Abbotsford Mission
Water & Sewer Services

2012 Water Supply Options Study

Stage 1 Report: Option Short Listing

July 2012

our water matters

EXECUTIVE SUMMARY

Background

As Abbotsford and Mission grow, water demands will continue to increase. At some point, the existing water sources will not be sufficient to meet those demands. In anticipation of such a time, the Abbotsford Mission Water & Sewer Commission (AMWSC) and its predecessor, the Central Fraser Valley Water Commission, spent considerable effort over the last 20 years investigating future water supply options. With the rejection of the Stave Lake P3 Water Supply project in November 2011, it is necessary once again to examine options. This exercise is important in 2012 to ensure there is sufficient time to plan, permit, design and build new supply infrastructure (which can take 5 – 10 years).

2012 Future Water Supply Options Study

Past source option reviews and recommendations hinged upon the assumption that the AMWSC sought a water supply solution that would best meet long-term needs (i.e. 20-100 years) at the lowest net present value. However, considering that such long term solutions come with significant up-front capital costs, the 2012 Water Supply Options Study ('the Study') also contemplates shorter-term (i.e. 5-10 year) interim steps that may be more immediately affordable.

The Study will be completed in three stages (Table E1). Ultimately, the objective is to identify a preferred strategy that ensures the supply of ample, high-quality potable water to Abbotsford and Mission in both the short and long term. This report is the culmination of Stage I.

Table E1 – Study Stages

Stage	Description	Deliverable
I	Initial Public Outreach & Option Short Listing	• **This Report: 'Water Supply Options Short-Listing'**
II	Further Investigations	• Draft Report: 'AMWSC's Future Water Supply Strategy'
III	Final Public Outreach & Reporting	• Final Report: 'AMWSC's Future Water Supply Strategy'

Stage I Conclusions

There are several water supply options available to the AMWSC to meet future water demands. However, some of those options are critically flawed and others have sufficient drawbacks to make it questionable whether the AMWSC should invest further resources into investigating their viability. Stage I examines supply options in three distinct categories: (i) existing source expansion & infrastructure optimization, (ii) new natural source development, and (iii) alternate supplies. For each category, options are characterized according to several factors. From this characterization, further option investigation is either recommended or discouraged. Out of eighteen options considered, six are suggested for further investigation (Table E2).

Table E2 – Stage I Conclusions Summary

Category	Continue Investigations	Abandon Investigations
Existing Source Expansion & Infrastructure Optimization	• **Norrish Creek**	• Cannell Lake • Abbotsford-Sumas Aquifer • Pump Norrish to Upper Mission • Store Treated Water for Peak Days
New Natural Source Development	• Stave-to-Cannell Lake Recharge • Miracle Valley Aquifer • **Fraser River** • **Stave Lake**	• Nearby Small Surface Sources • Other Local Aquifers • Hayward Lake • Chillwack Watershed • Harrison Watershed
Alternate Supplies	• Metro Vancouver Water	• Municipal-Scale Wastewater Reuse • Trucking Water for Peak Days • Connect to Clearbrook Waterworks District

The six preferred options provide the AMWSC with a set potential water supply solutions that span from small to large (Figure E1). However, the AMWSC has allocated a limited budget for the Study; therefore not all options can be short-listed for further investigation. Should the AMWSC maintain the Study budget as is, then Norrish Creek, Stave Lake, and the Fraser River are suggested priorities for Stage II's further investigations.

Figure E1 – Preferred Options vs. Capacity

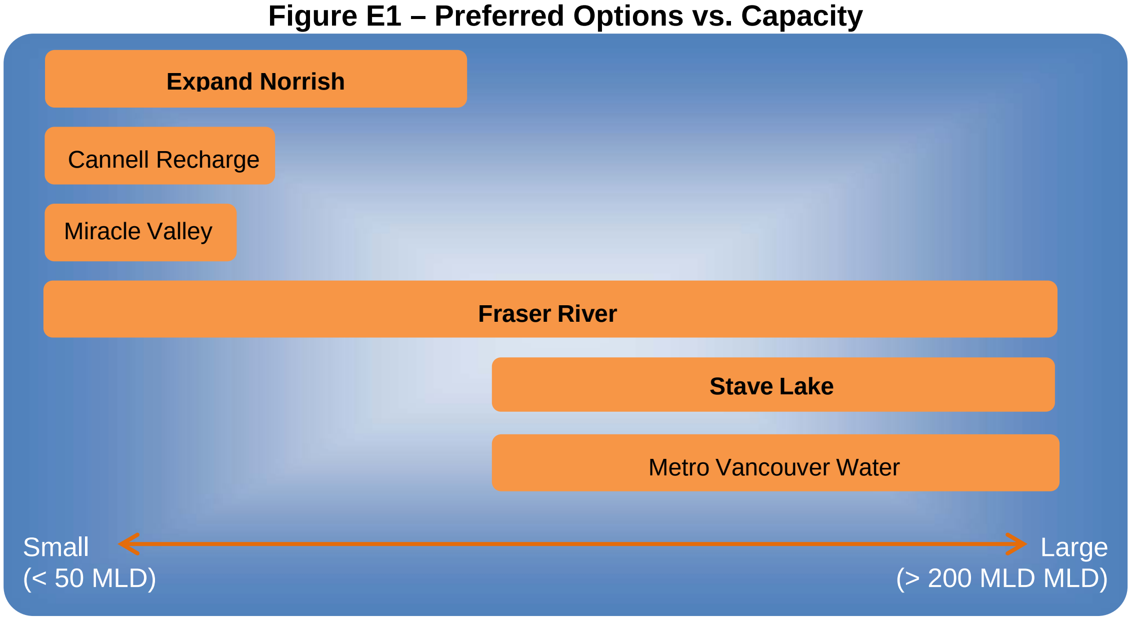


TABLE OF CONTENTS

Frequently used Acronyms

AMWSC = Abbotsford Mission Water & Sewer Commission

CEA = Canadian Environmental Assessment

CFVWC = Central Fraser Valley Water Commission

DFO = Fisheries and Oceans Canada

EA = Environmental Assessment

MOE = BC Ministry of the Environment

MOTI = BC Ministry of Transportation and Infrastructure

NPV = Net Present Value

ROW = Right-of-Way

WTP = Water Treatment Plant

1 BACKGROUND INFORMATION

1.1 History of Water Supply Option Investigations

Abbotsford and Mission are growing communities. Eventually, the municipalities will require additional potable water beyond what can currently be provided by the existing water sources and infrastructure. In anticipation of such a time, the Abbotsford Mission Water & Sewer Commission (AMWSC) and its predecessor, the Central Fraser Valley Water Commission (CFVWC), have investigated future water supply options over the past two decades. Twice, solutions were thought to have been identified.

<u>CFVWC's Previous Harrison Lake Solution</u>

In the late 1990s, the CFVWC believed that tapping into Harrison Lake would be the ideal long-term water supply solution for the Fraser Valley. The CFVWC's 1995/96 Master Plan Update (D&K, 1996-08, Section 5) was the first engineering study to contemplate additional water supplies for Abbotsford and Mission. That Master Plan prompted the CFVWC to focus on Harrison Lake, under the assumption that the Greater Vancouver Water District (GVWD, now Metro Vancouver) would be a partner sharing costs. Between 1996 and 2002, the CFVWC carried out conceptual level engineering work, pursued partnering discussions with GVWD and began initial environmental assessment (EA) steps. However, while preparing a Project Description to support the EA process (D&K, 2003-07), revised costs estimates suggested that a Harrison Lake supply strategy would be much more expensive than originally anticipated. Furthermore, it had become clear that GVWD's long-range plans would not include Harrison Lake. As such, the CFVWC's 2002 Master Plan (D&K, 2003-05, p.1-5) recommended that alternative sources be investigated.

A 2004 high-level supply options study (EarthTech, 2004-05) suggested that development of a new 25 MLD Abbotsford-Sumas Aquifer well field, followed by development of a Stave Lake supply, would be the most cost effective solution for the CFVWC to address anticipated supply shortages.

<u>AMWSC's Previous Stave Lake Solution</u>

The AMWSC assumed responsibility for the regional water supply system in late 2005. Following two consecutive summers (2006 & 2007) of water demands that neared the supply limits, the AMWSC installed the Bevan Wells (as per the first recommendation of the CFVWC's earlier 2004 supply options study). While the AMWSC's 2006 Water Master Plan (D&K, 2006-09) supported further examination of Stave Lake's potential, other studies continued to investigate alternatives. Such investigations considered existing source expansion and leveraging conservation to defer further capital works (e.g. KWL, 2006-08; KWL, 2008-08; KWL, 2009-02; Polis, 2009-08). Upon completion of the 2010 Master Plan Update (AECOM, 2010-04), the AMWSC concluded that Stave Lake would be the best long-term solution. However, with the lack of referendum approval for the Stave Lake P3 Water Supply project, as proposed in 2011, it became necessary to re-examine options.

1.2 The 2012 Water Supply Options Study

Throughout 2012 (and into 2013, if necessary), the AMWSC will again review its future water supply options. Past reviews and recommendations hinged upon the assumption that the AMWSC would provide a water supply solution that best meets long-term needs (i.e. 20 to 100 years) at the lowest net present worth (NPV). However, considering that such long term solutions come with significant up-front capital costs, the AMWSC will now also contemplate shorter-term (i.e. 5 to 10 year) interim steps that may be more immediately affordable.

The 2012 Water Supply Options Study ('the Study') will be completed in three stages as shown below. This report is the culmination of Stage 1.

Stage	Description	Activities	Deliverable
1	Initial Public Outreach & Option Short Listing	• Prepare public information materials that describe future water supply options • Public Outreach: Share options and seek other ideas • Short-list options for further investigation	• This Report: 'Water Supply Options Short-Listing'
2	Further Investigations	• Collect the data necessary to confirm viability and develop Class D (+/- 50%) cost estimates for each short-listed option • (Demand Projections and Water Efficiency Plan to be completed separately)	• Draft Report: 'AMWSC's Future Water Supply Strategy'
3	Final Public Outreach & Reporting	• Public Outreach: Present draft report to public for comment • Finalize report with public input	• Final Report: 'AMWSC's Future Water Supply Strategy'

1.3 Water Supply Selection Factors

Future water supply decision-making is a complex process. Before delving into the specific supply options available to the AMWSC, it is important to understand the fundamental factors that should be considered by any water utility seeking to increase its available supply.

For the purpose of weighing the benefits and drawbacks of supply options, selection factors are assigned qualitative descriptors. The blue call-out boxes accompanying discussions on the following pages describe terminology used within this document. These terms were chosen in consideration of the AMWSC's specific situation. Some of the descriptors may signify a 'critical flaw'. That is, there is at least one definite reason why the option is not suitable regardless of its other benefits. Terms shown in orange text within the call-out boxes are those that would be considered critical flaws.

Capacity

Large	Supply has more than 200 MLD available
Medium	Supply has 50 to 200 MLD available
Small	Supply has 10 to 50 MLD available
Negligible	Supply has less than 10 MLD; considered an unsuitable option

First and foremost, a community needs to understand how much water it needs. This determines the minimum supply size that should be considered. At this point of the Study, there is no commitment to any specific source capacity. Community water demand projections are being updated during 2012 to reflect the past few years of successful water demand management programs (and future anticipated impacts). Supply options ranging from small to large remain reasonable considerations until those demand projections are complete. Similarly, the timing of future water supply development remains unfixed. The final stage of the Study will contemplate future supply capacities and project timing.

Capacity Risk

Low	Possible threats to current capacity exist, but not expected to be significant
Moderate	Possible threats to current capacity exist, but economic contingencies could be incorporated into planning
Extreme	Guaranteed threats to current capacity exist that make option unsuitable

Related to above, one must also consider if the supply is likely to have its capacity threatened in the future by such things as climate change or other causes.

Distance

Very Far	Required pipeline would be longer than 40 km
Far	Required pipeline would be 10-40 km long
Nearby	Required pipeline would be less than 10 km long

The further the supply point from the customers, the longer the pipeline needed to convey the water. Pipeline construction is often the most expensive aspect of new water supply development. Distances shown throughout this document reflect the minimum length of pipeline (new and upsizing) needed to convey water from the source to the nearest tie-in point on the existing AMWSC transmission system.

Elevation

High	Allows full gravity supply
Moderate	Requires moderate amount of pumping
Low	Requires significant pumping

The relative elevation of the supply to the customers impacts the amount of pumping needed to push the water to the customers. Pumping is one of the most expensive annual operating costs for a water supply. Elevations shown throughout this document reflect the supply points' typical water levels.

Phasing Practicality

Flexible	Likely able to phase economically in 25 to 50 MLD increments
Limited	Economical phasing would be in at least 100 MLD increments

Often when developing a new water supply, one will do so in phases to spread costs over time. The practicality of phasing is most often an issue of distance. That is, if a supply point is located far away, it will be very expensive to upsize the pipeline each time more water is needed. It is more economical to start with a large pipe that significantly exceeds the size initially needed. Phasing can also be influenced by the geotechnical and environmental conditions of the land upon which infrastructure is to be built. For example, if a pipeline must be installed through a sensitive area that necessitates an onerous environmental assessment (EA), it may be more practical to install a large pipe initially than to later repeat the EA process and disturb the area with construction each time pipeline twinning is required.

Normal Water Quality

The natural water quality of the supply influences the complexity and cost of water treatment required to meet potable standards.

Excellent	Likely requires disinfection only
Good	Likely requires direct filtration plus disinfection (e.g. minimum surface water treatment standard)
Moderate	Likely requires enhanced treatment in addition to filtration and disinfection (e.g. not unusual, but higher cost)
Poor	Untreatable or requires specialized technologies (e.g. very costly)

Contamination Risk

Further to the normal water quality, one must consider the likelihood that natural or man-made phenomena could contaminate the water supply, rendering it unusable or requiring more rigorous water treatment processes.

