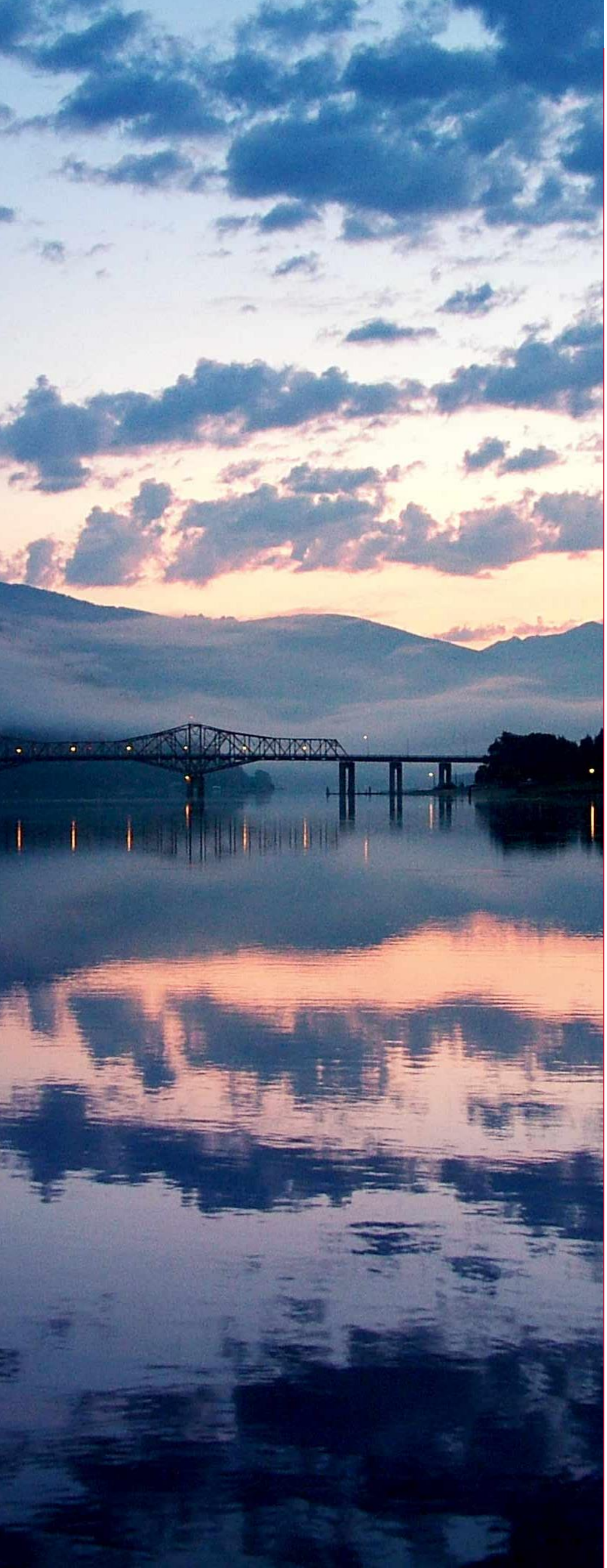

WATER MASTER PLAN UPDATE

Prepared for the City of Nelson

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Executive Summary

This report presents an update of the City of Nelson Water Master Plan of 2007. It provides a summary of the activities that the City has undertaken over the past 10 years, including:

- Undersized and corroded pipe replacements; re-build of pressure reducing stations
- Implementation of a public awareness and education program of water conservation techniques and incentives;
- Location and repair of significant leaks in the distribution network; and
- Installation of a UV disinfection facility at Mountain Station.

The update considers the progress and achievement of goals, the impact of more recent BC legislation, and the impact of climate change.

The analysis concludes that it is most efficient to direct the existing supplementary sources to the central Mountain Station facility for treatment and distribution to the entire City network. The objective is to provide the same quality water to all users and thereby avoid water quality advisories when the supplementary sources are utilized.

Extension of the Anderson/Fell and Selous Creek supply lines to Mountain Station with centralized treatment for all three sources is proposed as a Phase 1 (0 to 5 years) initiative, with an estimated capital cost of $6.4 million. The concept also provides the opportunity to utilize the pressure in the Selous Creek supply line for production of micro-hydro and use this energy to operate the UV disinfection system.

The UV disinfection in concert with chlorination is providing potable water that meets the BC Guidelines for turbidity and microbiological parameters. It will be prudent to set aside land at the Mountain Station site in case filtration is required in the long term.

The second phase (5-10 years) recommends the replacement of the 5-Mile Creek supply pipeline (originally installed in 1925). This installation is estimated as a capital construction cost of $5.2 million (in 2017 dollars). The new transmission line will also afford an opportunity for power generation and a collaboration with Nelson Hydro.

The longer term future may see a combination of high growth and reduced watershed yield from climate change. Therefore some concepts for utilizing Kootenay Lake as a seasonal supplementary source are presented.

The network analysis recommends continuing annual corroded pipe replacements and the addition of a treated water reservoir at the Park Street site. This will balance out the storage for the central part of the city and provide the required fire protection storage. The estimated cost of the Park Street reservoir is $1.6 million.

It is recognized that the utility has aging infrastructure and the City should plan for its replacement over time. An Asset Management Investment Plan (AMIP) is presented which includes a valuation of the existing assets and puts forward an annual investment to ensure the sustainability of the water utility. The annual investment is estimated as $1.5 million.

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1 INTRODUCTION

The City of Nelson Water Master Plan (WMP) was completed in March 2007 and adopted the same year. The past 10 years have seen the implementation of many of the recommendations in the 2007 WMP. The City is now elaborating an update process to assess the effectiveness of actions taken to date, identify what remains to be done, and what additional issues need to be dealt with. The update will articulate a plan for the water utility that will carry the City's water utility into the next 20 years.

It is reported that the 2007 Plan has served the City well, and staff have used it as a guide for implementing many of the recommendations. BC has introduced new water legislation in the intervening years. Some of the more recent water legislation includes:

- *the Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in BC (November 2012),*
- *the BC Water Sustainability Act (May 2014) and Regulations*
- *the Drinking Water Treatment Objectives for Ground Water Supplies (November 2015).*

The City's Official Community Plan (OCP) was also updated in 2012, and provides further guidance for updating the WMP.

The update process will review and expand on the water utility issues examined in the 2007 WMP. It will also bring in new considerations such as the impact of climate change on source water and watershed yields.

Recommendations for developing an Asset Management Plan for the water utility are included. The intent is to refine replacement value and formalize the investment schedule for the utility. It's also common to view a community supply watershed as an "asset" and evaluate the investments required to maintain the integrity and safety of the watershed.

Recommendations on preparation of a Financial Plan are also included. This will investigate potential funding sources from Federal and Provincial Governments, as well as revenue from the water system users.

Public consultation is not included at this time, but may be required if a new source is identified and requires a Water License. All Water License applications require First Nations consultation through a public process.

2 WMP UPDATE METHODOLOGY

The process for the WMP update is expected to fall under the main categories of the 2007 WMP within a "Source-to-Tap" approach. Indeed, the Province of British Columbia adopted the same approach to develop a "*Comprehensive Drinking Water Source-to-Tap Assessment Guideline*" issued in 2010. This Guideline will be applied to the source water and public health considerations. The transmission and distribution network assessment will be updated to reflect current conditions.

The key headings for the WMP Update include:

1. **Source (s) Evaluation**
2. **Water Quality and Treatment**
3. **Water Consumption and Demand**
4. **Potential for Power Generation**
5. **Water Delivery and Distribution**

The following sections provide a brief description of the study activities.

2.1 Source (s) Evaluation

The City has three existing sources: 5-Mile Creek, Anderson Creek (including Fell Creek) and Selous Creek. The primary source is 5-Mile Creek, while the other two creeks are used to supplement as required during drought conditions. These additional sources are being used to supplement 5-Mile Creek, but do not have the capacity to substitute for Five Mile. If Five Mile is lost for any reason (contamination, pipeline failure, or other), the secondary creeks may not supply sufficient water for the entire City. The analysis includes:

- Historical yield of the three watersheds and licensed withdrawals
- The potential for accessing additional sources either on a periodic or full-time basis. The other sources include: Clearwater Creek, Grohman Creek, Apex Creek and Kootenay Lake. These will be examined for the provision of supplementary water as well as the provision of a substitute source should the primary (5-Mile) source be lost for any reason.
- The overall characteristics of the watersheds and associated risks (wildfire, landslides, etc.)
- The condition of the 5-Mile supply pipeline and risk of failure or reduced service level
- The effect of climate change on the watershed yield
- Derivation of "low flow" projections for "drought" years
- The effect of climate change on water quality (flood events and erosion)
- Requirements for developing a comprehensive Source Protection Plan

The parameters for comparison of concepts include:

- Access
- Transmission routing difficulties
- Elevation and resultant pressure
- Licensing requirements
- Reliability of yield under extreme events such as drought
- Watershed risk factors for contamination
- Availability of power and telemetry infrastructure
- Capital and Operating Costs

Upland diversions lend themselves to the development of "small hydro" power generation. As part of the source exploration, it is proposed to investigate the potential for small hydro generation using the pressure available and the projected flows. Power generation relates to the product of pressure and quantity of flow. The quantity can be based on the City's actual consumption, or on a fixed flow with diversion of non-consumptive flow back to the stream. These types of initiatives are known as "run of river" and do not include storage. It will therefore be necessary to identify the potential users and their demand pattern as well as the transmission infrastructure necessary to service them.

2.2 Water Quality and Treatment

Recent BC legislation provides criteria and water treatment objectives for surface water sources and for groundwater sources. The 2007 WMP explored the potential for groundwater as a supplementary source but could find no evidence of a reliable aquifer with sufficient yield.

The approach will be to examine the historical water quality evidence from all existing and potential sources and determine if a strong case can be made to meet the Interior Health filtration exclusion criteria. The legislation is discretionary and leaves some decisions to the Drinking Water Protection Officer (DWPO). Even if the exclusion criteria can be met, the DWPO may still require that the City must provide a concept for future siting and development of a filtration facility.

The water quality and treatment review will also evaluate current technologies that offer appropriate disinfection without filtration and meet the *Microbiological Objectives for Surface Water Systems (2012).* In the case of the existing sources there are historical data on water quality. In the case of additional sources, the data may be scarce and the WMP will recommend a sampling and testing program for any preferred additional source(s).

The WMP will assess the site requirements and suggest preferred location options. It will also consider options for residuals management, and operator qualifications for a filtration plant should it become necessary.

2.3 Water Consumption and Demand

The 2007 WMP provides an analysis of historical consumption patterns in order to develop typical per capita demands under a range of conditions such as maximum daily demand (MDD) and annual average demand (AAD).

The historical data is updated with the City's meter records and with updated populations from the census data of 2006, 2011, and 2016. The previous WMP used the residential population for the derivation of per capita flows. Industrial, Commercial and Institutional (ICI) demands were assumed to be included in the per capita figures since the meter readings came from the overall consumption. Specific meter readings for ICI users were not available at the time. Some ICI customers have installed meters, but not all customers are metered.

The consumption data applied to the overall connected residential population can be considered a reasonably accurate reflection of consumption. This may have changed over the last ten years with the introduction of incentives such as low flow shower heads, toilet tank bags for low flush and other incentives in the City's water conservation program.

Outside use is one of the largest components of the MDD and the City has made efforts to reduce outside water use with staged sprinkling restrictions and public education programs on efficient irrigation techniques.

The other factor contributing to consumption is network leakage. The City has instituted a leak detection and repair program and the program has had a beneficial effect on overall consumption.

2.4 Water Delivery and Distribution

The distribution network has been upgraded on an annual basis since the 2007 WMP with the replacement of corroded pipes, replacement of undersized pipes and looping of mains where possible. The WMP will be updated by highlighting works that have been completed in the intervening years and identifying ongoing network improvements.

The 2007 WMP developed a computer hydraulic model (WATERCAD) of the network. It was calibrated with field flow testing at a number of hydrants throughout the city. The model will be updated to reflect the changes made over the past ten years.

2.5 Asset Management

The Water Master Plan focusses on the major elements of the water utility. The City also wants to include an asset management and investment perspective. This would provide context for the overall utility and the associated costs of capital investments, operation and maintenance, and extending the useful life of the utility's components.

2.6 Financial Plan

The Water Master Plan evaluates investments required to fulfill the water utility's mandate of providing safe and consistent potable water to the residents of Nelson. These investments represent the cost side of the equation. The City will later wish to examine the potential revenue sources to fund the investments.

Funding for utilities comes from the beneficiaries of the utility through user fees and taxes. Additional funding is typically available from senior levels of government under a variety of Infrastructure funding programs. Utility improvement directed at accommodating growth are typically funded by the proponents of growth through a variety of funding mechanisms such as Development Cost Charges (DCC's), developer contribution agreements, hook-up fees, and other approaches.

Sources of funding include:

- User rates and fees
- Taxes
- Development Cost Charges
- Development Agreements
- Reserves
- Grants (Federal/Provincial)
- Municipal borrowing

When making application to senior levels of government for infrastructure funding assistance, it will be necessary to demonstrate that the projects under consideration are for the benefit of the community as a whole with the goal of maintaining public health and an acceptable level of service for a municipal water utility. It will also be prudent to demonstrate that "growth pays its own way" and the resident taxpayers are not being asked to contribute to speculative ventures.

2.7 Public Consultation

Water Master Plans are often subject to public scrutiny and the City may wish to elaborate a public consultation process. There are five levels of public consultation typically available:

- Inform level – keeping residents informed
- Consult level – listen to and acknowledge concerns and provide feedback
- Involve level– work with stakeholders to address issues
- Collaborate level – look to stakeholders for direct advice in formulating options and solutions
- Empower level – implement proposals from stakeholders

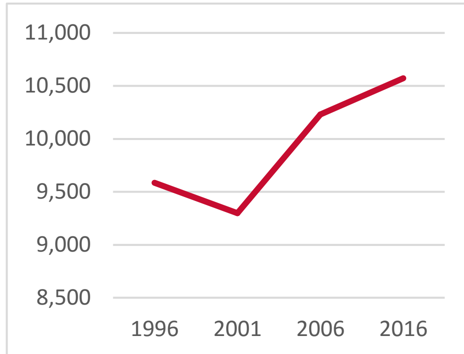
At this stage, the "Inform level" is considered adequate. If a Water License is required to develop a new water source, the Water Rights circulation protocol requires that the application be subject to First Nations consultation and public notification.

