Infrastructure Assessment Report

Town of Watson Lake
2006

for

Town of Watson Lake

Final Report, November 2006

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1.0 Introduction

The Town of Watson Lake is in the process of reviewing and updating the 1995 Official Community Plan (OCP) and preparing an Integrated Community Sustainability Plan (ICSP) in conjunction with the Liard First Nation. The latter plan is a requirement to access the municipality and First Nation shares of the Gas Tax Rebate funds that have been earmarked for infrastructure renewal and development.

In 1996, substantial portions of the municipality's records were destroyed when the municipal offices burned down. As such infrastructure records are incomplete and outdated. Some information relative to community planning is contained in the 1989 OCP prepared by Urban Systems of Calgary. However, at present there has been no overall infrastructure condition assessment work done that can be used for community and capital planning purposes.

The present infrastructure includes:

- a network of roads with BST or gravel surface, generally without curb and gutter and with surface stormwater drainage discharged via ditches and culverts to ponds, wetlands and minor watercourses.
- underground sewer and water service is available to only a limited portion of the community. Potable water is supplied from municipal wells and pumped to an in-ground 250,000 imperial gallon water reservoir where it is distributed by gravity to homes and businesses within the service area. Sewage is collected in a central lift station and pumped through a force main to a sewage lagoon. The majority of the water and sewage systems were constructed in the 1970's.
- solid waste is deposited in a landfill where it is deposited in trenches, burned, compacted and covered.
- the municipality has valid operational permits for the water supply, sewage treatment and waste disposal sites.

1.1 Scope of Infrastructure Assessment

The purpose of this assessment is to prepare an overview of the health and condition of the municipality's infrastructure. The assessment results will be incorporated into the new Official Community Plan and Integrated Community Sustainability Plan with priorities for subsequent action reflected in an updated 5 Year Capital Plan. The assessment will consider roads and surface drainage, water supply, sewage and solid waste disposal.

Specifically, the assessment will answer the following questions:

- What is the existing condition of the municipal infrastructure including remaining service life?
- What are the strengths and weaknesses of the present systems?
- What is the capacity of the existing systems to support the present population, an expanded service area (in the case of the sewer and water system) and a future population of 4-6,000 people within 10-20 years?
- Assuming the present sewer and water system can be expanded, which areas of the community can be serviced most economically and what are the principal constraints to service area expansion?

- From a "best practices" perspective, can the present infrastructure condition be benchmarked against current and probable future service standards and regulatory requirements?
- Are present operating practices and costs consistent with similar size municipalities with similar systems?

The assessment will also identify, to the extent possible, priorities for infrastructure renewal including any requirements for more detailed and comprehensive engineering assessments and provide an indication of probable order of magnitude costs for such improvements based on previous professional experience, knowledge of similar system improvement costs in other Yukon communities, etc. The cost estimates will include sufficient information for Council to understand the relative cost of a given capital project against another and its importance from a health/safety and system sustainability perspective.

Assessment Tasks include the following:

1. Review the present condition of the municipal infrastructure using available records (e.g. reports, as-built construction drawings and maintenance records keeping in mind that the records are incomplete as a result of the 1996 fire).
2. Visit the community, interview key staff and view present operating conditions.
3. Identify system capacity, service life remaining, O&M costs and ability of the present infrastructure to support growth to a population target of 4-6,000 within the next 20 years.
4. Identify integration opportunities to provide to or take service from related Liard First Nation infrastructure.
5. Identify the strengths and weaknesses of the present infrastructure to service existing and future growth
6. Benchmark present infrastructure condition and service life against similar Yukon municipalities, present regulatory standards and probable future regulatory changes.
7. Determine the significance of existing and potential emerging issues from a system operating cost and future replacement perspective and identify implications for the physical development of the community and overall community sustainability.
8. Identify opportunities for efficient and cost effective expansion of municipal services having regard to both expanding service to existing un-serviced portions of the community and orderly future development. Discuss both capital and O&M implications.
9. Identify the need for any additional detailed infrastructure assessment work and to the extent possible, recommend priorities for infrastructure refurbishment in the short, medium and long term for consideration in an updated 5 Year Capital Plan.
10. Prepare a brief overview report and present the findings to the OCP Steering Committee and Council.

2.0 Background Information

Watson Lake is a small resource industry based town in the south east corner of the Yukon, located at the intersection of the Alaska and Robert Campbell Highways. Previous studies have identified that the community has grown in the past, at an average growth rate of approximately 1.5 %, with a surge in growth during the 1970's to approximately 7%, then leveling off to a 1% growth rate in the 1980's. During the 1990's the population dropped significantly due to a slow down in the resource industries. Local population, as recorded by the YTG Bureau of Statistics, was indicated to be 900 people, based on the 2001 census, for the core community, and 1650 for the surrounding area population, based on 2001 Yukon Health Records.

The core community is serviced with underground piped water distribution and sewage collection systems:

- The water supply is from local shallow ground water wells.
- Water is pretreated with chlorine injection, and pumped to an elevated, underground storage reservoir which provides gravity pressure service through buried distribution mains. The reservoir has a working capacity of approximately 1.138 million liters (250,000 imperial gallons). Lots are serviced with heat traced single services to each lot.
- Sewage treatment and storage is provided by anaerobic lagoons, and a long term exfiltration storage cell. Sewage is collected in an underground piped collection system, which directs flow to two existing duplex lift stations. Effluent is lifted by forcemain to the south end of the community, where it again flows by gravity through a gravity outfall to the anaerobic treatment lagoons, and then by gravity to the long term storage cell. The storage cell works as an exfiltration pond, and has never been discharged. Lots are serviced with single gravity services to each lot.
- Solid waste is collected and disposed of in bury pits with soil cover, located at the solid waste site on the west end of the community.

The community is serviced by 3 major highways:

- The Alaska Highway runs east-west through the community providing a major link to Whitehorse on the north, and Fort Nelson on the south.
- The Robert Campbell Highway runs north through the community, from Watson Lake to Ross River, Faro and Carmacks.
- The Cassiar Highway intersects the Alaska Highway at Junction 37 approximately 20 kilometers west of Watson Lake, and connects to the south to Smithers, BC.

The local community road network consists of local and collector roadways with BST (Bituminous Surface Treatment) or gravel surfaces. Local drainage is provided by ditches and culverts, which drain to local depressions including the Wye Lakes.

3.0 Detailed Infrastructure Assessment

The detailed infrastructure assessment includes:

- Population projections,
- Review of existing development type and density
- Future development requirements to service population growth
- Future development potential and constraints
- Water supply and treatment review
- Water storage review
- Watermain distribution review and modeling for capacity, circulation, fire flow capabilities and service extensions
- Sewermain collection review for capacity assessment and service extension
- Sewer lift station review for capacity assessment and future upgrading
- Sewer forcemain assessment for capacity and future upgrading
- Sewer gravity outfall assessment for capacity and future upgrading
- Sewer treatment anaerobic cells for capacity and future expansion
- Sewer treatment long term retention cell for capacity and future expansion
- Local drainage issues, drainage basin identification, drainage requirements and local drainage system condition assessment.
- Solid waste collection site capacity and future expansion.

4.0 Geotechnical Considerations

A detailed geotechnical assessment has not been completed as part of this assessment. Geotechnical conditions are summarized from known conditions based on local experience and observations.

In general, the developed townsite is generally flat, and developed around 2 major depressions which are locally known as 1st Wye Lake and 2nd Wye Lake. Elevations range from 690 m at the lake surface to 750 m at the reservoir site, which is located on a ridge at the north side of the community. A second ridge rises on the south side of the community, to approximately the same elevation.

Soil conditions are generally consistent over the area, consisting of surface organics overlying a sandy silt, overlying silty sands and gravels. The gravels are coarse grained, and well drained. Ground water levels are quite shallow due to the proximity to the Wye Lake depressions.

Ground Ice and permanently frozen soils are not prevalent, however due to ground cover, and shade aspects, it is possible that discontinuous permafrost could exist in some areas.

The existing sand and gravel sub-soils are considered stable for water and sewer pipe installations, with little anticipated movement due to frost action. The surface silts, however, would be unstable and may result in frost heaving during winter, and soft road surfaces during spring thaw, resulting in road surface breakup and pot holes.

Frost penetration in the sands and gravel will be greater when the soils are dry, but may be mitigated due to the relatively high ground water table in lower areas. This will have an impact on water system heat losses and potential main freeze ups.