Low	Unlikely that any contamination will materialize.
Moderate	Possibility of contamination, but supply is large enough to buffer impact. Sufficient land would be secured to provide space for additional treatment technologies if later needed.
High	Probability of contamination, but of a nature that is economically treatable. The water treatment plant would be equipped with processes that only operate during the emergency.
Extreme	Severe contamination probable and the necessary provisions to treat contaminants make the option an uneconomical choice.

Permitting Complexity

(includes environmental impact)

Typical	Permitting is expected to be achievable within 2 to 3 years *
Challenging	Permitting is expected to take 3 to 5 years and there will be significant costs to complete studies required to support permit applications
Improbable	One or more permits may not be possible to secure, preventing project from proceeding or requiring uneconomical alternatives

* *Either a Provincial or Canadian EA would take a minimum of 2 years. Any option that diverts more than 27.3 MLD of surface water or 6.8 MLD of groundwater triggers a Provincial EA. If a major project is within 100 km of the Washington State border, US agencies have the option to participate in the review. A Canadian EA can be triggered for various reasons; if federal funding is received, it automatically triggers an EA.*

There are dozens of permits needed to develop a new water supply. A water license and an EA certificate are often the most challenging ones to obtain. Both can require years of consultation with the general public, First Nations and multiple government agencies. Assuming there are no outright regulatory objections that would block development, one must then estimate how long and what work is needed to secure the permits. The cost of permitting studies may become significant or the time to obtain permits may be unreasonable considering timeline needed to secure additional water.

Availability of Suitable Land

Likely	Most land required already belongs to Mission or Abbotsford or is Crown land. Cost of any acquisitions anticipated to be minimal.
Challenging	There are segments of required land that may be difficult and/or costly to procure.
Improbable	There are segments of required land that are likely impossible to procure and alternates are impractical.

The infrastructure to treat and convey water requires land. One must contemplate if the necessary land and right-of-ways (ROWs) can be secured at reasonable costs. The land parcels must also have suitable geotechnical conditions.

Redundancy Contribution

Helps	Minimizes critical system risk of losing supply during emergency
No Benefit	Does not minimize existing level of supply risk

System redundancy refers to having sufficient back-up infrastructure so that water demands can be met despite failure of any one source or component. With respect to the AMWSC system in particular, infrastructure in the Norrish watershed is subject to elevated natural disaster risks, which threatens 85% of the water currently supplied to Abbotsford and Mission. Similarly, the Fraser River crossings are vulnerable; loss would leave Abbotsford with only well water. Some new supply options are better suited to mitigating these existing system risks.

Cost

Assuming that multiple sources meet minimum requirements for all the above criteria, it then comes down to cost. One must consider the up-front investment (capital cost) and the funds necessary to keep the system running year after year (net present worth, NPV). At this point of the Study, no assumptions are made about the funds available or sources of funding. However, it is loosely assumed that any projects with capital costs significantly greater than $300 million[1] are not economical for the AMWSC. No qualitative descriptors are assigned to this particular selection factor since affordability is highly subjective and neither Abbotsford's or Mission's financial department have weighed into the Study at this stage.

The option short-list recommended within this report is based on non-cost factors alone (unless capital costs are predicted to be significantly greater than $300 million). For this reason, costs shown are minimum anticipated capital expenditures, provided merely to compare the relative anticipated cost magnitudes across the options. Class D (+/- 50%) capital and NPV estimates will be calculated for short-listed options for Stage II reporting.

Public Acceptance

Supportive	The majority of survey respondents and open house comments support further investigation of the option as a future AMWSC water supply
Divided	There is no clear public preference for or against the option
Opposed	The majority of survey respondents and open house comments oppose further investigation of the option

Even if costs and all other criteria seem optimal, a given source may be perceived as unsuitable by the community. For this reason, and to ensure that all supply ideas would be examined, the AMWSC held a public outreach program throughout May and June 2012. The program took the form of open houses and a survey. Outreach program outcomes are discussed within a separate report to the AMWSC (WSC 70-2012); specific public feedback is noted where applicable throughout this report.

[1] The $300 million affordability assumption stems from Abbotsford's 2011 financial analyses for the previously proposed Stave Lake Water Supply Project. It is also assumed that no federal or provincial grants are available at this time (other than P3 Canada Fund).

1.4 Water Sources in the Fraser Valley

There are two primary ways that a water utility can meet growing water demands. It can choose to increase the amount of supplied water or invest in programs that decrease the amount of water consumed. The AMWSC is exploring both options. The public outreach program suggests that the public supports this dual water planning strategy. This report focuses exclusively on the options available to the AMWSC to increase the available water supply. (The AMWSC's Water Efficiency Plan is a concurrent study examining means to reduce water demands).

In contrast to many regions of the world, Abbotsford and Mission are surrounded by an abundance of natural water bodies (as illustrated by Page 9 map). However, like any other water utility, the AMWSC faces the challenge of providing infrastructure to collect, treat and then deliver that water to customers' taps.

This report examines supply options in three distinct categories: (i) existing source expansion & infrastructure optimization, (ii) new natural source development, and (iii) alternate supplies. For each source category, options are characterized according to the factors described earlier. From this characterization, further option investigation is either recommended or discouraged. Those in the latter grouping may have a critical flaw or be perceived to have greater drawbacks than benefits. The Study has limited budget, so only those options that appear to be most viable can be short-listed for further investigation.

The following three report sub-sections contain tables that summarize the options. For each of the options, the final table row specifies the report section where information is discussed in further detail.

1.4.1 Increase Existing Source Withdrawals & Infrastructure Expansion

Table A (Page 10) examines how increasing water withdrawals from the three existing AMWSC water sources stand up against the selection factors previously discussed. It also presents two concepts that don't provide additional supply, but could increase the existing infrastructure's flexibility so that water can be re-distributed when and where demands are higher. These two options are system optimization concepts and are not readily compared to new supply selection factors.

1.4.2 New Natural Water Sources

Table B (Page 11) examines how developing new natural water sources stand up against supply selection factors previously discussed. Nine options, spanning from small to large capacity, are considered.

1.4.3 Alternate Supplies

Table C (Page 12) examines three options for obtaining water from other suppliers. It also contemplates reuse of wastewater on a municipal-scale.

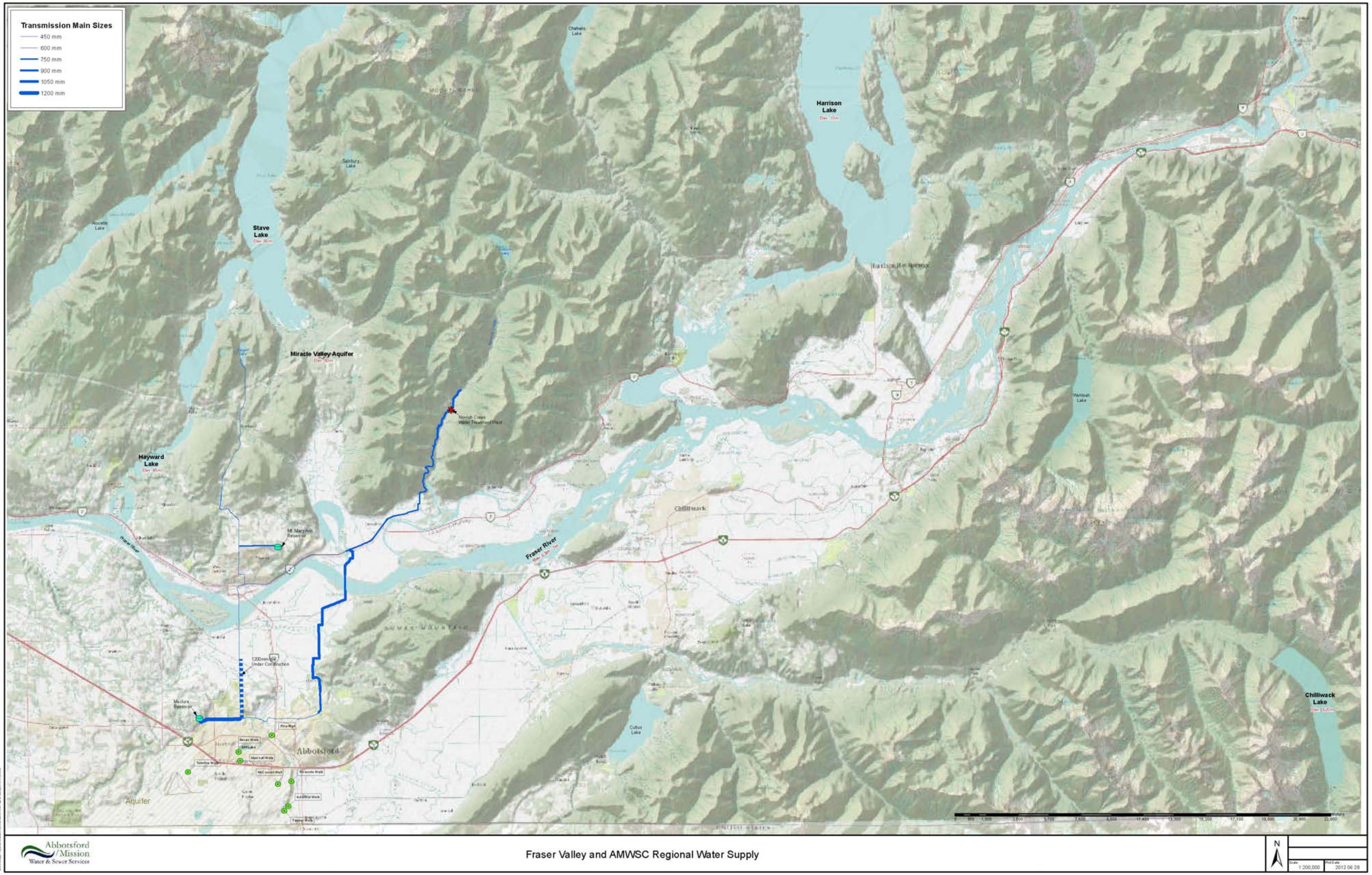

Transmission Main Sizes
450 mm
600 mm
750 mm
900 mm
1050 mm
1200 mm
Stave Lake
Harrison Lake
Hayward Lake
Miracle Valley Aquifer
Chilliwack
Fraser River
Abbotsford
Chilliwack Lake
Aquifer
Abbotsford / Mission Water & Sewer Services
Fraser Valley and AMWSC Regional Water Supply
N

Table A - Increase Existing Source Withdrawals & Infrastructure Optimization

- Green – benefit
- Yellow – drawback or unknown
- Orange – critical flaw
- Hatched – not applicable

	Increase Source Withdrawals			Infrastructure Optimization	
	Norrish Creek [1]	Cannell Lake	Abbotsford-Sumas Aquifer [2]	Pump Norrish Water To Upper Mission (or Cannell Lake)	Store Treated Water for Peak Days
Capital Cost	> $60M (for ~50 MLD) > $80M (for ~85 MLD)				
Extra Capacity	Medium	Negligible	Negligible	None, existing water re-distributed	None, existing water re-distributed
Capacity Risk	High			Low technical feasibility	Low technical feasibility
Location – Distance	Moderate (15-20 km)				
Location – Elevation	High (236 m)				
Phasing Practicality					
Normal Water Quality	Good				
Contamination Risk	Moderate				
Availability of Suitable Land	Likely [3]				
Permitting Complexity	Challenging				
Redundancy Contribution	No Benefit				
Public Acceptance	Supportive				
Conclusion	Continue Investigations	Abandon Investigations	Abandon Investigations	Abandon Investigations	Abandon Investigations
Discussions	Section 2.1.1	Section 2.2.1	Section 2.2.2	Section 2.2.3	Section 2.2.4

Table Notes:

1 – Includes discussions regarding (i) drawing more water by pumping rather than by installing a larger transmission main, (ii) use of a pipeline from Dickson Lake to WTP to minimize turbidity challenges, and (iii) diversion of water from base of watershed.

2 – Includes discussion regarding aquifer recharge.

3 – Changed from rating shown in public consultation booklet considering further information or considerations since date of booklet publishing. Refer to discussions for details.