3 CITY WATER DEMANDS

3.1 Updated Population and Water Consumption Data

A summary of the population data from 1996 to 2016 Canada Census is presented below:

Year	*Population*
1996	9,585
2001	9,298
2006	10,230
2016	10,572



The permanent population over the past 20 years has increased by approximately 1,000 people, representing an average annual growth rate of 0.5% per year. Population patterns dating back to 1956 indicate an increase of 3,800 people over 60 years, or the equivalent of an average annual growth rate of **0.6% per year.** A notable growth "spurt" occurred between 1961 and 1966, with an increase of 2400 people over 5 years (average of 6% per year).

The planning horizon for key elements of the water utility such as the transmission, storage and distribution network should be at least 50 years. If a long term growth rate of 0.6% per year is adopted, the 2066 population is projected as approximately 14,500. This is close to the estimated "build-out" population of 15,000 that was projected in the 2007 WMP. The "build-out" is an estimate of what could reasonably be accommodated within the current City limits under the provisions of the OCP. Therefore, the adoption of the 15,000 population horizon is appropriate for long term planning.

3.1.1 Updated Water Consumption Data

The City has accumulated consumption data and sewage flow data for the years 2008 through 2016. Previous data were available from the 2007 WMP. The City also provided daily consumption figures for 2016.

One of the useful correlations for water utility planning is to link the consumption to the population. Table 3.1 provides a summary of the consumption rates divided by the population on census years.

Table 3.1 – 20 Year Water Consumption Summary

Year	Census Pop.	Winter Avg.		Winter Max.		Summer High Monthly		Summer Max. Day	
		ML/d	L/c/d	ML/d	L/c/d	ML/d	L/c/d	ML/d	L/c/d
1996	9585	7.1	740	8.7	908	14.5	1513	18.6	1940
2001	9298	6.7	720	8.4	906	10.9	1172	13.9	1495
2006	9258	6.5	702	7.6	821	9.0	972	11.5	1242
2011	10230	5.8	567	7.2	704	9.0	880	11.9	1163
2016	10572	5.4	511	6.8	643	7.4	700	8.0	757

Discussion Notes:

1. The Winter Average Demand and the Winter Max Day Demand

These data represent the “inside use” through the months of October through April (7 months) when there is typically minimal outside use. The data are expressed in million Litres per day (ML/d) and Litres per capita per day (L/c/d).

The Winter Max Day figure is the most appropriate for source, treatment and distribution planning since this is likely to occur over an extended period through the non-irrigating months.

Table 3.1 shows a marked decrease in winter maximum consumption rates over the 20-year period (1996-2016). Although population has increased, water consumption has decreased, indicating a lower per capita consumption. This is likely attributable to the City’s efforts at educating residents and promoting water conservation, as well as regular leak detection and repairs.

Over the 20-year period (1996-2016) per capita demands for Winter Max Day dropped from over 900 L/cap/day to under 650 L/c/d. The recommended “inside use” long term per capita allowance in the 2007 WMP was 660 L/c/d.

The comparison with sewage flows is complicated by the influence of inflow and infiltration in the sewer system during wet weather or snowmelt. The autumn months of October/November typically exhibit both low rainfall and low yard sprinkling. Figure 3.1 provides a plot of water consumption and sewage flows for the years 2011 and 2016. The autumn month comparison shows a coincidence in the 5-6 ML/d range.

There appears to be a reasonable correlation between “inside use” for water and dry weather sewage flows. The analysis shows that 660 L/cap/d is a realistic figure to use for future demand projections. The “build-out” projection for inside use is 660 Lcd x 15,000 people = 9.9 ML/d.

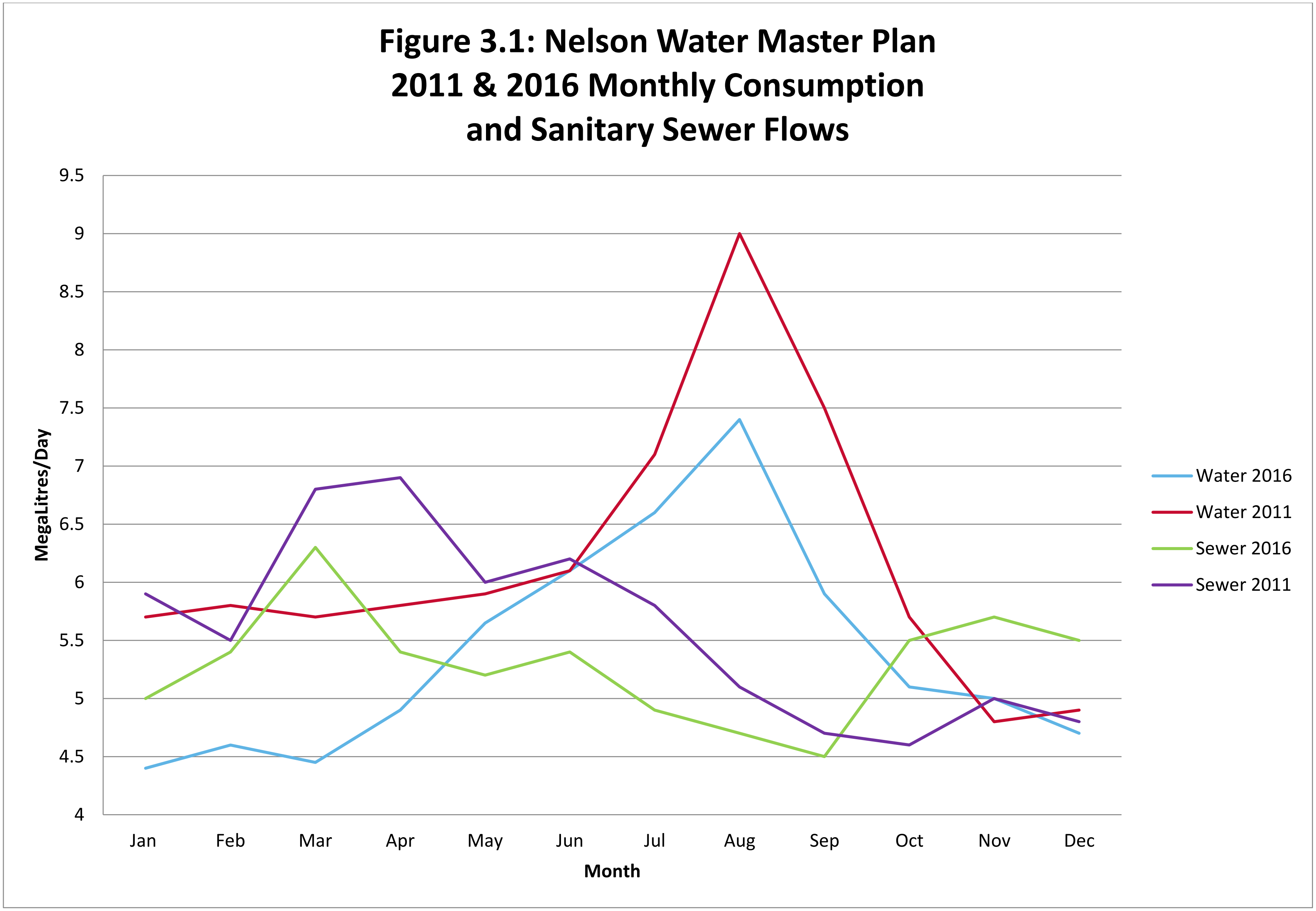


Figure 3.1: Nelson Water Master Plan
2011 & 2016 Monthly Consumption
and Sanitary Sewer Flows
MegaLitres/Day
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Water 2016
Water 2011
Sewer 2016
Sewer 2011

2. The Summer High Monthly Demand and Summer Max Day Demand

The average monthly consumption in Nelson is highest during the months of June, July and August. The summer Max Day Demand is the single highest day's consumption. The daily records for 2016 demonstrate the following:

Month	Daily Average (ML/d)	Highest Day (ML/d)
June	6.22	7.99 (June 7)
July	6.73	7.61 (July 25)
August	7.40	7.51 (August 17)

The data for previous years demonstrate higher monthly demand averaging 9 ML/d, further evidence that per capita consumption has decreased in both winter and summer.

The consumption data for the period 1996 to 2016 are plotted on Figure 3.2, expressed as per capita demand in Litres/day. The plots depict the winter average and winter maximum (representing inside use), and the summer monthly average and max day demands.

The comparison reveals some interesting patterns over the 20-year period:

a) The "inside use" average consumption decreased from 740 to 511 L/c/d over 20 years
b) The winter max day consumption decreased from 908 to 643 L/c/d over 20 years
c) The summer high monthly consumption decreased from 1513 to 700 L/c/d over 20 years
d) The summer max day consumption decreased from 1940 to 757 L/c/d over 20 years

Summer demands are also influenced by visitor population, which is not part of the census. If the City has data on seasonal visitation, the effect of visitation can be determined in more detail. The selection of a design figure for summer per capita demand is influenced by the apparent steady decrease in summer demands. The 2007 WMP suggests using a per capita demand figure of 1300 L/c/d based on the records from 1996 to 2006. However, the last 10 years show a notable decrease in per capita consumption during summer months (approximately 30%). It is suspected that this is due to a significant effort by the City to educate residents and promote water conservation as well as a rigorous leak detection and repair program. It therefore appears reasonable to project a reduced per capita summer MDD demand of 1,000 L/c/d.

3. Recommended Demands for Long Term Planning

The foregoing data analysis indicates that the City's efforts towards reducing water demands over the past 10 years have yielded positive results.

The recommended per capita demands to be used for long term planning are:

Winter MDD; 15,000 people @ 660 L/c/d = 9.9 ML/d (round to**10 ML/d**)

Summer MDD: 15,000 people @ 1,000 L/c/d = **15 ML/d**

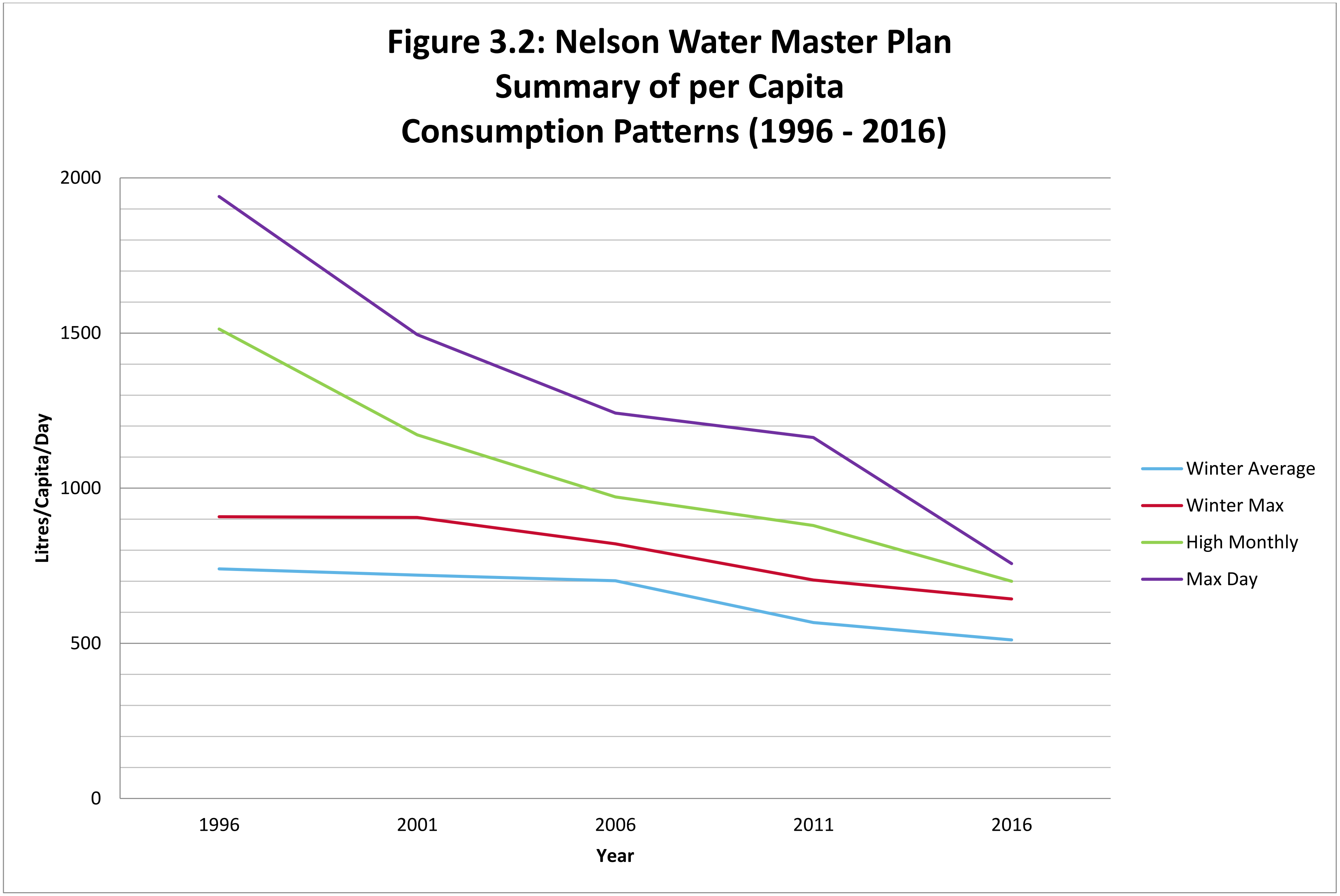


Figure 3.2: Nelson Water Master Plan
Summary of per Capita
Consumption Patterns (1996 - 2016)
2000
1500
1000
500
0
Litres/Capita/Day
1996
2001
2006
2011
2016
Year
Winter Average
Winter Max
High Monthly
Max Day

4 SOURCE EVALUATION

4.1 Existing Sources

4.1.1 Five Mile Creek

This has been the City's primary source since 1925. It continues to provide reliable high quality water, but questions have been brought up related to potential risks:

a) What is the risk of insufficient water supply during drought events; what is the maximum delivery capacity of the supply main; what is the maximum allowable diversion under the current license?
b) What is the risk of temporary loss of supply requiring a standby source?
c) Does climate change affect the frequency and severity of drought?