5.0 Design Criteria

For the purposes of this assessment, the following design criteria have been recommended and used in the analysis of servicing requirements in accordance with generally accepted servicing standards:

Water System Design Criteria:

Average Daily Demand (ADD)	10 cu.m./ha/day (Commercial/institutional) 500 l/c/day (residential)
Maximum Day Demand (MDD)	2 x ADD
Peak Hour Demand (PHD)	3 x ADD
Night Fill Demand (NFD)	0.65 x ADD
Minimum Velocity	0.15 m/s @ ADD (or as identified by Thermal Analysis)
Maximum Velocity	3.0 m/s @ PHD 5.0 m/s @ MDD plus Fire
Minimum Pressures	280 kpa @ MDD (ground level) 140 kpa @ MDD plus Fire (ground level)
Maximum Pressures	550 kpa (80 psi) desired 700 kpa (100 psi) maximum
Minimum Fire Flow	75 l/s (Residential) x 1.5 hr duration [1]
Maximum Fire Flow	200 l/s (Light Commercial) x 2.5 hr duration [1]

1. Based on recommendations from IAO (Insurers Advisory Organization)

Sanitary Sewer Design Criteria:

Average Daily Demand Flow	90% of ADD water demand
Peak Hour Flow	3 x ADD for Commercial 3 x ADD for Residential
Infiltration Allowance	6000 l/ha/day
Minimum Velocity	0.60 m/s
Maximum Velocity	3.0 m/s

Storm Water Management Criteria:

System Capacity	5 year Storm Intensity
Runoff Coefficients	0.9 asphalt parking lots and roadways
	0.7 commercial/industrial/multi-family
	0.35 residential
	0.15 open space
Inlet Time	15 minutes maximum
Rational Method	Q=CIA/360 (cu.m./s)
100 year storm	Overland flow and on-site surface storage
Discharge	Controlled discharge to Green Belt or surface storage areas

6.0 Future Growth and Population Projections

Current population figures from Yukon Bureau of Statistics and Yukon Health records are stated to be:

- Surrounding area 1515 (overall area population, from Health records)

The surrounding area population is derived from the Yukon Health Care files. The core area population is derived from the Canada Census data, and is assumed to represent the core community serviced area.

Community population varied from 1996 to 2006 as follows:

- 1996 Census 993 1996 Health Care 1791
- 2001 Census 912 2001 Health Care 1648
- Calculated current 839 to 840 Current Health Care 1515 (from Health records)

Assuming the same percentage ratio of serviced core area population to overall population, the community core population can be calculated to be 839 to 840.

Based on the growth projections provided by the Yukon Bureau of Statistics, the overall growth rates for the Yukon are projected to be:

- Low growth rate -6.0% over 10 years -0.6% ave. Annual
- Medium growth rate +4.5% over 10 years +0.45% ave. annual
- High growth rate +16.0% over 10 years +1.6% ave. annual

Assuming that the Yukon is on an upward growth rate for the foreseeable future, the anticipated normal growth over the next 20 years could be projected to be:

Core area (assumed townsite serviced population)

- Medium rate (0.45% ave. annual) 1.093 % x 840 = 920 population
- High rate (1.6% ave. annual) 1.374 % x 840 = 1155 population

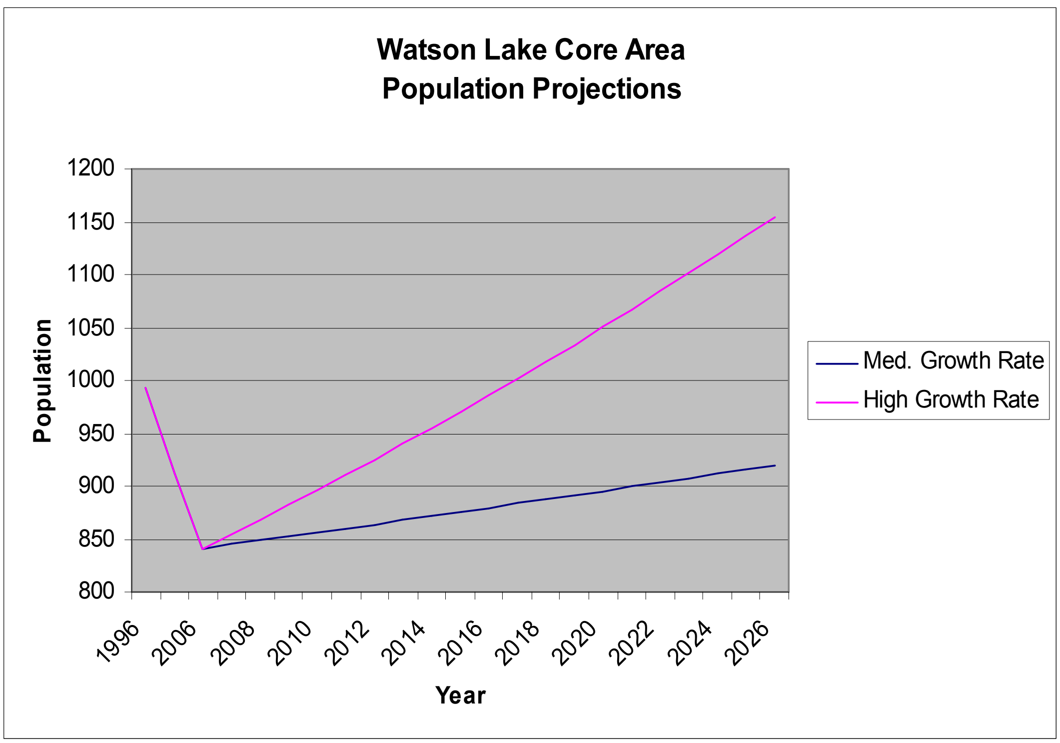
Overall area

- Medium rate (0.45% ave. annual) 1.093 x 1515 = 1655 population
- High rate (1.6% ave. annual) 1.374 x 1515 = 2081 population

The above growth projections represent normal growth rates based on birth/death ratios, and general family expansion. Other factors which have an impact on growth rates include economic development and business growth. Yukon Bureau of Statistics does not provide growth projections based on these variables, however, Watson Lake is situated in the centre of some resource rich development, which could result in above normal growth rates for the community.

For this reason, this assessment will consider potential growth of up to 4000 overall population over the next 20 years. This is approximately 200% more than the normal growth rate expected. A surrounding area population of 4000 would likely result in a core community population of approximately 2300 people, assuming the local / area ratio remains relatively constant.

The following chart shows the proposed medium and high growth rates projected over the next 20 years, for the core serviced area.



7.0 Current and Future Development and Dwelling Density

Current Development and Density

Census Canada data indicates that there were approximately 360 dwellings in the core community area, representing an approximate population of 900 in 2001.

This results in a dwelling density of approximately 2.5 persons / residence. This appears to be an appropriate density considering today's smaller family tendencies.

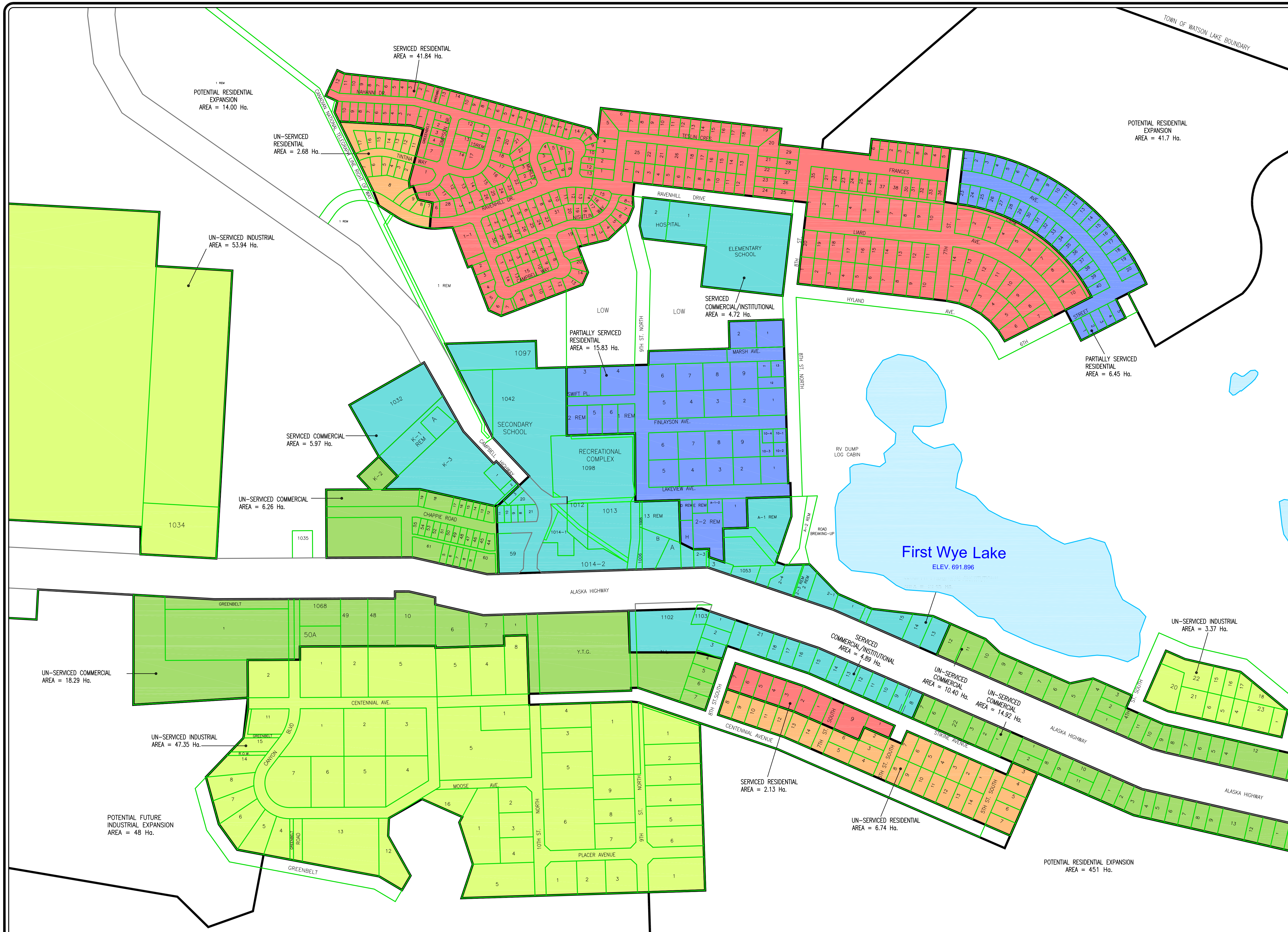
Based on information extracted from the overall community development plans the current development areas identified for the Watson Lake townsite are:

- Overall current developed area 400 hectares
  - Single family residential (serviced) 44 hectares
  - Residential partially serviced 22.5 hectares
  - Residential un-serviced 84.0 hectare
  - Commercial / institutional (serviced) 35 hectares
  - Commercial / institutional (un-serviced) 72.5 hectares
  - Industrial (un-serviced) 142.5 hectares

Assuming the 360 dwellings in the core area are all serviced, the single family residential dwelling density is approximately 360/66.5 = 6 units per hectare. With 2.5 persons / unit average density the serviced population density is approximately 15 persons / hectare. These densities are on the low side for typical serviced residential densities. More typical densities for serviced residential development would be in the order of 8 dwellings / hectare and 20 persons per hectare for single family residential development.

