Koers & Associates Engineering Ltd. (Koers) in February, 2004 to commence work on a water source and system assessment of the Breakwater water utility. The work was carried out generally in accordance with Koers Terms of Reference letter dated January 14, 2004, which was reviewed and accepted by the Vancouver Island Health Authority (VIHA) on January 30, 2004. The Terms of Reference letter, the project schedule, and the VIHA acceptance letter are enclosed in Appendix A of this assessment.

## 1.2 BACKGROUND

Last fall, fecal coliform bacteria were found in the Breakwater system at Hawthorne Rise and Meadow Lane. The VIHA issued a boil water advisory to Breakwater Enterprises on September 17, 2003. Following the boil water advisory, the VIHA ordered Breakwater Enterprises to undertake a water source and system assessment, pursuant to Section 19(1)(a) of the Drinking Water Protection Act. This order was issued on October 28, 2003.

## 1.3 OBJECTIVES

As identified in the Drinking Water Protection Act, the purpose of Breakwater's water source and system assessment is to identify, inventory, and assess

- (a) the drinking water source for the water supply system, including land use and other activities and conditions that may affect that source,
- (b) the water supply system, including treatment and operation,
- (c) monitoring requirements for the drinking water source and water supply system, and
- (d) threats to drinking water that is provided by the system.

## 1.4 REFERENCES

The following references have been used during the preparation of the Breakwater source and system assessment:

1. AWWA, Pathogen Intrusion into the Distribution System, 2001, by AWWA Research Foundation & American Water Works Association.

2. French Creek Watershed Study, 2001/2002, by the Ministry of Water, Land and Air Protection, Ministry of Sustainable Resource Management, Nanaimo Regional Office.
3. Guidelines for Canadian Drinking Water Quality (Sixth Edition), 1996, by Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial Committee on Environmental and Occupational Health.
4. Guidelines for Canadian Drinking Water Quality : Supporting Documentation, edited January 2002, by the Federal-Provincial Territorial Committee on Drinking Water.
5. Guidelines for Drinking-Water Quality, 2<sup>nd</sup> edition, Volume 1, by the World Health Organization.
6. Personal Communications with Representatives of Breakwater Enterprises Ltd.

## **2      BREAKWATER'S SOURCE ASSESSMENT**

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### **2.1      BREAKWATER'S FRENCH CREEK SURFACE WATER SUPPLY**

Breakwater's surface water supply consists of an infiltration gallery intake on French Creek. This intake is located just east of Drew Road, approximately 650 metres north of the railway bridge, that crosses over the creek, near the south end of Drew Road. The intake location of the French Creek surface supply is shown on Figure No. 1 and Drawing 9742-01-R6 (in pocket). Breakwater operates this surface supply under Land and Water BC Water Licence No. C035623. Water from French Creek is pumped up to the Drew Road Reservoir complex where it is chlorinated with sodium hypochlorite before entering the Drew Road Reservoir tanks.

Breakwater relies on the French Creek surface supply to help meet demands throughout the year. This supply is critical to Breakwater for two reasons. Water from French Creek is normally blended with Breakwater's local Drew Road well supplies to dilute the concentrations of iron and manganese that are naturally present in these groundwater supplies. In addition, the French Creek supply is relied on heavily during high demand periods in the summer and utilized to the full extent permitted under the water licence. French Creek water helps to fill the Drew Road Reservoirs, which supply water to the west side of the Breakwater system and provide emergency storage for fire fighting purposes. Without this source of water, Breakwater would not meet their current maximum day demands and coloured water problems, associated with iron and manganese, would occur more frequently as reliance on the local Drew Road well supplies would increase.

### **2.2      FRENCH CREEK WATERSHED**

The French Creek watershed has an area of approximately 65 km<sup>2</sup> (6500 ha), and is located between the Little Qualicum River and the Englishman River watersheds. The French Creek watershed originates at the edge of the Vancouver Island Mountain Ranges and contains Coombs, Hilliers, Dudley Marsh, and Hamilton Marsh. With the exception of the higher density urban areas in the lower reaches, most of the French Creek watershed is located upstream of Breakwater's surface water intake. There are a number of main transportation corridors that pass through the watershed and cross over the main channel of French Creek. These include the following:

- Grafton Avenue to the south, crossing the south fork of French Creek approximately 12.15 kilometers upstream from Breakwater's intake.
- The Alberni Highway (Highway No. 4A) located approximately 8.78 kilometres upstream from Breakwater's intake.

- The southern track of the E&N Railway (between Parksville and Port Alberni) located approximately 8.73 kilometres upstream of Breakwater's intake.
- The Inland Island Highway (Highway No. 19), located approximately 4.6 kilometres upstream of Breakwater's intake.
- The northern track of the E&N Railway (between Parksville and Qualicum), located approximately 0.65 kilometres upstream of Breakwater's intake.

The Island Highway (Highway No. 19A) is located well downstream of Breakwater's surface water intake and therefore does not impact the quality of Breakwater's surface water supply.

There are a significant number of minor roads, logging roads, and a couple main hydro transmission lines that move throughout the French Creek watershed. Some of the significant features located within the watershed are shown on Figure No. 1.

A number of small tributary streams and watercourses drain private and crown owned forestlands located in the southern high elevation areas of the upper watershed. These tributaries start to converge in the lowlands that are contained within the Agricultural Land Reserve, where they drain a variety of farmlands. The north and south forks of the creek converge about one kilometre south of the Alberni Highway. The lower watershed contains additional farming and forestlands, some commercial and industrial activities, rural properties, and some urban development. The French Creek watershed essentially has unrestricted access and is therefore considered unprotected.

The Ministry of Water, Land and Air Protection (WLAP) investigated the French Creek watershed in their 2001/2002 report. This report examined many aspects of the French Creek watershed that are relevant to this assessment, including hydrology, water use, development issues, sewage disposal within the watershed, and water quality. This report is available on the Ministry's website and therefore much of the information provided in the WLAP report is not reiterated in this assessment.

### 2.3 POTENTIAL SOURCES OF SURFACE WATER CONTAMINATION

There are obviously a number of potential sources of contamination within the French Creek watershed. However, contaminants must become water-borne and enter the surface water or the groundwater in order to contribute contaminants to a drinking water supply downstream. In many cases, contaminants are contained and prevented from becoming water-borne. In addition, there are natural purification processes that occur within a watershed that help to mitigate some of the potential threats. These include dilution, evaporation of certain fuel

compounds, and various physical, chemical, and biological processes that take place naturally in a watershed. For the purpose of this assessment, potential contamination sources have been characterized into the following categories:

- Major point source contamination such as wastewater outfalls and accidental spills (not including storm drainage outlets).
- Minor point source contamination such as storm drainage outlets.
- Non-point source contamination originating from all human activities within the watershed (not including microbial contamination).
- Non-point source microbial contamination that occurs naturally in the environment or originates from human activities or animals living within, or passing through, the watershed.

A contaminant from one of the source classifications identified above can be either acute or chronic in nature. If a contaminant becomes water-borne and enters the drinking water, an acute contaminant would make an individual ill in a very short period of time. A chronic contaminant would have to be consumed over a long period of time before an individual would become ill.

### 2.3.1 Major Point Source Contamination

Significant point source contamination originates from industrial or municipal wastewater outfalls or accidental spills of fuel or chemicals that discharge or escape into the surface water. Although there are no major wastewater outfalls discharging into French Creek, there is potential for an accidental spill in the watershed upstream of Breakwater's surface water intake. Such a spill has the potential to cause acute contaminants to enter Breakwater's surface water intake. Hazardous substances are routinely transported through the French Creek watershed, along the transportation corridors identified in the Section 2.2. It is not reasonable to assume the transport of these substances through the watershed can be stopped. Therefore, it is critical that the railway, the logging companies, and all fire departments responding to accidents within the watershed be aware there is a public drinking water source in the lower reaches of the French Creek watershed. These parties should also be advised that Breakwater Enterprises Ltd. and the VIHA must be notified immediately of any spill that occurs within the watershed. A quick response time is needed to ensure the spill can be monitored and, if necessary, the surface water supply shut down before spilled contaminants reach the intake.

**It is a recommendation of this assessment that a mail-out advisory and watershed map (showing the main watercourses and the extent of transportation corridors within the watershed) be created and sent to the railway, the logging companies, the Ministry of Transportation, the local road maintenance contractor, and all fire departments that could be called to attend an accidental spill within the French Creek watershed. Breakwater should investigate whether government assistance can be obtained for this type of notification program.**

### 2.3.2 Minor Point Source Contamination

Minor point source contamination includes sources such as storm drainage outlets that enter French Creek from roads or parking lot areas. Essentially anything that is deposited on the surface of a road or parking lot can enter the creek during a rainfall event. Typically, the initial flush that occurs at the beginning of a storm contains the highest concentration of contaminants. When flows in French Creek are high, these types of contaminants are normally diluted to insignificant levels. However, if a significant rainfall event occurs after a long dry period and flushes a large impervious road surface that discharges into the creek just upstream of a water intake, there may be elevated levels of contaminants in the creek for a short period of time. Higher concentrations of these contaminants could make their way into the water supply if the creek flows remain low and the contaminant travel distance is relatively short.

In the case of French Creek, the Inland Island Highway is the closest large impervious surface that could potentially flush chronic contaminants quickly into the creek system during a period of low creek flows in the summer. Surface drainage from the Qualicum Airport flows north to the Yambury Road right-of-way and therefore is not considered a potential threat to Breakwater's surface water intake on French Creek.

The Inland Island Highway crosses French Creek approximately 4.6 kilometres upstream of Breakwater's intake. There are some measures that have been put in place on the Inland Island Highway to reduce the possibility of chronic contaminants entering the creek. These include grass-lined ditches and vegetated sedimentation ponds. Cleaning of the road surface (sweeping and vacuuming) is also carried out along this section of highway by the road maintenance contractor. However, due to the area of asphalt that sheds surface runoff towards French Creek, the potential for chronic contamination should be investigated in further detail.

**It is a recommendation of this assessment that a contaminant survey be carried out downstream of the Inland Island Highway during a period of low creek flows to see if significant levels of chronic contaminants are being contributed to the creek system. Water sampling should be carried out downstream of the highway during (or shortly after) a major rainfall event.**

### 2.3.3 Non-Point Source (Non-Microbial) Contamination

The 2001/2002 French Creek report by WLAP provides a good overview of the non-point source pollution sources that exist, or potentially exist, within the French Creek watershed. Most of the potential non-point source (non-microbial) contaminant sources within the French Creek watershed have been identified in the WLAP report. Some of the significant contaminant sources are listed as follows:

- Runoff from roads including sediment, spilled contaminants, road de-icing products used in winter and dust control products used on gravel roads during the summer.
- Improperly abandoned fuel containment tanks.
- Wood preservatives originating from the storage of treated lumber within the watershed.
- Antifreeze, lubricants, brake fluid, particulate matter, and hydrocarbons originating from automobile storage yards, vehicles travelling the roads within the watershed, or vehicles that are operated or abandoned on private property.
- Sewage from human habitation of the watershed.
- The historical and ongoing use of fertilizers and pesticides within the watershed.
- The effect that overall development has on increasing sediment loads and stream temperatures.
- Erosion of stream banks and the resulting increased sediment loading that is associated with higher stream flows caused by increased runoff in the watershed.

As there is no known history of significant metal or chemical contamination of Breakwater's surface supply, this source assessment has focused primarily on potential non-point source microbial contamination, as outlined in the following section.

### 2.3.4 Non-Point Source Microbial Contamination

Because Breakwater's previous water quality problems were related to the presence of fecal coliform bacteria, this assessment has focussed primarily on potential non-point sources of microbial contamination within the French Creek

watershed. Potential sources of non-point source microbial contamination include:

- Feces from wildlife species that reside within or migrate through the watershed.
- Feces from livestock operations on farms located within the watershed.
- Feces from domesticated pets living within or passing through the watershed.
- Fish feces from spawning salmon, rearing salmon, and resident trout.
- Human sewage originating from human activities in the woods where washroom facilities are not available, failing septic fields, and illegal dumping of recreational vehicle holding tanks or garbage containing fecal matter such as diapers.
- The natural presence of certain bacteria living within the environment that test positive as indicator organisms on a fecal coliform or total coliform analysis.
- Application of manure fertilizers on farming operations.
- Cuttings or crop waste materials washing off agricultural lands into adjacent ditches or streams providing nutrients for microorganisms and increasing the biological oxygen demand of the water.
- Contaminants originating from fish hatchery operations.
- Decomposition of fish or animal carcasses located within or adjacent to the creek.

All of the activities listed above either do take place or are very likely to take place within the French Creek watershed. As this is an unprotected watershed, it is very difficult to control activities that could lead to non-point source microbial contamination of French Creek.

## 2.4 FRENCH CREEK WATER QUALITY

WLAP carried out a water quality monitoring program on French Creek between November 2000 and August 2002, in which they tested for nutrients, metals, fecal coliforms, and *E. coli*. WLAP established that the concentration of certain contaminants tended to increase as one moves downstream in the watershed. However, with the exception of fecal coliforms and *E. coli*, none of the parameters that were tested exceeded the drinking water quality guidelines.

As part of Breakwater's French Creek source assessment, a raw water quality testing program was carried out during the months of February, March, and April 2004, with some additional bacteriological testing performed in June, 2004.

#### 2.4.1 Testing for Bacteriological Contamination

Although it would be ideal to test potable water supplies for every type of pathogenic organism and contaminant known to man, this is impractical and would be too costly and time consuming to undertake such a testing program. Historically, total coliform and fecal coliform tests have been used to monitor the potability of drinking water. Due to the fact many of the indicator organisms that show up as a positive result on a total coliform test are not human pathogens, the total coliform test is not conclusive evidence that recent fecal contamination has occurred in a drinking water supply. Total coliforms are considered a good indicator of how effectively a water treatment system is performing because these bacteria generally have good survival characteristics. However, many of the total coliform bacteria do not originate from feces and therefore the total coliform test is not a reliable indicator of fecal contamination. Total coliforms are found in the environment in nutrient-rich waters, soil, and decaying plant materials. For this reason, additional bacteriological analyses were included in the raw water testing program of Breakwater's surface water source assessment.