With respect to the first question, historical yield data and hydraulic calculations show the following:

Flow	Million Litres/Day
Summer low flow (8 years of records)	19.7
Winter low flow (8 years of records)	6.2
Estimated 50-year summer low flow	10.4
Diversion License	16.8
Supply Pipeline Capacity	11.4

By comparison, the projected winter and summer water demands (MDD = Maximum Day Demand) for the "build-out" scenario are:

Population	Winter MDD	Summer MDD
15,000 (0.6%/yr)	9.9 MLd	15.0 MLd

The following becomes apparent when comparing supply versus demand:

The winter supply is limited by the Creek winter flows (lowest creek flows occur in winter). The forecast winter MDD for 15,000 people is higher than the 50-year return winter flow.

The summer MDD is limited by the pipeline capacity and Creek low flow. The summer MDD for 15,000 people is higher than the Creek 50-year return summer flow.

4.1.2 Available Supplementary Sources

Three additional creeks are currently connected to the system: Anderson Creek with Fell Creek, and Selous Creek. During a 50-year recurrence drought condition, they can supply an additional summer flow of 3.0 MLd. The available supplementary flow in winter is 0.6 and 0.5 MLd respectively for a total of 1.1 MLd.

These supplementary sources come close to making up the summer and winter shortfalls depending on what growth rate is chosen. In a severe drought situation, outside water use can be disallowed completely, and the MDD would reflect inside use only. In that instance, the 50-year summer low flow would be sufficient to meet indoor demand. There may still be a shortfall for winter MDD during a severe event.

Another method of making up a source deficiency is with storage. Storage could be constructed with an on-line impoundment or an off-line impoundment. An approximation of the required storage can be derived from the difference between the creek low flow and the City's projected demand. For the drought year condition this is 7 MLd for a period of approximately 3 months, or 630 ML (630,000 m^3). For example, a 10m high dam would have to flood an area of 63,000 m^2, or 6.3 hectares.

Construction of such an impoundment would require a series of government reviews and public consultation exercises. Given the terrain and the Provincial Park designation in the Five-Mile Creek watershed, this option would be extremely difficult to implement.

4.1.3 Anderson/Fell Creek Discussion

Anderson Creek and Fell Creek are currently used to supplement water supply when demand warrants. The intake on Anderson Creek is disinfected with gas chlorination and connected to the distribution network servicing Zone 3 and Zone 4. This source can provide supplementary water, but is not sufficient to act as a substitute for 5-Mile Creek since the yield is much smaller, and it only services Zone 3 and Zone 4 of the network.

The relative parameters for Anderson and Fell Creeks are:

Creek	Drainage Area (km^2)	License (ML/d)	50-year low flow (ML/d)
Anderson	9.1	6.8	1.5
Fell	4.4	6.8	0.7

The licensed diversion could provide up to 13.6 ML/d, but this flow is typically not available during the summer. The recorded flows in Anderson and Fell during the summer months are:

- Combined Mean low flow: 5.4 ML/d
- Combined Extreme low flow: 2.2 ML/d

Chlorination alone does not meet the current Interior Health requirements for water quality and does not provide sufficient microbiological barriers. The applicable Regulation is: *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia, November 2012.*

The Fairview Reservoir also services Zones 3 and 4 of the distribution network and is filled from a transmission main from the Mountain Station facility. This water is treated with gravity sedimentation (Mountain Station raw water pond), UV disinfection and chlorination.

4.1.4 Selous Creek/ Cottonwood Creek Discussion

The Selous Creek intake connects to the distribution network at the Stibbs PRV site. The intake is at elevation 859 m so it can service all pressure zones. Cottonwood Creek is not connected to the system, but a potential connection has been explored. A gravity diversion with an upland intake would involve in the order of 2100 m of transmission pipe located on the Old BNR railbed. A pumped diversion would involve a high lift pump station and approximately 800m of supply main.

The Selous Creek supply pipeline can be extended to Mountain Station via the old BNR rail bed. It would require in the order of 2400 m of pipe to extend to Mountain Station. This water would enter the Mountain Station treatment facility to be treated along with 5-Mile Creek water.

The approximate yields of Selous and Cottonwood Creeks are:

Creek	Drainage Area (km^2)	License (ML/d)	50-year low flow (ML/d)
Selous	14.5	4.5	1.6
Cottonwood	9.0	2.5	0.9

The gravity diversion of Cottonwood Creek would require an investment of approximately $2 million. The water quality of Cottonwood is unknown, so long term sampling is required to determine the value of pursuing this initiative. Cottonwood Creek is also subject to some risk from potential spills on Highway 6.

The Selous Creek supply is currently used periodically to supplement supply. It has a chlorination facility and feeds into the system at the Stibbs PRV site. It is capable of servicing Pressure Zones 2, 3 and 4. The water treatment of Selous Creek does not meet the 2012 Objectives, so further treatment would be necessary. UV disinfection could be added at the current treatment site, but this would not deal with turbidity issues.

The extension of the Selous supply line to Mountain Station would provide sedimentation, UV disinfection and chlorination.

4.2 Potential Additional Sources

The potential additional sources that have been identified are:

Clearwater Creek and Grohman Creek have relatively large watershed areas with a similar yield per unit area. Both can be accessed in their upper reaches and can connect to the City's supply infrastructure by gravity.

4.2.1 Initial Observations on Clearwater Creek

- The drainage basin feeds Ymir Creek and the Salmo River. Since a diversion would supply only the municipal water utility, it will not likely be considered an inter-basin transfer. However, downstream communities on the Salmo River would need to be consulted and any impact on downstream water users would need to be assessed.
- The City had a License on Clearwater Creek (#6864) for diversion of up to 5,250,000 Imp gallons/day (23.8 MLd). This License was cancelled in 1997.
- A new Water License application will require circulation to users and stakeholders.
- There is an active ski hill in the watershed, presumably with on-site wastewater management. This presents a risk to a domestic water supply.
- The watershed should be designated a community watershed and a watershed protection plan undertaken.
- The intake and diversion can be located at an elevation that would allow gravity flow to Mountain Station.

- Water quality at Clearwater Creek has not been monitored and this would be required over at least one year. The supply line from a Clearwater Creek intake could tie into the supply line from Selous Creek. Pressure limitations and capacity would need to be verified.
- The estimated 50-year summer low flow is 11.6 MLd and winter low flow is 4.3 MLd, so Clearwater Creek can not only supplement Five Mile Creek, it can substitute if there is a total loss of Five Mile Creek supply.

4.2.2 Initial Observations on Grohman Creek

- Grohman Creek is on the north shore of Kootenay Lake and flows directly into the Lake. It is not known at this time if there are any licenses downstream of a potential intake.
- The Water License application will involve circulation to users and stakeholders.
- The level and extent of industrial and recreational activities in this watershed needs to be determined.
- The intake and diversion should be located downstream of the junction with Baldface Creek in order to optimize capture. This elevation is approximately 1,000 m and is sufficient to reach the Mountain Station facility.
- The supply line from Grohman Creek will need to cross Kootenay Lake. This can be an underwater crossing or a pipe suspended on the bridge. A submarine crossings will require reviews by numerous provincial and federal agencies. A pipeline on the bridge will require review by BC MOTI
- It is preferable to pipe this supply directly to Mountain Station, since the distribution network is configured to supply treated water from that location. Supplying water from the bottom part of the system (Zone 4) will not service the upper zones due to one-way pressure reducing stations between the pressure zones. Treatment can also remain centralized at the Mountain Station site.
- The estimated 50-year summer low flow is 21.6 MLd and the winter low flow is 8.4 MLd, so Grohman Creek can not only supplement, but can substitute for Five mile Creek if there is a total loss of supply.
- Water quality on Grohman Creek will need to be determined with a full year of sampling and testing

4.2.3 Initial Observations on Kootenay Lake

- The supply quantity from Kootenay Lake is sufficient to both supplement and substitute when necessary.
- The City has an irrigation license on Kootenay Lake for 17.5 acre-feet (21.6 ML) per year, or through an irrigating season.
- The water quality in Kootenay Lake requires sampling and testing. Other utilities further upstream (e.g., Balfour, Ainsworth) are using Kootenay Lake successfully. Some monitoring was undertaken in 1997/1998 and again in 2005/2006. Both were relatively short –term sampling periods, but indicated that this water is generally of good quality with turbidity typically below 1.0 NTU and meeting the Guidelines for Canadian Drinking Water Quality (GCDWQ). The exception is the Trihalomethane Formation Potential (THMFP) which is above the GCDWQ maximum acceptable guideline.
- Kootenay Lake source will require pumping. The question of whether to pump only to the lower Zone 4 or to the Mountain Station facility needs to be evaluated.
- Pumping into the Five Mile supply line to the Mountain Station facility will service all pressure zones and access the treatment facility at Mountain Station. Pumping into Zone 4 will only service Zone 4, and require a treatment facility near the lake intake pump station.

5 POWER GENERATION OPPORTUNITIES

5.1 Power Generation Opportunities

Power generation from the use of an in-line turbine is possible. The power generation potential relates to flow and pressure in a pipeline. This power generation approach is referred to as "run-of-river". Power is made in accordance with the flow and pressure available in the pipeline. In effect, the turbine can be visualized as a pump running backwards. The generation potential formula is:

Power (kW) = (Flow (L/s) x Pressure (kPa)/1000) x efficiency (0.6)

Electrical energy cannot be stored, so the storage must be provided in the water. Hence when water is impounded with the use of a dam, water can be released through the turbine in accordance with energy demand. The geography in the areas of the water sources does not lend itself to any significant impoundment, so the power generation concept would likely fall in the "run-of-river" category.

The Five-Mile pipeline is not suitable for power generation since the pipe jointing system is designed for relatively low pressure. The pipeline has numerous pressure "break" tanks that spill any excess flow in order to keep pressures low. These overflows at the break tanks can harness some energy by running through a turbine. However, the infrastructure required and transmission lines to where the power can be used, do not yield any benefit with fractional power production at several remote sites.

The City commissioned Associated Engineering Ltd in 2011 to complete a report on Hydropower Feasibility Assessment. Two of the "run-of-river" opportunities included:

Grohman Creek	Clearwater Creek
Intake at 1,000 m, it is advantageous to locate the turbine at 550m (near Kootenay Lake), yielding an available pressure of 450 m (640 psi/4414 kPa). The winter low flow is 8.4 MLd, or 97 L/s. The potential power generation is 257 kW. The summer flow (30 MLd) yields much greater potential power at 920 kW. It should be noted that a pipeline operating at 640 psi requires special materials and jointing (high pressure steel with welded joints) and the costs will be significantly higher than normal municipal pressure pipe ratings of 150 and 250 psi.	Intake at 1,030 m, turbine location at 800m (near Mountain Station); available pressure: 230 m (328 psi/2260 kPa). The winter low flow in Clearwater Creek is 4.3 MLd, or 50 L/s. The potential power generation is 68 kW. The summer flow (17.6 MLd) yields greater power potential at 276 kW. It should be noted that a Clearwater diversion for the purpose of power generation may be considered an "inter-basin transfer" if that water is spilled into another watershed.

For either source, the design of the water diversion for power generation can be configured to relate directly to domestic water consumption. That is, the power generated relates directly to the consumption rate. However, the daily and seasonal variation in consumption rates results in inconsistent power generation. It is often more effective to design the pipeline for the power generation function with a consistent flow through the turbine, and divert "post-turbine" water to either domestic consumption, or spill to the waterway.

The Associated Engineering report also states that small power generation is achievable at the City's numerous Pressure Reducing Stations. These devices utilize the energy dissipated in pressure reduction to generate power. This is typically low wattage and could run from 200 watts to 800 watts depending on the flow and level of pressure reduction. The power is typically used in the vicinity of the station.

5.2 Discussion

The use of Grohman Creek as a supplementary or substitute water source will involve a very high pressure pipeline since it must come to Lake level. Not only does this incur high material costs for pipes, valves and fittings, but special measures in operation and maintenance procedures are required when dealing with pressures in the 500-600 psi range. Municipal crews are typically trained and familiar with system pressures in the 150-250 psi range.

This creek provides the highest predicted water supply even on drought years. At over 80 km^2, it has the largest watershed of any of the creeks under consideration. Its location, however, presents significant impediments to its development as a supplementary or substitute source.

A Clearwater Creek concept results in a similar hydraulic profile to the Five-Mile Creek supply main. This source has an advantage in that it can be connected to the current Selous Creek supply main, reducing the overall length of new construction. In such a concept, the pressure would require reduction prior to the Selous inter-connection.

If the supply line is developed as a high pressure main, it has potential to generate hydroelectric power. Likely the best location for power generation is at the Mountain Station site. In that scenario, the pipe would run directly from the Clearwater intake to Mountain Station and utilize a higher pressure rated pipe. The power generated could be used at the treatment facility.

The 2011 Associated Engineering report concludes with recommendations to pursue three potential energy generation opportunities:

- Hall Street PRV energy recovery
- Selous Creek diversion
- Grohman Creek “Run-of-River” project

Generation Opportunity	Notes
Hall Street PRV	Investment (2011 $) is estimated at $253,440. Power production is estimated at 186,670 kw-hrs /yr. The BC Hydro Standing Offer Program is currently in abeyance, however, a savings estimate can be made on the basis of $0.08/kw-hr, yielding approximately $15,000 per year. Debt repayment on $253,440 over 20 years at 3% per annum is approximately $17,000/yr. The business case for Hall St. PRV conversion is not strong. If a more accurate estimate of power generation based on actual flow reveals that a greater amount of kw-hrs can be generated the revenue could exceed the financing cost.
Selous Creek Diversion	The Selous Creek Option 1 diversion involves “flow in the existing 400 mm supply main from Selous Creek would be diverted to Cottonwood Creek via approximately 300 m of new pipe> The diversion would be located upstream of a throttling valve at the top of Stanley St.”. The design flow is 260 L/s; the net head is 190 m, and the generation capacity is 388 kW. The projected annual production is 765,080 kW. The projected annual revenue (expressed as avoided cost) is $32,439/yr. The estimated capital cost is $1,299,000. Financing $1,299,000 over 20 years at 3%/annum incurs an annual cost of $87,300.