There are some dwellings already located in the un-serviced residential area, therefore the current development density is likely even lower than estimated. If the current development densities could be increased, the amount of future development land requirements could be reduced.

Overall Plans 001 and 002 show the current development type and areas for the existing core community.



XREFS

GENERAL NOTES

SERVICED RESIDENTIAL = 44Ha.

PARTIALLY SERVICED RESIDENTIAL = 22.5 Ha.

UN-SERVICED RESIDENTIAL = 9.5 Ha.

SERVICED COMMERCIAL = 35.0 Ha.

UN-SERVICED COMMERCIAL = 57.6 Ha.

SERVICED INDUSTRIAL = 0

UN-SERVICED INDUSTRIAL = 104.7 Ha.

TOTAL = 273.3 Ha.

REVISIONS :

NO.	DATE	ENG.	DESCRIPTION
01	AUG.18 2006	RMS	ISSUED FOR CLIENT REVIEW
02	NOV.20 2006	RMS	ISSUED FOR FINAL REPORT

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WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL DEVELOPMENT TYPE SHEET 1 OF 2

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	1 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV. 20, 2006	DWG. NO.:	001
PROJECT NO:	6047		

XREFS

GENERAL NOTES

UN-SERVICED RESIDENTIAL = 74.5 Ha.

UN-SERVICED COMMERCIAL = 4.9 Ha.

UN-SERVICED INDUSTRIAL = 37.9 Ha.

TOTAL = 127.3 Ha.

REVISIONS :

NO.	DATE	ENG.	DESCRIPTION
01	AUG.16 2006	RMS	ISSUED FOR CLIENT REVIEW
02	NOV.20 2006	RMS	ISSUED FOR FINAL REPORT

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WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL DEVELOPMENT TYPE SHEET 2 OF 2

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	2 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
DATE:	NOV. 20, 2006	DWG. NO.:	002
PROJECT NO:	6047		

Future Development and Density

Assuming similar serviced development densities of 8 units / hectare, and 20 persons per hectare, the additional serviced development area to meet the 20 year development requirements would be:

- 1150 population (1150 – 840)/ 20 = 15.5 hectares additional
- 2300 population (2300 – 840)/ 20 = 73 hectares additional

These are fairly large development requirements, which would result in 25% to 100% increases over the current residential development.

With this amount of potential growth, one could assume that the development density would likely increase significantly, due to more multi-family and apartment type development to service the resource industry labor requirements.

It is difficult to estimate the commercial / institutional development requirements, but if one assumes the current ratio of development would be similar (commercial/residential ratio), then the commercial / institutional development requirements could be:

- 1150 population (35/67)x 15.5 = 8 hectares additional
- 2300 population (35/67)x 73 = 38 hectares additional

8.0 Development Potential and Development Constraints

Based on a general review of the local area development potential, the following areas have been identified for potential future development:

Residential Development:

- Infill infill of existing vacant or low density development
- Area 1 north west of existing Campbell Subdivision
- Area 2 north east of existing Frances Avenue
- Area 3 south east of existing Centennial Avenue

Constraints affecting future development potential include:

- height of land relative to the existing reservoir
- height of land relative to drainage basins and ground water elevation
- height of land relative to the existing sewage lagoons and disposal system.
- vertical slope of the land
- proximity of the land to the existing lagoons and solid waste disposal sites.

The existing water reservoir is located at an approximate elevation of 749 m. In order to maintain gravity pressures in the range of 280 kpa, the maximum height of development would need to be below 720 m to avoid the requirement for pressure booster stations in the water distribution system. Ideally, all new development should be serviceable from the existing reservoir, or from a new reservoir at a similar elevation. This would allow the entire system to be supplied from both, or either reservoir and avoid different pressure zones in the water system. Additional pressure zones can be accommodated, but it increases system complexity and reduces system flexibility.

The height of developable land will impact on the ability to provide sewage collection. If the land is too low, gravity collection will not be possible. Sewage lift stations and forcemains may be possible, but results in high development costs and long term O&M costs. Typical solids handling lift stations have a head limitation of approximately 50 m Total Dynamic Head.

The maximum vertical slope for typical residential development should not exceed approximately 15%, to avoid expensive side hill development, steep road grades, and high development costs.

Development control guidelines established by Yukon Environment Health require a 300 m development set back from an active sewage lagoon, and 450 m setback from a solid waste site.

Based on the above constraints, the potential land available for development has been identified on the overall site development plans.

The area of potential residential development to meet future needs could be as high as 73 hectares, unless there is a significant increase in development density from the current development scenario. There appears to be potential for approximately 530 hectares of development in the identified areas as follows:

- west of Campbell Subdivision +/- 14 hectares
- north of Frances Avenue +/- 40 hectares
- south of Centennial Avenue +/- 450 hectares

The potential development areas could meet approximately 700% of the long term residential development requirements. The Campbell and Frances Avenue expansion areas could meet the anticipated long term residential development requirements.

Note that the area south of Centennial includes a large block of Lands Set Aside for land claims negotiations that have yet to be settled. The final agreement could affect the amount of expansion lands available to the Town of Watson Lake, in the area south of Centennial Avenue.

The area of potential commercial development to meet future needs could be as high as 38 hectares. There is currently about 72.5 hectares of un-serviced commercial development space available. Some of this area does have current development, however the development is sparse. If this un-serviced area was serviced, and the development density was increased, this area could likely provide all of the future commercial space requirements.

It is difficult to identify the proper mix between commercial / industrial space requirements. There is currently a significant amount of un-serviced industrial space available. Some of this industrial space is occupied, but could be converted to higher density commercial space if necessary. It would be easier to expand and develop un-serviced industrial space, than it would be to develop additional serviced commercial space, therefore the conversion of existing industrial space to serviced commercial space would likely be more cost effective. It would be relatively easy to service some of the close-in industrial space, resulting in more serviced commercial space for development, if necessary.

9.0 Current and Future Water Demand and Sewage Production

Existing Water Demand and Effluent Production

The Town of Watson Lake provided water pumping records and sewage pumping records for the first six months of 2006. These records were reviewed and averaged to determine average daily pumping rates for water and sewage effluent.

From the pumping records provided, the following daily average pumping rates were identified:

- Daily average water consumption pumped 195,500 igpd (889525 l/d) (10.3 l/s)
- Daily average sewage effluent pumped 143,200 igpd (651560 l/d) (7.55 l/s)

Assuming at least 90% of the water use is returned to the sewer system as collected effluent, one would expect the water consumption and sewer production to be more closely correlated. Sewage generation is only about 73% of the water consumption.

Possible reasons for the large difference include:

- Incorrect meter calibrations at one, or both meters
- Leakage from the water system, that is not being collected as effluent
- Leakage from the sewer system, that is not making it to the lift station
- More water is being trucked from the truck fill, than is being recorded, and is not being returned to the sewer system.

Two bleeders have been identified on the water system. These bleeders operate at approximately 4 gal/min. average flow.

Approximately 5 loads @ 2200 gal / load are assumed to be hauled from the existing truck fill station daily.

Since it is not readily possible to determine which figures are in error, a review of the water consumption was completed to compare these rates with other typical rates, to see if the water consumption was reasonable.

Typical water consumption rates for piped water systems are considered to be:

- 500 litres per person day, for domestic residential usage, and
- 10 to 30 cubic meters per hectare per day for commercial / institutional usage. (commercial usage in Whitehorse varies from 8 cu.m/ha to 30 cu.m/ha, depending on the development area. The airport area uses 8 cu.m./ ha, which has development typical of Watson Lake commercial areas, with restaurants and motels.) For this assessment we will assume that 10 cu.m./ha is the typical commercial usage for Watson Lake.

Using the existing residential and commercial development areas as defined on the overall plans, and taking into account the census population for the core community area, the following average water consumption values were estimated:

- residential demand, 500 l/p/d x 850 persons = 425,000 l/d
- commercial demand, 35 ha x 10000 l/h/d = 350,000 l/d
- bleeder demand, 2 * 4 g/m * 4.55 l/g * 1440 m/d = 52500 l/d
- trucked demand, 5 loads * 2200 g/load * 4.55 l/g = 50000 l/d

Total anticipated water usage per day is therefore 877500 l/day.

Total anticipated sewer production per day is therefore 744750 l/day, assuming trucked water is not returned to the sewage collection system, and return rate is 90 % of supply rate.