Historical water quality testing information for samples taken in French Creek, at or near Breakwater's intake, confirms fecal coliform bacteria are present within the French Creek surface water. WLAP's 2001/2002 report also confirmed that fecal coliforms are present throughout French Creek. However, as there are some bacteria that belong to the fecal coliform group that live naturally on vegetation and in soils, a positive fecal coliform result does not provide absolute clarification that fecal contamination originating from the feces of humans or animals is present within the French Creek watershed. In addition to the standard total coliform and fecal coliform tests, *Escherichia Coli* (*E. Coli*) and enterococcus analyses were carried out on Breakwater's French Creek raw water supply during this assessment.

*E. Coli* are generally sensitive to environmental stresses and do not grow outside the human or animal gut. A positive *E. Coli* analysis confirms that the water source being tested has been impacted by recent fecal contamination. Although the bacteria that show as a positive on an *E. Coli* test are not necessarily pathogenic, they are enteric (live in the human and animal gut) and their presence does indicate the possible presence of pathogenic micro-organisms. A positive *E. Coli* test does not confirm the presence of the pathogenic *E. Coli* bacteria, such as *E. Coli* 0157-H7, which is a bacteria that has been responsible for a number of water-borne disease outbreaks across North America.

Enterococcus bacteria include streptococci that share certain biochemical properties. These bacteria are tolerant to a wide range of environmental conditions and most species of these bacteria are of fecal origin. Although there

are some species that are known to occur on plant materials, enterococcus bacteria are generally considered enteric and can be used to indicate fecal contamination and the possible presence of pathogens. Studies have shown that enterococcus bacteria have greater correlation to swimming-associated gastrointestinal illness, than do some of the other bacterial indicator organisms.

Water samples were taken from the discharge side of the pumps that draw water from the wet well located beside French Creek. The wet well is filled by creek water that is drawn into the infiltration gallery that is located below the bed of the creek. The infiltration gallery is examined in further detail in Section 3.1.1.

Results of the French Creek bacteriological testing are summarized at the bottom of Table No. 2. All four bacteriological analyses tested positive in each test performed, indicating that contamination originating from the feces of humans or animals is definitely occurring in the French Creek watershed.

The fecal coliform and E. Coli counts were relatively low (20 CFU/100 mL and lower) in the samples collected during this assessment. However, WLAP did observe fecal coliform counts as high as 140 CFU/100 mL at the Inland Island Highway crossing during August of 2001. WLAP also observed fecal coliform counts as high as 240 CFU/100 mL at the Barclay Crescent pedestrian bridge (below Breakwater's intake) during the summer of 2001. The higher fecal coliform counts found by WLAP at Barclay Crescent could be related to problematic septic fields in this area.

Total coliform bacterial counts appear to increase as the water temperature in the creek increases. In the last testing performed during this assessment on June 8, 2004, total coliforms exceeded 3000 CFU/100 mL. This may be explained by the following:

- Total coliform organisms occur naturally in the stream environment and do not necessarily originate from human activities. Their numbers may increase as temperatures increase.
- There is a fish-feeding program where young salmon are fed manually by volunteers. Increased nutrients in the creek pools just upstream of Breakwater's intake may enhance the growth of total coliform bacteria.
- As rainfall over the watershed decreases, the flows in French Creek start to fall off. This likely reduces the dilution of total coliform organisms and increases their concentrations.

- Less rainfall over the watershed reduces the amount of fecal matter that washes into the creek and this may offset the effect of dilution and explain why fecal coliform and E. Coli counts do not increase as dramatically as total coliform bacteria with increasing water temperatures.

Enterococcus counts also increased as water temperatures increased, reaching 1200 CFU/100mL on June 8, 2004. Enterococcus bacteria are known to have good survival characteristics in all types of water. The source and significance of the enterococcus bacteria in French Creek should be investigated further.

In order to identify the exact sources of bacterial contamination in French Creek, an extensive bacterial source tracking investigation would have to be carried out in the French Creek watershed. Such an investigation is beyond the scope of this assessment. However, as the French Creek watershed is not protected, it is more important to know that bacterial contamination is occurring, as it is unlikely that much can be done to remove the sources of contamination. Knowing that fecal contamination is occurring, there is also a possibility that water-borne microbial pathogens are also present in the French Creek surface supply. These could include bacterial, viral, and parasitic pathogens.

**Based on the investigations carried out during this assessment, the following recommendations are provided:**

- **To provide a higher degree of protection against microbial pathogens entering the Breakwater distribution system, a dual disinfection system should be implemented on the French Creek surface water source. Additional water quality testing and water treatment considerations for the French Creek surface water source are discussed later in this assessment report.**
- **Further investigations should be carried out to determine the cause of the elevated levels of enterococcus bacteria that occurred in early June, 2004.**

#### 2.4.2 Testing for Other Non-Microbial Contaminants

As detailed in their 2001/2002 report, WLAP carried out sampling on French Creek and analyzed for a number of metals including cadmium, chromium, copper, nickel, lead, and zinc. WLAP also tested for nitrate, total nitrogen, and phosphorus. WLAP did indicate they found one cadmium result in the upper watershed that exceeded the provincial criteria for aquatic life of 0.01 ug/L. A cadmium result of 0.02 ug/L was found by WLAP at Winchester Road on December 18, 2000. The current drinking water quality guideline for cadmium is 5.0 ug/L.

As part of Breakwater's source assessment of French Creek, some non-microbial water quality parameters were included in the water quality sampling program. These included iron, manganese, chloride, BTEX and VPH (VI-w6-10 minus BTEX), nitrate, total Kjeldahl nitrogen, and total phosphate. Analysis results from this testing are included in Table No. 2.

Iron and manganese were analyzed to confirm that the French Creek surface supply can be used successfully to dilute the concentration of iron and manganese in a blended water supply that contains mixed creek and well water.

Chloride was analyzed to establish whether there is any evidence of contamination resulting from significant sewage discharges or the historical use of road de-icing and gravel road dust control products.

The analysis of BTEX and VPH (VI-w6-10 minus BTEX) includes benzene, toluene, ethylbenzene, three forms of xylene (ortho, meta & para), styrene, methyl t-butyl ether, VHw6-10. These compounds are found in fuel products.

Nitrate levels provide an indication of the amount of agricultural fertilizers that are being washed off from crop lands and entering a water body. Ingesting excessive levels of nitrate can be harmful to infants.

Analyzing for total Kjeldahl nitrogen provides an indication of how much organic nitrogen and ammonia is present in a body of water. Ammonia can stimulate the growth of algae and can be toxic in high concentrations. Ammonia can also affect the chlorination process.

Analyzing for total phosphate provides an indication of the amount of phosphorous in a body of water. Phosphates arise from detergents and fertilizers. Phosphates in critical concentrations can stimulate the growth of nuisance organisms in a water body.

The non-microbial water quality parameters listed above were either below the detection limit or did not exceed the drinking water quality guidelines for the three series of tests that were performed on the French Creek raw water source.

Temperature readings were taken at the time water samples were drawn from the wet well. Surface water temperatures generally rise as the air and land temperatures increase during the spring and summer. Warmer water may enable pathogens to survive better once they become water-borne. Warmer water temperatures may also stimulate the growth of nuisance organisms and indicator organisms. As shown in Table No. 2, there is evidence that rising water temperatures may increase the numbers of certain indicator organisms in French

Creek. Increasing water temperatures can become more significant in a watershed that is experiencing ongoing development and where impervious surfaces are increasing.

Additional water quality testing for parameters that can affect chlorination is discussed later in this assessment report.

## 2.5 FLOOD PROTECTION AROUND GROUNDWATER WELLS

In addition to the French Creek surface intake, Breakwater currently has sixteen drilled wells connected to their system. A seventeenth drilled well (Well R8-2) has been constructed and will likely be put into operation in the near future. The Imperial Drive Well is a shallow drilled well source located approximately 40 metres from French Creek. The location of each well source is shown on Drawing 9742-01-R6 (in pocket).

As part of Breakwater's source assessment, we have examined each of the seventeen drilled wells and determined whether there is a potential for surface flooding to occur around the wellheads. If surface flooding is possible, we have looked at the potential risk associated with the flooding and examined whether contaminants could enter the top of the well casing or gain access into the wellhead piping that is located above the ground surface. We have assessed whether there is a low, moderate, or high risk of contamination from surface flooding. We have not assessed whether contamination from surface flooding could enter the ground adjacent to the individual well casings and migrate down to the water bearing materials in which the wells have been developed. The potential for contaminants to reach the well screens via the groundwater is beyond the scope of this assessment. Some general information on Breakwater's wells is provided in Breakwater's 2003 Utility Operation and Aquifer Management Report, prepared by EBA Engineering Consultants Ltd. The potential for surface flooding around each well is discussed below:

### 2.5.1 Oceanside Well No. 2

Oceanside Well No. 2 is located within a small right-of-way on a private residential lot on Windward Way. This well is located between two fairways of the Eaglecrest Golf Course. The nearest fairway is located approximately 50 metres to the west. Although the Oceanside Well No. 2 is Breakwater's highest capacity water source, this well is normally operated only in the summer (during peak demands) due to the elevated levels of iron and manganese that are present in this groundwater source. The top of the well casing is located below the adjacent ground level inside an underground concrete well enclosure that has a steel manhole lid at finished ground surface.

Although the well casing is below ground, there is a very low risk of surface floodwater entering the underground chamber and making its way into the well casing or the associated wellhead piping. A surface flood in this area would have to originate from a plugged sewer pipe, a broken water main, or some type of accidental contaminant spill occurring adjacent to the underground well enclosure. Due to the slope of the land around the well, liquid from a potential flood scenario would flow to the road and not accumulate around the top of the well enclosure.

It is possible for small amounts of residential irrigation water or sidewalk wash water to enter the well chamber. Sidewalk wash water could contain fertilizers, pesticides, and microbial contamination from animal or pet feces. However, the volume that could seep into the underground well enclosure is considered insignificant and the chance of this material entering the steel well casing is very remote.

There is potential for shallow groundwater to seep into the underground well enclosure and accumulate within. However, there is a sump pump set in the floor of the chamber that pumps accumulated liquid within the enclosure to a storm drain in the nearby road. As there are no septic fields in this residential neighbourhood, it is unlikely that significant microbial contamination could enter the top of the well casing from shallow groundwater located adjacent to the underground well chamber.

As the water from Oceanside Well No. 2 is pumped to the Drew Road Reservoir and chlorinated, the potential for microbial contamination of the water system from surface floodwaters developing around this well is considered low. If an accidental spill were to occur adjacent to the underground well chamber, it is unlikely that significant amounts of the spilled contaminant could enter the well's underground enclosure and very unlikely that any spilled liquid could enter the top of the well casing.

**Based on the investigations carried out during this assessment, the following recommendations are provided for the Oceanside Well No. 2:**

- **The existing sump pump should be inspected regularly to ensure it is operating and there are no leaks in the sump pump's discharge piping.**
- **The top of the well casing should be carefully examined to ensure it is water tight and liquid can not spill down the casing. If there is a surface casing this should be sealed watertight by welding the annular space between the surface casing and the well casing.**

- **A well casing air vent should be installed and extended to the top of the well enclosure.**
- **The lid to the chamber should be sealed.**
- **This well should be shock chlorinated before being put into operation each year.**
- **The new piping connection on the Oceanside Well supply main, located at the Drew Road Reservoir site, should be installed below ground.**

#### 2.5.2 Drew Road Well No. 1

The Drew Road Well No. 1 is located at the northeast corner of the undeveloped road intersection of Drew Road and Yambury Road. This well is situated on land that is sloping away at greater than 2.0 %. The well is located in the highest corner of a fenced pasture area that contains cattle.

Drew Road Well No. 1 is located within a locked metal kiosk that sits above ground on a concrete slab. The concrete slab is approximately 100 mm above the surrounding ground level. The well kiosk is located within the fenced pasture and is accessible to cattle.

Although concentrated upland floodwaters could potentially drain around the well kiosk slab, ponding around the well is not possible due to the sloping nature of the ground surface. Any fecal matter left by cattle would be washed down gradient from the well kiosk and therefore could not enter the top of the steel well casing.

As the water from Drew Road Well No. 1 is pumped to the Drew Road Reservoir and chlorinated, the potential for microbial contamination of the water system from surface floodwaters developing around this well is considered low. If an accidental spill were to occur adjacent to the well kiosk, it is unlikely that the spilled contaminant could enter the well's kiosk and very unlikely that any spilled contaminants could enter the top of the well casing.

#### 2.5.3 Ravensbourne Well No. 1

Ravensbourne Well No. 1 is located approximately 20 metres west of the undeveloped Yambury Road right-of-way and approximately 40 metres south of the E&N Railway track. The Town of Qualicum Beach has recently installed a new gravity sanitary sewer within the Yambury Road right-of-way, which is located east of the well, approximately 30 metres away.

The well casing is located within a locked metal kiosk that sits above ground on a concrete slab. The concrete slab is approximately 100 to 150 mm above the surrounding ground level. The top of the well casing is approximately 400 mm above the elevation of the concrete slab.

Ravensbourne Well No. 1 sits in a relatively low area that receives drainage from the Qualicum Airport and other upland properties. During the winter, concentrated storm drainage flows travel overland through this area before entering a 900 mm dia. culvert located under the E&N Railway tracks. The well is not located directly within the drainage course and is somewhat elevated above the normal drainage flow path. During an extreme rainfall event (1 in 100 year or greater), it is possible that storm drainage flows from upland areas could exceed the capacity of the railway culvert, causing floodwaters to back-up behind the railway grade. Based on the topography of the land, floodwaters would likely travel eastward towards Drew Road, where the flood would ultimately spill over the railway tracks before reaching the elevation of the steel well casing inside the Ravensbourne well kiosk. If the gravity sewer were to surcharge at the same time as a major flood, it is very unlikely this effluent could enter the top of well casing.

If an accidental spill occurred on the railway or a tanker truck turned over on the well's access road, the spilled liquid contaminant would tend to travel away from the well kiosk.

As the water from Ravensbourne Well No. 1 is pumped to the Drew Road Reservoir and chlorinated, the potential for microbial contamination of the water system from surface floodwaters developing around this well is considered low. If an accidental spill were to occur adjacent to the well kiosk, it is unlikely that the spilled contaminant could enter the well's kiosk and very unlikely that any spilled contaminants could enter the top of the well casing.

#### 2.5.4 Imperial Drive Well

The Imperial Drive Well is a shallow drilled well located approximately 40 metres northwest of French Creek, off the south end of Imperial Drive. The well casing and above ground wellhead piping are located inside a locked building. The top of the well casing is level with the concrete slab of the building.

The Imperial Drive Well is used mainly in the summer to help supply water through the high demand periods. The well is within the French Creek floodplain and is therefore susceptible to surface flooding if a major flood event were to occur within the French Creek watershed. Such an event would likely occur in the winter months when the well is not in operation.