	The report recommends that a pre-feasibility study be undertaken to establish a conceptual arrangement. The City could also consider a more modest investment by locating the power generation facility at the Mountain Station location. This achieves a net drop of 50m and the flow in the 400 mm diameter pipe would, on average, be up to the licensed amount on Selous Creek (4 ML/d, or 0.046 m^3/s. This combination could produce in the order of 20 kW. This level of power could be used locally to operate the UV and chlorination system.
Grohman Creek "Run-of-River" project	This is a large scale run-of-river concept, estimated at a capital cost of over $33 million, resulting in a financing cost of approximately $2.2 million per year. The estimated revenue (expressed as avoided cost) is $1,137,000 per year. The report recommends that the City commence investigation of Grohman Creek with hydrological flow recording. From the perspective of a supplementary or substitute water supply, this option would only be considered if there is a strong business case for the run-of-river power project on its own merits. Water supply from this source adds further complexity. If water is supplied only into Zone 4, it will not service the higher Zones 1, 2 and 3. The system piping and PRV's are designed to feed from the top down. If a direct line to Mountain Station reservoir is constructed, the pressure at lake level will be in excess of 600 psi, outside of typical municipal water system pressures.

The Associated Engineering report also considers Clearwater Creek for a "run-of-river" project, but does not put it on the list for further study. Clearwater Creek has a large watershed and could act as a supplementary or substitute source. Flow from both creeks would provide both a supplementary and substitute source directed to Mountain Station. However, it can be appreciated that there are some downstream impacts to construction of an intake on Clearwater Creek. Since the creek currently flows into the Salmo River, one of the potential impacts is on fish. Accordingly, an opinion was solicited from a fisheries biologist.

The biologist observations include the following:

- Fish observations include Bull Trout, Rainbow Trout and Eastern Brook Trout. "All fish observations in Clearwater Creek have been downstream of a fish migration barrier (MOE 2016) that is located approximately 6.5 km upstream of the confluence with the Salmo River."
- "Bull Trout are a blue-listed species in BC. The conservation status for the Salmo River Bull Trout population is ranked as a 'high risk of extirpation', which is the most serious category of risk."
- "Clearwater Creek contains critical habitats for the imperiled Salmo River watershed Bull Trout population. Changes to the quality, access and amount of habitat pose a potential impediment to a Clearwater Creek diversion because of the risk to the Bull Trout population.
- The biologist also advises that the Bull Trout population is present year-round, so even periodic diversions would likely have an impact.

The re-licensing of Clearwater Creek for municipal water supply would require hydrological and environmental studies to demonstrate that any proposed diversion and reduction of flow in the Salmo River would not impact the Bull Trout habitat.

6 SUPPLEMENTARY SOURCE CONCEPTS

6.1 Loss of Source Scenarios

The supply from Five Mile Creek can be lost for a significant period from any of the following events:

a) Pipeline collapse from slope failure or other natural event (the pipe is constructed overland on a very steep slope)
b) Water contamination from erosion and slides
c) Water contamination from forest fire, spills
d) Mountain pine beetle impacts
e) Climate change impacts

Any loss of source event for an extended period (i.e., long enough to repair the pipeline, or clean up a spill) should make provisions for activating a standby source. If the loss occurs in summer, the projected build-out MDD requires 15 MLd. This is not achievable with Anderson and Selous Creeks alone. Even if outside use is completely disallowed, the inside use MDD of 8-9 MLd is still not achievable with Anderson and Selous Creeks.

The analysis shows that in the longer term, development of an additional source will be prudent from both a supplementary water perspective and a substitute source perspective. The potential additional sources are described below.

A comparison of several supplementary/substitute water sources follows.

6.1.1 Concept 1: New Supply Pipeline from 5-Mile Intake

The 5-Mile Creek source is licensed for up to 16.8 ML/d. The long term MDD projection for the city is 15 ML/d including yard sprinkling. The long term inside use projection is 10 ML/d. Therefore, if appropriate sprinkling restrictions are in place, the License will provide sufficient water.

The historical summer low flows in 5-Mile Creek are 37.5 ML/d for an average year and 19.7 ML/d for an extreme drought event. These could further reduce by 15% due to climate change. The carrying capacity of the existing pipe is 11.1 ML/d and this represents the main constriction for provision of additional water in the long term.

The 2006 corrosion testing of this pipeline revealed that corrosion was not evident and is not expected to be an issue for the short term. Notwithstanding, a new pipeline should address the other concerns.

A new supply pipeline for 5-Mile Creek could deal with several issues:

- Ability to deliver water at a higher rate
- Ability to sustain higher pressure to allow some power generation
- Located and installed in a more accessible corridor and away from potential slope failure

A pipe size of 400 mm diameter can carry the long term MDD at a reasonable velocity of 1.5 m/s. The static pressure from the existing intake to Mountain Station is (1100m-800m) 300m, or 426 psi. A high pressure pipeline can be used, or pressure can be reduced with PRV's at appropriate locations.

A suggested route for the pipe is along the gravel access road to the intake. This road is accessible for excavating equipment and provides vehicle access to air valves and other appurtenances. It appears to have a registered RoW within the Regional District of Central Kootenay (RDCK).

If a high pressure pipeline is used, the pressure at the Mountain Station site will be static of 426 psi and a dynamic of 380 psi at MDD rate. On a yearly average it could produce in the order of 250 kW at the Mountain Station site.

6.1.2 Concept 2: Kootenay Lake Intake

The City currently has a License on Kootenay Lake for 17.5 acre-feet for the purpose of “watering” (License # C116233). It is assumed that “watering” refers to irrigation of City park areas. This is a small quantity, but it can be anticipated that a License to withdraw water for municipal purposes can also be available.

Assuming that a License can be obtained, three potential configurations can be considered:

1. Pump into the Zone 4 network: this services the lakeshore zone only, with an estimated demand of 40% of MDD. The static lift to the Hydraulic Grade Line (HGL) of 640m is 110m.
2. Pump to the Fairview Reservoir (services Zones 3 and 4, or 60% of MDD. The Fairview reservoir has a top water level of 702m, so the lift would be 172m above the lake level of 530m.
3. Pump to Mountain Station; this services the entire city from a reservoir level of 802 m; the static lift from the lake level is 272m.

A summary comparison table follows:

Configuration	Pump rate (L/s)	HGL (m)	Pump (HP)	Intake (mm)	Forcemain (L-dia)
#1 (to Z4)	46	130	100	350	600m - 300mm
#2 (to Fairview)	70	190	200	400	1500m - 350mm
#3 (to Mtn Stn)	116	290	530	450	2700m - 400mm

Configuration #1 is suitable as a supplementary water source when the flows from the upland sources are not sufficient to meet MDD. As a temporary supplementary source, it will require appropriate disinfection at the intake pumphouse location. Long term sampling could indicate that it may also require filtration.

Configuration #2 is also suitable as a supplementary source, but could service a larger part of the city. It will also need disinfection or filtration.

Configuration #3 provides a dedicated supply line to Mountain Station, so this would provide not only supplementary water for drought events, but could substitute for the loss of the upland sources and supply the entire city when required. Treatment would be achieved at the Mountain Station treatment facility. This configuration results in a very high installed power requirement, but full power would only be used during source loss events.

6.1.3 Concept 3: Addition of Apex Creek

The initial exploration reveals that diversion of Clearwater Creek will be difficult to achieve because of the fishery concern. Diversion of Apex Creek may have less impact but would require the appropriate hydrological study and determination of the impact of diversion on the fishery.

Apex Creek could potentially add 3.4 ML/d to the system during a 50-year return period drought. If this is used in conjunction with the other existing connected creeks (Anderson, Fell, 5-Mile, and Selous). Connection of Apex Creek will require an intake structure and approximately 9,000 m of pipe to connect to the Selous Creek system. The pipe size is 300 mm diameter.

6.1.4 Concept 4: Reduce Demand

It was previously estimated that the 50-year low flow for the existing licensed sources is:

Creek	50-Year Low Flow (ML/d)	
	Winter	Summer
Anderson	0.6	1.6
Fell	-	-
5-Mile	4.1	10.4
Selous	0.5	1.6
Totals	**5.2**	**13.6**

The 2007 WMP used the 2006 census population of 9258 to develop per capita consumption estimates. A further census occurred in 2011, indicating a resident population of 10,230. The 2016 Census data indicates a population of 10,572. The 2011 water consumption records show the following:

- The inside use (winter, fall) show an average consumption of 5.6 ML/d, or 547 L/c/d. Using a peaking factor of 1.2 yields an inside use MDD of 660 L/c/d (the same as the previous estimate).
- The summer high month usage is in August at an average of 9.0 ML/d, or 13.5 ML/d with a 1.5 peaking factor yields a Maximum Day of 1300 L/c/d - no change from the 2006 estimate

The City's population growth from the period 2006 to 2011 was 10.5% over 5 years, or approximately 2% per year. If a more modest long term growth rate of 1% per year is adopted, the 30-year population (2046) is 13,800. The 2007 WMP estimated the "build-out" population within the City boundary at approximately 15,000.

Adopting the foregoing unit rates, the forecast demands are:

	2046	Build-out (2060)
Population	13,800	15,000
Inside Use MDD (660 L/c/d)	9.1 ML/d	9.9 ML/d
Summer Use MDD (1000 L/c/d)	13.8 ML/d	15.0 ML/d

The round figures adopted in the WMP for long term demand **are: 10 ML/d for inside use and 15 ML/d for summer MDD.**

It is evident that if summer outside use is strictly forbidden during a drought year, the existing creeks can deal with the inside use.

Winter creek flow during a drought year is significantly less than summer flow and the inside use would need to be reduced to 5 ML/d. This represents a reduction of almost 50%. While it is recorded that efficient water fixtures such as toilets and faucets can reduce overall consumption by up to 20%, it is unlikely that a 50% reduction could be achieved.

Even with the best efforts at demand management, a supplementary source would still be required for the long-term demand in the winter months.

6.2 Initial Conclusions:

- 5-Mile Creek is the City's best primary source
- The supply pipeline is at low risk of damage from corrosion, but is at risk of structural damage from slope failure
- The pipeline is not rated for high pressure
- The supply pipeline is undersized for the long term forecast MDD
- Replacement with a larger high pressure pipeline would address the capacity shortfall and damage risk as well as provide an opportunity for power generation.
- The diversion of Clearwater Creek has serious difficulties with approvals due to the fish resource requirements.
- The diversion of Apex Creek may have potential for approvals. It can provide a nominal supplementary flow, but it does not yield sufficient water to act as a substitute source.
- Kootenay Lake can be considered for a supplementary source limited to Zone 4, or Zones 3 and 4 if pumped to Fairview reservoir. It can be a complete substitute if pumped to Mountain Station
- The Kootenay Lake source will require significant connected power to pump to Mountain Station.

6.3 Disinfection and Filtration

The City currently practices sedimentation and disinfection by means of Ultra-Violet irradiation and chlorination. Interior Health has suggested that all surface water supplies should be filtered, but have also provided a set of criteria for exclusion of filtration. These criteria can be briefly stated as follows:

1. 4-log inactivation of viruses and 3-log inactivation of protozoa with a minimum of 2 disinfection processes.
2. Provision of background levels of Cryptosporidium and Giardia
3. Watershed control program expressly intended to minimize contamination (source-to-tap modules)
4. Not more than 10% of raw water E.Coli samples exceed 20/100mL in any 6-month period
5. Not more than 10% of raw water total coliform samples exceed 100/100 mL in any 6-month period
6. Turbidity (prior to disinfection) does not exceed 1 NTU for 95% of the time in any 30 day period
7. Peak turbidity does not exceed 5 NTU for more than 2 days in a 1-year period
8. Average annual total Trihalomethanes do not exceed 0.10 mg/L

6.4 Supplementary Sources

The assessment shows the 5-Mile Creek will continue to be the City's best primary water source for the long term. However, the age and size of the 1925 supply line indicate that it should be replaced with a new larger pipe located in a more accessible corridor. The assessment also indicates that in order to make full use of the available supplementary sources (Anderson and Fell Cree and Selous Creek), these sources should be integrated into the supply system for treatment.

6.5 Anderson/Fell Creek Integration

It is possible to modify the current intake and provide treatment at the Fairview site. The main components would include:

- Renovation of the intake structures
- Provision of UV contactors

- Renovation of the chlorination facility
- Low lift pumping to the Fairview reservoir

This concept has several limitations.

- It would provide water to Zones 3 and 4 only, and would be considered “supplementary” to 5-Mile Creek, not a “substitute”.
- There is insufficient room for a settling pond at the Fairview site. Treatment with double barrier disinfection does not deal with high turbidity events, and filtration may become a requirement
- The concept would result in operation and maintenance of two treatment facilities.

An alternate concept would provide high lift pumping to the Mountain Station facility. The concept includes construction of a new high lift station and installation of a transmission pipe along the railway bed parallel to the Fairview supply line (approximately 1700 metres). This water would be directed to the Mountain Station raw water sedimentation pond, and thence to the existing UV and chlorination facility.

This concept has the advantage of making Anderson/Fell Creek water available to the entire city, and could supply all pressure zones. The system could therefore provide either supplementary water or substitute water. In a “replacement” circumstance, consumption restrictions would be mandatory.

In the context of a future 5-Mile Creek supply line replacement, the 1700m transmission line could be considered the first leg of the 5-Mile pipeline replacement.

The estimated investment for the implementation of a high lift pump station and transmission main to Mountain Station is $3.3 million.

6.6 Selous Creek Integration

The Selous Creek intake could be modified to include UV and chlorination. However, there is insufficient space for a settling pond. Since the existing supply line terminates at the Stibbs PRV, it only services Zones 3 and 4.

The considerations outlined above for the Anderson/Fell concept also apply to Selous. The extension of the supply line to the central facilities at Mountain Station would provide treatment of water from all three sources. It also avoids operating a separate treatment facility and the associated strat-up and shutdown procedures when called upon. The extension of the Selous supply main along the abandoned railbed is relatively straightforward. This concept also provides the opportunity to install a micro-hydro facility at the Mountain Station site and generate power that can be used for the Mountain Station UV facility.

The estimated cost of the supply main extension is $2.4 million. The cost of a micro-hydro facility at Mountain Station is estimated at $700,000.

The cost estimate breakdown for these concepts is provided in Appendix A. Figure 7.1 provides a graphic depiction of the concepts for centralized treatment.

6.7 Summary of Options for Supplementary or Substitute Water

The initial comparison shows that the capital investments are similar for either approach. However, the operation and maintenance of separate treatment facilities incurs higher annual costs. Further, since treatment facilities require start-up and shutdown time, the reaction to a source loss event could be delayed. The approach of directing supplementary water to Mountain Station for centralized management and treatment is the better long-term approach.