Table B – New Natural Sources

- Green – benefit
- Yellow – drawback or unknown
- Orange – critical flaw
- Hatched – not applicable

	Miracle Valley Aquifer	Stave-to-Cannell Lake Recharge	Fraser River [2]	Stave Lake	Nearby Small Surface Waters [5]	Other Local Aquifers [6]	Hayward Lake	Harrison Watershed	Chilliwack Watershed
Capital Costs	> $20M (no filtration) > $40M (with filtration)	> $50M	> $55M (25 MLD) > $210M (100 MLD)	> $200M [3] ($300M – Class C)			?	> $300M	>> $300M
Capacity	Small - Medium	Small-Medium	Small - Large	Large	Negligible	Negligible	Medium-Large	Large	Large
Capacity Risk	Unknown [1]	Low	Low	Moderate			Unknown	Low	Moderate
Location – Distance	Moderate (15 km) [1]	Nearby (10 km)	Nearby (1-10 km)	Moderate (20 km)			Moderate (16 km)	Far (60 km)	Far (80 km)
Location – Elevation	Moderate (90 m) [1]	Moderate (80 m)	Low (0.5-7 m)	Moderate (80 m)			Moderate (45 m)	Low (10 m)	High (620 m)
Phasing Practicality			Flexible	Limited			Limited	Limited	Limited
Normal Water Quality	Moderate [1]	Good	Moderate	Good			Good	Good	Good
Contamination Risk	Low	Moderate	High	Moderate			High	Moderate	Moderate
Permitting Complexity	Challenging [1]	Challenging	Unknown	Challenging [4]			Challenging	Challenging	Challenging
Availability of Suitable Land	Unknown	Likely	Likely	Likely			Unknown [1]	Challenging	Unknown
Redundancy Contribution	Helps	Helps	Helps	Helps			Helps	Helps	Helps
Public Acceptance	Divided	Unknown	Divided	Supportive			Divided	Divided	Divided
Conclusion	Continue Investigations	Continue Investigations	Continue Investigations	Continue Investigations	Abandon Investigations	Abandon Investigations	Abandon Investigations [7]	Abandon Investigations	Abandon Investigations
Discussion	Section 3.1.1	Section 0	Section 0	Section 3.1.4	Section 3.2.1	Section 3.2.2	Section 3.2.3	Section 3.2.4	Section 3.2.5

Table Notes:

1 – Changed from rating shown in public consultation booklet considering further information or considerations since date of booklet publishing. Refer to discussions for details.
2 – Includes discussion about riverbank filtration.
3 – While 2011 Stave Lake Class C (+/- 15%) cost estimates were approximately $300M, this value cannot be for comparative purposes in this report since all other options' capital costs are shown as anticipated minimums based on a consistent set of infrastructure cost assumptions. The $200M shown in the table sources from these same assumptions.
4 – While Stave Lake permitting is challenging, much progress has already been made on many approvals.
5 – Nearby Small Surface Waters = Mill Lake (Abbotsford), Mill Lake (Mission), Hatzic Lake, Vedder Canal, Sumas River, Albert Dyck Lake, Lost Lake, etc.
6 – Other Aquifers = other than the Abbotsford-Sumas Aquifer or Miracle Valley Aquifer. Includes discussion about 'deep wells'.
7 – While Hayward Lake has no critical flaw, there are sufficient drawbacks to prompt the conclusion that further investigations should be abandoned.

Table C – Alternate Supplies

- Green – benefit
- Yellow – drawback or unknown
- Orange – critical flaw
- Hatched – not applicable

		Improved Water Efficiency	Metro Vancouver Supply	Municipal Scale Wastewater Reuse	Truck In Water for Peak Days	Connect to Clearbrook Water District
Capital Costs		Strategies that reduce demands upon the municipal system will be explored in the AMWSC's Water Efficiency Plan: • Rainwater Harvesting • Greywater Reuse • Conservation Programs • Using Local Catchments for Firefighting Water	?			
Capacity			Medium-Large			Negligible
Capacity Risk			Low	Low technical feasibility		
Location	Distance		Moderate (25-30 km)			
	Elevation		Unknown			
Phasing Practicality			Limited			
Normal Water Quality			Excellent			
Contamination Risk			Low		High	
Permitting Complexity			Unknown			
Availability of Suitable Land			Unknown			
Redundancy Contribution			Helps			
Public Acceptance			Unknown			
Conclusion			Continue Investigations	Abandon Investigations	Abandon Investigations	Abandon Investigations
Discussions			Section 4.1.1	Section 4.2.1	Section 4.2.2	Section 4.2.3

2 EXISTING SOURCE EXPANSION

2.1 Investigate Further

2.1.1 Increase Norrish Creek Withdrawals

Option Description

The Norrish Watershed (Norrish) is the AMWSC's existing primary water source, consisting of a river intake, water treatment plant (WTP), upper watershed raw water reservoir (Dickson Lake), and more than 80 km of transmission mains that convey treated water to Abbotsford and Mission.

Should the AMWSC choose to invest in higher Norrish withdrawals, two discrete scenarios could be considered:

- Scenario A - Expansion up to flows supported under existing water licenses
- Scenario B - Expansion up to flows supported by watershed

Scenario A: The AMWSC holds two types of water licenses for the Norrish water supply. The first is for 'water withdrawal', which allows water diversion up to 141.5 MLD from Norrish Creek, with a yearly average of 92 MLD. The second is for water storage in Dickson Lake; during the summer, Dickson Lake water is released to replace what is diverted at the intake so that there are sufficient flows for fish in the creek. Thus, Scenario A could offer the AMWSC an additional 50 MLD on peak days. The water available for average day withdrawals would not significantly change from the 90 MLD that Norrish can already supply.

Scenario B: The amount of additional capacity that could be offered by Scenario B hinges upon the BC Ministry of Environment's (MOE's) interpretation of available watershed capacity. At this time, the best understanding of the watershed's available capacity stems from a 2009 hydrology study (KWL, 2009-02). The study concluded that, in a 1-in-25 drought year, Norrish would only be able to support a maximum day withdrawal of 155 MLD, with an annual average of approximately 125 MLD. However, if Dickson Lake's storage volume were increased by roughly 20%, then withdrawals could be increased up to approximately 175 MLD on peak days, with an annual average diversion of 140 MLD. Assuming that regulators would concur with the hydrology study findings, the additional water available from Norrish would be:

Units = MLD	Today's Physical Limitations	Today's Licensed Capacity	Unused Licensed Capacity	Unused Watershed Capacity	More Dickson Storage
			(relative to today's 90 MLD)		
Maximum	90 *	141.5	+52.5	+65	+85
Average		92	+3	+35	+50

* The pipeline from the WTP to the municipalities restricts flow to a maximum of 90 MLD.

Past Investigations

As the primary AMWSC water supply, Norrish has been well studied over the last 30-years. Significant studies are referenced throughout this report section to support assumptions and information provided.

- AE, 2008-12 – AMWSC System Optimization Study
- KWL, 2009-02 – Norrish Creek-Dickson Lake Water Supply Assessment
- AE, 2010-06 – Norrish Creek Power Generation Study
- CH2M HILL, 2011-01 – Strategic Plan for Norrish Water Treatment Plant Improvements

Rationale for Short-Listing

- ***Lower Costs than New Source Development:*** Due to existing infrastructure, initial capital costs may be lower than those to develop an entirely new source of equivalent capacity. Similarly, NPV per unit volume of water is likely to be less than most other options due to the advantage of Norrish WTP's high elevation.[2]

  There is potential to harness Norrish Creek for power generation, which could offset water supply costs. The concept has been contemplated to varying extents ever since the CFVWC first developed the Norrish water supply. Most recently, Associated Engineering (2010-06, p. 3) concluded that "*if the cost of electricity increases significantly in the future or the twinning of the [transmission main down the mountain] is once again considered, a Norrish power generation project may become economically viable*".

- ***Good Water Quality with Moderate Contamination Risk:*** Since the construction of the Norrish WTP, the water provided from the Norrish supply is consistently of high quality that meets or exceeds Canadian Drinking Water Guidelines. While the watershed above the intake is open to logging and limited recreation, the WTP is designed to address most anticipated contamination events.

- ***Minimal New Land Required:*** All of the land within the Norrish watershed is BC Crown land. The AMWSC holds tenures over areas for existing infrastructure. A Norrish supply expansion is anticipated to require tenure expansions in the areas of Dickson Lake and the WTP. If such works are approved via MOE and/or Fisheries and Oceans Canada (DFO,) crown land tenures are generally granted concurrently. Outside of the watershed, some additional land may be required for pipelines.

- ***Option has Public Support:*** The majority of respondents from the May 2012 public outreach program support continued investigation of a Norrish supply expansion.

[2] While Norrish offers the benefit of gravity-supplied treated water, one cannot overlook the fact that Dickson Lake water sometimes needs to be pumped into the creek (when its level drops below a certain level). If Norrish withdrawals increase, the amount of Dickson pumping will also increase.

Option Drawbacks

- ***High Capacity Risk:*** Norrish relies on rainfall and a melting snowpack to maintain creek flows through the summer. A change in climactic conditions could significantly change the water available to the AMWSC. The recently released Climate Change Adaptation Project report (Feltmate, 2012-06, p. xxvi) predicts that the Vancouver area will warm up by 2.0-2.5˚C by 2050 and precipitation during the summer months is expected to decrease 5-15% by 2020 and 10-25% by 2050. Higher winter temperatures mean that more precipitation will fall in the form of rain during the winter, reducing the later release of water via snowpack melting. Lower amounts of summer precipitation will also impact watershed hydrology. The 2009 hydrology study did not contemplate the impacts of future climate change.

- ***Challenging Permitting:*** There are several permitting challenges anticipated with a Norrish supply expansion:
  (i) Any construction with the Norrish watershed has the potential to be considered a 'harmful alteration, disruption or destruction' (HADD) of fish habitat. The DFO would likely subject the project to a Canadian Environmental Assessment (CEA). The AMWSC's recent Norrish Intake Upgrade project took more than two-years to permit and DFO expectations added 7% (approximately $500,000) to the project costs.
  (ii) (Scenario B only): The MOE and DFO may feel that the watershed cannot sustainably support as much, or any, of the withdrawal volumes suggested by the 2009 hydrology study. Thus, the expectation that an additional 85 MLD could be diverted from the Norrish watershed may be optimistic. Additionally, the AMWSC should be prepared for a long water licensing process. In the early 1990s, it took over 5-years from the date of application until the CFVWC secured the most recent Norrish license increase. The DFO continued to object to the license for several additional years.
  (iii) The BC Ministry of Transportation and Infrastructure (MOTI) no longer allows construction of high pressure pipelines along its highway ROWs. To expand Norrish, a 6 km segment along the Lougheed Hwy (between Dewdney and Hatzic) would need to be twinned. While the MOTI can issue exceptions to their policy, 2-years of negotiations had yet to secure such an exemption for a 1 km section of the previously proposed Stave pipeline. If an exemption cannot be secured from the MOTI, then ROWs would be required adjacent to the highway across no less than a dozen properties.

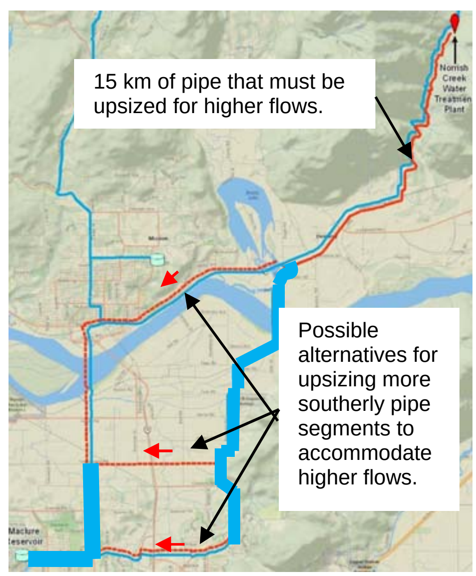
- ***No Redundancy Benefit:*** Expanding the Norrish system would create an even greater dependency on the source. Granted, a second transmission main would provide additional operational flexibility, assuming it isn't converted into a power station penstock (i.e. currently, repairs on the single main cannot occur without shutting off the entire supply). However, unless that second main is installed along an alternate route, both old and new pipes are at risk of a simultaneous failure (e.g. in a significant earthquake or landslide). The existing pipe is buried under the access road leading to the WTP. The only alternate route thought to be feasible is along an old forest road on the east side of Norrish Creek. Installation costs would be higher since pipeline length would be longer and the road would need to be reinstated.

- ***Other – Questionable Technical Viability:*** Two key points should be recognized as potential technical hurdles with a Norrish expansion:
  - (i) There may be sections of the existing access road that do not allow twinning of the transmission main (or could only be done at significant cost). There are areas that have very little width, with bedrock cliffs to one side and steep drops into the valley on the other. While blasting the bedrock to make room for a second pipe would typically be the solution, the existing pipe along those sections is made of 'pre-stressed concrete pipe', which could be damaged by the blasting.
  - (ii) (Scenario B only): The Dickson Lake dam is mostly a natural structure, formed by a landslide thousands of years ago. This factor may make it a high technical risk to increase the storage volumes in the lake (i.e. higher water level = higher pressure on the loosely organized landslide constituents = dam failure).

Minimum Anticipated Capital Costs

Scenario A: No less than $60 million is anticipated, as broken out in the table below. Subsequent paragraphs explain the assumptions leading to the values provided for the first two infrastructure components.

#	Description	Minimum $
1	Twin pipeline from WTP to Abbotsford	$45M
2	Upsize WTP for turbidity events	$10M
3	Other upgrades and permitting	$5M
4	Power Generation Infrastructure?	-



1 – Twin pipeline from WTP to Abbotsford:
Approximately 15 km of pipe between the WTP and 2nd River Crossing would need to be twinned. Assuming a minimum pipe diameter of 1000 mm, the cost of this pipe segment would be no less than $35 million.[3] (If the existing main is used for power generation, then a larger pipe would be required). To fully maximize Norrish flows, at least another 5 km would need to be twinned south of the Fraser River. This would cost no less than $10 million.[4]

[3] Cost Basis: Installed cost of 1050mm main between intake & WTP in 2011 = $2.6M/km & installed cost of 1200mm main along Gladwin in 2012 = $2.6M/km. 15km x $2.6M = $39M (round down to $35M). This compares to the $32M estimate, increased to 2012 dollars, provided by Associated Engineering in 2008 (AE, 2008-12b, p. 6).

[4] Cost Basis: Installed cost of 1200 mm main along Gladwin Road in 2012 = $2.6M/km. 5km x $2.6M = $13M (round down to $10M).

Pumping Rather than Twinning?

The option of using pumping in lieu of twinning transmission mains has twice been evaluated. In 2004, the concept was first explored at a high level with a conclusion that a pump station may be more economical than twinning pipe (D&K, 2004-01). In 2008, the idea was reviewed with the pump station capital costs estimated at twice that suggested in 2004 and an NPV greater than that for a twinned transmission main (AE, 2008-12) . Furthermore, it was concluded that a pump station would cause high risks to existing infrastructure due to high water velocities and transient pressures. Associated Engineering (2008-12b, p.8) concluded that: "*A new pump station would place undue strain upon on the existing Norrish Creek Transmission Main and have high operational costs…from an engineering and cost perspective, it is recommended that the twin pipeline option be pursued.*" Further examination of pumping is not suggested.