Using these figures as assumed typical rates, the **actual water consumption is approximately 1.0% higher than expected** (889525/877500), and the actual **sewer production is approximately 13% lower than expected** (651560/744750).

Based on these results it appears that water consumption is relatively close to what would be expected. Effluent production appears low, and there may be some exfiltration occurring from the sewer system, although this is less likely due to the typical high ground water levels in much of the piped sewer area. One would expect more infiltration than exfiltration in these conditions. It is also possible that the assumed commercial usage may be too high, and that there is actually leakage occurring from the water system, which is reflected in the lower effluent generation.

There is insufficient information available to be able to determine with any accuracy exactly what is happening in the systems. Detailed leakage testing on both the water and sewer systems would be required to determine these conditions. Note that during the preparation of this report, the Town repaired a watermain leak near the school, which reduced daily flows by approximately 60,000 litres per day.

Public Works personnel noted that a common occurrence is leaking water services, which have been abandoned or isolated due to residences not being occupied. It is quite possible that there are leaks on abandoned services which have not come to the surface due to the coarse gravel and sand soil strata in the area. These leaks, if they are present could continue undetected. One possible solution is to check all abandoned or isolated services for leaks, and to relocate the curb stop valves next to the watermain, instead of at the property lines. This will help to eliminate services freezing and breaking due to freeze up when the water is turned off at the property line cc valves. There are approximately 30 services which have been abandoned, and could be leaking.

Future Water Demand and Effluent Production

Future water demand and effluent production may vary significantly, depending on the economic growth in the area. Based on the normal anticipated growth rate, the 2026 serviced population could grow to approximately 1150. To assess the potential to service a major economic boom development scenario, we will assume a future growth to approximately 4000 people in the surrounding area, and approximately 2300 in the core serviced area. This will represent a 200 % increase over the normal expected growth.

For assessment purposes we will assume that the water consumption figures are relatively accurate, and assume that effluent production will be 90% of the water usage.

Using the suggested typical water consumption rates, and effluent production rates, and multiplying by the anticipated future population and development scenarios, the following future water usage and effluent generation has been determined:

- Residential Demand, 500 l/p/d x 2300 pop. = 1150000 l/d, plus
- Commercial demand, 10 cu.m/ha/day x 73 ha = 730000 l/d

Total anticipated future demand = 1880000 l/d, = 22 l/s
Total effluent production at 90% of water consumption = 1692000 l/d, = 20 l/s

These figures represent the demands for a total population of 4000 persons in the surrounding area, and 2300 in the serviced core community.

10.0 Current and Future Water Supply Requirements

The current water supply for the Town of Watson Lake consists of 2 active ground water wells in the vicinity of 1st Wye Lake and 6th Street. Wells 1 and 1A are currently providing the total water supply. A third well, #2 has been abandoned due to poor water quality and potential for contamination from surrounding development. It is assumed that both wells 1 and 1A do not have proper casing seals to prevent surface contamination of the aquifer.

A 4th new well has been drilled in the vicinity of the existing wells, but has not been placed into production due to high turbidity, iron and manganese levels. It is possible that the iron and manganese levels are elevated due to turbidity, and may drop once the well is pumped for a long period of time at a high rate of production. The new well has been drilled with a casing seal to prevent surface contamination form entering the well.

The existing wells are assumed to have the following available capacities:

- Well 1, 155 igpm, 12 l/s
- Well 1A, 133 igpm, 10 l/s
- Well 2005-1, 168 igpm, 12.7 l/s

Current flow monitoring equipment installed in the newly renovated pumphouse indicates the following pumping rates:

- Well 1 pumps at 11.5 l/s at 6 psi head,
- Well 1A pumps at 9.8 l/s at 6 psi head,
- Combined flow is 20.7 l/s at 7 psi head. (both wells pumping together)
- Inlet water temperature was observed at 3.3 Celcius.

Water supply and pumping equipment is typically designed to meet the maximum day demands for the community. Maximum day demands are typically 2 times the average annual daily demands for most serviced communities.

The existing wells 1 and 1A can therefore meet approximately 50% of the projected long term requirements, or service up to 1150 population. The existing wells can meet 100% of the current maximum day demand, however, if one well should fail or require maintenance, there is no backup well to cover maximum day demands.

If well 2005-1 was brought on line, the three wells could meet 77% of the long term requirements, or service up to 1800 population. Well 2005-1 could also provide backup to Well 1 or 1A, for emergency backup requirements during maximum day demands.

To meet the anticipated long term requirements an additional well or wells with a combined capacity of an additional 10 l/s would be required. It is anticipated that 1 additional new well could be drilled to provide this capacity. At current growth rates, the additional well would not likely be required in the next 20 years. A second additional backup well of at least 10 l/s capacity would also be required to provide emergency backup if any of the 4 production wells had to be taken out of service during maximum day demands.

The water quality from existing well 1 meets Canadian Drinking water standards but is quite hard.

The water quality from well 1A has elevated turbidity, iron and manganese.

The combined water quality from mixing these 2 wells is consistently above the recommended drinking water standards.

The water quality from well 2005-1 is also high in turbidity, iron and manganese, but these could be reduced with treatment for turbidity, or possibly with long term pumping. Some odor attributed to hydrogen sulphide gas was also noted in Well 2005-1.

High turbidity can also be linked to water born pathogens and can also impede affective water treatment. It has been previously recommended by others that well 2005-1 not be connected to the water system without proper treatment for turbidity.

Water from Wells 1 and 1A is currently pre-chlorinated prior to pumping into the water system at the existing booster pumphouse.

The existing contact chamber in the existing booster pumphouse is large enough to provide required chlorine contact time prior to the water entering the distribution system. However, due to the high turbidity there is a risk of poor treatment results, and even with the installation of chamber baffles, the contact time cannot be significantly increased to meet the minimum contact requirements for future demand requirements.

It has previously been recommended that a new treatment facility be constructed to provide turbidity treatment and required storage to provide sufficient contact time for pre-chlorination treatment.

Well 2005-1 should be brought on-line to provide emergency backup supply requirements during periods of maximum day demand. If treatment is required, a new pumphouse/treatment facility would have to be constructed.

Wells 1 and 1A should be equipped with proper surface casing seals to prevent surface water contamination of the ground water aquifer.

11.0 Current and Future Booster Pump Requirements

The existing booster pumphouse was recently upgraded to include new booster pumps and controls. 2 new booster pumps were installed with a rated capacity of 25 l/s @ 54 m TDH for each pump. The new booster pumps were observed to pump 25 l/s at 73 psi (51.5 m). The new booster pumps can meet the current maximum day requirement, with 100 % backup capacity, with a two pump installation. The booster pumphouse elevation is approximately 701 m.

Future booster pump installations should be capable of pumping at least 2 times the average day demand for assumed maximum day requirements. Therefore future booster pump capacity in the order of 44 l/s total capacity could be required. Future booster pump installation should provide at least 50% backup capacity for the anticipated maximum day demand, assuming a

three pump installation. A third 25 l/s booster pump would therefore be required to meet the future maximum day demand. It would be preferable to have this pump on-line as a backup pump, in case of duty pump failure. However, it could also be provided as a drop-in spare, as replacement can be achieved relatively easily in the new pumphouse.

12.0 Current and Future Water Storage Requirements

Current water storage for emergency storage, fire storage and balancing storage is provided by an elevated, underground , 2 cell concrete reservoir with a working capacity of approximately 250,000 igals. (1137500 litres).

The reservoir is located on the north side of the townsite, above the Campbell subdivision at an elevation of approximately 750 m. The reservoir elevation provides approximately 49 m of elevation head, or 70 psi of static water system pressure.

Typically, water storage is provided for fire protection, emergency storage and balancing storage to meet peak hour demands.

Fire storage requirements are a function of fire flow demand and duration. Typical fire flow demand for light commercial / industrial fires is 200 l/s, for a duration of 2.5 hours. Total fire storage required is approximately 1800000 litres. (400,000 igals).

Emergency storage is a function of system complexity, security of service and time required to make system repairs. Major water line breaks can take up to a full day to repair. Therefore, Emergency storage for up to 100 % of average day demand should be provided. Total future average day demand for 2300 population and 73 hectares of commercial development, is estimated to be 1,880,000 l/day. (415000 igals)

Balancing storage to meet peak hour demands is typically 25% of the average day demand, in addition to the emergency storage. Balancing storage to meet the future demands is therefore approximately 470000 litres (100000 igals).

The total required future storage is therefore 4150000 litres (915000 igals). With the existing reservoir capacity of 1137500 litres, an additional 3012500 litres (663000 igals) of storage is required.

The existing reservoir does not meet the recommended minimum fire storage requirements, and even with existing wells in production during a fire, the total production and storage falls short of the recommended fire storage requirements.

A new reservoir, with at least 2 cells to allow for cleaning and maintenance, should be constructed. The new reservoir capacity could be provided by adding on to the existing reservoir, however, it may be more beneficial to construct the new reservoir in a location that was more central to the overall future development if possible. This will result in shorter trunkmains, and lower headloss and overall pumping costs. The new reservoir elevation should be similar to the existing reservoir elevation, to allow for balanced system operation, and consistent operating pressures throughout the water system.

Another option is to add some of the required capacity at the existing reservoir site, by twinning the existing reservoir, and building the remaining future storage requirements at a new location. This would provide for some additional storage on the north side of town, where some of the near future expansion could occur, but the remaining storage needs would be provided by a new reservoir on the south side of town, where much of the longer term future development would likely occur. The available expansion area on the north side of town can possibly meet the near future expansion requirements for up to 2300 population, therefore the total reservoir requirements to service this population could be built at the existing reservoir site. Development beyond this level would require a new reservoir at a new site on the south side of town.