The Anderson/Fell investment brings significant gains in source water and makes it available at the central treatment location. The pipeline from Fairview to Mountain Station can also form part of the 5-Mile Creek supply line in future. The same pipeline and booster station can be used to transfer Kootenay Lake water to the central treatment location for a future Kootenay Lake supply if Kootenay Lake is accessed in the long term.

The Selous Creek supply line extension is also a good investment as it brings this water to the central treatment and distribution location. The Cottonwood Creek pipeline is of marginal value since it can only add a nominal amount of supplementary water (licensed) and an almost insignificant amount during a drought year. Water quality and risks associated with potential spills are also factors to consider.

Overall, the potential additional combined water from Anderson/Fell and Selous can provide:

- Up to 18 ML/d if 5-Mile Creek is lost due to a pipeline break or source contamination.
- Up to 3.8 ML/d as supplementary water under drought year conditions. The 50-year low flow in 5-Mile Creek is 10.4 ML/d, so supplementing with 3.8 ML/d brings the total close to the projected MDD of 15 ML/d.
- In either case, the long term MDD for “inside use” of 10 ML/d can be satisfied; outside use and sprinkling should be severely curtailed during drought events.

Figure 7.1 presents a schematic of the proposed system modifications in three phases:

Phases	Notes
Phase 1	Includes a booster station at Fairview and a transmission main to Mountain Station, as well as the extension of the Selous Creek supply line to Mountain Station. This results in all upland licensed sources brought to a central location at Mountain Station where sedimentation, UV disinfection and chlorination can be carried out (time period 0 to 5 years). Power generation from the Selous Creek supply should be considered at this time. Capital cost estimate: $6.4 million.
Phase 2	Includes the construction of the remainder of a new transmission line from 5-Mile Creek intake. This would connect to the transmission line from the Fairview booster. The estimated capital cost is $5.2 million. Power generation at the Fairview site should be considered to service the high lift pump station.
Phase 3	May need to consider inclusion of a Kootenay Lake intake in the long term, if it is determined that the three connected sources are so impacted by climate change that they cannot produce sufficient water during drought events. The intake, pump station and transmission main would direct water to the Fairview Reservoir site, where it would be boosted to Mountain Station for treatment. The requirement for this additional source would be determined through rigorous monitoring of consumption over the next 10 years (time period 10-20 years)

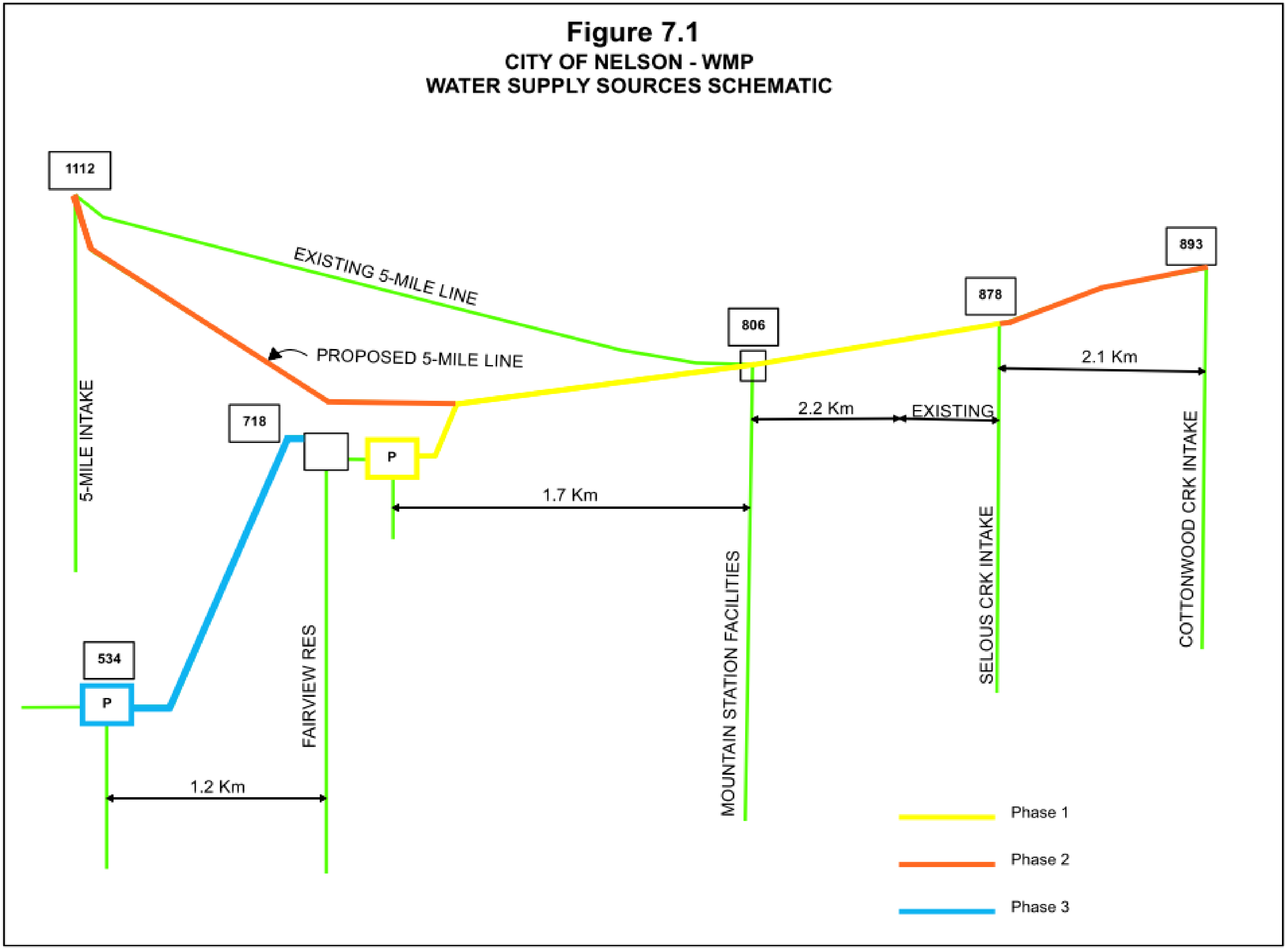


Figure 7.1
CITY OF NELSON - WMP
WATER SUPPLY SOURCES SCHEMATIC
1112
EXISTING 5-MILE LINE
PROPOSED 5-MILE LINE
5-MILE INTAKE
806
878
893
2.1 Km
2.2 Km
EXISTING
718
P
1.7 Km
534
P
FAIRVIEW RES
MOUNTAIN STATION FACILITIES
SELOUS CRK INTAKE
COTTONWOOD CRK INTAKE
1.2 Km
Phase 1
Phase 2
Phase 3

6.8 Distribution Network

The system hydraulic model has been updated and reflects available fire flows at a variety of nodes in the network. The 2007 WMP had a series of recommended line upsizing. Some, such as the mains in the Mount St. Francis area were upgraded in 2007. It is evident that the installation of the Fairview reservoir and the larger mains in the Mount St. Francis area has significantly increased the available fire flows in that area to a range of 9800 -13,500 L/min.

Two views are presented. Figure 4 shows available fire flows during the 2017 MDD condition; Figure 5 shows available fire flow during the MDD at “build-out” condition. In both cases the small dead-end pipes in some culs-de-sac indicate fire flows below 3,600 L/min (red bullets). This is due to the velocity criterion in the subdivision servicing bylaw which requires that the maximum velocity during fire flow to be no greater than 3.5 m/s. This criterion corresponds to the MMCD (Master Municipal Construction Documents) used by most municipalities in BC. There are some jurisdictions that use a 4 m/s criterion for maximum velocity. This would provide a slight increase in available fire flows.

The City of Nelson bylaw requires the following fire flows:

Building Type	Flow (L/min)
Single Family Residential	3,600
Multi-Family Residential	5,400
Institutional	9,000
Commercial	9,000
Industrial	13,300

It is noted that the CPR Land industrial area is deficient (red bullets). The short dead-end lines do not need immediate replacement. The City can adopt a program to replace 100 mm diameter and 150 mm diameter dead-end pipes with larger sizes when the time comes to replace them, and to investigate the potential for looping cul-de-sac lines through the backs of lots.

6.9 Treated Water Storage

Treated water storage is currently available at the Fairview Reservoir (1,900 m^3) and at the Rosemont Reservoir (1,400 m^3). The Mountain Station chlorination tank cannot be considered as finished water storage since it is required for chlorine contact time and should not be drained down in a fire. The large open reservoir at Mountain Station is raw water storage.

The Park Street reservoir has been de-commissioned since it was in very poor condition and exposed to contamination.

The typical formula for provision of finished water storage is: A+B+C, where:

A is the required fire storage

B is 25 % of MDD (for peak hour demands)

C is 25% of (A+B) for emergency storage.

The fire flow is given by the Fire Underwriters Survey and relates to the fire flow for the highest requirement (in this case 13,500 L/min for Industrial). The FUS table specifies 3 hours at 14,000 L/min, or 2520 m^3.

The future MDD at build-out is 15 ML/d; 25% of MDD is 3,750 m^3. It is impractical to dedicate 3,750 $m^3$for peak hourly demands. Peak demand events typically occur in morning and evening times for a period of approximately 3 hours each time. Therefore an allowance of 6 hours should be adequate to cover the peak hourly demands. The peak hour storage provision can be 6/24 x 3750 = 940 m^3.

Emergency storage is: 25% (A+B) = 25% x 3460 = 860 m^3.

The desirable treated water storage is: 2520 + 940 + 860 = 4320 m^3

The existing finished water storage at Fairview and Rosemont reservoirs totals approximately 3,300 m^3, so there is a nominal 1,000 m^3 shortfall in finished water storage. The former Park Street reservoir site is available for installation of additional finished water storage. It is central to the system and piping into and out of the site is available.

6.10 Water Filtration

The current 5-Mile source meets the requirements for avoiding filtration, and sedimentation, UV disinfection and chlorination are sufficient. The water quality in Anderson/Fell and Selous may be similar and sedimentation and disinfection may be sufficient. However, monitoring of these additional sources should determine if the filtration avoidance provisions are applicable.

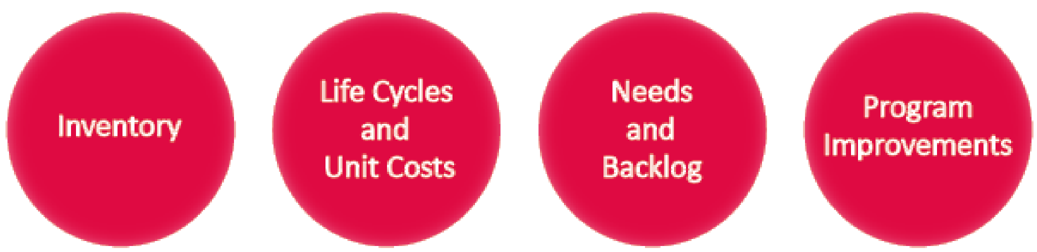
If source water parameters do not meet the microbiological objectives, filtration may be required in future. This means that turbidity and micro-biological indicators should be rigorously monitored for the long term. The Mountain Station settling pond appears to be providing good sedimentation and turbidity records have been remarkably low. However, the inclusion of Anderson/Fell and Selous Creeks may result in higher turbidity seasonally. Therefore the WMP should include a comprehensive data collection and monitoring program to address any potential turbidity concerns.

8 ASSET MANAGEMENT

A standardized element rating system can be used that combines the risk of failure and the consequence of failure to arrive at an overall risk assessment on an element-by-element basis.

The objective will be to integrate an Asset Management Investment Plan within the Water Master Plan with the following tasks:

- List all asset categories and major sub-categories
- Develop historical cost and depreciation calculations
- Assess current replacement value and remaining value (from City's Tangible Capital Asset data)
- Expected life remaining based on age and design life
- Adjusted life for condition
- Infrastructure deficit
- 20-year renewal costs and timing
- Total and annual average renewal costs
- Average Annual Life Cycle Investment (AALC**8.1 The Asset Management exercise is a four step analytical approach:**



Much of this work will already be completed in the context of the WMP. The Asset Management Investment Plan would extend the effort by developing a budgeting framework with 3 investment levels:

- Level 1 (Investment level) for strategic planning (Council and senior management);
- Level 2 (Program level) for tactical planning with management and staff
- Level 3 (Project level) for on-going operations, design and construction

8.1 Terms and Definitions

Asset Remaining Life: the remaining life of an asset is calculated as Asset Remaining Value/Replacement Value

Asset Condition	
<0 years	very poor
0-25 years	poor
25-5- years	average
50-75 years	good
75-100 years	very good

***Investment Required**:* cost to replace an asset (in 2017 dollars) and ensure it provides the same function

Average Annual Life Cycle Investment (AALCI): the summation of each asset's annual depreciation (this should be considered in conjunction with unfunded liability as this is a forward-looking parameter that does not consider the past)

20-year Average Annual Investment (20 Year AAI): the summation of expenditures over a 20 year planning horizon divided by 20.

Unfunded Liability: a measure of the amount of infrastructure that has passed its theoretical service life but still provides service to the community.

8.2 Asset Management Investment Plan (AMIP)

The AMIP is an asset renewal forecast that can be used to inform long-term funding decisions to reliably provide services into the future. It is designed to answer the following questions:

1) What assets do we own?
2) How much are our assets worth?
3) What condition are our assets in?
4) When will our assets pass their service life?
5) How much do we need to invest in our assets?

Through answering these questions the community can begin to build awareness of the magnitude and timing of infrastructure investments; understand revenue requirements over the long term, and assess the urgency of investments.

The AMIP is not a capital plan that sets out specific projects, and it is not a cost tool to be used for construction tenders.

The AMIP is just one component of a larger framework that should be considered in developing an effective asset management program.

Table 8.3 presents a summary of the water utility assets and their valuation. The base replacement value is approximately $60 million, of which $48 million are the pipes in the ground. The 20-year Average Annual Investment is calculated as approximately $1.5 million per year to fund expected infrastructure replacements over the next 20 years. The Average Annual Life Cycle Investment is $938,000, representing the summation of each asset's annual depreciation.