2 – Upsize WTP processes for creek turbidity events: The WTP is currently designed to treat approximately 140 MLD of raw water and would require minimal modifications under typical creek water quality conditions. However, only 54 MLD is currently available during creek turbidity events. Since such events generally only occur during fall/winter/spring, when demands are average or less, one could argue that the WTP process for high turbidity could be sized only for average flows. Scenario A's average flow would be 92 MLD. To secure an additional 38 MLD of capacity for turbidity events, no less than $10 million would be required (for either more membranes or pre-treatment to the slow sand filters). [5]

Pipeline from Dickson rather than Upsizing WTP?

It has been suggested that rather than upsizing WTP processes for turbidity events, a pipeline should be run from Dickson Lake to the WTP (since turbidity predominantly arises from eroding Norrish Creek banks). Assuming that the pipe could be installed 'as the crow flies', its length would be 8 km. It would be more realistic to assume it would be installed in the 12 km roadway. If it was only used to address expansion capacity needed for turbidity events, one could possibly size it moderately (i.e. 600 or 750 mm diameter). One can assume that such a pipe would cost a minimum of $20M.[6] Thus, for Scenario A, the pipeline is likely to be more expensive than WTP upsizing. However, should Scenario B be pursued, the idea may be more competitive. Added note: Power recovery from excess hydraulic head may be possible at times to offset pipeline cost.

[5] Cost Basis: CH2M HILL, 2011. Table 5 → 36 MLD of slow sand pretreatment for approximately $9M or another 27 MLD of membranes for approximately $5M. The latter estimate is considered low now that the 2012 membrane expansion project has concluded.

[6] Cost Basis: Recent installed costs for 750 mm pipeline within an Abbotsford urban area project were $1.3M/km. 12km x $1.3M = $15.6M (rounded up to factor for construction in rough terrain)

Scenario B: No less than $80 million would be required to complete the following work:

#	Description	Minimum $
1	As described for Scenario A	$60M
2	Increase Dickson Lake Storage Capacity	$10M (1)
3	Increase WTP Capacity (from 140 to 170 MLD)	$15M (2)
4	Power Generation Infrastructure?	-

1 - Cost Basis: $10 million estimate is double the cost of installing the new Norrish Creek Intake in 2012.

2 - Cost Basis: In 2003, the 27 MLD Norrish membrane filtration plant + the facilities shared with the slow sand filters cost approximately $15M. At 2% inflation/year, that results in approximately $18M in 2012 dollars (round down to $15M).

The value of expanding the Norrish water supply system hinges upon how much water demand will increase over the next 20-25 years. While a Norrish expansion may have lower upfront costs than new source development, those costs will still be significant. If projected demands over the next 20-25 years will be greater than what the watershed can sustain, then Abbotsford and Mission will face the costs of two major water system projects within a single generation.

Divert water at base of watershed?

One resident suggested that diverting Norrish Creek water at the base of the watershed might avoid the costly construction and maintenance of assets up the risky access road. The option description also proposed that the existing transmission main down the mountain could be converted into a penstock for power generation that would offset costs for a new WTP & pumping station at the bottom of the mountain. At first glance, the main concerns with this vision are:

(i) The lower reaches of Norrish Creek are shallow channels; diverting water would require damming, which is unlikely an acceptable alternative to MOE and DFO; and

(i) Converting the existing transmission main into a penstock without providing a new main down the mountain means that approximately $100 million in existing assets would be abandoned since the treated water from the existing WTP would no longer have an outlet.

Further Investigations Required

In order to confirm the viability of a Norrish expansion and to develop Class D cost estimates, the following further investigations are required:

In-House	Consultants
Scenario A	
• Hydraulic modeling to refine necessary transmission main pipe sizes • Meet with MOE and DFO to determine likelihood and scope of a CEA and to better understand other permitting processes & timelines • Meet with MOTI to determine if Lougheed Highway ROW can be used for pipeline twinning. If not, explore viability and cost of ROWs adjacent to Lougheed Hwy • Calculate NPV and refine capital costs to a Class D accuracy	• Obtain geotechnical and engineering opinion on benefit of routing a new transmission main along east side of Norrish Creek • Update 2010 Power Generation Study findings to determine impact upon capital costs and NPV • Independent review of in-house cost estimates
Scenario B	
• Meet with MOE and DFO to better determine willingness to increase water license capacities and the upper capacity limits that they might contemplate • Calculate NPV and refine capital costs to a Class D accuracy	• Geotechnical, environmental & engineering investigations to assess viability, options and costs for increasing Dickson Lake storage volume • WTP expansion conceptual design and costing • Review 2009 Hydrology Study findings from perspective of climate change to determine if key conclusions would change significantly

2.2 Abandon Investigation

2.2.1 Negligible Extra Capacity – Cannell Lake

Cannell Lake resides in a small (2.1 km^2) watershed. A 2009 watershed assessment (KWL, 2009-08) investigated if withdrawal amounts higher than the licensed 9.1 MLD would be possible. Based on study outcomes and after two years of further supporting work, the Province granted the AMWSC an amended water license. It allows an annual average withdrawal of 11.8 MLD with daily maximums up to 69 MLD, contingent upon the time of year and lake water level. The higher flows can only be sustained for short periods (e.g. After 3 weeks at 60 MLD in spring or early summer, there would be insufficient volume remaining to satisfy the upper zones of Mission for the rest of the year).

In isolation, there is no opportunity to draw additional capacity from the Cannell watershed. However, as further described in Section 0, existing Cannell infrastructure might be leveraged in a Stave-to-Cannell recharge strategy.

2.2.2 Negligible Extra Capacity – Abbotsford-Sumas Aquifer

The AMWSC currently has 19 wells drawing water from the Abbotsford-Sumas aquifer. The aquifer also supplies water for agriculture, several local industries, Clearbrook Waterworks District (CWD), Whatcom County in Washington State and private well users.

In a recent letter from the BC Ministry of Forests, Lands and Natural Resources Operations (MFLNRO, 2012-05-18), their Regional Hydrogeologist advises that the current extraction from the aquifer represents 38% of its average annual estimated recharge volume. While this makes it seem like there is an abundance of unused water, she goes on to explain that the sustainable yield of an aquifer is assumed to be 50% of recharge (so that sufficient volumes are reserved for environmental needs). She also points out that the 38% is merely relative to the average annual estimated recharge; some years will have less recharge. From this perspective and considering all the competing users (who may also want additional capacity), there is little additional water that the AMWSC could sustainably withdraw from the aquifer.

The AMWSC has recently experienced the challenges of permitting new aquifer withdrawals through the Bevan Wells project. As part of the required EA process, the AMWSC developed a groundwater model to determine the effects of increasing the draw from the aquifer by 25 MLD. This exercise determined that the base flow of two local streams would be affected and that there would be negative impacts to an existing CWD well field. Ultimately, after four years of studies and consultation, the Province issued an EA Certificate in May 2011. However, the Certificate restricts well operation to May through September, imposes an upper limit on the annual volume extracted and required that the AMWSC construct mitigation works for the streams and CWD. Numerous other notifications, consultation, and monitoring commitments are also stipulated that more than double the annual Bevan Well operating costs. After December 2015, the wells are to be used only for emergency and maintenance purposes unless the AMWSC requests that the Province amend the EA Certificate terms.

Considering the Province's commitment to improving groundwater management (as part of BC's Living Water Smart Plan) and the knowledge gained during the Bevan Wells EA process, the aquifer may not be the best choice to meet future water needs. Further to this, the aquifer is highly vulnerable to contamination; nitrate concentrations already do not meet acceptable levels for drinking water in parts of the aquifer.

Aquifer Recharge?

It has been suggested that the AMWSC consider aquifer recharge to allow greater extraction. This is done in various areas of the world by injecting highly treated wastewater into the aquifer. Typically the strategy is applied where aquifer levels are consistently dropping year-over-year due to excessive withdrawals. Since the Abbotsford-Sumas Aquifer recharges fully most years via abundant rainfall (Piteau, 2010-02), artificial recharge isn't considered a significant benefit for addressing the intensive summer withdrawals. Furthermore, not only would it be difficult to permit aquifer recharge with wastewater, it would be an expensive undertaking considering the additional level of treatment necessary and the new pipelines to deliver it to a suitable injection location.

2.2.3 Pump Norrish Water to Upper Mission (or Cannell Lake)

Currently, the Cannell Lake system is the only source that can supply the upper elevations of Mission. For this reason, AMWSC operators are cautious about over-using Cannell Lake. However, if Norrish water could be pumped to upper Mission elevations (or into Cannell Lake), additional water could be reserved in Cannell Lake for peak days. While this option does not generate any additional supply, it might improve system flexibility so that water can be redistributed to where it is needed.

When the Norrish supply was originally built in the early 1980s, the intent was to supply water by gravity up to Mission's pressure zone III (i.e. approximately to the elevation of Cherry Street). However, planners also included provisions for pumping Norrish water up to elevations as high as Cannell Lake itself. In 1985, the CFVWC built the Cannell Lake Booster Station at the intersection of Cedar Street and Best Road. The pumps have never operated.

Under existing system conditions, the Cannell Lake Booster Station cannot operate due to insufficient pump suction head. While there may be ways to reconfiguring the booster station (or install new infrastructure) to introduce Norrish water into Upper Mission or all the way up to Cannell Lake, it would come at the cost of reducing the hydraulic gradient to Abbotsford. This means that there would insufficient pressure available to effectively fill Maclure Reservoir. With respect to the concept of using Norrish water to recharge Cannell Lake; this isn't likely to pass permitting hurdles considering that the water would need to be de-chlorinated before discharge into the lake. For these reason, and other technical concerns beyond the scope of this report, pursuing solutions to supply Upper Mission or Cannell Lake with Norrish water are not suggested for further investigation.

2.2.4 Store Treated Water for Peak Days

Residents question why Abbotsford and Mission don't have more or bigger reservoirs to store treated water for high use days. Combined, the municipalities already have 13 treated water reservoirs. Such reservoirs are only sized to smooth out daily variations and provide for fire flow, not to reserve water for peak periods lasting several days or weeks.

A reservoir sized to store multiple days of treated water would be enormous. For example, to store just three days of Abbotsford and Mission's 2010 maximum day demand (i.e. 320 ML), visualize a reservoir that covers 10 soccer fields and is 2 stories high.[7] Even assuming land could be found for such a reservoir (or multiple smaller reservoirs), the cost would be as expensive as other supply options (but doesn't actually provide more water into the system).[8] Furthermore, such large treated water reservoirs are rarely recommended due to water quality concerns associated with stagnation during non-peak times.

The above does not preclude the AMWSC (or Abbotsford or Mission) from adding some additional treated water reservoir capacity in the future. However, it would be added in much smaller volumes for reasons other than storing water for peak day demands (e.g. system pressure balancing, peak hour storage).

[7] Assumption: 100 x 65 m soccer field & 2.5 m story.

[8] Assumption: Mt. Mary Ann (6.8 ML) built for roughly $2.5M in 2003. At 2% inflation per year, cost in 2012 dollars would be approximately $450K/ML. Thus, a 320 ML reservoir would be greater than $140M.

3 NEW SOURCE DEVELOPMENT

3.1 Investigate Further

3.1.1 Miracle Valley Aquifer

Option Description

The Miracle Valley aquifer is a small (approximately 10 km^2) groundwater supply located at the northern end of Hatzic Valley.

Past Investigations

The Miracle Valley aquifer was first considered in 2003. At that time, Piteau Associates (2004-01, p. 20) recommended that '*development of a high capacity well field [i.e. >10-15 MLD] in the [Miracle Valley] aquifer appears feasible*'. This preliminary desktop study was followed by another one in 2007 (Piteau, 2007-12), which increased the estimated potential well field yield to 15-20 MLD.

In late 2011, the District of Mission had test wells drilled in the Miracle Valley Aquifer to confirm/refute the earlier desktop conclusions. That study (Piteau, 2012-04) revealed that groundwater flow diverges northward and southward at the valley's high point. Long-term withdrawals from the southern portion are expected to reduce area creek flows, some of which are already considered compromised fish habitat. Long-term withdrawals in the range of 18 MLD (or greater) are more likely to be sustainable in the northern aquifer area, but lead and manganese levels above the Canadian Drinking Water limit were found in the test well water.

Rationale for Short Listing

- ***Potential Small Capacity Supply Solution:*** As described above, preliminary studies suggested that the aquifer may have sufficient water quantity to meet short-term water demand growth. If filtration is not required, the option may be the least cost small capacity solution.
- ***Helps with Redundancy*:** In contrast to expanding Norrish Creek (as an alternate small-to-medium sized supply option), a Miracle Valley Aquifer supply would add system redundancy.

Option Drawbacks

The results of the latest groundwater investigation have changed the perspective on the potential viability of the Miracle Valley Aquifer:

- ***Capacity Risk Concerns:*** Prior to the study, it was assumed that the aquifer was hydraulically linked to Stave Lake, reducing its capacity risk. However, this may not be the case. With the aquifer potentially dependent exclusively on recharge from valley creeks and precipitation, its relatively small capacity may be sensitive to minor climate shifts.
- ***Lower than Expected Water Quality:*** Prior to the study, it was felt water quality would be good. The presence of lead above drinking water limits is a concern.
- ***Challenging Permitting:*** Prior to the latest groundwater investigation, it was assumed that a typical (2-3 year) EA would be required. However, the mere fact that the aquifer recharges compromised fish habitat is likely to turn the EA process into a much more complex process (based on experience with the Bevan Wells EA).