The water from the Imperial Drive Well is pumped to the Drew Road Reservoir and chlorinated. The potential for microbial contamination of the water system from surface floodwaters developing around this well is considered low in the summertime and moderate in the wintertime.

If an accidental spill were to occur adjacent to or within the well building, there is a moderate risk that the spilled contaminants could enter the top of the well casing.

**Based on the investigations carried out during this assessment, the following recommendations are provided for the Imperial Drive Well:**

- **If the Imperial Drive well is operated in the wintertime the risk of contamination from surface flooding could be reduced, by installing a liquid sensor within the building. Such a sensor should be connected to the well controls and should prevent the well pump from operating during a major flood event.**
- **The existing well casing should be extended approximately 400 mm so it is significantly higher than the level of the concrete slab.**

#### 2.5.5 Church Road Wells No. 1, 2, 3 and 4

The Church Road Wells No. 1, 2, 3 and 4 are located within the fenced compound of the Church Road Reservoir complex. Breakwater operates these wells throughout the year. Water from these wells receives a low dose of sodium hypochlorite before entering the Church Road Reservoirs.

The land surrounding the Church Road Wells slopes away to the north at approximately 5.0 %. These wells are located to the north (down gradient) of the E & N Railway, a gas station, gravel pit operations, and various commercial and light industrial activities. Church Road is located on the east side of these wells, approximately 20 metres away from Church Road Well No. 1.

The potential for floodwaters or a spilled liquid contaminant to accumulate around the well casings is relatively low. The Church Road Wells were originally in underground chambers that were upgraded in 1998. The well casings were raised and extended above the surrounding ground surface. The individual well casings and associated wellhead piping are now contained within above ground metal kiosks. The well casing's projections above the concrete slabs of the Church Road well kiosks are in the range of 100 to 400 mm.

The potential for microbial contamination of the water system from surface floodwaters entering the top of the four Church Road well casings is considered very low. If a minor amount of natural microbial (bacterial or viral) contaminants entered the wells from the surface, the microbes would be killed by the Church Road chlorination system. Significant microbial contamination from non-natural sources would have to originate from upland septic fields or an accidental spill from a vehicle such as a septic tank truck. Due to the sloping nature of the surrounding land, it is not physically possible for a liquid containing microbial contaminants to accumulate in any significant volume and cause flooding around the Church Road wells. Likewise, it is unlikely that an accidental chemical or fuel spill could enter the top of the well casings in the Church Road Reservoir complex. A tanker truck would have to drive into one of the well kiosks, separate the wellhead piping from the well casing, and spill its load directly over the well. Even though this is a very unlikely scenario, the accident would be noticed in time to shut the Church Road wells and reservoirs down before the spilled contaminants could make their way into the Breakwater water system.

#### 2.5.6 Springhill Road Well No. 1

Springhill Road Well No. 1 is located on the South side of Springhill Road approximately 80 metres east of Church Road. This well is down gradient from a lumber storage yard, the E&N Railway, and the Regional District of Nanaimo's Transfer Station. The well casing and associated wellhead piping is located inside a locked metal kiosk which is located adjacent to the roadside ditch. Springhill Road Well No. 1 pumps groundwater to the Church Road Reservoirs, where it receives a low dose of sodium hypochlorite prior to entering the reservoirs.

The top of the well casing is relatively low in relation to Springhill Road and the adjacent ditch. There is a small diameter culvert located in front of the well kiosk that could be subject to plugging due to the thick grass and roadside vegetation growing in this area.

Although the water from Springhill Road Well No. 1 is pumped to the Church Road Reservoir and chlorinated, the potential for microbial or chemical contamination of the water system from surface floodwaters developing around this well is considered moderate due to the low level of the well casing. If a contaminant entered the storm drainage in the Springhill Road ditch from an upland source during a major rainfall event, or an accidental spill were to occur adjacent to the well kiosk, it is possible that the contaminants could flood the well's kiosk and enter the top of the well casing or the wellhead piping.

**Based on the investigations carried out during this assessment, the following recommendations are provided for Springhill Road Well No. 1:**

- **The risk of contaminants entering Springhill Road Well No. 1 during a flood could be reduced by extending the well casing approximately 400 mm so it is higher than potential flood levels.**
- **The vegetation in the ditch around the well should be kept cut down and the existing culvert in front of the well kept clear.**

#### 2.5.7 Springhill Road Well No. 2

Springhill Road Well No. 2 is located on the South side of Springhill Road approximately 230 metres east of Church Road. This well is located down gradient from a large piece of property on which activities such as log home building have taken place and there is also a private residence on the property. This well is also down gradient from the Regional District of Nanaimo's Transfer Station and the E&N Railway. Springhill Road Well No. 2 pumps groundwater to the Church Road Reservoir complex where it receives a low dose of sodium hypochlorite.

The original well casing and associated wellhead piping is located inside a locked metal kiosk that is located adjacent to the road. A second well casing has been drilled immediately to the west of the metal kiosk and is contained within a concrete manhole structure. Some of the piping leading to the new well casing is exposed and it is not difficult to gain entry into the concrete manhole.

There is a low risk of contaminants entering the old and new well casings as a result of surface flooding around Springhill Road Well No. 2.

**Based on the investigations carried out during this assessment, the following recommendations are provided for Springhill Road Well No. 2:**

- **Although it is unlikely that contaminants from surface flooding could enter the well casings of the old and new Springhill Road Well No. 2, the exposed piping should be covered over and the concrete manhole chamber made more secure. This should be done to make it more difficult for vandals to dump something down the well casing that is located inside the concrete manhole.**

#### 2.5.8 Hills of Columbia Well No. 6

Hills of Columbia Well No. 6 is located at the end of Springhill Road. This well pumps groundwater to the Church Road Reservoirs where it receives a low dose of sodium hypochlorite. Due to the elevation of this well in relation to the road,

the potential for microbial or chemical contamination of the water system from surface floodwaters developing around this well is considered low. If an accidental spill were to occur adjacent to the well kiosk, it is unlikely that the spilled contaminant could enter the well's kiosk and very unlikely that any spilled contaminants could enter the top of the well casing. Some drainage swales could be constructed to divert any concentrated upland drainage or spilled contaminants around the well kiosk.

#### 2.5.9 Hills of Columbia Well No. 7

The Hills of Columbia Well No. 7 is located at the bottom of a large fill embankment that supports the road grade of the Inland Island Highway. The well is located approximately 50 metres east of a swamp that has formed in a depression that appears to have been created by the highway fill. The swamp has a culvert outlet that is graded northward under the highway, away from the well.

The well is located down gradient from some gravel pit operations, some large rural properties, the E & N Railway, and a helicopter landing pad where fuel drums appear to be stored.

The Hills of Columbia Well No. 7 pumps groundwater to the Church Road Reservoirs. Water from this well currently receives a low dose of sodium hypochlorite before entering the Church Road Reservoirs.

The potential for contamination of the water system from surface floodwaters entering the top of the Hills of Columbia Well No. 7 well casing (or the above ground wellhead piping) is considered low. The culvert under the highway would have to plug and the existing swamp level rise substantially to reach the elevation of the well casing. Concentrated drainage flows travelling along the base of the highway fill embankment are not expected to reach the level of the well casing.

Due to the volume of traffic passing by the Hills of Columbia Well No. 7, there is a moderate risk that an accidental contaminant spill will occur near this well in the future. It is unlikely that a spilled contaminant could enter the top of the Hills of Columbia Well No. 7 well casing unless a tanker truck left the highway and drove directly into the well kiosk. If this were to occur, the well controls would likely be damaged and the well pump would stop pumping water from the well.

**Based on the investigations carried out during this assessment, the following recommendations are provided for Hills of Columbia Well No. 7:**

- **To minimize the effect of an accidental spill that may occur near the well kiosk, some drainage swales should be excavated around the well kiosk to**

**direct any spilled liquids around the well. These swales would also help direct concentrated storm drainage away from the well.**

- **The highway culvert that drains the nearby swamp should be inspected annually and any debris blockages removed.**

#### 2.5.10 Hills of Columbia Well No. 9

Hills of Columbia Well No. 9 is located approximately 25 metres north of the E & N Railway. This well pumps groundwater to the Church Road Reservoirs. Water from this well currently receives a low dose of sodium hypochlorite before entering the Church Road Reservoirs.

The land around the well slopes to the north at approximately 5.0 % and therefore the potential for contamination of the water system from surface flooding developing around this well is considered low. If an accidental spill were to occur on the railway located to the south, it is unlikely that spilled contaminants could enter the well's kiosk and very unlikely that any spilled contaminants could enter the top of the well casing.

#### 2.5.11 Hills of Columbia Well No. 11

The Hills of Columbia Well No. 11 is located between Springhill Road and the E & N Railway. This well pumps groundwater to the Church Road Reservoirs. Water from this well currently receives a low dose of sodium hypochlorite before entering the Church Road Reservoirs.

Due to the sloping nature of the land around this well, the potential for contamination of the water system from surface flooding is considered low. If an accidental spill were to occur adjacent to the well kiosk, it is unlikely that the spilled contaminant could enter the well's kiosk and very unlikely that any spilled contaminants could enter the top of the well casing.

#### 2.5.12 Bosa No. 1 Well

The Bosa No. 1 Well is located approximately 25 metres north of the E & N Railway. This well is located beside a residential property and automobiles are parking close to this well. This well pumps groundwater to the Church Road Reservoirs. Water from this well currently receives a low dose of sodium hypochlorite before entering the Church Road Reservoirs.

The land around the well slopes away to the north and therefore the potential for contamination of the water system from surface flooding developing around this well is considered low. If an accidental spill were to occur on the railway located

to the south, or from activities taking place on the residential property, it is unlikely that the spilled contaminant could enter the well's kiosk and very unlikely that any spilled contaminants could enter the top of the well casing.

#### 2.5.13 Lornedunn Well No. 2

Lornedunn Well No. 2 is located on Lornedunn Road approximately 20 metres west of Church Road and 15 metres south of the E & N Railway. There is a large dairy farm located to the west of this well.

This well is connected directly to Breakwater's distribution system via the Church Road supply main and is normally operated only in the summer, during peak demands. There is no treatment on this well.

The top of the well casing is located below the adjacent ground level inside an underground well enclosure that has a steel manhole lid at finished ground surface. The well chamber is equipped with a sump pump that discharges to the adjacent road ditch. There is also a flood sensor on this well that shuts the well down in the event of a flood inside the chamber.

The potential for contamination of the water system from surface flooding developing around this well is considered low.

**Based on the investigations carried out during this assessment, the following recommendations are provided for Lornedunn Well No. 2:**

- **The existing sump pump in Lornedunn Well No. 2 should be inspected regularly to ensure it is operating and there are no leaks in its discharge piping.**
- **The existing bolt-down lid to the chamber should be fitted with a gasket.**
- **This well should be shock chlorinated before being put into operation each year.**

#### 2.5.14 Well R8-2 in French Creek

Well R8-2 is located to the northwest of the Lee Road and Highway 19A intersection. Morningstar Creek is located just to the west of Well R8-2. Once connected, this well will pump water directly into Breakwater's distribution system via the water main on Lee Road. Water from this well will be chlorinated with sodium hypochlorite before entering the distribution system.

Well R8-2 has a pitless adapter on the well casing. The pitless adapter and well casing are located within a concrete manhole chamber to protect the well casing from damage and tampering. The chamber has also been elevated to reduce the possibility of floodwaters entering the casing. The well casing air vent has been extended above the anticipated flood level, up the side of the adjacent pump house. A more detailed review of this well has been carried out by EBA Engineering Consultants Ltd. EBA's report on Well R8-2 is included in Appendix B.

### **3 BREAKWATER'S SYSTEM ASSESSMENT**

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The Breakwater water system services approximately 1620 individual water customers. The water system consists of submersible well pump systems, vertical turbine pump systems, chlorination systems, concrete reservoirs, controls and monitoring equipment, a booster pump station, distribution piping, and miscellaneous appurtenances such as valves, fittings, fire hydrants, and individual service connections. Breakwater's system assessment has been separated into five categories including Supply/Treatment/Storage Works, Distribution System, Security Measures, Operation and Maintenance, and Water Quality Sampling and Monitoring.

#### **3.1 BREAKWATER'S SUPPLY / TREATMENT / STORAGE WORKS**

With the exception of Lornedunn Well No. 2, the components of Breakwater's system that are involved with supply, treatment, and storage of water are all connected to and/or controlled by the Church Road and Drew Road reservoir facilities. The Breakwater system components involved with supply, treatment, and storage of water are assessed below:

##### **3.1.1 French Creek Infiltration Gallery**

Breakwater's French Creek infiltration gallery is situated on the lower reaches of French Creek, as described in Sections 2.1 and 2.2. The infiltration gallery was upgraded in 1996 under the Ministry of Health Waterworks Construction Permit No. 13-0702, and is still in good working order.

The intake consists of two stainless steel screens (200 mm dia.) that are positioned approximately 1.0 m below the creek bed. The total length of subsurface screen is approximately 12.7 metres. The screens have 6.35 mm (0.25 inch) slots and are surrounded by a filter pack consisting of 10 mm – 25 mm screened drain rock. The drain rock filter pack is covered by the creek's natural gravel bed materials. The infiltration gallery acts as a primary filtering system, allowing subsurface creek water to enter the screens under low velocity, but preventing larger particles of organic matter or debris from being drawn into the pump intakes located beside the creek. The infiltration gallery does not filter out natural turbidity, colour, suspended solids, potential waterborne contaminants, or microorganisms.

Breakwater's infiltration gallery provides an effective means of extracting water from French Creek. As with most infiltration galleries, sand and gravel fines gradually migrate towards the screens and consolidate within the voids of the natural stream gravel and drain rock filter pack, slowly reducing the hydraulic capacity of the intake. To address this, Breakwater back-flushes the infiltration

gallery with compressed air in early, mid, and late summer. A compressed air hose is connected to an existing uncapped air injection port located inside a service box beside the creek. The back-flushing program loosens the consolidated fines and re-opens the voids in the gravel materials, improving the water's ability to flow through the gravel to the subsurface screens.

The infiltration gallery supplies water to an underground concrete wet-well, from which water is pumped to the Drew Road Reservoir via two vertical turbine pumps. The pumps, discharge piping, and wet-well are enclosed inside a locked well house that is generally suitable for preventing rodents, birds, and bats from entering the wet-well. The infiltration gallery, pumps, and well house are generally in good condition.