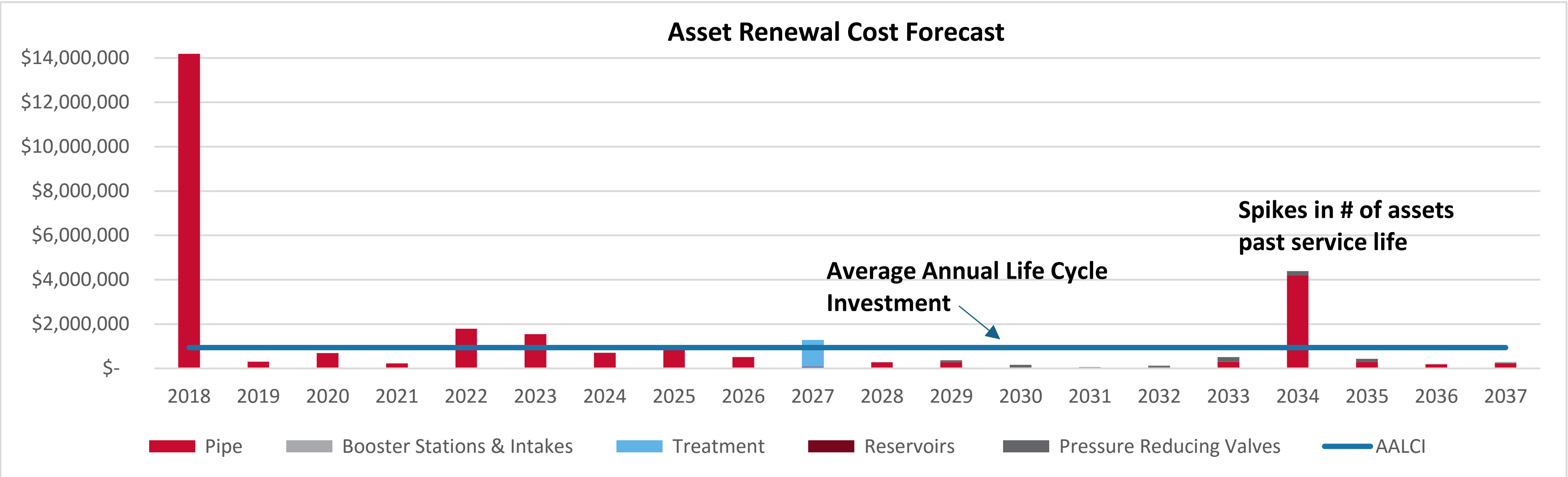
Graph 8.3 depicts the annual renewal cost forecast for the 20-year period. Graph 8.4 depicts the Average Annual Life Cycle Investment in pie chart format. It is evident that the largest portion of investment relates to aging pipe replacement.

8.3 Summary of Water Utility Assets

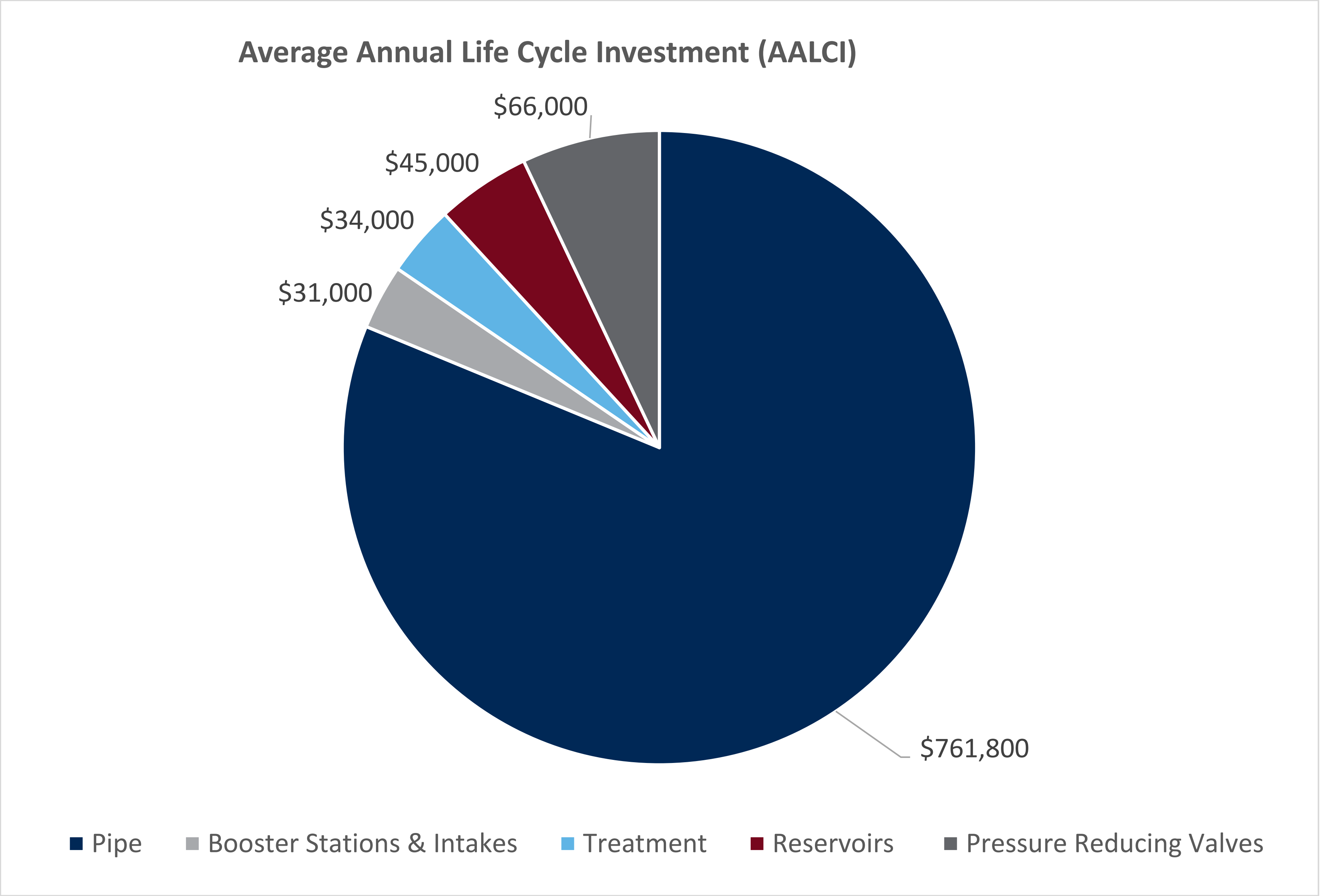
Table 8.3 Water System By Category

Water System Sub-Category	Replacement Value	Infrastructure Deficit (Value of Infrastructure past Service Life)	20 Year Total Forecast	20 Year Average Annual Investment (AAI)	Average Annual Life Cycle Investment (AALCI)
Pipe	$ 48,267,700	$ 14,186,900	$ 6,902,200	$ 1,345,110	$ 761,800
Booster Stations & Intakes	$ 2,950,000	$ -	$ 50,000	$ 2,500	$ 31,000
Treatment	$ 2,200,000	$ -	$ 1,200,000	$ 60,000	$ 34,000
Reservoirs	$ 4,000,000	$ -	$ -	$ -	$ 45,000
Pressure Reducing Valves	$ 2,790,000	$ -	$ 850,000	$ 42,500	$ 66,000
Total	**$ 60,207,700**	**$ 14,186,900**	**$ 29,002,200**	**$ 1,450,110**	**$ 937,800**

Graph 8.3 Asset Renewal Cost Forecast



Graph 8.4 Average Annual Life Cycle Investment



9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Water Sources

The detailed review of all potential water sources reveals that the most prudent course of action is to retain and protect the 5-Mile Creek source and integrate the Anderson/Fell Creek and Selous Creek source into the central treatment facility. It is also recommended that the 5-Mile Creek pipeline, originally installed at the turn of the century, be replaced with a new larger diameter pipeline located in a more accessible corridor. Other water sources such as Grohman Creek and Clearwater Creek could be developed but would incur excessive capital costs and licensing would be very difficult to obtain.

The combined flow from these sources could meet the "build-out" demand projections, provided that:

a) The City continues to rigorously promote all facets of water conservation and continues to find and repair leaks;
b) The effect of climate change on watershed yields is below 15% reduction in yield on a drought year

If demands exceed the predictions and additional water is required for drought events, the addition of Kootenay Lake as a part-time supply is recommended. This source can be pumped to the Fairview site and be transferred to the central treatment facility via the proposed Fairview pump station.

The recommended phasing for the capital projects is as follows:

Phase 1: Integrate Anderson/Fell Creeks and Selous Creek to the Mountain Station central treatment facility. Install small power generation facility on the Selous Creek pipeline.

Anderson/Fell supply line:	$1,400,000
Selous supply line	$2,400,000
Fairview pump station	$1,900,000
Selous power generation	$ 700,000
Total Phase 1 (0-5 years):	**$6,400,000**

Phase 2: New intake and pipeline for 5-Mile Creek

Intake:	$ 400,000
Pipeline	$4,800,000
Total Phase 2 (5-10 years)	**$5,200,000**

Phase 3: Kootenay Lake Supply

This phase may not be necessary if water demands are reduced and the impact of climate change is less than the forecasted 15%. Consequently, a cost estimate for this source development is not made at this time.

9.2 Network Improvements

The updated water network hydraulic analysis indicates that the extensions and replacements made between 2007 and 2017 have significantly improved flows and fire protection in many areas of the city. It also shows that there are still some nodes where undersized or dead-end mains result in a shortfall for fire flow. This can be addressed with the ongoing annual network improvement program.

Fire flow storage is somewhat deficient and this can be corrected by installation of a treated water reservoir at the Park Street site, It is recommended that a 1500 m^3 concrete reservoir be installed at the Park Street site. This would balance storage for the west, east, and central areas of the city. The estimated cost of a 1500 m^3 reservoir is $1,600,000.

9.3 Power Generation Opportunities

The study indicates new sources of water supply would be very costly. The costs could be offset by development of run-of-river power generation but this would be speculative for a municipal water utility and better left to energy providers.

A modest power generation facility utilizing a pipeline from Selous Creek appears to be a good opportunity to generate sufficient power to run the UV facilities at Mountain Station. It is recommended that this be explored further with the City power utility.

In the longer term, a new supply pipeline from 5-Mile Creek could also be considered for power generation and it is recommended that this also be explored with the City power utility. This power could help offset the power costs of pumping from Fairview to Mountain Station.

Power generation at the PRV stations could also generate modest power but the payback on iinvestment is marginal.

9.4 Funding Strategies

Funding for the capital projects outlined above will require senior government assistance. This is available under a range of programs such as the Clean Water and Wastewater Fund (CWWF), the Gas Tax Strategic Priorities Fund and other programs.

The funding strategy should also include consultation and education of Nelson residents on the investments required to maintain a high level of service and public health protection. When municipal borrowing is necessary to maintain this high level of service, the users must fund the loan payments through taxes and user fees. When expenditures relate to accommodating growth, the funding should come from the beneficiaries in the form of development cost charges and development agreements so that growth pays its own way.

9.5 Asset Management Investment Plan

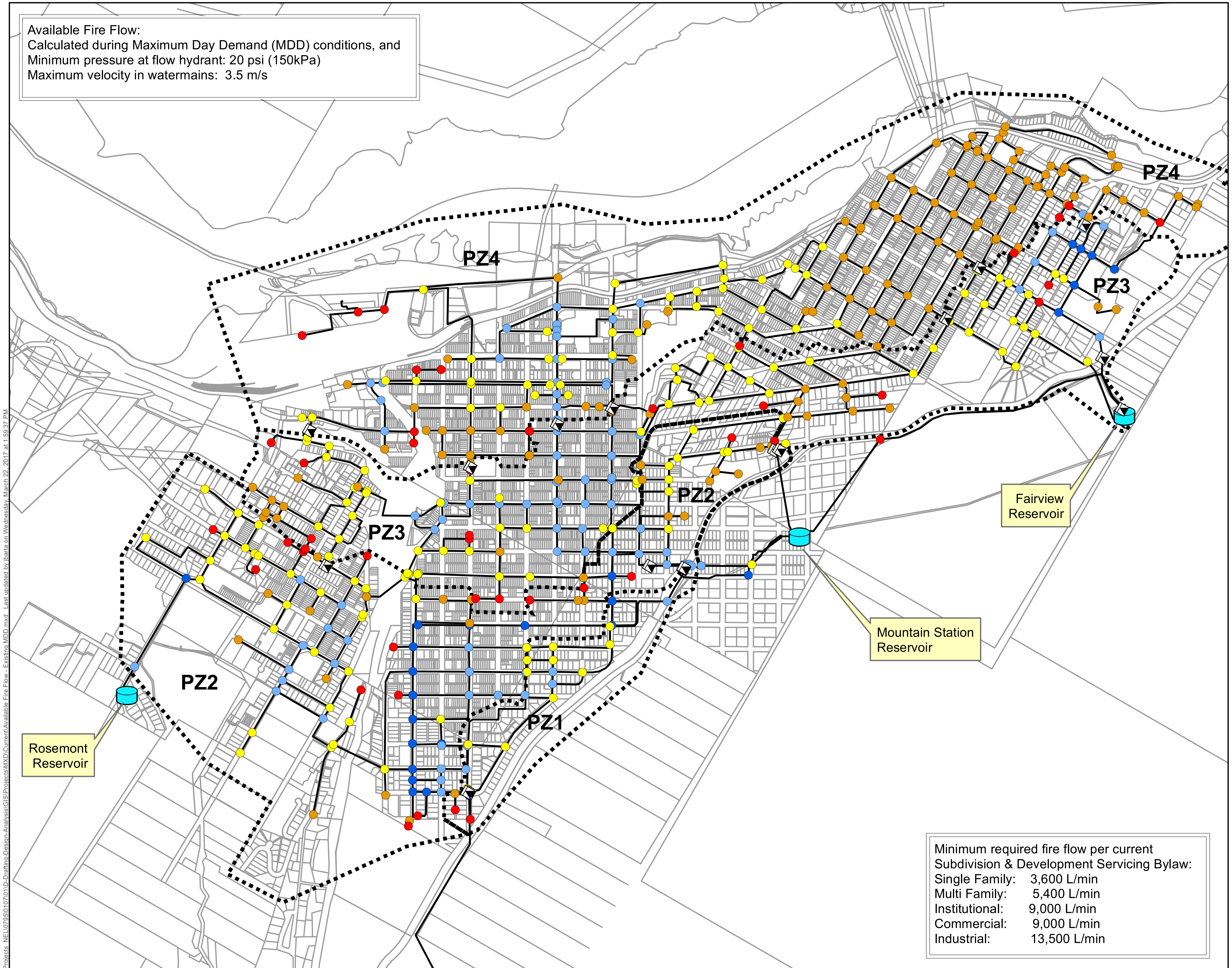
The brief valuation of existing infrastructure shows that, notwithstanding potential investments to augment source water supply, funds should be set aside for replacement of critical water utility assets as they age and come to the end of their design life. Largest among these is the underground pipe network, some of which dates back to the turn of the century. The valuation shows an approximate value of the utility's assets of $60 million and a projected investment of approximately $1.5 million per year to protect and renew those assets on an annual basis.