Minimum Anticipated Capital Costs

A minimum of $20 million is anticipated for a Miracle Valley Aquifer project if filtration is not required; this estimate increases to $40 million with filtration:

#	Description	Min $	Comment
1	20 MLD Well Installation	$5M (1)	
2	15 km transmission main to closest AMWSC transmission main tie-point	$15M (2)	
3	20 MLD greensand filtration plant	$20M (3)	If high lead (or other contaminant) concentrations are confirmed

1 – Cost Basis: Bevan Well project costs of approximately $6M for 25 MLD. Includes: environmental assessment and other permitting, well drilling, pump station and disinfection facility.

2 – Cost Basis: Recent costs for 600mm pipeline within an Abbotsford urban area were $1M/km. 15km x $1M = $15M

3 - Cost Basis: No cost estimates currently available for greensand. Assuming $1M/MLD.

Further Investigation Required

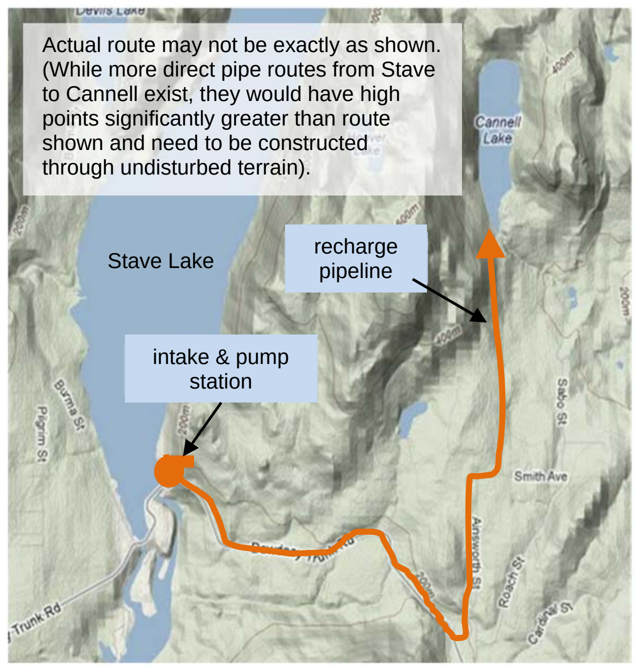
In-House	Consultants
• Meet with DFO and MOE to determine likely approval processes and timelines • High-level property investigations to confirm possible infrastructure locations • Calculate NPV and refine capital costs to a Class D accuracy	• Hydrogeological field investigations to confirm highest available aquifer yields, hydraulic link to Stave Lake and re-check lead concentrations • If a hydraulic link to Stave Lake is confirmed, explore potential for Miracle Valley to be a medium or large capacity source. Include analyses for pumping water for Cannell Lake recharge. * • Independent review of in-house cost estimates

* Potentially, a case could be made for a solution incorporating pumping of water from Miracle Valley wells to Cannell Lake (i.e. similar to option described next in Section 3.1.2). This, and other Miracle Valley sub-options, may warrant further investigation, especially if the aquifer is hydraulically linked to Stave Lake. Unfortunately, the costs to pursue Miracle Valley investigations are significant. An estimate of $250,000 has been received for the hydrogeological field investigation alone. (This is higher than Mission's 2011 field work costs because new test well drilling would need to occur further north in undeveloped terrain; almost half the estimate is for temporary road construction and environmental mitigation).

3.1.2 Stave-to-Cannell Lake Recharge

<u>Option Description</u>

Rather than a large capacity Stave Lake solution, it has been suggested that the AMWSC pump raw Stave Lake water into Cannell Lake so that the latter could be used as a reliable 60 MLD supply at all times. While further thought is required to flush out the concept, initial thoughts are to install a raw water transmission system using similar design (albeit on a smaller scale) as that previously proposed for the 2011 Stave Lake Supply project. That is, an intake and pump station would be located on the east shore of Stave Lake upstream of BC Hydro's Blind Slough dam. A pipeline would convey water along Dewdney Trunk Road to Ainsworth Street, where it would then travel up to Cannell Lake along a similar route as the existing water transmission mains. A 60 MLD filtration plant would then be required somewhere downstream of Cannell Lake.



<u>Past Investigations</u>

There have been no past investigations for this option.

Rationale for Short-Listing

- ***Small-to-Medium Capacity Option:*** The AMWSC has expressed a desire to contemplate short-term water supply options.
- ***Low Capacity Risk:*** BC Hydro (2011-08) completed Stave Lake hydraulic modeling to examine the impact of 400MLD Abbotsford water diversions proposed for the previous Stave Lake Water Supply project. They found that the Lake could almost always support this full withdrawal flow without impacting BC Hydro's operations or downstream fish habitat. A Cannell Recharge project would divert only 1/10th of the previously modeled flows.
- ***Good Normal Water Quality with Moderate Contamination Risk*: ** Preliminary water quality investigations (D&K, 2009-03) confirm that Stave Lake is a high quality source. Cannell Lake also produces good quality water (AMWSC, 2011). Cannell Lake lies in a protected watershed and Stave Lake is sufficiently large to buffer most anticipated water quality impacts.
- ***Suitable Land Likely Available:*** Previous Stave Lake investigations and known conditions along the existing Cannell water supply infrastructure suggest that land would be available for Cannell recharge infrastructure.
- ***Helps with Redundancy*:** In contrast to expanding Norrish Creek (as an alternate small-to-medium sized supply option), a Cannell Lake recharge project would add system redundancy.

Option Drawbacks

- ***Low Elevation (= Higher NPV):*** Cannell Lake is approximately 200 m higher than Stave Lake, requiring significant pumping power.
- ***Challenging Permitting:*** Any transfer of water from one natural water body to another triggers a CEA. This, along with other permitting challenges known to be associated with Stave Lake (e.g. negotiating water sharing with BC Hydro, high archeological site density around Stave Lake), will mean that permitting could take several years and require numerous studies.
- ***Other:*** It is important to understand that a Stave-to-Cannell Recharge project would not be a straightforward upgrade into a future large-scale Stave Lake water supply without significant up-front planning and extra investment. Considering the geotechnical, archeological and environmental conditions around Stave Lake, a small intake and pump station would not be easily retrofitted later for large capacities.

Minimum Anticipated Capital Costs

While the capital costs of such a project are largely unknown, a minimum of $50M is anticipated:

#	Description	Min $	Comment
1	Stave Lake intake & pump station to raise water 200 m	$10M (1)	
2	8 km transmission main from Stave Lake to Cannell Lake	$10M (2)	Neither of the two existing Cannell Lake transmission mains, known as the '400' and the '600', can likely be converted to convey raw up to Cannell Lake. The '400', installed in the 1960s, is past its theoretical lifespan and may be decommissioned in the coming decade
3	60 MLD WTP	$30M (3)	By introducing Stave Lake water into Cannell Lake, full filtration will be necessary (unlike current possibility for UV-disinfection to meet Fraser Health protozoa treatment requirements, which would cost closer to $5M for a 60MLD system).

1 - Cost Basis: Previously estimated 400 MLD (with screens & pumps initially sized for 100 MLD) Stave Lake intake and pump station was $50M. Due to site geotechnical, environmental and archeological conditions, the value cannot be scaled back proportionally by capacity. $10M is merely a rough estimate.

2 – Cost Basis: Recent costs for a 750mm pipeline within an Abbotsford urban area were $1.3M/km. 8km x $1.3M = $10.4M (rounded down).

3 - Cost Basis: In 2003, the 27 MLD Norrish membrane filtration plant + the facilities shared with the slow sand filters cost approximately $15M. At 2% inflation/year, that results in approximately $18M in 2012 dollars. Rounded down and doubled.

Further Investigations Required:

In-House	Consultants
• Meet with DFO and MOE to determine likely approvals (CEA, water licensing and other) processes and timelines • Calculate NPV and refine capital costs to a Class D accuracy	• Conceptual engineering and costing • Independent review of in-house cost estimates

3.1.3 Fraser River

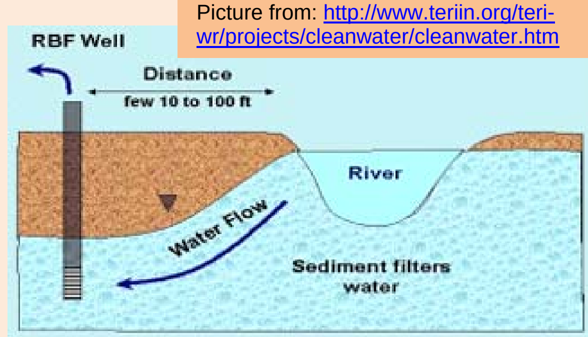
Option Description

The Fraser River is the closest, large source of fresh water to Abbotsford and Mission. Due to its proximity, it has the best potential to begin as a small supply and later provide medium or large capacities.

While the option requires significant further investigations, a preliminary vision starts with an intake at the north-east end of the Matsqui Prairie. (The suitability of an intake location will depend on river hydraulics). A WTP would be situated somewhere in the same area, on land above the flood zone. Between 1 and 10 km of new transmission main would be needed, along with pumping to raise water up to the Maclure Reservoir (or other municipal take-off points).

Riverbank Filtration?

A resident has suggested that wells drilled near the Fraser River would provide high water yield. This is indeed possible; such a concept is known as riverbank filtration (RBF). Riverbank sediments provide pre-filtration that may eliminate WTP processes that would be required if the water were drawn directly from the river. The viability of riverbank filtration depends on hydrogeological conditions aligning the river. Water treatment and geotechnical experts would need to be consulted to know whether riverbank filtration is practical for a Fraser River supply option. A particular concern for the Fraser River, where dykes are preventing flooding, is whether RBP might increase the incidence of boils.



Picture from: http://www.teriin.org/teri-wr/projects/cleanwater/cleanwater.htm

Past Investigations

Planners in the 1950s considered the Fraser River as a possible water supply for the Fraser Valley (WDP, 1959-09, p.8). They envisioned using riverbank filtration (as described on the previous page). However, their final recommendation was to stick with groundwater, which most Valley municipalities did for the following two decades. Later, in the mid-1970s, new water supply options investigations (that ultimately led to the Norrish supply) also included the Fraser River (D&K, 1974-06).

The CFVWC contemplated the Fraser River in its 1995 Master Plan (D&K, 1996-08, Section 5.3). In this round of water supply option analyses, cost estimates suggested that it would be more expensive than other options due to higher levels of required treatment.

Most recently, the AMWSC included the Fraser River as a supply option in its 2010 Master planning process. From a cost perspective, it was estimated at approximately 5% more expensive (capital and NPV) than the preferred Stave Lake option (AECOM, 2010-04, p. 5-4). However, that planning never contemplated the possibility of phasing its development in small (e.g. 25-50 MLD) increments, which might make it more economical than Stave Lake.

Rationale for Short-Listing

- ***Large Capacity with Moderate Capacity Risk*:** The Fraser Watershed is enormous, draining most of southwestern British Columbia. Considering that a 100 MLD diversion represents approximately 0.001% of river's low season flow at Mission[9], there is negligible capacity risk despite competing uses and climate change.
- ***Close Distance = Flexible Phasing Opportunity:*** By far, the Fraser River is the closest, large capacity source to Abbotsford & Mission. This translates into significant opportunities to start with small (e.g. as low as 25-50MLD) capacity.
- ***Likely Land Availability:*** Since the infrastructure for a Fraser River supply would be completely within the boundaries of Abbotsford and Mission, it would likely be easier to acquire land than for other options requiring works outside of the two municipal regions.

Option Drawbacks

- ***Divided Public Acceptance:*** While the Fraser River offers the AMWSC an exciting opportunity, the impact of public perception cannot be understated. In many North American regions, the Fraser River would be considered an enviable raw water source for potable supplies. However, British Columbia is blessed with abundant supplies of more pristine raw water. Currently, no large municipalities leverage the Fraser River as a potable water supply. There is no question that the water can be treated to potable standards; the question is whether the general customer can be convinced of the fact. If the Fraser River is ultimately selected as a future Abbotsford and Mission water source, significant time and investment should be contemplated for public education. Water treatment piloting will be required for several years upon which to base full-scale design; that exercise could certainly be expanded for education with the piloting site serving as a public demonstration.

[9] Water Survey of Canada, Daily Discharge for Fraser River at Mission (Station 08MH024). Data shown on graph suggests that minimum flows during records collected since 1965 are approximately 1000 m^3/s = 86400 MLD. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=08MH024&report=daily&year=2010

- ***Low Elevation (= High NPV):*** The Fraser River water level typically ranges from 0.5 to 7 m. Water will need to be pumped to serve customers. However, the proximity of the Fraser River increases the opportunity to minimize pumping by segregating the supply system into zones, possibly with the Fraser River supplying lower elevations and Norrish servicing higher ones.
- ***Moderate Water Quality:*** Preliminary water quality investigations (D&K, 2009-03) indicate that the Fraser River normally has moderate water quality. A WTP with enhanced treatment processes would be required upstream of filtration.

Pharmaceuticals & Personal Care Products?

In recent years, there has been much media attention given to the detection of pharmaceuticals and personal care products (PPCPs), which have passed into source waters from wastewater. Considering that many upstream communities and industries do discharge their wastewater to the Fraser River, some individuals have expressed significant concern with PPCPs. However, consider two points key points from the American Water Works Association (which is the largest association of water professionals in the world):

(i) "*The concentrations of PPCPs in water are at extremely low levels – far, far below the doses and amounts commonly prescribed or routinely consumed by the general public. No current scientific study has found that these low levels pose any human health issues. …someone could drink more than 50,000 eight-ounce glasses of water per day containing the highest concentrations of PPCPs detected in any study and not suffer health effects, except from drinking way too much water*" (AWWA & Hoffbuhr, 2009, p.20).