There is a community fish hatchery located just upstream of Breakwater's intake that is operated by local volunteers. This is a small facility with egg incubation and fry rearing operations.

The stream bank in front of the well house is armoured with rock rip-rap to prevent erosion of the bank and the well house has been constructed at a high enough elevation to withstand most flooding. However, flood proofing of the well house and the wet-well is not a practical consideration as this is a surface water intake that draws water directly from the creek that will cause the flooding.

**Based on the investigations carried out during this assessment, the following recommendations are provided for the French Creek Infiltration Gallery:**

- **Some general house cleaning and regular maintenance should be carried out on this facility, as discussed in Section 3.4.**
- **The air injection port used to flush the infiltration gallery should be cut down, so it fits within the existing service box, and capped.**
- **Breakwater should maintain regular contact with the local volunteer group that is running the fish hatchery located above their intake. Information on when eggs are being incubated, the methods used to prevent disease and infection in the hatchery, and the types of waste generated at the facility should be obtained.**

### 3.1.2 Wellhead Construction Details

The wellhead consists of the piping, fittings, check valve, air valve, air vent, shut-off valve(s), and metering components that are typically installed at the top of the well pump riser piping where it exits the well casing. There are generally two

categories of wellheads in the Breakwater system including low-pressure wellheads and high-pressure wellheads. For the purpose of this assessment, a low-pressure wellhead typically experiences internal pipe pressures less than 40 psi and a high-pressure wellhead typically experiences internal pipe pressures greater than 40 psi.

The wellhead piping and pump riser pipe is generally constructed of high-pressure piping and should be sealed watertight. On municipal type wellheads where the pump riser pipe exits the well casing and connects to the wellhead piping, the annular space between the riser pipe and well casing has to be sealed to ensure contaminants from spills or floods can not spill down the well casing. This annular space is generally sealed using one of two methods. The first method includes the use of a sanitary well seal that has friction fitted rubber 'O' ring seal connections for the pipes, tubes, and cables that lead down the well casing. The second method involves welding a flange to the top of the well casing onto which a second flange is bolted and connected directly to the pump riser pipe. The second flange (upper flange) is essentially a blind flange that has been drilled and tapped to accept the pump riser pipe, the cables (complete with strain relief connections), the casing vent, and the small pipes or tubes that enter the well casing. This method is generally considered a more robust and a better way of sealing the well casing from surface contamination as seals are made from bolted flanges (with gaskets) and threaded pipe connections rather than friction fitted rubber 'O' ring seals. The well casing air vent and air release valve vents should be extended high enough to be above any potential flood level.

On some wells, the main well casing is inserted through a larger diameter shallow surface casing such that there is an annular space between the two casings. If left in place, the surface casing is typically sealed with bentonite grout. It is also good practice to weld and seal the annular space between the two casings (at the surface) to provide additional protection against surface contaminants entering the annular space and making their way down the outside of the main well casing.

#### Breakwater's Low-Pressure Wellheads

Low-pressure wellheads are located on wells that are at a similar elevation as the reservoir to which they are pumping water. During pump start-up and shut-down, pressure surges can occur in the well supply main located between the wellhead and the reservoir. During these surges, pressures can cycle up and down in the well supply main and wellhead piping. If pressures drop too low during these pressure surges, it is possible for the wellhead piping system to experience negative pressures. If the fluctuations in pressure are extreme, pump control valves are used to control the problem. If a wellhead that had a leak, or a low-level air release valve was flooded at the time the negative pressures occurred,

contaminants could be drawn into the water system. The Breakwater wells that have low-pressure wellheads are listed as follows:

- Drew Road Well No. 1
- Ravensbourne Well No.1
- Oceanside Well No. 2
- Church Road Wells No. 1, 2, 3, and 4
- Springhill Road Well No. 1
- Springhill Road Well No. 2
- Hills of Columbia Well No. 6
- Hills of Columbia Well No. 7
- Hills of Columbia Well No. 9
- Hills of Columbia Well No. 11
- Bosa No. 1 Well

Of the wells listed above, only Springhill Road Well No. 1 has been identified as being at moderate risk of surface flooding. The other wells listed above are at low risk of surface flooding.

**Based on the investigations carried out during this assessment, the following recommendations are provided for the low-pressure wellheads:**

- **The recommendations provided for Springhill Road Well No. 1, in Section 2.5.6, should be implemented.**
- **Springhill Road Well No. 1 should be retrofitted to have a flanged well seal system installed at the top of the well casing with watertight flanged or threaded connections for all pipes entering the casing. In addition, the casing vent and air valve vent should be extended as high as possible inside the well kiosk. All vents should have screens.**
- **All wells listed above should be retrofitted with flanged well seal systems the next time the pumps are removed from the individual wells for maintenance or replacement. In addition, all casing vents and air valve vents should be extended at least 0.8 metres above the concrete slab on which the well kiosk is sitting. All vents should have screens.**
- **All wells listed above that have an unsealed annular space between the surface casing and the well casing should have this space sealed off by welding.**
- **Some general house keeping and regular maintenance should be carried out on all wellhead enclosures as discussed in Section 3.4.**

### Breakwater's High-Pressure Wellheads

High-pressure wellheads are located on wells that are at a significantly lower elevation than the top water level of the reservoir they pump to, or the system hydraulic grade line that they have to pump against. Breakwater's high-pressure wellheads include the following:

- Imperial Drive Well
- Lornedunn Well No. 2
- Well R8-2

The wellheads at these wells are generally at lower risk of experiencing negative pressures and therefore are considered at low risk of having contaminants enter the wellhead piping.

The wellhead piping of Lornedunn Well No. 2 is considered appropriate and in good working condition.

The wellhead piping of Well R8-2 has just recently been installed under Vancouver Island Health Authority Waterworks Construction Permit No. 13-1205. This is a high-pressure wellhead system that is contained within a locked concrete block building.

The Imperial Drive Well is at moderate risk of flooding during the winter and therefore some improvements should be undertaken as explained in Section 2.5.4 and as identified below:

**It is a recommendation of this assessment that the Imperial Drive Well be retrofitted with a flanged well seal system. In addition, the casing vent and air valve vent shall be extended at least 1.5 metres above the slab of the well house.**

#### 3.1.3 Well Supply Mains

The well supply mains are the pipes that connect the wells with the reservoirs. Due to the starting and stopping of well pumps, these pipes can experience pressure surges. When the well supply mains are under higher pressures (greater than 40 psi), they are less likely to experience negative pressures during these pressure surges, assuming the well supply mains are adequately sized to handle the pumping flows. When the well supply mains are under lower pressures (less than 40 psi), they are more likely to experience negative pressures during pressure surges. When negative pressures occur, it is possible for contaminants in the soils

or the shallow groundwater to enter older well supply mains through leakage sites on the pipes.

In the case of Lornedunn Well No. 2 and Well R8-2, the well supply mains connect directly to the distribution system and are therefore under high-pressure. The Imperial Drive well supply main is also considered a high-pressure system. The well supply mains on these three wells have a low probability of negative pressures occurring. Therefore, during normal operation, it is unlikely that any contaminants in the soils surrounding these well supply mains can enter the water system through leakage sites on the pipes.

The well supply main that connects the Drew Road Well No. 1 and Ravensbourne Well No. 1 to the Drew Road Reservoirs is a low-pressure system that was installed in 1997. Although this pipe may experience low pressures, there is a low probability that contaminants can gain entry into the water system via this well supply main as the pipes and fittings are only seven years old.

The well supply main that connects the Oceanside Well No. 2 to the Drew Road Reservoir is a low-pressure system that was installed in 1999. Although this pipe may experience low pressures, there is a low probability that contaminants can gain entry into the water system via this well supply main as the pipes and fittings are only five years old. There is one air valve on this well supply main that is located inside a subsurface chamber. Currently, this supply main rests idle for most of the year and is only used when Oceanside Well No. 2 is operated in the summer.

The well supply main that connects Church Road Wells No. 1, 2, 3 and 4 to the Church Road Reservoirs is a low-pressure system contained within the fenced compound of the Church Road Reservoir complex. Although the pipes in this well supply main system may experience low pressures, there is a low probability that contaminants can gain entry into the water system due to the small footprint of the well supply main system and the well drained soils in which these pipes are located.

The well supply main that runs down Springhill Road is a low-pressure system that runs adjacent to a ditch, is down gradient of some light industrial activities, and passes below a swamp that is located at the toe of a fill embankment on the Inland Island Highway. This well supply main has an air valve located within a subsurface chamber and a flushout located within the swamp. Due to the possibility of negative pressures occurring on this well supply main, there is a moderate risk of contaminants entering the water system from this pipe system.

**Based on the investigations carried out during this assessment, the following recommendations are provided for the well supply mains:**

- **The air valve on the Oceanside Well No. 2 supply main should be inspected regularly while this main is in operation to ensure the air valve is not flooded by groundwater.**
- **The Oceanside Well No. 2 supply main should be flushed out thoroughly prior to use and tested for total coliform and fecal coliform before being put into operation each year.**
- **A pressure test should be carried out on the Springhill Road well supply main to establish the rate of leakage occurring (if any) on the pipe running down Springhill Road and the pipe that is located adjacent to the Inland Island Highway. The results of the leakage test should be reviewed by a professional engineer and appropriate remedial measures taken if necessary. Remedial measures may include repair of leaks, modifications to the air valve and flushout assemblies, and/or increasing the operating pressure of the well supply main.**

#### 3.1.4 Calculation of CT Values at the Church Road and Drew Road Facilities

The calculation of CT values provides an indication of the level of disinfection that is taking place in a water supply prior to human consumption of the water. In general, the longer the disinfectant is in contact with the raw water (T in minutes) and the higher the concentration of disinfectant (C in mg/L at the point of consumption), the higher is the chance that a pathogenic organism within the raw water will be inactivated.

CT values have been published for various degrees of disinfection requirements. The required CT value for a particular water treatment system depends on the degree of pathogen inactivation required, and the temperature and pH of the water being treated. For Breakwater's Church Road and Drew Road water treatment facilities, we have estimated the CT values for each system and examined whether they are appropriate for the water sources under review.

##### CT Calculation at Church Road

Under normal operation, the reservoirs at Church Road are configured in parallel such that the flow of water splits three ways after treatment and fills each of the three reservoirs independently. The configuration of the Church Road Reservoirs is shown on Drawing No. D9137-07-R1.

Estimated CT values have been calculated for each of the three Church Road Reservoirs for the anticipated inflow and outflows that could be experienced at this facility. The maximum inflow through the water treatment system is approximately 460 imperial gallons per minute (igpm). Combined peak hour reservoir outlet flows in the summer are estimated to reach approximately 1200 igpm and fire flows could potentially reach 2200 igpm. Actual system CT values are normally estimated using peak hour flow rates.

Spreadsheets #1 through #6 list the CT values estimated at the Church Road facility over the anticipated inlet/outlet flow ranges, at free chlorine residuals of 0.5, 0.4, and 0.3 mg/L at the point of consumption. This is the range that free chlorine residuals are currently set at Church Road. CT values have been calculated when the reservoirs are full and when their levels are down 1.0 metre below top water level. Under peak hour flow conditions, the CT values at the Church Road facility fall within the range of 12 - 29 min x mg/L, depending on the free chlorine residual at the point of consumption and the level of the reservoir. During an extreme fire flow it has been estimated that CT values could drop to 7 min x mg/L.

During the months of February, March, and April 2004, random readings of water temperature and pH were taken in the field prior to chlorination and from within Church Road Reservoir #3 (following chlorination). As shown on Table 4, temperatures of the raw water prior to chlorination were in the range of 10.2 – 13.8 degrees Celsius while pH was in the range of 6.86 – 7.45. Temperatures following treatment were in the range of 9.3 - 16.2 degrees Celsius while pH was in the range of 7.04 – 7.47.

Under peak hour flow conditions and the water temperature and pH ranges determined in the field during this assessment, the CT values estimated for the Church Road water treatment facility are sufficient to provide 99.99 % (4-log inactivation) of viruses by free chlorine. As the Church Road water treatment system receives water from sources that are not under direct influence of surface water, this level of treatment is considered appropriate for this facility.

**It is a recommendation of this assessment that temperature and pH readings be taken at the Church Road Reservoir facility during the months of November through February. The data obtained should be reviewed by a professional engineer to ensure the virus inactivation level established in this assessment holds true for the temperature and pH ranges determined over the colder winter months.**

CT Calculation at Drew Road

Under normal operation, the reservoirs at Drew Road are configured in series as shown on Drawing D9137-06-R3.

Estimated CT values have been calculated at Drew Road for the anticipated reservoir inflow and outflows that could be experienced at this facility. The maximum inflow through the water treatment system is approximately 400 igpm. As the Drew Road Reservoirs are drained by a booster pump system, outlet flows are limited to the capacity of the booster pumps. The outlet flows during current peak hour demands in the summer can approach 600 igpm. Under current fire flow conditions, outlet flows from the reservoir can approach 800 igpm. Once a new system loop is installed across French Creek, the future peak hour outlet flows will increase to approximately 800 - 900 igpm (assuming the 25 horsepower booster pump is operating) and fire flows leaving this facility could reach 1350 igpm.

Spreadsheets #7 through #12 estimate the CT values that are achieved at the Drew Road facility over the anticipated inlet/outlet flow ranges, at free chlorine residuals of 1.2, 1.0, and 0.8 mg/L at the point of consumption. CT values have been calculated when the reservoirs are full and when their levels are down 1.2 metres below top water level. For current peak hour flow conditions, the estimated CT values at the Drew Road facility are summarized as follows:

FREE RESIDUAL CHLORINE CONC. (mg/L)	RESERVOIR LEVEL	ACHIEVED CT VALUE (min x mg/L)
1.2	Full	174
1.0	Full	145
0.8	Full	116
1.2	Down 1.2 m	103
1.0	Down 1.2 m	86
0.8	Down 1.2 m	69

During the months of February, March, and April 2004, random readings of water temperature and pH were taken in the field prior to chlorination and from the outlet of the booster pumps following chlorination. As shown on Table 4, temperatures of the raw water (prior to chlorination) were in the range of 7.0 – 13.6 degrees Celsius while pH was in the range of 6.93 – 7.51. Temperatures following treatment were in the range of 7.0 – 11.8 degrees Celsius while pH was in the range of 6.94 – 7.58.