For this assessment we will assume that a new reservoir is immediately built at the existing site to add approximately 3000000 litres of storage at this site, and an additional new reservoir would be added in the future, at a site on the south side of town, to increase the future storage as required to service the additional expansion requirements to the south.

This will provide storage of 4150000 litres to meet fire storage, emergency storage and balancing storage requirements for up to 2300 population, which is the maximum population anticipated to be serviceable on the north side of town, at the current density and available expansion potential.

13.0 Current and Future Effluent Pumping, Treatment and Storage Requirements

The sewer system is currently serviced by 2 existing lift stations. Each lift station is connected to an upgraded, 2100 m long, 200 mm DI forcemain, which discharges at the top of a gravity outfall main on the south side of town near the old lagoon site. The 250 mm gravity discharge main carries the effluent approximately 1800 m to the anaerobic lagoons, and then to the long term storage lagoons further south.

There is no emergency standby power supply for either lift station.

The older lift station is a duplex pump system with 2 – 15 Horse power units, with an assumed pumping capacity of approximately 13 l/s @ 30 m TDH, which was designed to operate with the previous 150 mm forcemain. The old lift station is used as an emergency backup to the new lift station.

The newer lift station is a duplex pump system with 2 -25 horse power units, with a design pumping rate of 22 l/s @ 26 m TDH.

The upgraded forcemain could carry up to 45 l/s before reaching approximately 50 m TDH. This is based on a gravity head difference of 25 m between the lift station and the discharge end height, and approximately 25 m of friction head at a flow rate of 45 l/s. 50 m is the approximate limiting head for solids handling effluent pumps. Therefore the limiting capacity of the forcemain is assumed to be approximately 45 l/s, without pumping restrictions, or additional lift station installations.

The newer lift station could probably be upgraded to handle up to 45 l/s, which would require upgraded pumps with approximately 60 horse power.

The 250 mm gravity discharge main has a minimum capacity of approximately 31 l/s, assuming a minimum flushing velocity of 0.6 m/s at 0.25 % grade. The actual capacity may be higher, depending on the actual pipe grades.

The lift stations, forcemain and gravity discharge must be capable of meeting the peak hour effluent generation, which is typically approximately 3 times the average daily effluent production rate. Based on the current and future effluent production rates, the current and future peak hour rates are:

- Current rate, 7.5 l/s ADD, x 3 = 22.5 l/s peak hour flow rate
- Future rate, 20.0 l/s ADD, x 3 = 60 l/s peak hour flow rate

The existing newer lift station, upgraded forcemain and gravity outfall can meet the current peak hour demand flow rates.

The new lift station is currently at capacity, based on the current average daily effluent production and assumed peaking factor. The lift station will require pump upgrades to meet additional future development flow rates. The actual peaking factor may vary, and could be higher or lower. Observations should be made at the lift station during peak hour flow periods to see if the pumps are keeping up with the peak hour flows. If the peak demand factor is higher than assumed, it is possible that a single pump cannot keep up, and the second pump may have to operate, or surcharging will occur in the mains. Since both pumps are rated at 26 m TDH, it is possible that the peak flows exceed the pump capability and surcharging may be occurring in the collection system, which could result in flooding of basements, or overland discharging. Pump upgrading may be required immediately.

An emergency standby generator or increased effluent storage should be provided at the new lift station, to provide backup capacity during long power outages. The existing collection piping and lift station sump can provide some emergency storage, but it is limited due to the risk of backup and flooding of basements, or overland flows. Increased storage in the form of large diameter horizontal pipe or box culvert may be possible, but would require disturbance of the adjacent roads and right-of-way. A permanent standby generator and control building could be built, or a portable generator with manual connection and switching could be provided, if it is deemed that there is sufficient emergency storage capacity to allow time for the portable to be mobilized during a power failure. More detailed

assessment is required to determine which option is most suitable and cost effective.

The existing upgraded forcemain can meet future flow demands up to approximately 45 l/s before reaching limiting head losses of approximately 50 m for solids handling effluent pumps. The forcemain could handle higher flow rates of up to 83 l/s before total head would exceed the pipe design working pressure of 1035 kpa. (150 psi or 105 m). **The existing forcemain should be able to handle additional future development of up to approximately 1700 serviced population. The forcemain capacity should be reviewed in conjunction with the lift station upgrade design.**

The existing 250 mm gravity outfall can handle additional peak hour flow of up to at least 31 l/s, and possibly more, depending on the actual minimum pipe grades. Some surcharging in manholes could also be accommodated, which could increase the outfall capacity even more. **The gravity outfall should be able to handle additional future development of up to approximately 1200 serviced population at a minimum, and possibly more depending on actual outfall grades**. **The outfall capacity should be reviewed in conjunction with the lift station upgrade design.**

The existing anaerobic lagoons have a design treatment capacity of approximately 1100000 litres / day. (1100 cu.m./day). The current effluent discharge is approximately 652000 litres /day, from the piped collection system. The additional effluent hauled and disposed of at the lagoon is not known. **The existing anaerobic lagoons can meet the current piped system treatment requirements, and can service additional development up to approximately 1500 serviced population.** The total effluent production will be affected by the number of residents being serviced by trucked effluent from holding tanks. Monitoring of trucked effluent will be required in the future to ensure that the design capacity of the anaerobic lagoons is not exceeded by future development.

The existing long term storage lagoon was designed to meet storage requirements for a population of approximately 2100 total, at a design effluent production rate of 680 l/p/d, or a total average daily flow rate of 1428000 litres/day. The current effluent production rate is approximately 652000 l/day, therefore the storage lagoon can meet the current effluent production requirements. **The storage lagoon should be able to meet the future development requirements for up to approximately 1900 serviced population, assuming the effluent production rate remains the same.** The total effluent generation will be affected by the population serviced with trucked effluent and holding tanks. Monitoring of trucked effluent will be required in the future to ensure that the design capacity of the storage lagoon is not exceeded.

The existing storage lagoon is currently acting as an exfiltration pond, and has never required discharge. The actual capacity may be significantly greater than is currently assumed. A more detailed hydro-geological assessment is required to determine the ultimate capacity of the storage lagoon.

14.0 Current Water Distribution System Condition and Capacity

The existing water distribution system pipe network consists of 150 mm, 200 mm and 250 mm Asbestos Cement, Ductile Iron and Polyethylene mains. Mains are assumed to be un-insulated and buried at approximately 3.0 m bury for freeze protection.

Overall Dwg. 003 shows the existing water system and system components.

The watermains have forced circulation using 2 circulation pumps. One pump is located in the booster pumphouse, and circulates the mains on Frances Ave., Liard Ave., and Hyland, as well as 6th St. and a short portion of 8th Street. This is a new pump installed as part of the recent booster pumphouse upgrade, and has a design flow rate of 5 l/s @ 4.5 m.(0.4 kW) A second circulation pump is located in the circulation station on the Robert Campbell Highway at the truck fill site. This pump circulates the remaining mains. The capacity of this pump was not available, however the operator was able to determine the motor horsepower at 7.5 hp (5.5 kW), and the inlet and outlet operating pressures of 385 kpa and 465 kpa. Assuming a pump efficiency of 65%, the pump capacity has been calculated to be approximately 45 l/s.

Previous water temperature tempering equipment has been abandoned.

To meet the recommended design standards the water distribution system must be capable of providing up to 200 l/s fire flow for commercial areas, and 75 l/s fire flows for residential areas, during maximum day demand periods. Maximum velocities at these flows should not exceed 5 m/s. Minimum system pressures at fire flows should not be less than 140 kpa (20 psi) at the lowest pressure point.

Fire hydrant spacing should be approximately 150 m for residential hydrant coverge and 90 m for commercial hydrant coverage.

A review of the existing hydrant coverage indicates that residential coverage is generally acceptable. **An additional hydrant on Frances Ave. and Hyland Ave. would provide the necessary additional coverage.**

The commercial hydrant coverage is lacking in all commercial areas. **At least 10 additional hydrants should be installed in the commercial areas to improve hydrant coverage to meet the recommended design standards.**

Watermain capacities for the existing mains have been determined, based on maximum recommended velocities of 5 m/s as follows:

- 150 mm, Area = .018 sq.m. V = 5 m./s Q = 0.09 cu.m./s (90 l/s)
- 200 mm, Area = .031 sq.m. V= 5 m/s Q = .155 cu.m/s (155 l/s)
- 250 mm, Area = .049 sq.m. V = 5 m/s Q = .245 cu.m./s (255 l/s)

The capacity of the existing mains appears to be sufficient to provide necessary fire flows, providing minimum and maximum pressures can be maintained in the water system. System pressures are a function of pipe friction and available head. The static system head is provided by the elevation difference between the reservoir water level and the distribution system. The reservoir operating level is approximately 749 m, resulting in static pressures of 500 kPa (70 psi).