(ii) Drinking water treatment processes exist that can remove PPCPs (AWWA & Hoffbuhr, 2009, p24-25).

- ***High Contamination Risk:*** Considering the expanse of the Fraser Watershed, some may argue that the Fraser River is a source with an unacceptable contamination risk. However, the Fraser River conveys massive volumes of water; this offers an unparalleled ability to buffer upstream contamination. Secondly, the nature of a river is that most contamination events will pass as water flows downstream. Thirdly, assuming the entire source is economical, the WTP for the Fraser River would have treatment processes built up front to deal with all but obscure contamination types.

  On a separate contamination note, the river's tidal zone extends up to the Mission Bridge. While not anticipated to be a problem, investigations will need to contemplate whether an outcome of climate change may include the back-up brackish water to a Fraser River intake location.

- ***Permitting Complexity Unknown:*** No discussions have ever occurred to ascertain the permitting that would be required with a Fraser River source. Considering that a 'large withdrawal' from AMWSC's perspective represents a mere fraction of even low river flows, use of the Fraser River may be viewed more favourably than other sources. For this reason, an EA and water licensing may not be as challenging as that for other options. That said, the Fraser River is also a key natural resource for First Nations, fisheries, and other users. No conclusions can be drawn until there have been meetings with the various regulators to develop realistic expectations for water licensing, the EA and other permits.

Minimum Anticipated Capital Costs

A significant amount of further information is needed for even rough cost estimates of a Fraser River supply option. However for the purposes of this report, assuming a 400 MLD ultimate capacity) a minimum of $55 million is the anticipated starting point for an initial 25 MLD capacity, whereas a 100 MLD starting capacity would be no less than $210 million.

#	Description	Minimum Cost (25 MLD)	Minimum Cost (100 MLD)
1	Intake (1)	$5M	$15M
2	WTP (2)	$35M	$150M
3	Pump Station(s) (3)	$10M	$25M
4	Transmission Mains (4)	$5M	$20M

Cost Bases:
1 – Costs are educated guesses only since no similar infrastructure costs available to serve as a basis at time of report writing.
2 – Assuming $1.5M/MLD (approximately 50% more than direct filtration WTP assumption used for other options).
3 – Assuming $0.5M/MLD, rounded down to nearest $5M.
4 – Assuming 750mm pipe @ $1.3M/km (installed cost of recent Abbotsford main) x 5km = $6.5M, rounded down to $5M.
5 – Assuming 1200mm pipe @ 2.3M/km (installed cost of AMWSC Gladwin main) x 10 km = $23M, rounded down to $20M.

Further Investigations Required:

To develop Class D cost estimates for a Fraser River source, the following information must be clarified:

In-House	Consultants
• Meet with DFO and MOE to determine likely approvals (EA, water licensing and other) processes and timelines • Determine possible land requirements for new infrastructure • Calculate NPV and refine capital costs to a Class D accuracy	• Investigate suitable intake location(s), design(s) and costs. To include a cursory analysis of potential climate change impacts on future river water quality & tidal range • Conceptual WTP process design and costing • Hydraulic modeling to determine how best to connect a Fraser River supply into existing system (forms basis for transmission main and pumping costs) • Desktop geotechnical, environmental and archeological investigations to support possible permitting costs

3.1.4 Stave Lake

Option Description

The vision for a Stave Lake Water Supply is essentially unchanged technically from that proposed in 2011. The water would be drawn from Stave Lake using a submerged intake located within the old Stave River channel, a few hundred meters upstream of BC Hydro's Blind Slough Dam. A tunnel would connect the intake to an on-shore pump station, which would lift the water to a treatment plant located along Dewdney Trunk Road in the vicinity of Cannon's Pit. From there, the treated water would be conveyed along Clay and Wren streets in Mission before crossing under the Fraser River and joining into the existing 1200 mm transmission main along Abbotsford's Gladwin Road. The only variations from 2011's vision is that the ultimately capacity of 400 MLD may be lowered if updated demand projections suggest that less would be needed over a 100-year horizon.

Note: While a route along Hatzic Valley, with a first phase consisting of wells in Miracle Valley, has been contemplated, the option doesn't seem promising. Previous investigations in 2009/10 for such a route suggested that it would be significantly more expensive than the routing through north Mission. However, if Miracle Valley does proceed as an interim supply solution, the costs of later extending collection up into Stave Lake could be again examined.

Past Investigations

Stave Lake was considered as a potential municipal water supply option by the CFVWC in the mid-1990s. However, it was dismissed due to concerns that it is a BC Hydro power generating reservoir (D&K, 1996-08). When the CFVWC re-considered options in 2004 (EarthTech 2004-05), the challenge of negotiating Stave Lake water allocation with BC Hydro seemed more palatable considering its projected development costs relative to other options. Through late 2006 and 2007, AMWSC staff held discussions with the BC Water Stewardship Office and BC Hydro. Those discussions suggested that neither organization had fundamental objections to Stave Lake becoming a municipal water supply and that the cost to compensate BC Hydro for lost power generating potential would not render Stave Lake less attractive than alternative sources.

In 2008, the AMWSC began the next master planning cycle. At that time, water quality testing of Stave Lake (and other potential water sources) began. Following 18 months of demand projection analyses, water quality testing, continued discussions with upper government levels, public meetings, initial consultations with interested First Nations, and conceptual-level engineering, the 2010 Water Master Plan (AECOM, 2010-04) recommended that the AMWSC move forward with preliminary-level Stave Lake studies. A conceptual Stave Lake Water Supply engineering report (AECOM, 2010-03) was also released with starting points for possible intake designs, water treatment alternatives and routes for conveying water from the lake to Mission and Abbotsford. Through 2010 and 2011, preliminary engineering was completed in preparation of a procurement phase.

Had the Stave Lake Water Supply been approved during the November 2011 referendum, the plan had been to proceed into a procurement/detailed design phase in early 2012, with a project construction start sometime in 2013 (assuming all permitting and EA requirements were in order).

Rationale for Short Listing

- ***Large Capacity with Moderate Capacity Risk***: The watershed is sufficiently large to be a long-term water solution with only moderate capacity risk anticipated from climate change and competing water uses. BC Hydro (2011-08) completed Stave Lake hydraulic modeling to examine the impact of 400MLD water diversions proposed for the previous Stave Lake Water Supply project. They found that the Lake could almost always support this full withdrawal flow without impacting BC Hydro's operations or downstream fish habitat.
- ***Distance:*** Stave Lake would require 20 km of transmission main to connect into the existing Abbotsford-Mission supply system. This is closer than most other large capacity options.
- ***Good Normal Water Quality with Moderate Contamination Risk***: Preliminary water quality investigations (D&K, 2009-03) confirm that the lake is a high quality source. While not a protected watershed, it is sufficiently large to buffer most anticipated water quality impacts.
- ***Much Progress Already Made Through Challenging Permitting:*** Considerable work has been completed to assess approvals for a project at Stave Lake. Both a Provincial and Federal EA would be required. Both of these permitting processes were well underway until November 2011 with many supporting studies completed. As well, First Nations were engaged in discussions. The water in Stave Lake is licensed to BC Hydro, therefore, a water sharing agreement with BC Hydro would be required in addition to a water license issued by the MOE. By November 2011, agreement term negotiations were nearing completion. The MOTI no longer allows high-pressure pipelines along their highway ROWs. It would be necessary to obtain an exemption for a short length of pipeline along the Lougheed Highway. By November 2011, discussions with the MOTI were nearing a successful resolution.

- ***Suitable Land Likely Available:*** Previous Stave Lake investigations confirmed suitable locations on Crown land for almost all proposed infrastructure.
- ***Helps with Redundancy***: Adds another significantly sized source to system, thus reducing reliance on Norrish Creek.
- ***Public Acceptance:*** The 2012 public outreach generally indicates support for the use of Stave Lake as a water supply.
- ***Other:*** A Stave Lake WTP, located appropriately, could also accept Cannell Lake water and avoid the need for a separate capital investment in a Cannell Lake WTP, which has been mandated by Fraser Health.

Option Drawbacks

- ***Elevation:*** Stave Lake's average surface water level is approximately 80 m. To deliver the water to the municipalities, it would need to be pumped up approximately 150 m.
- ***Limited Phasing Practicality:*** Distance makes it impractical to initially install a pipeline that provides less than 100 MLD. In 2011, it was envisioned that a Stave Lake Water Supply would be staged in 100 MLD increments up to an ultimate capacity of 400 MLD. Sufficient land would be secured for the ultimate capacity. Similarly, an intake tunnel and raw water pump station building would be sized up for the ultimate capacity. The pumps and water treatment processes would be installed in 100 MLD increments. Most of the pipes would be sized for at least the first two phases (i.e. 200 MLD). Those segments through environmentally sensitive areas (e.g. across Fraser River) may be sized to meet additional flows.

Minimum Anticipated Capital Costs

In 2011, CH2M HILL was retained to develop engineering Class C (+/- 15%) cost estimates for the Stave Lake Water Supply project. The high end of the Class C cost estimate for phase one of the Stave Lake Water Supply was estimated at $328 million. This value makes it seem like certain other options are just as attractive as Stave Lake; however, if one applies the same rough assumptions for minimum costs to Stave Lake as have been applied to other options throughout this report, then the comparison becomes more valid with Stave Lake minimum costs estimated at greater than $200M:

#	Description	Minimum $
1	Stave Lake intake & pump station to raise water 200 m	$50M (1)
2	20 km of transmission main from Stave Lake to Cannell Lake	$50M (2)
3	100 MLD WTP	$100M (3)

1 – Cost Basis: As per 2011 estimates.
2 – Cost Basis: Complete 20 km uses 1200 mm pipe at $2.6M/km (as per value used to calculate minimum pipeline costs for other reported options)
3 – As per 2011 estimate (rounded down from $120M to reflect same value used for other large capacity options that require similar treatment).

Further Investigation Required

Relatively accurate cost estimates for Stave Lake already exist. However, if the AMWSC's 2012 Demand Study suggests that less than an additional 400 MLD would be required over the next 100-years, then an in-house analysis will be completed to choose a more suitable ultimate capacity and adjust anticipated costs accordingly. Similarly, if Miracle Valley is investigated as a short-term supply solution, those investigations should include thoughts (i.e. conceptual design & costing) for later extending up into Stave Lake for large capacity withdrawals.

3.2 Abandon Investigations

The first two options discussed below were raised as options prior to or during the Study's initial public outreach. The discussions below explain why the options are not viable. Hayward, Harrison and Chilliwack Lakes were all initially presented as possible options. Their discussions below are more detailed to explain why they were originally considered, but are no longer recommended for further investigations.

3.2.1 Nearby Small Surface Sources

The following sources are examples of surface water sources that are too small to consider relative to their distance from the nearest AMWSC system tie-in point, are already allocated for other water uses, or are at extreme risk of capacity reduction during drought:

- Albert Dyke Lake
- Cultus Lake
- Hatzic Lake
- Lost Lake
- Mill Lake (Abbotsford)
- Mill Lake (Mission)
- Sumas River
- Vedder Canal
- Wahleach Lake

3.2.2 Other Local Aquifers

Over the decades, Fraser Valley aquifers have been identified and studied to varying degrees. Local hydrogeologists have a good understanding of areas underlain by high groundwater yields. Leveraging that expertise, the CFVWC and AMWSC have explored potential aquifer viability at various times (e.g. amongst several others: Khloen Leonoff, 1989-08; Piteau, 2004-01). The principal conclusion that can be drawn from these multiple investigations is that, other than the Abbotsford-Sumas and Miracle Valley Aquifers, there are no promising alternate local groundwater options of reasonable capacity.

Deep Wells?

A resident has suggested that deeply sourced groundwater (e.g. >200 m) would be able to meet the AMWSC's future needs. While certain areas of the world are underlain by large, deep underground water sources, there is no evidence of such water under Abbotsford or Mission (other than the Abbotsford-Sumas Aquifer).

3.2.3 Hayward Lake

Rationale for Initial Consideration

- ***Closer than Stave Lake:*** Hayward Lake was originally considered as an alternate diversion point to Stave Lake that would potentially allow 5km to be cut from the required transmission main distance.
- ***Good Normal Water Quality*:** Preliminary water quality investigations (D&K, 2009-03) confirm that the lake normally has good water quality. Mission has an existing small water supply system that draws from Hayward Lake.
- ***Helps with Redundancy*:** Hayward Lake would add another significantly sized source to system, thus reducing reliance on Norrish Creek.

Past Investigations

Water supply plans in the 1970s (D&K, 1974-06) and the 1990s (D&K, 1996-08) briefly mention Hayward Lake as a potential water source. However, similar to conclusions of the time for Stave Lake, it was dismissed due to concerns that it is a BC Hydro power generating reservoir.

In 2010 (AECOM, 2010-04, p. 5-4), a Hayward Lake supply option was actually predicted to be the lowest cost option of those studied. However, those costs were not statistically much lower than Stave Lake. Due to concerns about contamination risk from the Mission landfill, Stave Lake was rated as a more optimal solution than Hayward.

Main Concern

- ***Contamination Risk:*** Hayward Lake is situated downstream of the Mission landfill. There has already been one confirmed incident of leachate release from the landfill into Hayward Lake. While water treatment processes exist to address landfill leachate contamination, such processes add to the cost of the treatment plant. In the case of Hayward, the confirmed landfill leachate risk would mean that processes would need to be designed and built up front.