Under peak hour flow conditions and the water temperatures and pH ranges determined in the field during this assessment, the CT values estimated for the Drew Road water treatment facility are more than sufficient to provide 99.99 % (4-log inactivation) of viruses by free chlorine. However, under peak hour flow conditions, the achieved CT values are not always sufficient to provide 99.9 % (3-log) inactivation of giardia cysts with the free chlorine residuals that are likely occurring at the first water service within the system at this time. For this surface water source, CT values should remain above 130 min x mg/L in the summer when water temperatures are above 10 degrees Celsius and peak hour demands are likely to occur. In the existing system, if the reservoir levels are down and peak hour conditions occur, the Drew Road water treatment system would achieve a 90 % (1-log) inactivation of giardia cysts during an extreme demand period. This inactivation level will reduce once the new system loop is completed across French Creek. The peak hour flows used in the Drew Road CT analysis requires the 25 horsepower booster pump to be operating.

**Based on investigations carried out during this assessment, the following recommendations are provided:**

- **Undertake a water testing program on the French Creek surface supply to determine whether the creek supply contains cryptosporidium and giardia parasites.**
- **No reduction in current chlorine levels should take place at Drew Road until testing for cryptosporidium and giardia parasites has been completed or a dual disinfection system has been put in place.**
- **Consider installing a dual disinfection system on the French Creek surface supply, as recommended in Section 2.4.1.**
- **Carefully investigate the implications of the new system loop across French Creek prior to putting it into operation.**
- **Consider improvements to the reservoirs that would increase the contact time within the tanks and improve CT values.**
- **Carry out regular inspections of the operating valves on the piping system that links the three Drew Road Reservoirs to ensure these tanks are always operating in series.**
- **Regular draining and cleaning of the Drew Road Reservoirs should be undertaken during the winter season when peak hour demands are low.**

**Taking one of these reservoirs off line can greatly reduce the CT value provided by the Drew Road water treatment system and storage facility.**

- **Determine the temperature and pH of the water entering the Drew Road Reservoirs during the months of November, December and January and have this information reviewed by a professional engineer to ensure the inactivation levels established in this assessment hold true over the colder winter months.**

### 3.1.5 Breakwater's Chlorination Systems

Breakwater's main chlorination systems are located at the Church Road Reservoir and Drew Road Reservoir sites. They also have the ability to chlorinate water from the Oceanside Well No. 2 near the wellhead. Well R8-2 also has its own chlorination system. Currently all chlorination in the Breakwater system is carried out using a solution of 12 % sodium hypochlorite that is diluted with water and injected at a rate that is proportional to the flow of water being treated.

#### Church Road Chlorination System

The Church Road chlorination system was installed in 1998. Prior to installation, testing for total coliform bacteria occasionally returned positive results on this side of the Breakwater system. As the water sources feeding the Church Road Reservoirs are drilled wells that are not under the influence of surface water, the main reason for installing a chlorination system at this location was to prevent total coliform bacteria from growing in the reservoirs and within Breakwater's eastern distribution system. Since the chlorination system has been installed at Church Road, there have been no problems associated with total coliform bacteria on this side of the Breakwater system.

The Church Road chlorination system consists of a single LMI chlorine injection pump that is pulsed by a control system that monitors the flow entering the Church Road Reservoirs and the chlorine residual within the reservoirs. Essentially the flow meter provides the major adjustment and the chlorine analyzer provides the capability to make finer adjustments to the rate of chlorine injection. The system is currently set to provide a free chlorine residual of 0.4 mg/L at the inlet of the Church Road Reservoirs. The chlorine injection pump draws a solution of liquid sodium hypochlorite and water from a plastic storage drum and injects this solution into the metered flow stream entering the reservoirs. All chlorination equipment is enclosed within a locked building located in the northeast corner of the Church Road Reservoir complex.

The chlorine residual analyzer is supplied a constant flow of treated water from near the inlet of Church Road Reservoir No. 2. This water is supplied using a small booster pump that runs continuously. The reagent for the chlorine residual analyzer is stored in a small container that is exposed and located outside the building. The low alarm setting for free chlorine residual at Church Road is currently set at 0.25 mg/L.

Sodium hypochlorite is delivered to Church Road approximately once every three or four weeks during the summer. Two 45 gallon drums are delivered each time a delivery is made. During peak demand periods, approximately half a drum per week is used at Church Road. Liquid Sodium hypochlorite is transferred from the delivered drums to the plastic storage drum using a chemical transfer pump. The solution that is injected into the water supply is a mixture of one part water and one part 12 % sodium hypochlorite. The level of solution in the plastic storage drum feeding the chlorine injection pump is checked by Breakwater every Monday, Wednesday, and Friday. There is no low level alarm system on this storage drum.

The Church Road chlorination system is considered suitable for the following reasons:

- The water supplies that fill the Church Road Reservoirs are drilled wells that are not at any significant risk of being contaminated by surface flooding. In addition, these wells have been developed within confined aquifers.
- The CT values established in Section 3.1.4 are sufficient to provide adequate inactivation of bacteria and viruses at the free chlorine residual levels currently being applied at the Church Road facility.
- There were no total coliform or fecal coliform bacteria found in the raw water testing that was performed during this assessment.
- There is no recent history of bacterial problems on this side of the Breakwater system.

**Based on investigations carried out during this assessment, the following recommendations are provided for the Church Road chlorination system:**

- **The reagent reservoir for the chlorine residual analyzer should be installed within a vandal-proof enclosure.**
- **Some general house cleaning and regular maintenance should be carried out at the Church Road chlorination facility as discussed in Section 3.4.**

Drew Road Chlorination System

The Drew Road chlorination system was installed in the late 1980's. All water supplies entering the Drew Road Reservoirs, including the French Creek surface source and the local Drew Road well supplies, are chlorinated by this system.

The Drew Road chlorination system consists of a single LMI chlorine injection pump that is pulsed by a control system that monitors the flow entering the Drew Road Reservoirs and the chlorine residual within the reservoirs. The system is currently set to provide a free chlorine residual of 1.5 mg/L at the inlet of Drew Road Reservoir No. 1. The chlorine injection pump draws a solution of liquid sodium hypochlorite and water from a plastic storage drum and injects this solution into the metered flow stream entering the reservoirs. All this equipment is enclosed within a locked building located at the Drew Road Reservoir complex.

The chlorine residual analyzer is supplied a constant flow of treated water from near the inlet of Drew Road Reservoir No. 1. This water is supplied to the analyzer using a filtered gravity feed line from the reservoir. The low alarm setting for the free chlorine residual at Drew Road is currently set at 0.5 mg/L.

Sodium hypochlorite is delivered to Drew Road approximately once every week during the summer. Two 45 gallon drums are delivered each time a delivery is made. During peak demand periods, approximately one drum of 12 % sodium hypochlorite is used at Drew Road per week. Liquid sodium hypochlorite is transferred from the delivered drums to the plastic storage drum using a chemical transfer pump. The solution that is injected into the water supply is a mixture of one part water and three parts 12 % sodium hypochlorite. The level of solution in the plastic storage drum feeding the chlorine injection pump is checked by Breakwater every Monday, Wednesday, and Friday. There is no low level alarm system on this storage drum.

There is a re-circulation pump that re-circulates and re-chlorinates water within the Drew Road reservoirs to help maintain chlorine residuals during periods of low demand. When the free chlorine residual within Drew Road Reservoir No. 1 falls to 1.2 mg/L, this pump is turned on by the control system. The re-circulation pump draws water from the outlet of the reservoirs and re-circulates it through the chlorine injection system where the water is re-chlorinated and then pumped back into the inlet of the reservoirs. There is a double-check backflow preventor on this re-circulation system to prevent raw water from by-passing the reservoirs and flowing directly into the distribution system.

Based on investigations carried out during this assessment, the following recommendations are provided for the Drew Road chlorination system:

- **Due to the threat of pathogenic organisms entering Breakwater's French Creek surface supply, it is recommended that the existing Drew Road chlorine injection pump system be upgraded to a duplex system. The duplex system should be installed with flow monitoring devices on the sodium hypochlorite discharge tubing that are capable of sending alarms when the chlorine injector lines become blocked, or the chlorine injection pump fails, or the sodium hypochlorite storage tank empties. If the flow monitor senses a problem with the flow of sodium hypochlorite, the control system should automatically turn on the second chlorine injection pump and trigger an alarm notification on the first failure. If the flow monitor on the second chlorine injection pump also senses a problem, the control system should send out an immediate call-out alarm and lock off the French Creek surface water intake pumps. This will ensure that a malfunctioning chlorine injection system does not enable untreated surface water to enter the Drew Road Reservoirs. The two chlorine injection pumps should alternate so that each pump operates 50 % of the time.**
- **The filter on the water supply to the chlorine residual analyzer should be cleaned regularly to ensure the analyzer is always functioning properly.**
- **Some general house cleaning and regular maintenance should be carried out on the Drew Road chlorination facility as discussed in Section 3.4.**

#### 3.1.6 Examination of Raw Water Quality Prior to Chlorination

As part of the water quality testing that was carried out during the months of February, March, and April 2004, a number of parameters were analyzed due to their potential effects on chlorination. Turbidity is one of the more significant water quality parameters because it can hide or mask undesirable constituents such as pathogenic organisms and hinder disinfection by free chlorine. Other water quality parameters such as iron, manganese, and ammonia can increase the chlorine demand of the water being treated. This is important on water systems that have multiple sources that can be contributing varying amounts of water at anyone time such that the chlorine demand is continually fluctuating, making it difficult to maintain a constant and reliable chlorine residual in the treated water supply. Other water quality parameters such as colour and total organic carbon can contribute to the formation of disinfection by-products following chlorination.

#### Church Road Raw Water Quality

Table No. 1 provides a summary of the raw water quality parameters tested at the Church Road treatment facility during this assessment. Testing was carried out on samples of the blended water from the Church Road / Springhill Road well supplies, prior to chlorination. Water samples were taken when the majority of the wells that feed the Church Road Reservoirs were operating. The water quality results are comparable to previous testing that has been carried out on the individual Church Road / Springhill Road well supplies.

Based on the analysis performed during this assessment, and a review of previous analyses performed by others, no raw water quality parameters have been identified in the local Church Road / Springhill Road well supplies that will have a significant impact on the effectiveness of the Church Road chlorination system. In addition, based on the low levels of total organic carbon found in the blended water, there is a low potential for the formation of disinfection by-products at this facility.

#### Drew Road Raw Water Quality

Table No. 2 provides a summary of the raw water quality parameters analyzed from the French Creek intake. Table No. 3 summarizes the raw water quality parameters analyzed from a blended mixture of the French Creek intake supply and the Ravensbourne Well No. 1 supply. All analyses were carried out on water sampled prior to treatment. The water quality results listed in Tables No. 2 and 3 are comparable to previous testing that has been carried out on the French Creek intake and the Ravensbourne Well No. 1 supply.

For the water samples taken from the creek intake during the months of February, March, and April 2004, significant water quality results are identified as follows:

- The natural colour of the French Creek intake water remains relatively constant at approximately 15 Colour Units.
- The turbidity of the creek intake water has fluctuated from 0.9 NTU in February, to 0.3 NTU in March, to 0.6 NTU in April, remaining just below the Maximum Acceptable Concentration (MAC) of 1.0 NTU over the water sampling period.
- The results for total suspended solids have followed a similar pattern to turbidity, fluctuating from 12 mg/L in February, to 1.5 mg/L in March, to 3.0 mg/L in April.

- The total organic carbon levels in French Creek have gradually reduced as the weather became warmer and rainfall in the watershed reduced, dropping from 3.5 mg/L in February to 2.7 mg/L in April.
- Iron and manganese levels have remained less than detectable.
- Total Kjeldahl nitrogen levels are insignificant.

For the water samples taken from the blended supply of the French Creek intake water and Ravensbourne Well No. 1 water during the months of February, March, and April 2004, significant water quality results are identified as follows:

- The natural colour, turbidity, and total organic carbon levels improve in the blended water, as compared to the raw creek water.
- Total Kjeldahl nitrogen levels remain insignificant in the blended water.
- Iron levels remain low in the blended water.
- Manganese levels increase in the blended water to slightly above the Aesthetic Objective (AO) of 0.05 mg/L.

The percent UV transmittance of the French Creek intake water was also measured in the lab during the months of February, March, and April 2004. Based on the results listed in Table No. 2, percent UV transmittance improved as the concentration of total organic carbon reduced. A UV disinfection system could be considered as a means of providing dual disinfection of the French Creek intake source. Based on the testing performed during this assessment, a UV system could likely be used successfully to disinfect the creek supply during the summer, when the clarity of the water is improved but bacterial counts increase.

The total organic carbon (TOC) levels that have been established during this assessment indicate there is a potential to form disinfection by-products, such as total trihalomethanes (TTHM), during chlorination of the creek water. When TOC is in the range of 2.0 - 4.0 mg/L, some treatment may be necessary to reduce the TOC levels and reduce the formation of TTHM in the treated water supply. Testing carried out within the Breakwater system (Leeward Way) by the Central Vancouver Island Health Region on March 1, 2001, indicates that TTHM was less than the IMAC guideline of 0.1 mg/L. Future testing should be carried out at the Drew Road Reservoir facility.

The effects of blending the French Creek surface water with the other three well supplies (Oceanside Well No. 2, Drew Road Well No. 1, and Imperial Drive

Well) was not investigated during this assessment because these wells are not operated during the winter and early spring. Based on previous testing by others, the Oceanside Well No. 2 and the Drew Road Well No. 1 both have elevated levels of iron and manganese that will add to the chlorine demand of the blended water being treated at the Drew Road facility when these wells are operated. Based on testing performed on February 21, 2002, the Oceanside Well No. 2 source had a turbidity level of 2.09 NTU. There is no recent water quality data available for the Imperial Drive Well.