Water System Hydraulic Review

To determine the system capacity under operating conditions, a water model was constructed to simulate the system operation. The model inputs include the known pipe sizes and lengths, assumed pipe friction coefficient of 120, and known elevations of the water reservoir and pipe nodes, pumping capacities and recirculation pump capacities. The system was then modeled at various flows to determine system conditions at those flows. The system was modeled at the following operating flows and checked for pressures, velocities and fire flows in various locations:

- average day demand (total demand at 827500 l/d, 9.6 l/s) (Note: demand includes residential, commercial and bleeders. Truck fill demand was not included, as it is intermittent, and will be modeled as a single node demand).
- maximum day demand (average day demand x 2)
- peak hour demand (average day demand x 3)
- fire flows available (at maximum day demand plus fire at specified node)
- truck fill demand at specified node (11 l/s, assumes 10000 l load in 15 minute fill time)

Water model assessment indicates that fire flows for residential fire demands are acceptable for all hydrant locations except the west end of the Campbell Subdivision on the radial supply line at the west end of Nahanni Drive.

Water model assessment indicates that fire flows for commercial demands are acceptable in some areas, but are low in the vicinity of the high school, recreation centre, and along the Alaska Highway east of 8th street. These areas require fire flow improvements which can be provided by looping the watermain at the rear of the recreation centre, and by upgrading a portion of the watermain along the Alaska Highway east of 8th Street.

Recirculation flows appear to be suitable in most areas, but are low on Stikine Avenue. This can be corrected by creating a positive circulation loop in this area, by installing a valve or eliminating a short section of watermain on the Alaska Highway near 8th Street. This change would not affect fire flows in the area.

Residual pressures appear to be satisfactory in all areas with residential fire flows up to 75 l/s.

Residual pressures are low in a large part of the water system with commercial fire flows up to 200 l/s. Improvements for commercial fire flows can be obtained by the addition of new looped watermains on 9th Street, Finlayson Ave. and Lakeview Ave.

Recommended water system improvements include the following:

1) add new fire hydrants to increase fire protection coverage in some residential and most commercial areas.

2) install new 250 watermain on Lakeview Avenue to increase commercial fire flows in the core commercial area.

3) install new 250 and 200 watermains on 9th Street and on access lane behind the Recreation Centre to improve fire flows in this area.

4) install new 200 mm watermains on Finlayson and Marsh Avenues to service new development.

5) Upgrade existing watermain along Alaska Highway south of 8th St. to improve commercial fire flows in this area, are provide for future expansion to the south along the Alaska Highway.

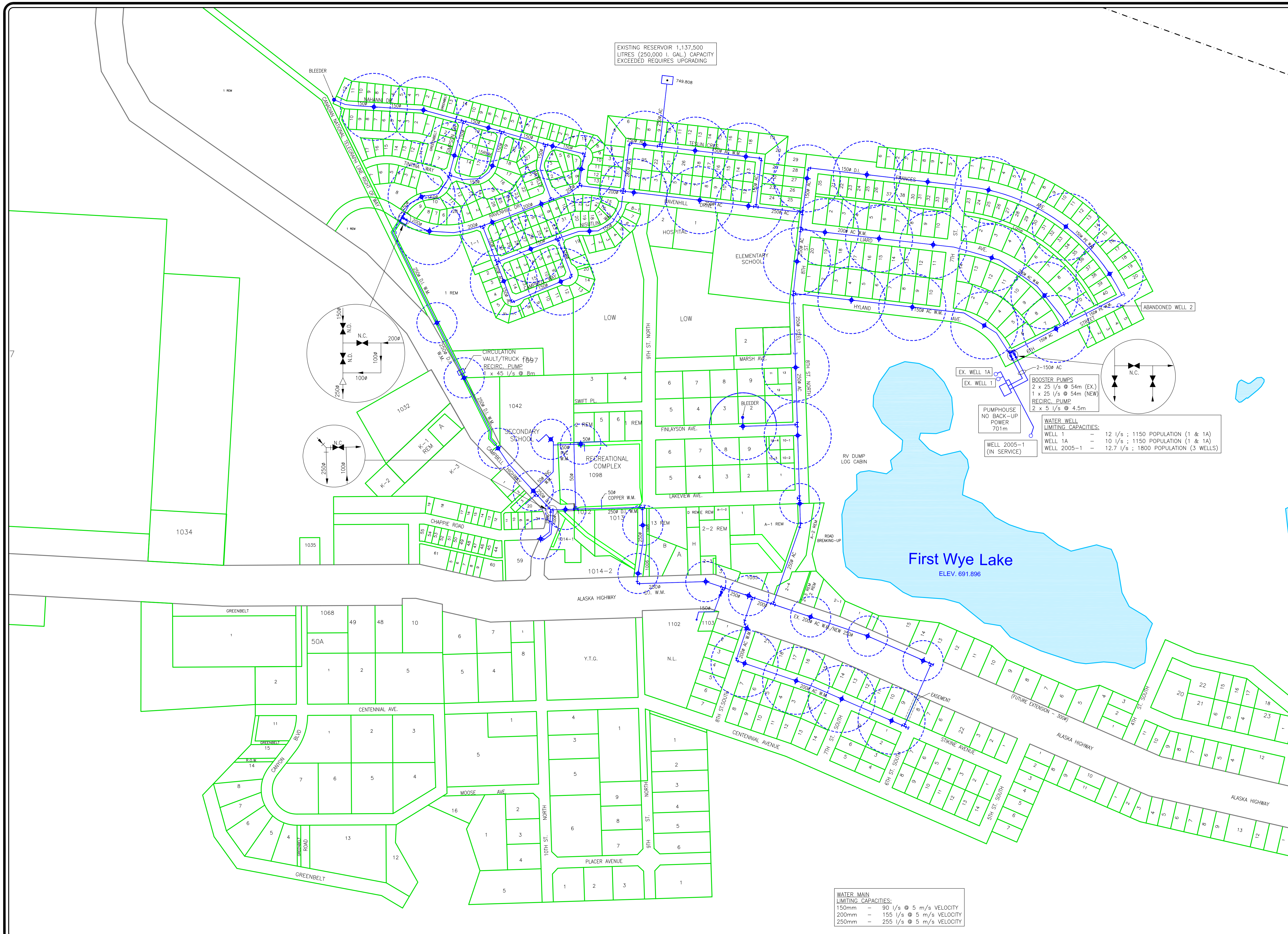
6) Upgrade and expand the water system for future development expansion to the west of Campbell subdivision, and to the north of Frances Avenue as required to meet future development demands. The order of development will require an economic analysis to determine which development is the most cost effective to proceed with.

The existing water system can be upgraded to meet the short term requirements noted above, and limited expansion to incorporate the proposed infill development.

Expansion of the existing water system to service major new development, or to service existing un-serviced areas, will require a detailed assessment of the overall water system to determine the upstream and downstream affects of any proposed new development.

Each proposed development should be assessed to determine the potential system impacts. This would require updating of the current water model to include the proposed development schemes and impact assessment.

Recommended water system improvements are shown on Dwg. 004.



XREFS

LEGEND

EXISTING HYDRANT LOCATIONS

HYDRANT COVERAGE
– 150m SPACING RESIDENTIAL
– 90m SPACING COMMERCIAL

NOTE:

WATER SUSTEM VALVES IDENITIED AS N.C. (NORMALLY CLOSED) ARE CLOSED FOR WINTER SEASON RECIRCULATION REQUIREMENTS

REVISIONS :

NO.	DATE	ENG.	DESCRIPTION
01	AUG.18 2006	RMS	ISSUED FOR CLIENT REVIEW
02	NOV.20 2006	RMS	ISSUED FOR FINAL REPORT

Quest Engineering Group
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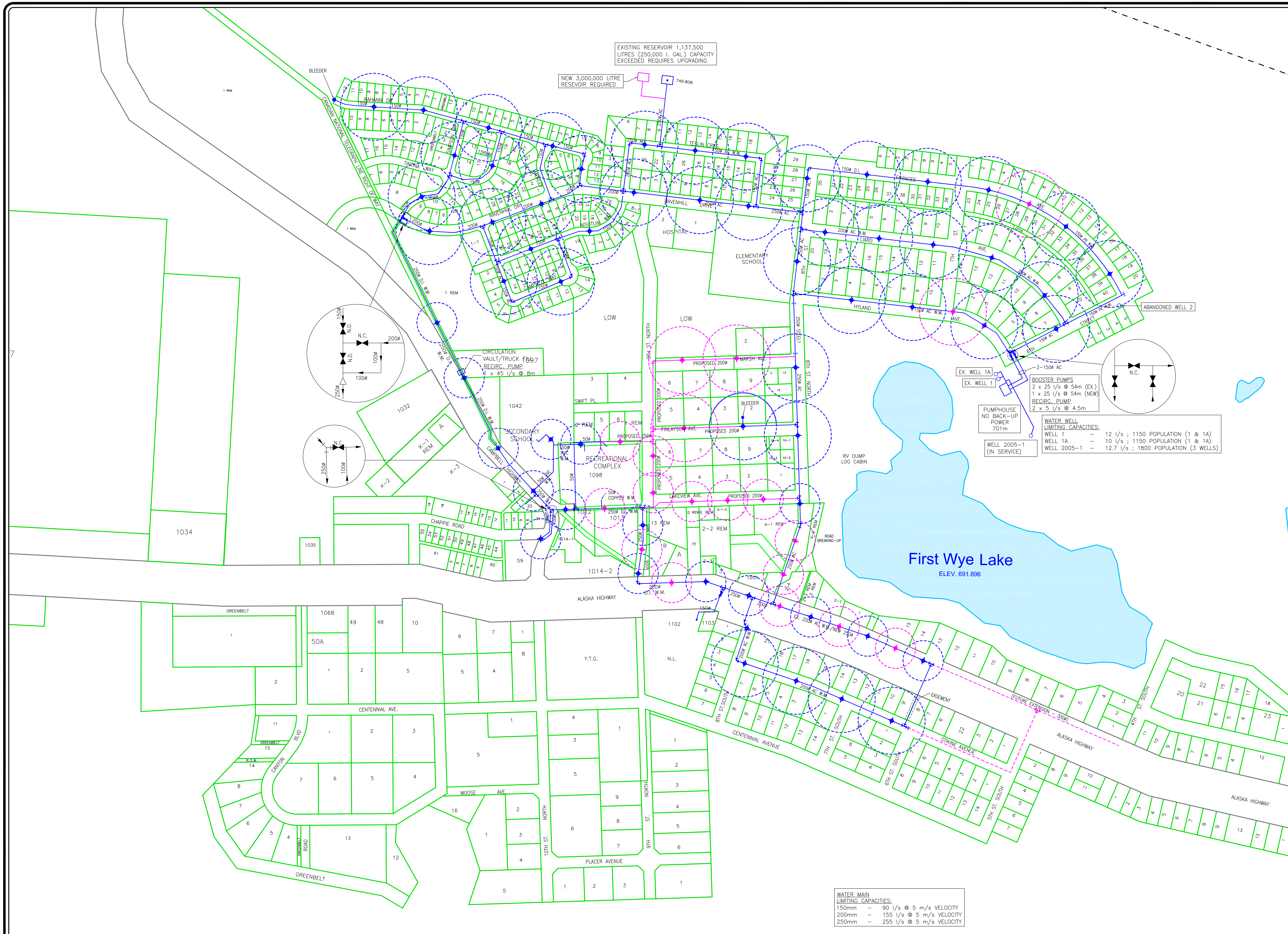
WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL LAYOUT WATER SERVICE SHEET 1 OF 1