Other Mentionable Drawbacks

- ***Capacity Risk Unknown, but Potentially Moderate-High:*** Hayward Lake is a reservoir where level is controlled both upstream and downstream by BC Hydro dam operations. There are times of the year when Hayward Lake almost reverts back to its prior river channel state.
- ***Public Perception:*** While survey respondents were divided on whether Hayward investigations should continue, open house attendees who were aware of the upstream Mission landfill made specific mention of this particular concern.

- ***Lower Elevation than Stave Lake:*** While withdrawing water from Hayward Lake rather than Stave Lake would eliminate a portion of charges from BC Hydro for their lost power generation potential (i.e. would only require paying for lost downstream Ruskin dam power generation), the lake is approximately 55 m lower than Stave Lake which would increase pumping power. Whether lower BC Hydro charges or pumping costs have a greater impact upon NPV has never been fully examined.

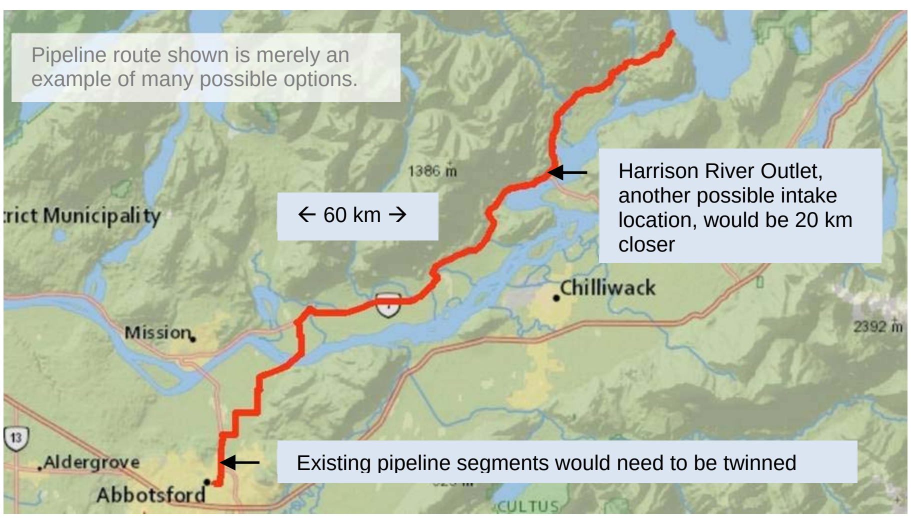
Final Notes

Other than possibly confirming and costing the necessary treatment processes to address potential landfill leachate, no further investigation of Hayward Lake is recommended.

3.2.4 Harrison Watershed - Too Far Away

For large water supply projects (i.e. 200 MLD or greater), pipelines are generally the most expensive upfront cost.[10] The installed cost per kilometer of large transmission mains will be no less than $2.5M/km.[11] Thus, any water supply project requiring more than 40 km of pipeline will exceed $100 million for the pipeline alone. The Harrison Watershed is one large source option that would require such a long pipeline.

Harrison Lake Relative to Abbotsford & Mission



[10] Unless source is close to consumers (i.e. requires only a short pipeline) or source water quality is such that a complex (i.e. expensive) WTP is required.

[11] Actual installed costs of AMWSC's 1200mm diameter Gladwin transmission main in 2011/12 were $2.6M/km. Larger pipes will have higher costs as will construction through more challenging terrain (e.g. not within an existing flat roadway).

Rationale for Initial Consideration

- ***Large Capacity with Low Capacity Risk*:** The Harrison Watershed is by far the largest within the Lower BC Mainland with only small existing licensed water users. There is virtually no risk of the capacity being threatened for the foreseeable future.
- ***Good Normal Water Quality with Moderate Contamination Risk*:** Preliminary water quality investigations (D&K, 2009-03) confirm that the lake is a high quality source. While not a closed watershed, Harrison's vastness provides an enormous buffering capacity against contamination.
- ***Helps with Redundancy*:** Adds another significantly sized source to system, thus reducing reliance on Norrish Creek.

Past Investigative Outcomes

In the late 1990s, the CFVWC considered Harrison Lake as the most promising future water source option (D&K, 1996-08, Section 5-7) and invested 5-years into preliminary permitting and engineering investigations. It envisioned Harrison as a supply to be leveraged by more than just Abbotsford and Mission. Several years of discussions occurred with Metro Vancouver, then Langley/Surrey. However, the CFVWC was unable to confirm any partners. Metro Vancouver chose to focus its long-term water planning on its existing Coquitlam, Seymour and Capilano sources. By 2003, further engineering work had revealed that project cost estimates were significantly greater than originally expected (D&K, 2003-05, p 1-5).

The AMWSC again considered Harrison Lake in its 2010 Master planning process. The option was deemed too costly with an estimated price tag 50% greater than preferred options (AECOM, 2010-04, p 5-4).

Critical Flaw

- ***Distance (capital cost):*** While the Harrison Watershed could be 'the' ultimate water supply solution for the entire Lower BC Mainland, it would take the interest of more than just Abbotsford and Mission to make the vision economically viable. The AMWSC has more than once contacted its neighbouring jurisdictions (i.e. Chilliwack, Langley and Maple Ridge) to determine if there might be such interest. Responses received in 2010 confirm that no other municipality wishes to partner on a water supply at this time. Metro Vancouver's 2011 Drinking Water Management Plan (2011-06, p.12) envisions its existing three sources to be sufficient for at least another century.

A Harrison Watershed supply would cost more than $300 million:

1 - Drawing water directly from Harrison Lake would require at least 60 km of transmission mains (new or twinning). This translates into a pipeline cost of no less than $150 million (and likely much greater).[12] (Even if the outlet of the Harrison River were contemplated as the intake location, the distance is 40 km).

2 - Fraser Health Authority has verbally advised that Harrison Lake water would require filtration. A 100 MLD filtration plant would cost no less than $100 million.[13]

3 – An intake and pump station would be required. $50 million is assumed for this infrastructure.[14]

4 - Permitting and land acquisitions would add to the already described $300 million costs.

Other Mentionable Drawbacks

- ***Low Elevation (= Higher NPV)***: Harrison Lake's elevation is 10 m. Pumping costs would be greater than that of other large capacity options (e.g. Fraser River, which is at a similar elevation but closer to customers or Stave Lake, which is at 80 m).
- ***Challenging Permitting***: The pipeline would need to pass by, or through, no less than five First Nation reserves.
- ***Challenging Land Acquisition***: More than 20 km of transmission main would best be routed along the Lougheed Highway. The MOTI no longer allows high pressure pipelines within their highway ROWs.
- ***Limited Phasing Practicality***: Distance makes it impractical to initially install a pipeline that provides less than 100MLD.

Final Notes

Further investigation of the Harrison Watershed as a future water supply is not recommended for Abbotsford and Mission at this time. Despite its benefits, Harrison's distance and elevation renders it more expensive than Stave Lake, which is an equally viable large source option from the perspective of every other selection factor. While the majority of public survey respondents and open house attendees support use of the Harrison Watershed, it is unlikely that further investigation will refute the existing conclusion that Harrison is simply more expensive than either a Stave Lake or Fraser River large capacity option.

[12] Higher costs likely since the minimum $150M cost estimate stems from 1200 mm pipe installed in existing flat roadways with no geotechnical or environmental challenges. Pipe would likely need to be bigger.

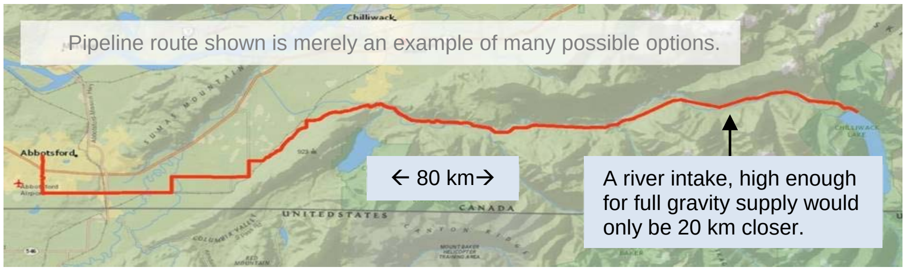
[13] Cost Basis: 100 MLD Stave Lake WTP was estimated at $100M in 2011; a Harrison Lake WTP would require a similar plant.

[14] Cost Basis: Same as 2011 Stave Lake Intake & Pump Station estimate. (While Stave Lake's challenging site conditions push its intake & pump station costs above typical, Harrison Lake requires a larger pump station due to lower elevation. For purposes of this report, the two factors are assumed to nullify one another).

3.2.5 Chilliwack Watershed - Too Far Away

The Chilliwack Watershed is located at even a further distance than the Harrison Watershed and would require a costly transmission main.

Chilliwack Lake Relative to Abbotsford & Mission



Rationale for Initial Consideration

- ***Large Capacity with Moderate Capacity Risk***: The watershed is sufficiently large to be a long-term water solution with only moderate capacity risk anticipated from climate change and competing water users.
- ***High Elevation***: Chilliwack Lake is a high elevation source conducive to full gravity supply. This feature offers the added possibility of cost recovery through power generation.
- ***Good Normal Water Quality with Moderate Contamination Risk***: Preliminary water quality investigations (D&K, 2009-03) confirm that the lake is a high quality source. While not a closed watershed (i.e. all human presence restricted), it is sufficiently remote that human impact is less than that upon watersheds closer to urban areas.
- ***Helps with Redundancy***: Located on the south side of the Fraser River, a Chilliwack source would provide greater supply security to Abbotsford.

Past Investigative Outcomes

As far back as the late 1950s, planners contemplated the Chilliwack Watershed as a possible water supply for the Fraser Valley (WDP, 1959-09, p.12). They envisioned that it might meet the needs of jurisdictions as far west as Surrey. Ultimately, those planners decided that such a project would be prohibitively expensive in light of distance and the relatively sparse population density of the time.

Interest in Chilliwack Lake revived in the mid-1990s when the CFVWC first recognized that Norrish Creek would not meet customers' demands indefinitely. The CFVWC's 1995 Master Plan (D&K, 1996-08, Section 5.5) mentioned the lake as a future option. However, similar to conclusions reached decades earlier, it was again dismissed due to its distance from consumers. Furthermore, planners perceived the watershed's overlap into the United States as a drawback since Canadian authorities would have little control over water quality impacting activities across the border.

The AMWSC again considered Chilliwack Lake in its 2010 Master planning process. For a third time, the option was deemed too costly with an estimated price tag 75% greater than preferred options (AECOM, 2010-04, p. 5-4).

Critical Flaw

- ***Distance (capital cost):*** The initial costs of a Chilliwack Lake Water Supply would be much greater than $300 million:
  1- Drawing water directly from Chilliwack Lake would require at least 80 km of transmission mains. This translates into a pipeline cost of no less than $200 million (and likely much greater).[15] A river intake alternative could shorten the distance, but the benefit of a full gravity disappears approximately 20 km downstream from the lake.

  2- While there is a chance that the Fraser Health Authority (FHA) would grant filtration exemption, one cannot make this assumption since the watershed is open to recreation and logging. Although unconfirmed, Chilliwack Lake may also be subject to turbidity-causing landslides (which are common to other mountainous lakes of the region). A 100 MLD filtration plant would cost no less than $100 million.[16]

  3- Permitting, land acquisitions and other infrastructure (e.g. intake) would add to the already described $300 million pipeline and WTP costs.

  Note: There is no information at this time regarding the potential impact of coupling power generation with a Chilliwack Water Supply project. While such a strategy may make NPV more attractive, the power infrastructure would require even further up front capital investment.

Other Mentionable Drawbacks

Chilliwack Lake's remoteness indirectly creates other drawbacks:

- ***Challenging Permitting***: Likely to be more challenging than other sources merely since larger tracts of land would be disturbed during construction and since part of the watershed lies in the United States (which would necessitate the involvement of foreign regulators in any EA process).

- ***More Challenging Land Acquisition (Maybe)***: While land availability hasn't been investigated, logic suggests that a longer pipeline is likely to travel across additional lands needing ROWs. The pipeline would need to pass by or through at least one First Nation reserve.

[15] Higher costs likely since the minimum $200M cost estimate stems from 1200mm pipe installed in existing flat roadways with no geotechnical or environmental challenges. Pipe would likely need to be bigger.

[16] Cost Basis: 100 MLD Stave Lake WTP was estimated at approximately $100M in 2011; a Chilliwack Lake WTP would require a similar plant.

- ***Limited Phasing Practicality:*** Distance makes it impractical to initially install a pipeline that provides less than 100MLD.

Final Notes

Further investigation of the Chilliwack Watershed as a future water supply is not recommended for Abbotsford and Mission at this time. There are other large capacity supply options (i.e. Stave Lake and Fraser River), located entirely within Canada, which would be available at lower cost. The majority of public survey respondents and open house feedback concur with eliminating Chilliwack Lake from further investigations.