**The following recommendations are provided based on the water quality testing carried out during this assessment:**

- **Breakwater should continue a water quality monitoring program on the French Creek supply that includes turbidity, colour, total suspended solids, TOC, and % UV transmittance. This testing should continue on a monthly basis until a full year of data has been obtained. Testing would preferably take place immediately following a rainfall event.**
- **The French Creek source should always be blended with one of the better quality Drew Road well supplies to help reduce turbidity, colour, total suspended solids, TOC, and the levels of micro-organisms in the flow stream prior to chlorination.**
- **A turbidity meter should be installed on the French Creek surface supply and a monitoring / control system be put in place to record and log all turbidity data. The control system should be capable of shutting this supply down if a turbidity spike occurs in French Creek.**
- **Turbidity, TOC, iron, manganese, total suspended solids, and natural colour should be analyzed in the raw water for each possible combination of blended water that could occur during the summer demand period. Samples for testing should be taken prior to chlorination. All water quality results should be reviewed by a professional engineer.**
- **Total trihalomethanes should be analyzed in the treated water (following chlorination) for each possible combination of blended water that could occur during the summer demand period. Samples for testing should be taken from the inlet to the first reservoir following at least 30 minutes of continual chlorination of the blended water flow stream being tested. Results should be reviewed by a professional engineer.**

- **Total trihalomethanes should be analyzed in the blended creek and Ravensbourne Well No. 1 water (following chlorination) during normal winter operation once TOC levels in the creek supply start to approach 3.0 - 4.0 mg/L. Results should be reviewed by a professional engineer.**
- **Breakwater should investigate whether the Arrowsmith bulk water supply is likely to be available in the near future. If not, Breakwater should start to plan for treating the iron and manganese in the well supplies that are connected to the Drew Road Reservoirs. An investigation into treating these supplies was carried out by BC Research Inc. in May, 2002.**

### 3.1.7 Breakwater's Control Systems

Breakwater's main control systems are located at the Drew Road and Church Road Reservoir facility. These two systems can communicate with each other and to Breakwater's supervisory control and data acquisition (SCADA) software located on a central computer in Breakwater's office via modems over a dial-up telephone line. The main features of Breakwater's control systems are discussed as follows:

#### Church Road Control System

The Church Road control system monitors the water level in the Church Road Reservoirs and controls the operation of twelve wells including all the Church Road and Springhill Road wells and the new Well R8-2. The Church Road control system can also signal for the Drew Road booster pumps to operate. The reservoir level is obtained from a pressure transducer that is set within the reservoir and connected to the Church Road control panel. The local well pumps are set to respond to 1<sup>st</sup>, 2<sup>nd</sup>, or 3<sup>rd</sup> call from the Church Road controls, depending on the level of water in the reservoirs. The local well pumps start when called to operate by the Church Road controls and pump water to fill the Church Road Reservoirs. Depending on the level in the Church Road Reservoirs, one of the following tasks is carried out:

- When the water level in the Church Road Reservoirs drops to 2.62 metres, the pumps that are on first call start pumping.
- When the water level in the Church Road Reservoirs drops to 2.49 metres, the pumps that are on second call start pumping.
- When the water level in the Church Road Reservoirs drops to 2.03 metres, the pumps that are on third call start pumping.

- When the water level in the Church Road Reservoirs drops to 1.91 metres, the control system sends out a warning notification to Breakwater that the Church Road Reservoir level is low.
- When the water level in the Church Road Reservoirs drops to 1.78 metres, the control system sends out an emergency notification to Breakwater that the Church Road Reservoir level is critically low.

Well pumps at Church Road Wells No. 1, 2, 3 and 4 are controlled from the local control panel at Church Road via underground telemetry cables. There are some modifications being made to the well controls in the Springhill Road area. Once these modifications are complete, Hills of Columbia Well No. 9 will be controlled via an underground telemetry cable between the Church Road control panel and the well kiosk. Springhill Road Well No. 1, Hills of Columbia Well No. 6, 7, & 11 and Bosa Well No. 1 will be connected to a secondary control system, located in the Springhill Road Well No. 2 kiosk, via underground telemetry cables. The Springhill Road Well No. 2 controls will be connected to the Church Road controls via a radio link.

The new Well R8-2 at French Creek will be controlled via a dial-up modem between the Church Road controls and a control system in the Well R8-2 pump house. Well R8-2 will pump chlorinated water directly into the distribution system and does not fill the Church Road Reservoirs directly.

The Drew Road booster pumps can also be controlled from Church Road via a dial-up modem between Church Road and Drew Road. The Drew Road booster pumps draw water from the Drew Road Reservoirs to boost system pressures on the west side of the system when the Church Road Reservoirs are unable to maintain system pressures in this area.

#### Drew Road Control System

The Drew Road control system monitors the reservoir level and controls the operation of five pumps including the French Creek intake, the Imperial Drive Well, Ravensbourne Well No. 1, Drew Road Well No. 1, and Oceanside Well No. 2. The reservoir level is obtained from a pressure transducer that is set within the reservoir and connected to the Drew Road control panel. The supply mains from the wells are connected directly to the Drew Road chlorination system and reservoir inlet. The pumps on these wells are set to respond to 1<sup>st</sup> or 2<sup>nd</sup> call from the Drew Road control system, depending on the water level in the Drew Road Reservoir. Control tasks are initiated essentially the same way as at Church Road except that there is no third call level in the reservoir. All the well pumps are controlled locally via underground telemetry cables between the Drew Road control panel and the individual well kiosks.

The Oceanside well has an adjustable timer to control both the maximum length of time the well pump operates and the minimum length of time between pumping cycles. This timer is used to limit the volume of water extracted from Oceanside Well No. 2 in an effort to reduce the concentration of iron and manganese entering the blended water at the Drew Road Reservoirs.

The Drew Road control system also controls the three Drew Road booster pumps including a 10, 15 and 25 horsepower pump. The three booster pumps can be called to operate, responding to either low system pressures at the Drew Road facility or a falling water level in the Church Road Reservoirs.

Based on the information obtained and investigations carried out during this assessment, Breakwater's control systems are considered to be appropriate and are similar to those found in other water utilities.

#### 3.1.8 Breakwater's Monitoring Equipment and Alarm Systems

Breakwater's control systems perform the following monitoring tasks:

- The water level in each well that is connected to the reservoirs.
- The water levels in the reservoirs.
- The free chlorine residuals in the reservoirs.
- The operation of individual pumps.

Breakwater's control systems provide the following alarm notifications:

- If a pump fails in the system, an alarm is triggered.
- If a chlorine residual level at Church Road or Drew Road drops too low, an alarm is triggered. Currently the low chlorine alarm is set at 0.25 mg/L at Church Road and 0.5 mg/L at Drew Road.
- If a reservoir level drops too low, an alarm is triggered.

Currently there are no intrusion alarms on any of Breakwater's facilities.

When an alarm is triggered, an automatic dialer starts a call-out process that dials a series of phone numbers until an acknowledgement of the problem is gained by

the control system. The operator receiving the alarm notification decides whether or not the problem is urgent and requires immediate attention.

Problems or mechanical failures associated with water treatment equipment have potentially the most serious public health implications. Possible failures that could occur on Breakwater's water treatment systems include the following:

- Failure of a chlorine injection pump.
- Blockage or breakage of the tube that transports sodium hypochlorite solution from the chlorine injection pump to the flow of water being treated.
- Draining of the sodium hypochlorite storage tank.

Currently the failures listed above would cause eventual fall-off of free chlorine residuals in the Breakwater reservoirs. The chlorine residual analyzers would eventually detect the lower chlorine residuals and trigger an alarm notification to Breakwater. It is possible for a large volume of unchlorinated water to enter the reservoirs before an operator receives the alarm and is able to mobilize to site and correct the problem. This would create the potential for pathogenic contamination of the Drew Road Reservoirs from the French Creek surface supply.

When the new well R8-2 is commissioned, the control system will monitor salinity levels in this well and automatically shut the pump down if salinity levels are too high. The Well R8-2 control system is also designed to detect any problems with the flow of sodium hypochlorite and shut the well pump down if such a problem occurs.

**The following recommendations are provided based on the investigations carried out during this assessment to improve vulnerability of the system during alarm conditions:**

- **As recommended in Section 3.1.5, a duplex chlorine injection pump system should be implemented at Drew Road.**
- **Breakwater should start to generate monthly trending graphs of chlorine levels and reservoir levels at both the Drew Road and Church Road facilities. The daily volume of water pumped into each reservoir facility should also be recorded and plotted on a monthly trending graph. All trending information should be filed carefully and kept on record.**

### 3.1.9 Breakwater's Church Road and Drew Reservoirs

Breakwater's Reservoirs are located on Church Road and Drew Road. These two facilities provide all the storage in the Breakwater system, and are detailed on Drawings D9137-07-R1 and Drawing D9137-06-R3 (in pocket).

#### Church Road Reservoirs

There are three operational reservoirs at Church Road with a combined storage volume of approximately 375,000 imperial gallons. There is one small reservoir that has been taken off the system, drained, and abandoned. The three operational reservoirs have a top water level of 79.0 metres (geodetic datum) and provide water to the Breakwater system by gravity. During low demand periods in the winter, it is estimated that the water in the Church Road Reservoirs is turned over or exchanged once every 2 – 3 days. During summer demand periods, water in these reservoirs is exchanged on a daily basis. Breakwater currently cleans the Church Road Reservoirs annually. The three Church Road Reservoirs are described below:

Church Road Reservoir No. 2 was constructed in the mid 1980's and consists of a low level, partially in-ground, rectangular concrete structure with a peaked wooden roof. The outer roof membrane is constructed from dark coloured asphalt shingles. The structure is vented with standard residential type hooded vents. There are some large dents in the peak of the roof and a number of areas where insects can gain access into the reservoir. Treated water enters the inlet at the north side of the reservoir and exists through the outlet at the south side. There is an overflow on the north end of the tank that discharges directly to the ground adjacent to the tank. This overflow provides a direct opening into the reservoir.

Church Road Reservoir No. 3 was constructed in the late 1980's and consists of a low level, partially in-ground, rectangular concrete structure with a flat concrete roof slab. The structure is vented with a goose-neck style vent that has a plastic screen. There is a large metal access hatch that is hinged and locked. This hatch is not insect proof. Treated water enters the inlet at the north side of the reservoir and exists through the outlet at the south side. There is a built-in overflow on this tank that is directed to a long section of drain piping that discharges into the Church Road ditch.

Church Road Reservoir No. 4 is approximately 3 years old and consists of a low level, partially in-ground, rectangular concrete structure with a flat concrete roof slab. This structure shares a common wall with Church Road Reservoir No. 3. The structure is vented with a goose-neck style vent that has a plastic screen. There are some large cracks that have formed where the roof slab is supported by

the walls on the north and south sides of the reservoir. There is a large metal access hatch that is hinged and locked. This hatch is not insect proof. Treated water enters the inlet at the north side of the reservoir and exists through the outlet at the south side. There is a built-in overflow on this tank that is directed to a long section of drain piping that discharges into the Church Road ditch.

The Church Road Reservoirs are very exposed and large areas of concrete surface are subject to direct sunlight for most of the day. As indicated in Table 4, temperature readings taken before and after chlorination during the month of April indicates there was an increase in temperature as the water passed through the reservoirs. This increase was in the range of approximately 2 - 3 degrees Celsius. It is possible that the water has stratified within the tanks and the warmer water is sitting at the top and the cooler water is sitting in the bottom of the tank. This can lead to stagnation of the upper layer of warmer water. This may explain why one of the manual free chlorine residual readings taken during this assessment on April 7, 2004, dropped to 0.08 mg/L, as shown on Table No. 4. Some of the water temperatures observed in the Church Road Reservoirs during this assessment exceeded the AO value of 15.0 degrees Celsius.

None of the Church Road Reservoirs have baffles. Baffles may improve the contact time, reduce short-circuiting, and in some cases reduce stagnant water problems.

#### Drew Road Reservoirs

There are three operational reservoirs at Drew Road with a combined storage volume of approximately 280,000 imperial gallons. The three reservoirs have a top water level of 40.0 metres (geodetic datum). During low demand periods in the winter, it is estimated that the water in the Drew Road Reservoirs is turned over or exchanged once every 2 – 3 days. During summer demands, water in these reservoirs is exchanged on a daily basis. The Drew Road Reservoirs do not provide water to the Breakwater system by gravity, but rather supply the Drew Road booster pumps. Breakwater cleans the Drew Road Reservoirs annually. The three Drew Road Reservoirs are described below:

Drew Road Reservoirs No. 1 and 2 are approximately 30 years old and consist of low level, rectangular concrete structures with a flat concrete roof slab. The structures are vented with a goose-neck style vent that has a metal screen that is corroded. Each reservoir has a large metal access hatch that is hinged and locked. The hatches are not insect proof. Treated water enters the inlets at the south side of the reservoirs and exists through the outlets at the north side. There are built-in overflow systems on the tanks that drain into an overflow drain that discharges to the ditch on Drew Road.

Drew Road Reservoir No. 3 is approximately 3 years old and consists of a 5.0 metre high, rectangular concrete structure with a flat concrete roof slab. The structure is vented with a small hooded metal vent. There are two large metal access hatches on this reservoir that are hinged and locked. These hatches are not insect proof. Treated water enters the inlet at the south side of the reservoir and exists through the outlet at the north side. There is a built-in overflow system on this tank that drains into an overflow drain that discharges to the ditch on Drew Road.

As indicated in Table 4, temperature readings taken at the inlet and outlet of the Drew Road Reservoirs indicates there are no substantial increases in water temperatures as the water passes through these reservoirs.

None of the Drew Road Reservoirs have baffles. Baffles may improve the contact time, reduce short-circuiting, and in some cases reduce stagnant water.

**The following recommendations are provided based on the reservoir investigations carried out during this assessment:**

- **The wooden roof structure on Church Road Reservoir No. 2 should be inspected for leakage, mould, mildew, and rot. This roof system should likely be replaced in the next 2 to 5 years. In the mean time, all cracks and entry points into the reservoir should be sealed to prevent entry of insects and small rodents. The existing overflow should be modified to prevent pests from entering the reservoir. This overflow outlet should also be screened and extended well beyond the base of the reservoir to prevent erosion and undermining of the tank foundation during overflow conditions.**
- **The overflow outlet for Church Road Reservoirs No. 3 and No. 4 should be screened where it enters the ditch with an oversized screen mechanism. These pipes should be flushed and the screen cleaned regularly.**
- **A more detailed investigation into water temperatures and possible stratification of the tanks should be carried out on the Church Road Reservoirs during the summer and fall months. Water temperatures should be taken at the inlet, within the individual reservoirs (at different levels in the water column), and at a couple locations on the Church Road supply main to establish how water temperatures are affected as the water passes through the reservoirs and travels down the Church Road supply main towards the distribution system. If the water temperatures increase within the reservoirs, consideration**

should be given to covering the reservoirs with a reflective paint to reduce the temperature of the concrete structures and reduce the heat transfer to the water inside. If stratification is occurring, a mixing system and/or installation of a baffling system within the tanks should be investigated.