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	3 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV. 20, 2006	DWG. NO.:	003
PROJECT NO:	6047		



XREFS

LEGEND

- EXISTING HYDRANT LOCATIONS
- HYDRANT COVERAGE
  - 150m SPACING RESIDENTIAL
  - 90m SPACING COMMERCIAL
- PROPOSED NEW HYDRANT/W.M. LOCATIONS
- PROPOSED NEW HYDRANT COVERAGE
  - 150m SPACING RESIDENTIAL
  - 90m SPACING COMMERCIAL

NOTE:

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REVISIONS :

NO.	DATE	ENG.	DESCRIPTION
01	AUG.16 2006	RMS	ISSUED FOR CLIENT REVIEW
02	NOV.20 2006	RMS	ISSUED FOR FINAL REPORT

ASSESSMENT

OVERALL LAYOUT WATER UPGRADES SHEET 1 OF 1

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	4 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV.20, 2006	DWG. NO.:	004
PROJECT NO:	6047		

Water System Maintenance Review

The current maintenance requirements for the water system include a couple of watermain breaks per season, plus annual mainline flushing through fire hydrants to remove sediment build up, and to check system component operation. This is fairly typical maintenance compared to other communities with similar water systems.

Although a majority of the water distribution system was constructed in the 1970's, the water system is assumed to be in generally good condition. The older asbestos cement pipes are bedded in granular bedding and natural granular soils, which are generally stable. The installation is not subject to much frost action, therefore pipe damage is minimized. The newer PE pipes should last indefinitely.

The system life expectancy should last for the foreseeable future without any major concerns. Pipe replacement should not be required unless upgrading for capacity deficiencies is required.

Routine maintenance includes annual flushing of mains at hydrants to remove sediment buildup in the lines. No major maintenance issues have been identified. System maintenance requirements are typical of other similar sized community water systems.

One particular maintenance issue that re-occurs is the repair of leaks on abandoned or un-used water service connections. Several residences have been vacated due to loss of jobs in the area. The water services are sometimes abandoned by the home owners, or the water supply is turned off. When this happens, the service line is left to freeze, creating splits in the copper services or curb stops. This is a particular problem where the curb stop is located across the road from the mainline, and the service is sure to freeze when not in use. One way to reduce this problem is to install the curb stops at the mainline, instead of at the property line at the end of the service. Under this scenario, the water can be turned off at the main, the service drains, and can remain un-used without risk of freezing and damage.

It is recommended that all abandoned or un-used services be checked for leakage, and that they be upgraded with a curb stop located at the mainline. There are approximately 30 services which have been shut off or abandoned, that should be checked and upgraded as noted.

Water System Thermal Review

A review of the water system thermal regime was completed to determine if heating of the water might be required for freeze protection. Even though the water is circulated, heat is still lost from the system. The amount of heat loss is a function of pipe thermal resistance, ground temperature and water temperature. Ground temperatures are affected by soil thermal resistance and ambient air temperatures. Dry granular soils will generally be colder than moist soils, due to the affect of latent heat in the ground water.

Inlet water temperatures are approximately 3 Celcius in the winter months. Ground temperatures are assumed to be approximately -10 Celcius, with an average winter air temperature of approximately -25 Celcius. Heat loss from the bare water pipes can be estimated using steady state heat loss equations and has been calculated to be:

- 150 mm, 166 W/m, 4000 m, total loss, 664000 W
- 200 mm, 178 W/m, 2300 m, total loss, 409400 W
- 250 mm, 188 W/m, 3200 m, total loss, 601600 W

Total Loss = 1675000 W

The daily heat loss is therefore 144720 MJoules.

The total heat loss from the system must be offset by new heat addition into the system, or freezing will eventually occur, and will start in areas of minimal flow, where cooling is the greatest. The heat addition to the system is in the form of warm water, and is equal to the available heat in the water entering the system each day. The average daily water consumption is estimated to be 902500 l. The heat addition, at 3 Celcius water temperature is approximately 11372 MJoules per day.

The estimated daily heat loss is significantly greater than the heat input, therefore the water system should be freezing. However, actual operations prove this is not the case. It is likely that a large portion of the water system is below ground water level, and the heat loss is much less than calculated. If ground water levels were to drop such that pipes were exposed to colder ground temperatures, there may be a risk of watermain freeze ups.

Return temperatures of the circulating water systems should be monitored in the late winter, to see how much the temperatures are dropping. If temperatures begin to drop to near freezing, there may be a need to begin heat addition to the water system to prevent freeze ups.

As additional development occurs, the water system lengths and overall heat loss will continue to rise. Heat loss on bare pipes will increase more than the heat addition from water use. It may be cost effective to consider insulated watermains for future developments. Insulated watermains lower heat losses significantly, and may eliminate the need for heat addition in the future. Insulated mains also reduce the need for deep bury, which can reduce construction capital costs. A cost / benefit analysis should be completed for any new expansions to determine if insulated pipes are more cost effective in the long term. Heating costs using fossil fuels will continue to rise over the foreseeable future.

15.0 Current Sewer Collection System, Condition and Capacity

The existing sewage collection system consists of 200 mm and 250 mm Polyethylene and Asbestos Cement pipes.

The current sewer system and components is shown on Dwg. 005.

The capacity of the existing collection system is limited by the pipe size and pipe grade. The minimum capacities for the 200 mm and 250 mm pipes, assuming a minimum grade to provide 0.6 m/s cleansing velocity, is estimated to be:

- 21 l/s for 200 mm @ 0.35% minimum grade, C=.013
- 34 l/s for 250 mm @ 0.35% minimum grade, C=.013

These minimum capacities could service the following total population, assuming peak hour flows of 3 x Ave. Daily Flow, at 450 l/p/d average effluent production:

- 1340 total population for 200 mm pipe
- 2175 total population for 250 mm pipe

These figures represent residential load only, and do not include infiltration or additional commercial loading. At present commercial loading is assumed to be approximately 44% of the total effluent production.

Based on this assessment the existing 250 trunk collection main along 8th Street could service approximately 2175 population north of the lift station (assuming all residential), and 1220 south of the lift station (56% residential, 44% commercial), for a total serviced population equivalent of 3395.

Depending on the location and design for the potential expansion area south of Centennial Street, it may be possible to direct some of the effluent directly to the 250 mm gravity discharge, and avoid an increase of pumped effluent at the existing lift station. It may also be possible to connect future forcemains directly to the existing forcemain, downstream of the existing lift station, to avoid increased pumping at the lift station, and reduce the load on the existing 250 mm trunk collection mains. These possibilities would be identified during the preliminary designs for any future expansion plans.

The existing 200 mm collection mains can easily accommodate the existing development areas. The ability of any particular segment to handle potential expansion would be determined during the preliminary design for proposed future expansion areas. Some upgrading of existing piping may be required to accommodate future extensions and expansion, beyond the existing development areas.

Although a majority of the sewer collection system was constructed in the 1970's, the sewer system is assumed to be in generally good condition. The older asbestos cement pipes are bedded in granular bedding and natural granular soils, which are generally stable. The installation is not subject to much frost action, therefore pipe damage is minimized. The newer PE pipes should last indefinitely.

The system life expectancy should last for the foreseeable future without any major concerns. Pipe replacement should not be required unless upgrading for capacity deficiencies is required.

Routine maintenance includes annual flushing of sewers to remove grease and sludge buildup in the lines. No major maintenance issues have been identified. System maintenance requirements are typical of other similar sized community sewer systems.