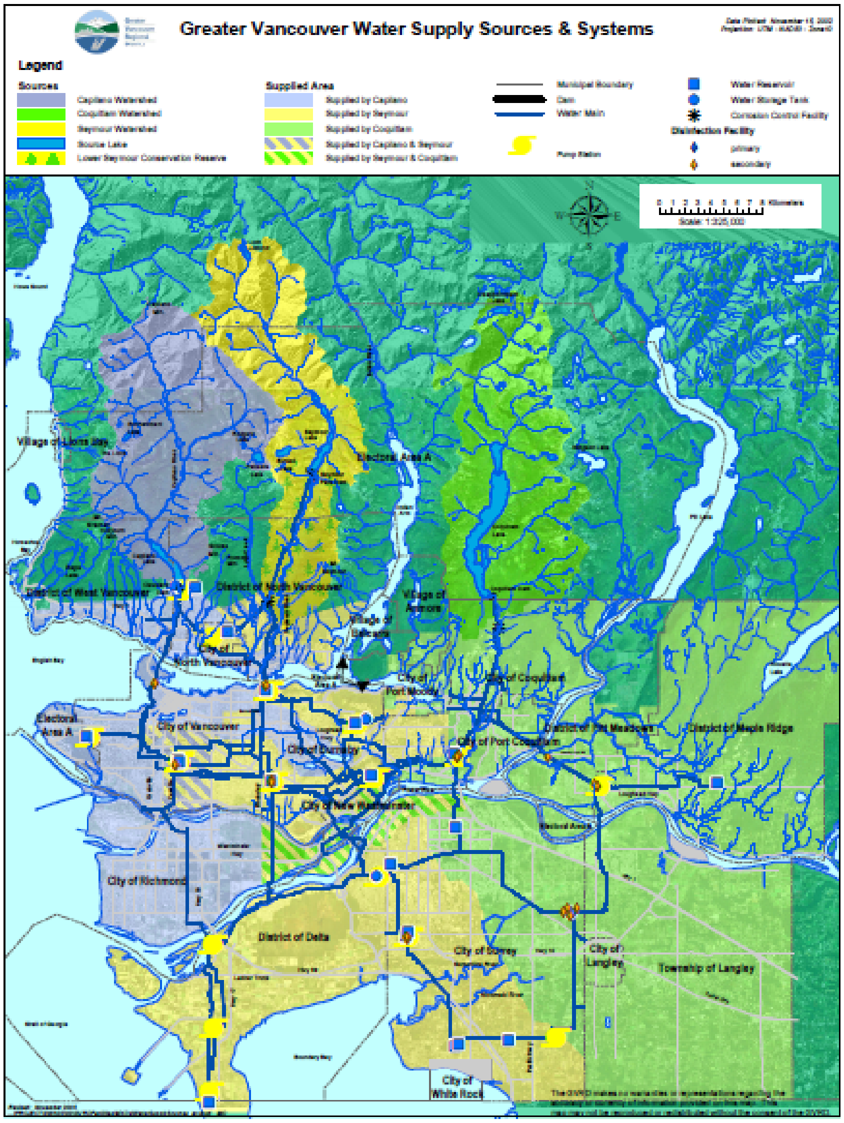
4 ALTERNATE SUPPLIES

4.1 Investigate Further

4.1.1 Metro Vancouver Supply [17]

<u>Option Description</u>

Metro Vancouver (Metro) supplies potable water from their Seymour, Capilano and Coquitlam reservoirs to approximately 2 million people in municipalities that span as far east as Maple Ridge and Langley. Metro treats and transmits the water to the municipalities, who are then responsible for distribution to their individual customers (much like the AMWSC does for Mission and Abbotsford). The AMWSC may be able to connect to the Metro system and then purchase bulk water to supplement existing AMWSC supplies. Based on system maps, the closest likely take-off points from the Metro transmission system would be somewhere in central Maple Ridge or the City of Langley. Both locations are at least 25 km from the nearest suitable tie-in points on the AMWSC system. In terms of new infrastructure requirements, transmission mains between the two water systems would be required, booster pump station(s) and/or reservoir(s) may be needed, and disinfection booster treatment would be necessary.



[17] The Water Source Options Public Consultation Booklet suggested that Metro Vancouver would not be a good supply option due to the anticipated pipeline length. However, further investigation into possible connection points in the Metro & AMWSC systems suggests that distances maybe shorter than originally assumed.

Past Investigations

In the 1970s, water planners considered bringing water from Metro to the central reaches of the Fraser Valley (CFVRD, 1971-04), but then decided to instead develop Norrish Creek. The CFVWC again briefly considered the option in its 1995 Master Plan (D&K, 1996-08, Section 5.4), but dismissed it under the assumptions that Metro had an impending supply shortage and that their bulk water costs would be prohibitive. The first of these assumptions now appears moot since Metro currently claims ample supply for many decades to come (Metro, 2011-06, p.12).

Rationale for Short-Listing

- ***Possible Low Capital Cost:*** Considering that a Metro supply would not require a water filtration plant, initial capital costs may be less than those to develop a large new natural water source.
- ***Low Capacity Risk:*** If the AMWSC were to enter into a supply agreement with Metro, it would likely be guaranteeing a given supply volume.
- ***Excellent Normal Water Quality with Low Contamination Risk:*** The AMWSC would receive water already treated to potable standards. Considering that Metro has begun filtration on the Seymour-Capilano sources and will be using ozone plus UV on its Coquitlam source, its treated quality would be excellent.
- ***Helps Redundancy:*** Should there be a failure of the Norrish Creek source, a Metro supply would reduce the impact.

Option Drawbacks

- ***Possible Higher NPV:*** While the capital costs may be less than developing a large new natural source, the NPV may be higher due to the Metro's bulk water costs.
- ***Many Unknowns:*** Metro may not have the excess capacity or a willingness to supply the AMWSC with water. The terms of a supply agreement may not ultimately be in the best interests of the AMWSC.

Minimum Anticipated Capital Costs

No costs for this infrastructure are assumed at this time since values are likely to vary significantly depending on the nature of a water supply agreement with Metro.

Further Investigations Required

In-House	Consultants
• Since no recent discussions have occurred with Metro to determine if they have excess capacity in their system and/or whether there is a willingness to supply water to the AMWSC, a letter would first need to be sent by the AMWSC to indicate a potential interest in Metro water. • If Metro has an interest in supplying water to the AMWSC, then Metro and AMWSC staff could enter into technical discussions to determine conceptual level supply options and costs.	• Metro Vancouver would likely charge the AMWSC for their time exploring conceptual level supply options and costs.

4.2 Abandon Investigations

The discussions below explain why the following three alternate supply options are not considered viable.

4.2.1 Municipal-Scale Wastewater Reuse

In more and more areas of the world, municipalities are offsetting demands upon their natural water supplies by reusing wastewater. In most cases, the wastewater is reused for non-potable purposes (e.g. irrigation and toilet flushing). In other locations, it is pumped into the ground for aquifer recharge.

In Abbotsford & Mission, wastewater flows to the JAMES wastewater treatment plant. The plant is located on the south side of the Fraser River and west of the Abbotsford-Mission Bridge. On a municipal-scale, it would be an enormous undertaking to re-route the plant's effluent for reuse. Not only would the level of wastewater treatment need to be increased, but the AMWSC would need to install a non-potable pipe network to deliver the water to where it could be used. Considering the plant's location, it makes more sense to withdraw water from the Fraser River upstream of the plant, where less treatment would be required and no secondary pipe network is needed.

On a municipal scale, wastewater reuse is not recommended for further investigation. The AMWSC's Water Efficiency Plan will explore the viability of the concept for individual customers and/or neighbourhoods.

4.2.2 Trucking Water for Peak Days

Trucking water to meet peak day demands has significant health, safety and financial risks. Allowing the system to run low on water causes a loss of pressure in the distribution network, which can lead to water contamination, reduced firefighting capabilities and pipe collapse. Trucking water should be limited to emergency response only.

4.2.3 Connect to Clearbrook Waterworks District

The Clearbrook Waterworks District (CWD) is an independent water system within Abbotsford. The CWD sources water from the Abbotsford-Sumas Aquifer through a series of wells. While there is a courtesy connection to the CWD system for emergency use, the CWD does not have enough excess capacity in its system to supply the AMWSC. There would also be issues with different system pressures should the CWD and AMWSC systems be linked.

CONCLUSIONS

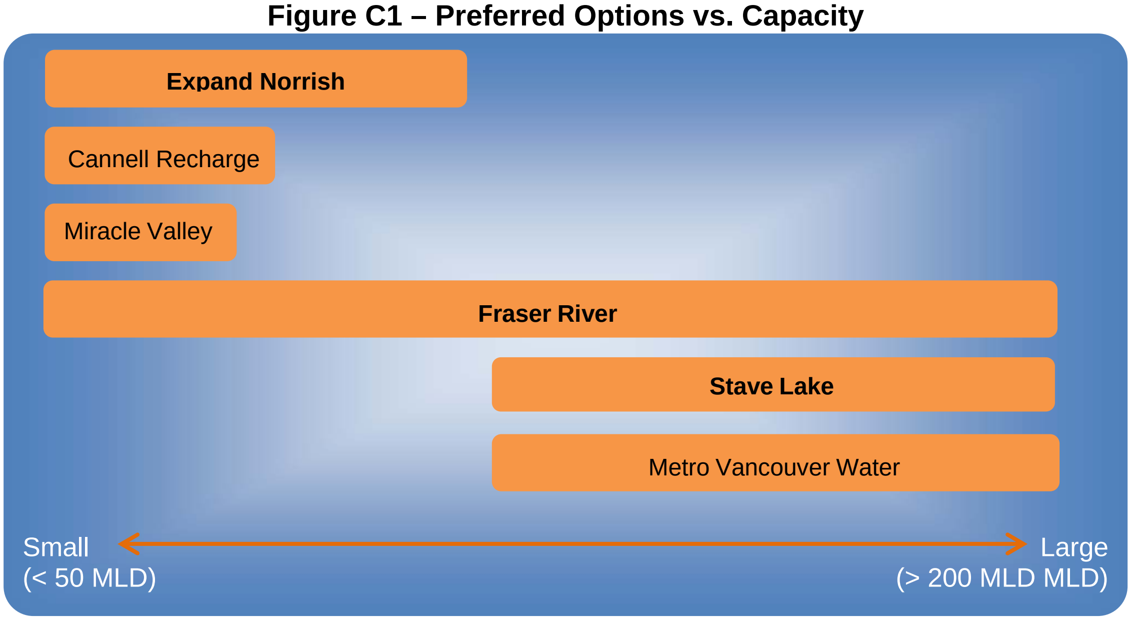
There are several water supply options available to the AMWSC to meet future water demands. However, some of those options are critically flawed and others have sufficient drawbacks to make it questionable whether the AMWSC should invest further resources into investigating their viability. This report has examined supply options in three distinct categories: (i) existing source expansion & infrastructure optimization, (ii) new natural source development, and (iii) alternate supplies. Out of eighteen options considered, six are suggested for further investigation (Table C1).

Table C1 – Stage I Conclusions Summary

Existing Source Expansion	New Natural Source Development	Alternate Supplies
• **Norrish Creek**	• Stave-to-Cannell Lake Recharge • Miracle Valley Aquifer • **Fraser River** • **Stave Lake**	• Metro Vancouver Water

The six preferred options provide the AMWSC with a set potential water supply solutions that span from small to large (Figure C1). However, the AMWSC has allocated a limited budget for the Study; therefore not all options can be short-listed for further investigation. Should the AMWSC maintain the Study budget as is, then Norrish Creek, Stave Lake, and the Fraser River are suggested priorities Stage II's further investigations.

Figure C1 – Preferred Options vs. Capacity



REFERENCES

AECOM, 2010-04. *AMWSC Water Master Plan*.

AECOM, 2010-03. *Stave Lake Water Supply Conceptual Design*.

AE (Associated Engineering), 2008-12. *AMWSC System Optimization Study.*

AE, 2008-12b. Technical Memo. System Pressure Study – Identification of Alternatives.

AE, 2010-06. *Norrish Creek Power Generation Study*.

AMWSC, 2011. 2011 Annual Water Quality Report.

AWWA & J. Hoffbuhr, 2009. *The Truth About Pharmaceuticals & Personal Care Products in Your Water*.

BC Hydro, 2011-08. *City of Abbotsford Water Withdrawal from Stave Lake Reservoir: Operations Modeling*.

CFVRD (Central Fraser Valley Regional District), 1971-04. *Regional Water Supply Study*.

CH2M HILL, 2011-01. *Strategic Plan for Norrish Water Treatment Plant Improvements*.

D&K (Dayton & Knight), 1974-06. *DARD/CFVRD Water Feasibility Study*.

D&K, 1996-08. *1995/96 Update of Master Plan*.

D&K, 2003-07. *Harrison Water Supply Project Description Report*.

D&K, 2003-05. *2002 Update of Master Plan*.

D&K, 2004-01. Matsqui Flats Booster Station Feasibility Review.

D&K, 2006-09. *Master Plan Update*.

D&K, 2009-03. *Water Sampling Program for Water Supply Options – 2008 Annual Report*.

EarthTech, 2004-05. *FVRD Water Source Options Financial Analysis*.

Feltmate, Dr. B and Dr. J. Thistlethwaite. 2012-06. *Climate Change Adaptation: A Priorities Plan for Canada*.

Klohn Leonoff, 1989-08. *Groundwater Supply – Sumas Mountain.*

KWL (Kerr Wood Leidal), 2006-08. *Drought Management & Water Conservation Study*.

KWL, 2008-08. *Water Development Plan for Cannell Lake*.

KWL, 2009-02. *Norrish Creek – Dickson Lake Water Supply Assessment*.

Metro Vancouver, 2011-06. *Drinking Water Management Plan*.

MFLNRO, 2012-05-18, *Letter from Michele Lepitre, Regional Hydrogeologist*.

Piteau Associates, 2004-01. *Assessment of Groundwater Source Options: Abbotsford and Hatzic Valley Areas.*

Piteau Associates, 2007-12. *Hydrogeological Assessment of the Miracle Valley Aquifer*.

Piteau Associates, 2010-02. *Hydrological Investigation for the Bevan Well Field Environmental Assessment.*

Piteau Associates, 2012-04. *Hydrogeological Investigation for Groundwater Supply, Miracle Valley*.

Polis, 2009-08. *Soft Path for Water Strategy for the AMWSC*.

WDP (Western Development & Power), 1959-09. *Summary Report - A Preliminary Engineering & Economic Study of Water Supply in the Fraser Valley*.

Abbotsford Mission
Water & Sewer Services