9.6 Action Plan

A brief list of initiatives for implementation includes:

1. Prepare a capital projects implementation plan for Phase 1 initiatives
2. Prepare and submit funding assistance application to the CWWF and SPIG programs
3. If borrowing is required, prepare a public information and consultation plan
4. Commission an investigation of the Mountain Station reservoir to determine if any remediation measures are required
5. Prepare a funding plan for s new Park Street reservoir
6. Collaborate with the city power utility on power generation for the Selous Creek pipeline
7. Continue leakage investigations and repair as necessary
8. Conduct a preliminary survey of a pipeline corridor for a new 5-Mile Creek supply line
9. Undertake discussions with city power utility on generation options for the 5-Mile Creek pipeline
10. Renew efforts to inform public and provide incentives for reduced water usage

Appendix A



CITY OF NELSON

City of Nelson

Water Master Plan Update

Available Fire Flow
Maximum Day Demands (2017)

Legend

- PRVs
- Reservoirs

Available Fire Flow

- less than 3,600 L/min
- 3,600 to 5,400 L/min
- 5,400 to 9,000 L/min
- 9,000 to 13,500 L/min
- greater than 13,500 L/min
- Pressure Zones
- Distribution System

0 100 200 400 600
Metres

Coordinate System: NAD 1983 UTM Zone 11N
Scale: 1:15,000

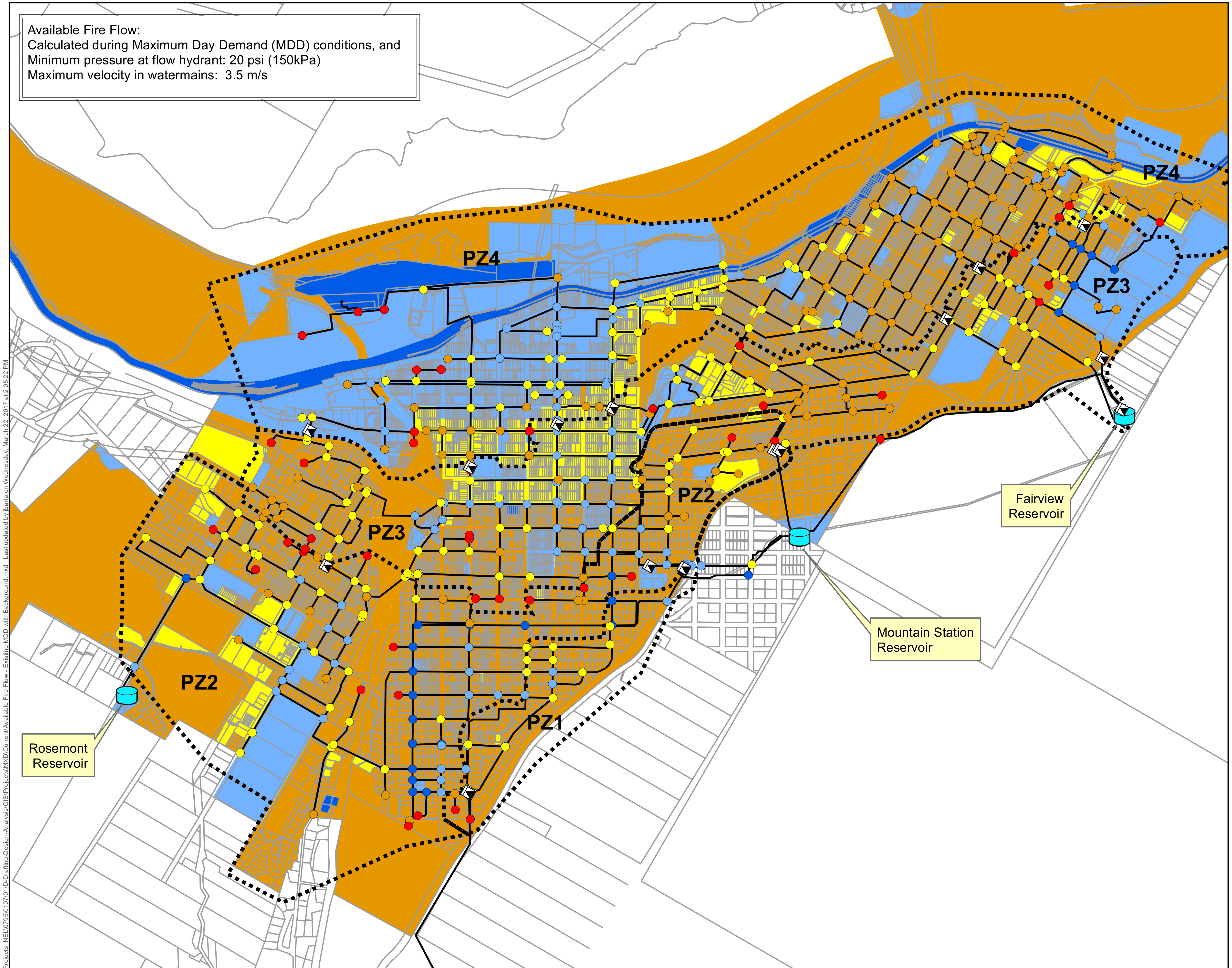
Data Sources:
Data provided by -

Project #:	0795.0107.01
Author:	JB
Checked:	PG
Status:	~ DRAFT ~
Revision:	A
Date:	2017 / 3 / 22

URBAN systems

FIGURE 1a

U:\Projects_NEL\0795\0107\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\Available Fire Flow - Existing MDD.mxd Last updated by ibarta on Wednesday, March 22, 2017 at 1:59:37 PM



CITY OF NELSON

City of Nelson
Water Master Plan Update

Available Fire Flow Maximum Day Demands (2017)

Legend

- PRVs
- Reservoirs

Available Fire Flow

- less than 3,600 L/min
- 3,600 to 5,400 L/min
- 5,400 to 9,000 L/min
- 9,000 to 13,500 L/min
- greater than 13,500 L/min
- Pressure Zones
- Distribution System

Required Fire Flow based on Zoning

- 3,600 L/min (Single Family)
- 5,400 L/min (Multi-Family)
- 9,000 L/min (Commercial/Institutional)
- 13,500 L/min (Industrial)

0 95 190 380 570
Metres

Coordinate System: NAD 1983 UTM Zone 11N

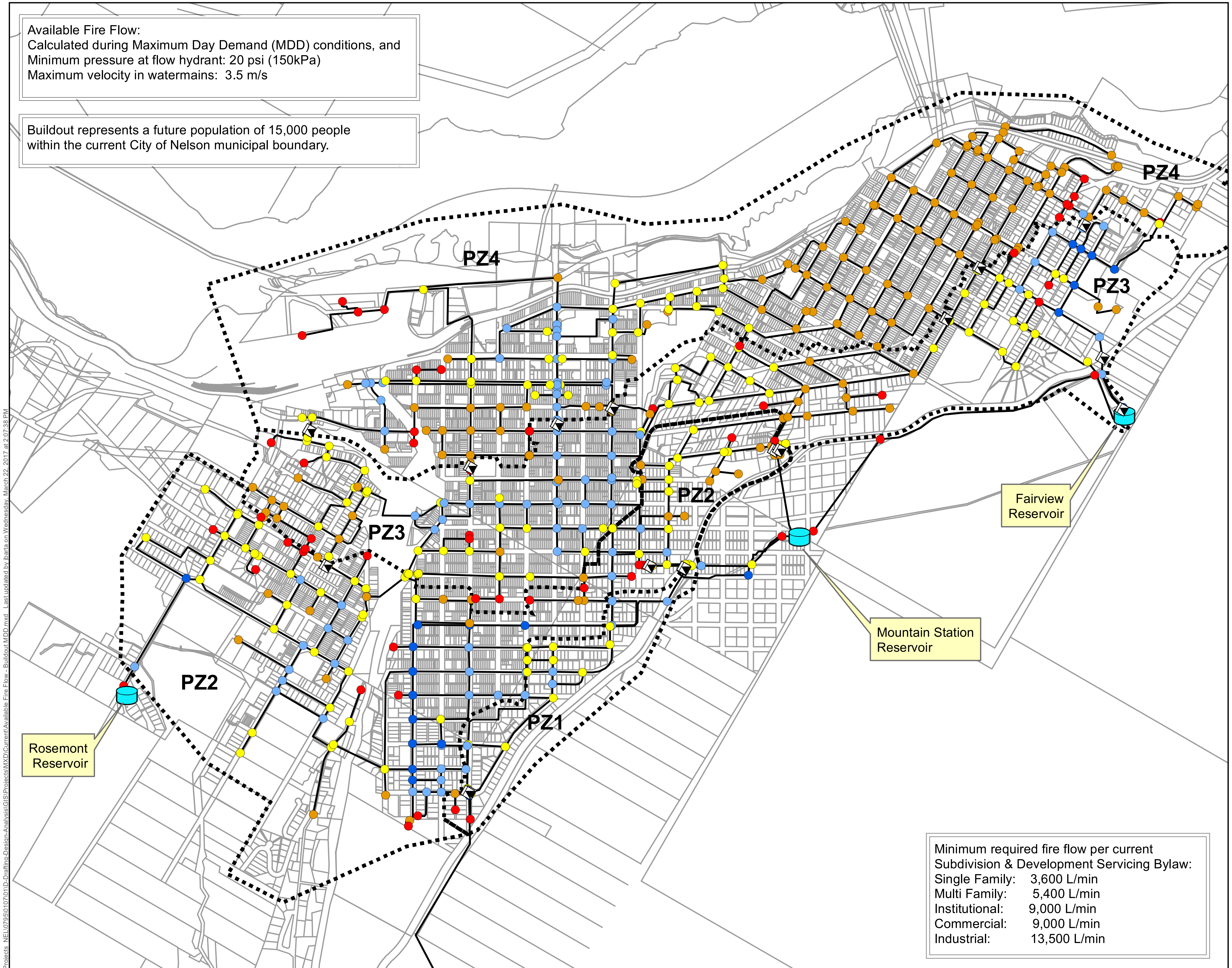
Scale: 1:15,000

Data Sources:
Data provided by -

Project #:	0795.0107.01
Author:	JB
Checked:	PG
Status:	~ DRAFT ~
Revision:	A
Date:	2017 / 3 / 22

URBAN systems

FIGURE 1b



City of Nelson

Water Master Plan Update

Available Fire Flow
Maximum Day Demands (Buildout)

Legend

- PRVs
- Reservoirs
- less than 3,600 L/min
- 3,600 to 5,400 L/min
- 5,400 to 9,000 L/min
- 9,000 to 13,500 L/min
- greater than 13,500 L/min
- Pressure Zones
- Distribution System

0 95 190 380 570
Metres

Coordinate System: NAD 1983 UTM Zone 11N

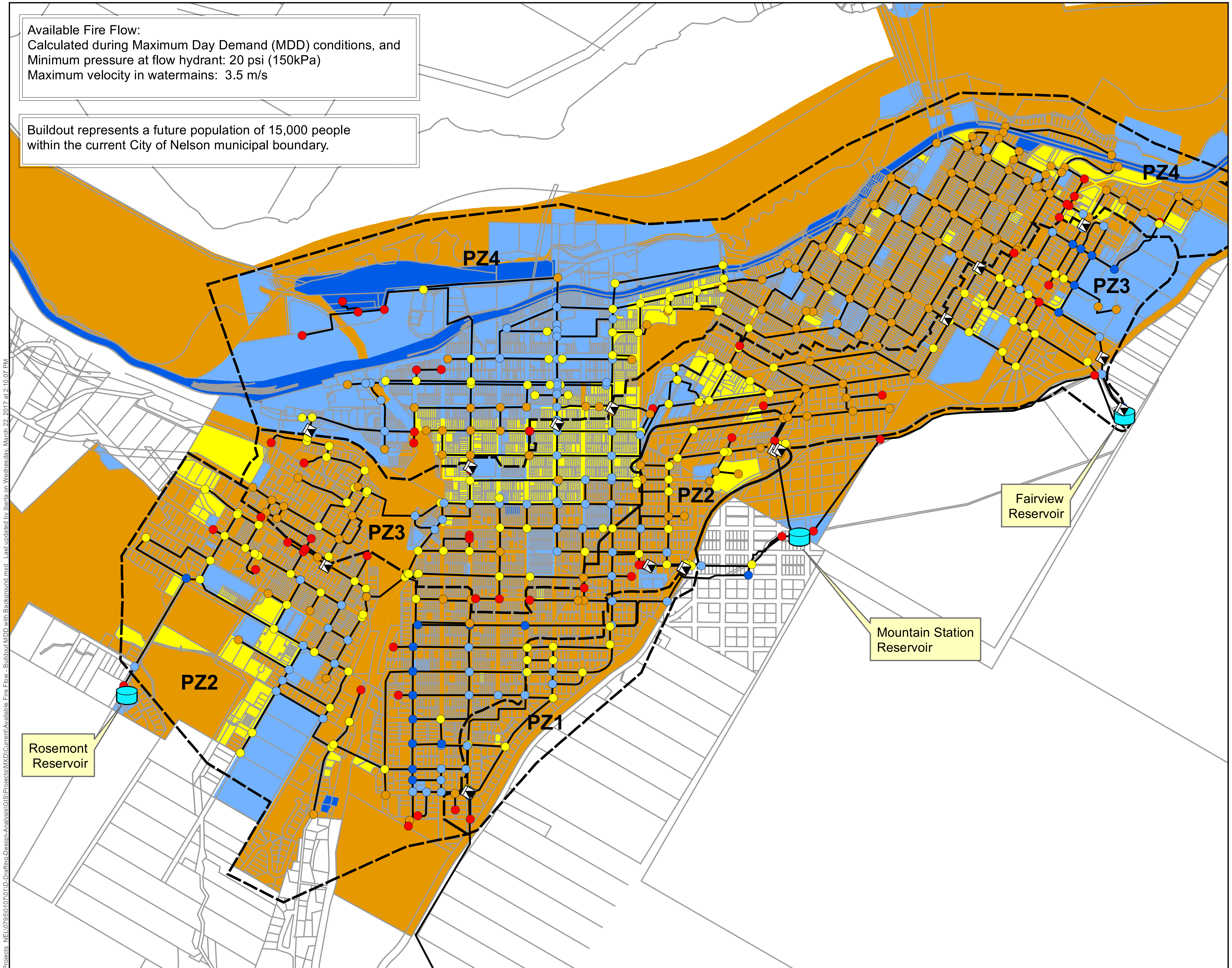
Scale: 1:15,000

Data Sources:
Data provided by -

Project #:	0795.0107.01
Author:	JB
Checked:	PG
Status:	~ DRAFT ~
Revision:	A
Date:	2017 / 3 / 22