- The cracks on Church Road Reservoir No. 4 should be inspected and sealed to prevent roof drainage from entering the reservoir.
- The access hatches at Drew Road and Church Road should be retrofitted by installing seals on the lids to prevent insects from entering the reservoirs.
- The overflow outlet pipes for the Drew Road Reservoirs should be screened where the drain pipe enters the Drew Road ditch with an oversized screen mechanism. These pipes should be flushed and the screen cleaned regularly.
- Baffles should be investigated for the Breakwater Reservoirs as a way of potentially increasing the chlorine contact time and preventing short-circuiting and stagnant water pockets from forming. A baffling system may be particularly beneficial on Drew Road Reservoir No. 3, due to its volume and the increased contact time that may be achieved.
- The size of vents at both reservoir facilities should be examined in detail to ensure they can pass sufficient volumes of air during fire flow conditions and not create negative pressures within the tanks. Negative pressures within the tanks could draw water into the tanks from the overflow drains. Any corroded vents should be replaced.

#### 3.1.10 Operation & Effectiveness of Breakwater's Treatment & Storage

All of Breakwater's water treatment and storage facilities are located at Church Road and Drew Road. Chlorination will also take place at Well R8-2 once this well is connected to the system.

##### Church Road Storage & Treatment

The Church Road water treatment and storage facility has performed well in recent years. The main purpose of the Church Road Reservoirs is to provide storage for fire fighting and peak hour demands. Although there have been no major fires in the Breakwater system, Church Road has sufficient storage to

provide at least 2.0 hours of the highest fire flow that can be provided by Breakwater's distribution system.

The Church Road chlorination system is providing adequate inactivation of indicator and nuisance organisms that may originate from the Church Road well supplies and attempt to colonize the east side of the Breakwater system where most of the Church Road water is distributed. Based on the available historical free chlorine residuals that have been taken from the east side of the Breakwater system, free chlorine residuals are remaining above 0.2 mg/L.

#### Drew Road Storage & Treatment

The Drew Road water treatment and storage facility is currently performing three main functions. These are discussed below:

The Drew Road Reservoirs provide additional storage for fire fighting and peak hour demands on the west side of the Breakwater system. The water stored at Drew Road is required to supplement the water stored at Church Road, in order to maintain adequate system pressures on the east side of the Breakwater system. The Drew Road storage facility has operated well in recent years.

The Drew Road chlorination system is required to disinfect the French Creek surface water source to inactivate pathogenic organisms that are potentially in the French Creek surface supply. In addition, the Drew Road chlorination system is required for inactivation of nuisance organisms (total coliform bacteria) that may originate from the French Creek surface source or the Drew Road well supplies. There have been occasions when adequate disinfection of the French Creek surface water source may not have occurred. Just prior to the boil water order last September, there was a period when free chlorine residuals in the Drew Road tanks dropped below 0.15 mg/L. Although some disinfection can still take place at these low chlorine levels, if the water in the storage tanks did not receive sufficient contact time before being pumped into the system, bacteria and viruses from the French Creek surface supply may not have been inactivated during the period when chlorine levels were found to be low last fall. In addition, if the fecal coliform bacteria that were found in the system were introduced through a cross connection, it is possible that higher chlorine residuals could have destroyed most of these bacteria as they entered the distribution system.

The Drew Road chlorination and storage facility is also currently being used to provide some treatment of the iron and manganese that is naturally present in the Drew Road well supplies. In addition to blending surface water with well water to dilute the iron and manganese in the well supplies, there is some oxidation of iron and manganese taking place through chlorination, and some of the oxidized iron and manganese is settling out in the reservoirs. However, oxidation of manganese

with chlorine is slow at pH levels below 8.5 and therefore manganese levels can still be elevated above the AO of 0.05 mg/L in the west side of the Breakwater system during those periods when the Drew Road well supplies are heavily utilized. Evidence of incomplete treatment of manganese is further confirmed by the letter complaints that were received from Breakwater customers during this assessment. The majority of discoloured water complaints were from customers living in Breakwater's west side where the water from the Drew Road wells is distributed after passing through the Drew Road Reservoirs.

Recommendations on water treatment improvements at the Drew Road facility are provided in Sections 3.1.4, 3.1.5, 3.1.6, and 3.1.8.

### 3.1.11 Breakwater's Drew Road Booster Pump Station

Breakwater's Drew Road booster pump station on Drew Road contains the three booster pumps, the Drew Road chlorination system, and the Drew Road system controls, all of which are enclosed inside a locked wooden building. All water sources that supply the Drew Road Reservoirs flow through the Drew Road booster pump station before entering the reservoirs. All water leaving the reservoirs flows through the Drew Road booster pump station via the booster pumps. The Drew Road booster pumps perform the following functions:

- The Drew Road booster pumps draw chlorinated water from the low level Drew Road Reservoirs, pressurize it, and feed the chlorinated water into the Breakwater system.
- Roughly half of Breakwater's total water supply is generated on this side of the system and the booster pumps are capable of matching and exceeding the total flow provided by all water supplies that feed the Drew Road Reservoirs. This ensures that maximum day demands are provided to the system and peak hour demands can be provided from storage in the Drew Road Reservoirs.
- The existing 10 and 15 horsepower booster pumps are operated regularly, boosting system pressures on the west side of the Breakwater system during high demands when the Church Road Reservoirs are unable to maintain system pressures.
- During low demand periods, the Drew Road booster pumps are still operated to prevent water in the Drew Road Reservoirs from going stagnant.
- The 25 horsepower booster pump is essentially on stand-by, ready to provide additional flows for fire fighting when required within the Breakwater system. This pump is not normally operated unless there is a fire because it creates high velocities in the distribution piping around Drew Road, stirring up deposits that have accumulated in the pipes

(particularly the Drew Road supply main), causing coloured water problems in the distribution system.

During a power failure, the Drew Road Booster pumps are not able to operate because there is no back-up generator at this facility. During a power outage, the Church Road Reservoirs must supply all water to the Breakwater system.

Due to the coloured water problems that can occur when the 25 horsepower pump is operated, the 10 and 15 horsepower booster pumps perform most of the pumping at the Drew Road Booster pump facility. A new system loop across French Creek is planned to provide better fire protection in the area around Robertson Boulevard. Once this new system loop is in place, pipe velocities in the Drew Road area will reduce and coloured water problems associated with operation of the 25 horsepower booster pump will reduce. The new system loop will also enable higher flows of water to be transferred from the Drew Road Reservoirs into the distribution system.

The configuration of the Drew Road booster pump system is considered appropriate. However, the building is very small and there is limited working space available for performing inspections and maintenance. The facility could also use tidying up and some general house keeping.

**The following recommendations are provided based on the investigations carried out during this assessment for improvements to the booster pump station:**

- **The Drew Road booster pump station facility requires some general house keeping as discussed in Section 3.4.**
- **The current building is too small. If a new iron and manganese water treatment facility is constructed at this site, consideration should be given to re-building the existing booster pump and chlorination facilities and incorporating these into the new facility.**
- **Consideration should be given to providing sufficient back-up power at this facility to operate critical controls, pumps and water treatment components during an extended power outage. A back-up power supply could be in the form of an on-site back-up diesel generator, or a transfer switch system enabling connection of a portable generator.**

## 3.2 BREAKWATER'S DISTRIBUTION SYSTEM

After the treated water leaves the two Breakwater reservoir facilities it flows under pressure through a network of distribution pipes to the individual water services that are connected to the utility. Breakwater's distribution piping consists of asbestos cement, PVC, and some polyethylene pipes. Some of Breakwater's older asbestos cement pipes are approximately 40 years old. For the past ten years, Breakwater has been actively assessing the condition, hydraulic characteristics, and age of their distribution system. Breakwater has an annual pipe replacement program where sections of the oldest piping are replaced each year. Breakwater has also been working to loop dead end mains to improve system circulation and increase fire flows throughout the system. The majority of new piping that has been installed in the last fifteen years has been pressure tested to 1.5 times the working pressure of the pipe, prior to being put into service.

In addition to their annual pipe replacement program, Breakwater performs regular flushing and swabbing in their system, and fire hydrant maintenance.

### 3.2.1 Flushing and Swabbing

As with all water utilities, flushing and swabbing of the distribution piping is carried out to eject sediments and deposits that have accumulated in low velocity sections of the distribution system. With modern fire flow requirements, water supply mains have to be sized larger to supply the fire flows needed to meet current building codes and fire protection standards. Under low flow conditions, sediment can settle out of the water flow stream and accumulate at the bottom of the pipes. Sites where porous sediments accumulate can be colonized by total coliform bacteria that hide in the sediment, protected from the effects of chlorine. When high demand periods occur, such as during peak demand periods in the summer, water velocities can increase and re-suspend these accumulated sediments, and total coliform bacteria, causing coloured water problems and positive total coliform counts throughout the system. In the Breakwater system, these problems are amplified due to the iron and manganese found in the Drew Road well supplies. Although a small portion of the iron and manganese is oxidized by the chlorination process and settles out in the Drew Road Reservoirs, there is still iron and manganese accumulating in the distribution piping, adding to the colour problems that are being experienced in some areas. Based on the complaints received from water customers during this assessment, most of the problems are occurring west of French Creek, where treated water from the well supplies containing iron and manganese is distributed.

Currently Breakwater carries out swabbing within their system every five years. The Drew Road supply main is swabbed every year because this is the first pipe

that is contacted by the water leaving the Drew Road Reservoir. Swabbing is performed by inserting a plastic or foam projectile (called a pig) into the water supply mains and forcing the pig through the pipe using water pressure. As the pig moves through the water supply main it scours the sediments and deposits inside the pipe, suspending them so they can be flushed out of a fire hydrant or flushout assembly that is located downstream of the swabbing operation.

Flushing in the Breakwater system is carried out annually during the fire hydrant maintenance program. Due to the iron and manganese problems on the west side of the system, areas around Johnstone Road and the Oceanside development are flushed every 2 – 3 months. Although the flushing and swabbing program should continue, the only way to properly address the coloured water problems on the west side will be to find an alternate water supply or provide adequate treatment of the iron and manganese found in the Drew Road well supplies.

**It is a recommendation of this assessment that a uni-directional flushing program be developed for the Breakwater system.**

### 3.2.2 Potential for Cross-Connections and Backflow

System pressures within Breakwater's distribution pipes normally remain above 40 psi. Under these conditions, the pressure within the pipes is higher than outside the pipes so the internal water pressure at leakage sites tends to force water from the pipe, keeping contaminants from entering the pipe.

There are occasions when system pressures drop below 40 psi, such as during a major fire when the fire department may be required to draw large volumes of water to fight a fire. Although pressures can drop lower than 20 psi during a major fire, normally there is still higher pressures inside the distribution piping than outside. However, there are some situations when negative pressures can occur such as during a major water main break, or when a water main is shut down to enable new construction or maintenance to take place.

During a major water main break the broken pipe is normally isolated, by shutting off a group of line valves, until the system pressure is taken off the broken pipe. As the pressure in the water main approaches zero, contaminants adjacent to the break can enter the pipe. Back siphonage can also occur as the broken water main drains and water is drawn into the supply main from private connections that do not have backflow prevention devices or from small leakage sites along the pipe.

When a tie-in is made to an existing water supply main in the distribution system, the section of main being tied into is isolated, de-pressurized, and drained so the tie-in can proceed. If the section of supply main is long and contains a number of

water services, there is a potential for back siphonage from water services that do not have backflow prevention devices. In addition, any submerged air valves have the potential to enable contaminants to enter the isolated section of supply main as it drains.

**Based on the investigations carried out during this assessment, the following recommendations are provided for the distribution system:**

- **A survey should be carried out in the Breakwater system to determine which water service connections have backflow prevention devices and which ones do not. Commercial irrigation services should also be inspected during this survey. Once the survey has been completed, an upgrading program should be implemented to provide backflow prevention devices at property line for those services that do not currently have backflow prevention.**
- **All air valve chambers in the Breakwater distribution system should be inspected on a regular basis. Chambers that are subject to flooding should be upgraded to ensure contaminants do not enter the air valve vent systems when the water supply main is de-pressurized.**
- **Breakwater should develop a standard procedure for performing repairs to broken water mains and constructing new tie-ins within the system. Recommended guidelines for this work are available through the American Water Works Association. Breakwater's standard procedures should be developed with the assistance of a professional engineer.**

### 3.2.3 New Construction

There are currently two types of new construction that take place in the Breakwater system. There is the new construction that Breakwater undertakes themselves, and there is the new construction that is performed by private developers within the service area. All new construction requires a Waterworks Construction Permit from the Vancouver Island Health Authority. All new water supply mains installed in the Breakwater system are pressure tested, flushed, and disinfected. Following disinfection, the water in the new supply main is tested for total and fecal coliform bacteria before water in the new pipe is consumed by the public.

All new construction work that is undertaken by Breakwater is under their control and therefore the risks of contamination occurring during Breakwater's projects

are minimal. When new construction is carried out by a private developer, the following procedures are currently in place:

- Breakwater has all new construction that is proposed within their system reviewed by a professional engineer before it is constructed.
- Breakwater requires the developer to provide a copy of the VIHA Waterworks Construction Permit for all new water distribution piping proposed within their system. This ensures the VIHA has reviewed the waterworks that are proposed prior to construction.
- Breakwater requires the developer to construct the new water supply main in isolation of the Breakwater system until it has been pressure tested, flushed, chlorinated, and tested for bacteriological contamination. Any temporary connections that are used to fill and flush the new water distribution pipes have to include backflow prevention devices that are capable of protecting the system from contamination.
- Breakwater requires a copy of the bacteriological analysis before the new pipe can be tied into the Breakwater system.
- Breakwater must be present when the tie-in is taking place to their system.
- Breakwater requires a copy of the record drawings for the new water distribution piping. These drawings have to be certified by a professional engineer.

**Based on the investigations carried out during this assessment, the following recommendations are provided for new construction:**

- **The new construction procedures listed above should be followed at all times.**
- **Under no circumstances should anyone, other than Breakwater, be permitted to operate a valve, fire hydrant, or flushout within the Breakwater system.**

### 3.3 SYSTEM SECURITY

The Drinking Water Protection Act states that a person must not destroy, damage, or tamper with a drinking water system. In addition, a person must not introduce anything or cause or allow anything to be introduced into a domestic water system or drinking water source if it will result in a drinking water health hazard.

Breakwater's existing security measures include the following:

- The Church Road and Drew Road Reservoirs are located inside fenced compounds that have locked gates. With the exception of Church Road

Reservoir No. 2, all reservoirs that are connected to the system have locked metal hatch covers. Church Road Reservoir No. 2 has a plywood cover nailed over the access that is located in the south wall.

- Most of Breakwater's wells are located in locked metal kiosks or buildings. Oceanside Well No. 2, Lornedunn Well No. 2, and Springhill Road Well No. 2 are located inside subsurface concrete chambers that have standard manhole frames and covers. Only Church Road Wells No. 1, 2, 3 and 4 are located inside locked and fenced compounds.
- Breakwater's Drew Road Pump Station is housed in a locked building that is located within a fenced compound.

In a water utility the size of Breakwater that obtains its water from multiple sources, including an unprotected watershed, it is very difficult to provide fail safe security and it is essentially impossible to prevent vandalism and/or premeditated criminal acts from taking place. However, it is possible to reduce the chances of accidental or unintentional acts or incidents from taking place that could potentially threaten the water utility. The best way to do this is through a public education program that lets the public and government authorities know where the drinking water supplies are located and what activities are considered potential threats. Public education could be accomplished by placing advertisements in local newspapers, working with local interest groups, and partnering with local governments and other water utilities in the area. Signage at reservoirs, wells, and around the French Creek intake could also be used to notify the public that irresponsible activities could lead to contamination of a public drinking water supply. Unfortunately, the down side of such a public education and notification program is that it makes it easier for an individual with harmful intentions to inflict damage or contaminate a drinking water system.

**Based on the investigations carried out during this assessment, the following recommendations are provided for system security:**

- **The main facilities in the Breakwater system should be inspected regularly by Breakwater and all fences, gates and locking mechanisms should be maintained in good working order.**
- **Consideration should be given to initiating a public education and signage program that covers all Breakwater's water sources and water storage facilities.**

## 3.4 OPERATION AND MAINTENANCE

### 3.4.1 Assessment of Breakwater's Operation & Maintenance Procedures

Breakwater has indicated they carry out operation and maintenance (O & M) of their water system in general conformance with the O & M procedures that were established during their 1995 Water Rates Study. A copy of the 1995 Water Rates Study can be obtained from Breakwater.

In general, there are three main components of Breakwater's O & M program. There are operational tasks that are required to keep the water system functioning, such as the setting of pump controls and re-filling the sodium hypochlorite storage tanks at the chlorination facilities. There are regular maintenance procedures that are carried out such as flushing, swabbing, fire hydrant maintenance, and cleaning of reservoirs. And there is breakdown maintenance that takes place throughout the year including the repair of broken water mains and the replacement of pump components that wear out.

As with all private water systems, the amount of regular maintenance that can be performed is directly proportional to the funds that are available from the sale of water within the utility. Budgets for private water system maintenance will not increase substantially in this province until water customers are willing to pay significantly more for the water they use. Taking this into consideration, there are some important and cost-effective O & M procedures that should be considered for the Breakwater system.

**Based on the investigations carried out during this assessment, the following recommendations are provided for O & M procedures:**

- **Breakwater should start to develop O & M manuals for their system. These manuals could be phased in over a number of years. An O & M manual covering all system components involved with water treatment should be developed first. A water treatment O & M manual should cover the metering units that pace the chlorine injection pumps, the chlorine injection pumps themselves, the SCADA software control logic, and all associated water treatment components including the residual analyzer. The O & M manual should include the shop drawings of the individual components, the manufacturers recommended installation methods and maintenance procedures, and maintenance schedules where Breakwater can record when maintenance and/or replacement of individual components takes place.**

- **Breakwater should start to undertake regular house keeping of their main facilities. This should include general cleaning of all buildings, well enclosures, underground chambers, and wet-wells to remove insects, dirt, and unnecessary debris that has accumulated in and around these facilities. In addition, grass and vegetation should be kept cut down and the areas surrounding the facilities kept tidy to give the appearance that the facility is operational and not abandoned. Worn out or broken components, such as pressure gauges, should be replaced. Cracks or openings in structures should be sealed up to prevent insects, snakes, and rodents from entering the facilities. Screens on air vents should be kept in good working order and replaced when necessary.**
- **For critical components of the water treatment system that have limited operational life spans, Breakwater should maintain a stock of spare parts for these components to ensure they can be repaired quickly.**
- **All operation and maintenance recommendations provided in previous sections of this assessment should also be considered by Breakwater.**

#### 3.4.2 Qualification of Water System Operators

The Vancouver Island Health Authority has classified the Breakwater system as a WS1 water system serving approximately 4000 people. The Drinking Water Protection Regulation requires all level 1 water systems to have the operator of the system certified to the appropriate level under the Environmental Operators Certification Program by January 1, 2005.

Breakwater's manager currently holds a level II certification in water distribution. The maintenance personnel that perform the majority of the operation and maintenance tasks in the Breakwater system are not certified but they do have adequate experience and knowledge of water system maintenance and repair and they do work under the supervision of Breakwater's manager.

Based on the recommendations made in this assessment, Breakwater's Drew Road water treatment facility will likely have to be upgraded in the near future. Under the Drinking Water Protection Regulation, Breakwater will be required to have an operator that is certified to the appropriate level, under the Environmental Operators Certification Program, for the water treatment facility that is ultimately put in place.

### 3.5 WATER QUALITY TESTING AND MONITORING

#### 3.5.1 Raw Water Testing of the French Creek Surface Water Supply

Breakwater is not currently required to carry out regular raw water quality testing and monitoring of their French Creek surface water supply. A water quality testing and monitoring program for specific parameters has been recommended for the French Creek surface supply in previous sections of this assessment. Once this testing has been carried out and the data has been assessed, there may be a requirement to carry out ongoing water quality testing and monitoring of specific water quality parameters, especially if filtration of the French Creek surface water is not required prior to disinfection. If filtration is not installed on the French Creek surface water supply, the following water quality parameters may have to be tested for in the French Creek water on an ongoing basis.

- If cryptosporidium and giardia parasites are found in the French Creek surface supply, testing to determine the concentrations of these parasites should be carried out each quarter. Testing should be carried out after a significant rainfall event.
- The concentrations of E. Coli bacteria should be tested at regular intervals in the French Creek surface supply. Testing should be carried out after a significant rainfall event.
- As recommended previously in this assessment, a turbidity meter should be installed to monitor and record the level of turbidity in the French Creek surface water supply prior to disinfection.

#### 3.5.2 Raw Water Testing of Breakwater's Well Supplies

Based on the historical testing that has been carried out on Breakwater's well supplies, there are some wells in the Breakwater system that have elevated levels of iron, manganese, and turbidity. These parameters have been discussed previously in this assessment.

There is a fourth parameter that was identified by EBA Engineering Consultants in Breakwater's 2001 Utility Operation and Aquifer Management Report. EBA indicated that the concentration of ortho-phosphates in samples collected from Drew Road Well No. 1 and Oceanside Well No. 2 exceeded the Canadian Drinking Water Quality Guidelines. EBA recommended in their report that the source of the ortho-phosphates should be investigated.

### 3.5.3 Testing of Treated Water Within the Breakwater Distribution System

Under the Drinking Water Protection Regulation, Breakwater is required to sample the water within their distribution system once a week for total coliform and fecal coliform bacteria. Samples are collected from three different areas in the Breakwater system and provided to the VIHA each week. Free chlorine residual levels are also measured by Breakwater when these samples are taken, to check whether the residual levels in the system are staying above 0.20 mg/L.

Due to the serious consequences associated with a positive fecal coliform test result, Breakwater should ensure their methods of sampling are carried out very carefully to avoid a false positive bacterial result. Samples should never be drawn from a hydrant or a flushout assembly that has a drain system. Contaminants from the adjacent soils can enter the hydrant or flushout piping through the drain port and provide false positive bacterial results. In addition, samples should never be drawn from sinks that have mixing or swivel faucets as these fixtures are known to provide false positive bacterial results. Prior to obtaining water samples from outside hose bibs, Breakwater should disinfect the hose bib with a mild bleach solution and thoroughly flush the hose bib prior to obtaining a water sample for testing.

All Breakwater's fecal coliform and total coliform testing results are reviewed by the VIHA. If fecal coliform bacteria are detected within the system, a boil water order is issued by the VIHA.

**Based on the investigations carried out during this assessment, the following recommendations are provided for water testing:**

- **Once additional testing of the French Creek surface supply has been completed, as recommended in Sections 3.1.4 and 3.1.6, the results should be assessed and used to help determine the type of dual disinfection system that should be installed on the French Creek surface water source, and whether filtration will be required prior to disinfection. Once these factors are determined, an ongoing water quality testing program should be established for the French Creek surface water supply.**
- **The source of the ortho-phosphates in Breakwater's Drew Road Well No. 1 and Oceanside Well No. 2 should be confirmed and investigated further if necessary.**
- **Breakwater should maintain logs of all current and historical raw water testing carried out at each individual water source. This information will**

**be useful for identifying any water quality changes or trends that may start to occur in these water sources.**

- **Breakwater should consider testing E. Coli bacteria in their distribution system in place of fecal coliform bacteria.**
- **Breakwater should start to maintain logs of all chlorine residual readings taken within the distribution system, including any readings taken at the outlet of the Church Road and Drew Road Reservoir facilities.**
- **When the VIHA is processing a sewage disposal permit for a property located near one of Breakwater's water sources, notification should be provided to Breakwater so they can assess any potential impacts to their water source and establish whether additional testing should be carried out on that water source.**

## 4 ASSESSMENT OF CONTAMINATION THREAT

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### Groundwater Contamination Threat

The following factors have been considered in order to assess the contamination threat associated with Breakwater's groundwater supplies:

- As previously recommended in this assessment, there are some improvements that should be carried out on some of Breakwater's well supplies. The water from the well supplies, where improvements have been identified, is chlorinated prior to entering the Breakwater distribution system.
- Lornedunn Well No. 2 is the only well source that is not chlorinated. This well is only used in the summer when there is a low risk of surface flooding.
- The Breakwater well supplies have been developed in confined aquifers.

**Based on the water source and water system investigations carried out during this assessment, there is a low risk of contamination occurring in the Breakwater system as a result of contaminants that could potentially originate from Breakwater's groundwater sources. This conclusion is subject to the implementation of recommendations that have been provided by EBA Engineering Ltd., and the outcome of any additional groundwater quality investigations that have been recommended in this assessment.**

### French Creek Surface Water Contamination Threat

The following factors have been considered in order to assess the contamination threat associated with Breakwater's French Creek surface water supply:

- The French Creek watershed is unprotected.
- There are a large number of natural and human related activities that could potentially contribute acute or chronic contaminants and/or microbial pathogens to French Creek.
- The French Creek surface water supply is not filtered prior to disinfection.
- There is a single chlorination system disinfecting the French Creek surface water supply before it enters Breakwater's distribution system. There have been occasions in the last few years when free chlorine levels have fallen below the levels intended to provide adequate disinfection.

**Based on the water source and water system investigations carried out during this assessment, there is a moderate to high risk of contamination occurring in the Breakwater system as a result of contaminants or pathogens that may potentially originate from Breakwater's French Creek surface water source.**

## **5 HIGH PRIORITY RECOMMENDATIONS**

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Recommendations for improvements to the Breakwater water sources and distribution system have been provided throughout this assessment report. Those recommendations that are considered highest priority are reiterated below:

- 1. Due to the threat of pathogenic organisms entering Breakwater's French Creek surface supply, it is recommended that the existing Drew Road chlorine injection pump system be upgraded to a duplex system. The duplex system should be installed with flow monitoring devices on the sodium hypochlorite discharge tubing that are capable of sending alarms when the chlorine injector lines become blocked, or the chlorine injection pump fails, or the sodium hypochlorite storage tank empties. If the flow monitor senses a problem with the flow of sodium hypochlorite, the control system should automatically turn on the second chlorine injection pump and trigger an alarm notification on the first failure. If the flow monitor on the second chlorine injection pump also senses a problem, the control system should send out an immediate call-out alarm and lock off the French Creek surface water intake pumps. This will ensure that a malfunctioning chlorine injection system does not enable untreated surface water to enter the Drew Road Reservoirs. The two chlorine injection pumps should alternate so that each pump operates 50 % of the time.**
- 2. Undertake a water testing program on the French Creek surface supply to determine whether the creek supply contains cryptosporidium and giardia parasites.**
- 3. Breakwater should continue a water quality monitoring program on the French Creek supply that includes turbidity, colour, total suspended solids, TOC, and % UV transmittance. This testing should continue on a monthly basis until a full year of data has been obtained. Testing would preferably take place immediately following a rainfall event.**
- 4. The French Creek source should always be blended with one of the better quality Drew Road well supplies to help reduce turbidity, colour, total suspended solids, TOC, and the levels of micro-organisms in the flow stream prior to chlorination.**
- 5. Total trihalomethanes should be analyzed in the blended creek and Ravensbourne Well No. 1 water (following chlorination) during normal winter operation once TOC levels in the creek supply start to approach 3.0 - 4.0 mg/L. Results should be reviewed by a professional engineer.**

- 6. A turbidity meter should be installed on the French Creek surface supply and a monitoring / control system be put in place to record and log all turbidity data. The control system should be capable of shutting this supply down if a turbidity spike occurs in French Creek.**
- 7. To provide a higher degree of protection against microbial pathogens entering the Breakwater distribution system, a dual disinfection system should be implemented on the French Creek surface water source. Once additional testing of the French Creek surface supply has been completed, as recommended in Sections 3.1.4 and 3.1.6, the results should be assessed and used to help determine the type of dual disinfection system that should be installed on the French Creek surface water source, and whether filtration will be required prior to disinfection. Once these factors are determined, an ongoing water quality testing program should be established for the French Creek surface water supply.**
- 8. No reduction in current chlorine levels should take place at Drew Road until testing for cryptosporidium and giardia parasites has been completed or a dual disinfection system has been put in place.**
- 9. It is a recommendation of this assessment that a mail-out advisory and watershed map (showing the main watercourses and the extent of transportation corridors within the watershed) be created and sent to the railway, the logging companies, the Ministry of Transportation, the local road maintenance contractor, and all fire departments that could be called to attend an accidental spill within the French Creek watershed. Breakwater should investigate whether government assistance can be obtained for this type of notification program.**
- 10. It is a recommendation of this assessment that a contaminant survey be carried out downstream of the Inland Island Highway during a period of low creek flows to see if significant levels of chronic contaminants are being contributed to the creek system. Water sampling should be carried out downstream of the highway during (or shortly after) a major rainfall event.**
- 11. Breakwater should investigate whether the Arrowsmith bulk water supply is likely to be available in the near future. If not, Breakwater should start to plan for treating the iron and manganese in the well supplies that are connected to the Drew Road Reservoirs. An investigation into treating these supplies was carried out by BC Research Inc. in May, 2002.**