URBAN systems

FIGURE 2a



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CITY OF NELSON

City of Nelson
Water Master Plan Update

Available Fire Flow
Maximum Day Demands (Buildout)

Legend

- PRVs
- Reservoirs
- less than 3,600 L/min
- 3,600 to 5,400 L/min
- 5,400 to 9,000 L/min
- 9,000 to 13,500 L/min
- greater than 13,500 L/min
- Pressure Zones
- Distribution System

Required Fire Flow based on Zoning

- 3,600 L/min (Single Family)
- 5,400 L/min (Multi-Family)
- 9,000 L/min (Commercial/Institutional)
- 13,500 L/min (Industrial)

0 100 200 400 600
Metres

Coordinate System: NAD 1983 UTM Zone 11N

Scale: 1:15,000

Data Sources:
Data provided by -

Project #: 0795.0107.01
Author: JB
Checked: PG
Status: ~ DRAFT ~
Revision: A
Date: 2017 / 3 / 22

URBAN systems

FIGURE 2b

Appendix B

CITY OF NELSON - WATER SYSTEM

Asset Management Investment Plan (Forecast of Infrastructure Renewal)

Level 2 - Water

Sub-category	Asset Description	Year Built	Service Life	Current Replacement Value	Loss in Value	Remaining Value	Expected Remaining Life	Infrastructure Deficit (Backlog)	Investment Year (Current Dollars)																				20 Year Total	Average Annual Life Cycle Investment (AALCI)
									2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037		
Pipe	Diameter (mm)																													
	>500			$ -	$ -	$ -	0%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	=500			$ -	$ -	$ -	0%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	=450			$ -	$ -	$ -	0%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	=400			$ 3,065,802	$ 2,248,255	$ 817,547	27%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,065,802	$ -	$ -	$ -	$ 3,065,802	$ 51,097
	=350			$ 406,890	$ 116,597	$ 290,292	71%	$ 84,343	$ 84,343	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 84,343	$ 5,438
	=300			$ 5,711,335	$ 4,070,822	$ 1,640,513	29%	$ 3,574,348	$ 3,574,348	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,490	$ -	$ -	$ 173,631	$ -	$ -	$ -	$ 3,751,469	$ 88,560
	=250			$ 2,206,315	$ 1,813,949	$ 392,366	18%	$ 904,169	$ 904,169	$ -	$ -	$ -	$ 794,999	$ 120,349	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,819,517	$ 35,733
	=200			$ 7,944,778	$ 3,068,255	$ 4,876,524	61%	$ 1,374,935	$ 1,374,935	$ 75,455	$ 168,932	$ -	$ 215,401	$ 61,341	$ 307,575	$ 196,048	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,399,687	$ 111,964
	=150			$ 14,178,740	$ 10,163,250	$ 4,015,490	28%	$ 3,929,260	$ 3,929,260	$ 124,723	$ 311,690	$ 136,995	$ 360,596	$ 803,384	$ 218,235	$ 452,078	$ 384,500	$ 34,691	$ 208,387	$ 193,071	$ 23,638	$ -	$ -	$ 177,303	$ -	$ 174,138	$ 144,278	$ 167,725	$ 7,844,692	$ 234,491
	<150			$ 3,615,377	$ 1,996,006	$ 1,619,371	45%	$ 1,045,757	$ 1,045,757	$ 30,968	$ 47,066	$ 36,088	$ 2,614	$ 201,929	$ 17,111	$ 104,205	$ 6,983	$ 20,044	$ 9,518	$ 24,064	$ 8,977	$ -	$ 43,893	$ 57,411	$ -	$ 53,918	$ -	$ 17,882	$ 1,728,428	$ 58,334
			Subtotal	**$ 37,129,000**	**$ 23,477,000**	**$ 13,652,000**	**37%**	**$ 10,913,000**	**$ 10,913,000**	**$ 231,000**	**$ 528,000**	**$ 173,000**	**$ 1,374,000**	**$ 1,187,000**	**$ 543,000**	**$ 752,000**	**$ 391,000**	**$ 55,000**	**$ 218,000**	**$ 217,000**	**$ 33,000**	**$ 3,000**	**$ 44,000**	**$ 235,000**	**$ 3,239,000**	**$ 228,000**	**$ 144,000**	**$ 186,000**	**$ 20,694,000**	**$ 586,000**
Program Support																														
Engineering & Design				$ 11,138,700	$ 7,043,100	$ 4,095,600		$ 3,273,900	$ 3,273,900	$ 69,300	$ 158,400	$ 51,900	$ 412,200	$ 356,100	$ 162,900	$ 225,600	$ 117,300	$ 16,500	$ 65,400	$ 65,100	$ 9,900	$ 900	$ 13,200	$ 70,500	$ 971,700	$ 68,400	$ 43,200	$ 55,800	$ 6,208,200	$ 175,800
Sub-total				**$ 11,138,700**	**$ 7,043,100**	**$ 4,095,600**		**$ 3,273,900**	**$ 3,273,900**	**$ 69,300**	**$ 158,400**	**$ 51,900**	**$ 412,200**	**$ 356,100**	**$ 162,900**	**$ 225,600**	**$ 117,300**	**$ 16,500**	**$ 65,400**	**$ 65,100**	**$ 9,900**	**$ 900**	**$ 13,200**	**$ 70,500**	**$ 971,700**	**$ 68,400**	**$ 43,200**	**$ 55,800**	**$ 6,208,200**	**$ 175,800**
Total				**$ 48,267,700**	**$ 30,520,100**	**$ 17,747,600**	**37%**	**$ 14,186,900**	**$ 14,186,900**	**$ 300,300**	**$ 686,400**	**$ 224,900**	**$ 1,786,200**	**$ 1,543,100**	**$ 705,900**	**$ 977,600**	**$ 508,300**	**$ 71,500**	**$ 283,400**	**$ 282,100**	**$ 42,900**	**$ 3,900**	**$ 57,200**	**$ 305,500**	**$ 4,210,700**	**$ 296,400**	**$ 187,200**	**$ 241,800**	**$ 26,902,200**	**$ 761,800**
Booster Stations & Intakes																														
				$ 2,950,000	$ 1,522,333	$ 1,427,667	48%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ 50,000	$ 30,667
			Subtotal	**$ 2,950,000**	**$ 1,522,000**	**$ 1,428,000**	**48%**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 50,000**	**$ 50,000**	**$ 31,000**
Treatment																														
				$ 2,200,000	$ 1,244,000	$ 956,000	$ 0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,200,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,200,000	$ 34,000
			Subtotal	**$ 2,200,000**	**$ 1,244,000**	**$ 956,000**	**43%**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 1,200,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 1,200,000**	**$ 34,000**
Reservoirs																														
				$ 4,000,000	$ 863,500	$ 3,136,500	78%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 44,500
			Subtotal	**$ 4,000,000**	**$ 864,000**	**$ 3,137,000**	**78%**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 45,000**
Pressure Reducing Valves																														
				$ 2,790,004	$ 562,401	$ 2,227,603	89%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 90,000	$ 120,002	$ 60,000	$ 60,000	$ 200,000	$ 180,000	$ 140,000	$ -	$ -	$ 850,002	$ 66,225
			Subtotal	**$ 2,790,000**	**$ 562,000**	**$ 2,228,000**	**80%**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 90,000**	**$ 120,000**	**$ 60,000**	**$ 60,000**	**$ 200,000**	**$ 180,000**	**$ 140,000**	**$ -**	**$ -**	**$ 850,000**	**$ 66,000**
Total				**$ 60,207,700**	**$ 34,712,100**	**$ 25,496,600**	**42%**	**$ 14,186,900**	**$ 14,186,900**	**$ 300,300**	**$ 686,400**	**$ 224,900**	**$ 1,786,200**	**$ 1,543,100**	**$ 705,900**	**$ 977,600**	**$ 508,300**	**$ 1,271,500**	**$ 283,400**	**$ 372,100**	**$ 162,900**	**$ 63,900**	**$ 117,200**	**$ 505,500**	**$ 4,390,700**	**$ 436,400**	**$ 187,200**	**$ 291,800**	**$ 29,002,200**	**$ 937,800**

Appendix C

URBAN

CONSTRUCTION COST ESTIMATE

CITY OF NELSON
WMP
SELOUS WATERMAIN COST ESTIMATE

USL File: 0795.0107.01
Date: 05/01/2017
This Estimate is Class: D

COST ESTIMATE

	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	SUBTOTAL COSTS	TOTAL COSTS
1.0	**Selous Watermain**					
1.1	450 mm PVC C905 DR18 Watermain (Supply & Installation)	2200	l.m.	$450.00	$990,000.00	
1.2	450 mm Gate Valve	6	ea	$10,000.00	$60,000.00	
1.3	Watermain Tie-In	2	ea	$10,000.00	$20,000.00	
1.4	Air Release Valve Chamber Allowance	4	ea	$15,000.00	$60,000.00	
1.5	Utility Conflict Allowance	1	ls	$30,000.00	$30,000.00	
1.6	Granular Base (100mm thick x 4m wide)	10400	sq.m	$14.50	$150,800.00	
1.7	Pavement Restoration	3200	sq.m	$50.00	$160,000.00	
1.8	General Requirements (5%)	1	ls	$73,540.00	$73,540.00	
	Subtotal					$1,544,340
	Contingency Allowance (30%)					$463,302
	Design and Construction Allowance (15%)					$301,146
	Total					$2,308,788
	Rounded Total					$2,400,000

URBAN

CONSTRUCTION COST ESTIMATE

CITY OF NELSON
WMP
ANDERSON WATERMAIN COST ESTIMATE

USL File: 0795.0107.01
Date: 05/01/2017
This Estimate is Class: D

COST ESTIMATE

	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	SUBTOTAL COSTS	TOTAL COSTS
2.0	**Anderson Watermain**					
2.1	450 mm PVC C905 DR18 Watermain (Supply & Installation)	1700	l.m.	$450.00	$765,000.00	
2.2	450 mm Gate Valve	5	ea	$10,000.00	$50,000.00	
2.3	Watermain Tie-In	2	ea	$10,000.00	$20,000.00	
2.4	Creek Crossing (above existing culvert)	1	ls	$25,000.00	$25,000.00	
2.5	Air Release Valve Chamber Allowance	3	ea	$15,000.00	$45,000.00	
2.6	Utility Conflict Allowance	1	ls	$30,000.00	$30,000.00	
2.7	Granular Base (100mm thick x 4m wide)	4800	sq.m	$14.50	$69,600.00	
2.8	General Requirements (5%)	1	ls	$50,230	$50,230.00	
					Subtotal	$1,054,830
					Contingency Allowance (30%)	$316,449
					Design and Construction Allowance (15%)	$205,692
					Total	$1,371,279
					Rounded Total	$1,400,000

URBAN

CONSTRUCTION COST ESTIMATE

CITY OF NELSON
WMP
PUMP STATION COST ESTIMATE

USL File: 0795.0107.01
Date: 05/01/2017
This Estimate is Class: D

COST ESTIMATE

	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	SUBTOTAL COSTS	TOTAL COSTS
3.0	**Fairview High-Lift Pump Station Estimate**					
3.1	General Requirements	1	ls	$60,000.00	$60,000.00	
3.2	Tie-in & Yard Piping	1	ls	$180,000.00	$180,000.00	
3.3	Demolition & Removals	1	ls	$40,000.00	$40,000.00	
3.4	Booster Station Building & Finishes (80m²)	1	ls	$200,000.00	$200,000.00	
3.5	Booster Pumps (Supply/Install)	1	ls	$220,000.00	$220,000.00	
3.6	Interior Pipe / Valve Assembly	1	ls	$90,000.00	$90,000.00	
3.7	Plumbing & HVAC	1	ls	$30,000.00	$30,000.00	
3.8	Electrical (Power/Distribution)	1	ls	$120,000.00	$120,000.00	
3.9	Instrumentation & Controls (SCADA)	1	ls	$160,000.00	$160,000.00	
3.10	Standy Power	1	ls	$150,000.00	$150,000.00	
					Subtotal	$1,250,000
					Contingency Allowance (30%)	$375,000
					Design and Construction Allowance (15%)	$243,750
					Total	$1,868,750
					Rounded Total	$1,900,000

URBAN

CONSTRUCTION COST ESTIMATE

CITY OF NELSON
WMP
POWER GENERATION COST ESTIMATE

USL File: 0795.0107.01
Date: 05/01/2017
This Estimate is Class: D

COST ESTIMATE

	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	SUBTOTAL COSTS	TOTAL COSTS
4.0	**Selous Power Generation Estimate (30 KW)**					
4.1	General Requirements (5%)	1	ls	$20,000.00	$20,000.00	
4.2	Diversion Piping/Valving	1	ls	$80,000.00	$80,000.00	
4.3	Generator Building (40 m²)	1	ls	$100,000.00	$100,000.00	
4.4	Pelton Wheel Generator	1	ls	$90,000.00	$90,000.00	
4.5	Process Piping / Valving	1	ls	$40,000.00	$40,000.00	
4.6	Wiring and Distribution	1	ls	$30,000.00	$30,000.00	
4.7	Instrumentation & SCADA	1	ls	$60,000.00	$60,000.00	
					Subtotal	$420,000
					Contingency Allowance (30%)	$126,000
					Design and Construction Allowance (15%)	$81,900
					Total	$627,900
					Rounded Total	$700,000