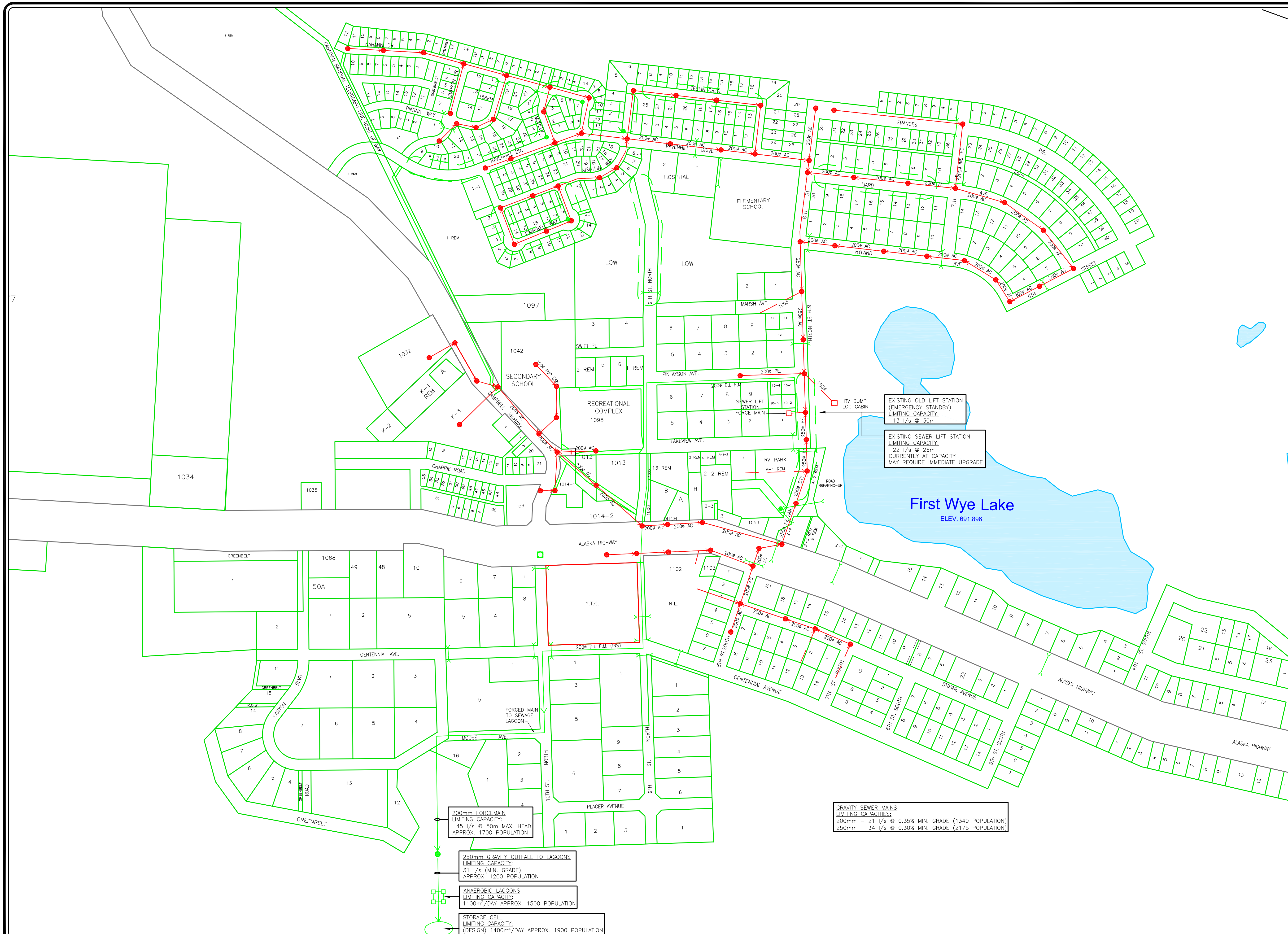
Collection system expansion on Lakeview, Finlayson and Marsh Avenues could provide additional development potential and densification of development in these areas. New 200 mm collection mains should be installed in these areas to allow additional development potential. Mains should be installed in conjunction with watermain improvements in these areas.

The existing sewer system can be upgraded to meet the short term requirements noted above, and limited expansion to incorporate the proposed infill development.

Expansion of the existing sewer system to service major new development, or to service existing un-serviced areas, will require a detailed assessment of the overall sewer system to determine the upstream and downstream affects of any proposed new development.

Each proposed development should be assessed to determine the potential system impacts.

Suggested Sewage System upgrades and infill expansion are shown on Drawing 006.



XREFS

LEGEND

EXISTING M.H. & SAN. MAIN LOCATIONS

NOTE:

WATER SUSTEM VALVES IDENITIED AS N.C. (NORMALLY CLOSED) ARE CLOSED FOR WINTER SEASON RECIRCULATION REQUIREMENTS

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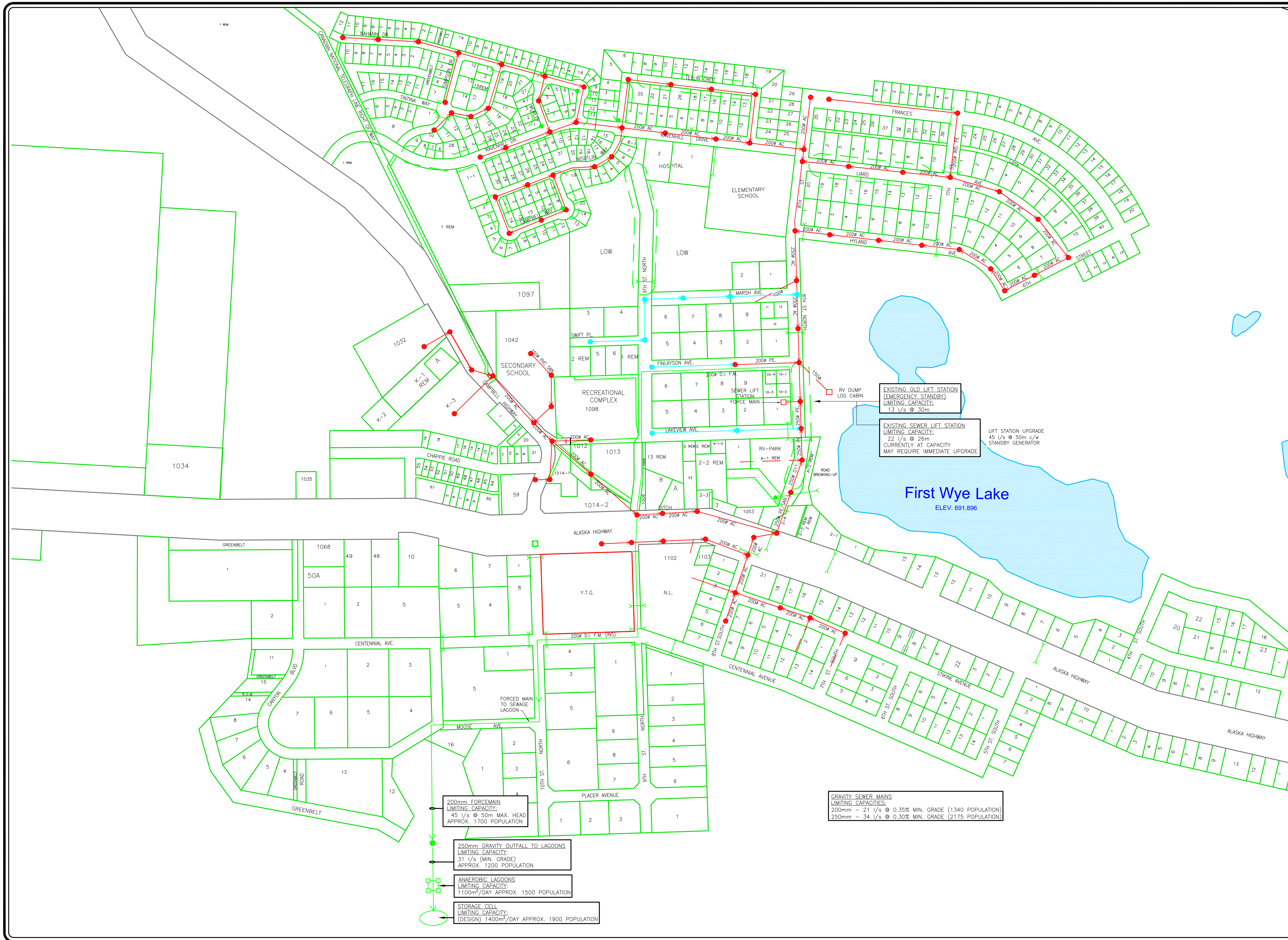
WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL LAYOUT SANITARY SERVICE SHEET 1 OF 1

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	5 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV.20, 2006	DWG. NO.:	
PROJECT NO:	6047		005



XREFS

LEGEND

EXISTING M.H. & SAN. MAIN LOCATIONS

PROPOSED NEW M.H. & SAN. MAIN LOCATIONS

NOTE:

WATER SUSTEM VALVES IDENITIED AS N.C. (NORMALLY CLOSED) ARE CLOSED FOR WINTER SEASON RECIRCULATION REQUIREMENTS

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WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL LAYOUT SANITARY UPGRADES SHEET 1 OF 1

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	6 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV.17, 2006	DWG. NO.:	006
PROJECT NO:	6047		

16.0 Solid Waste Collection and Waste Site Capacity

A detailed solid waste management plan was completed by others in 2003. The following assessment and design information was noted in the operational plan:

- 2003 area population total 2305, (1600 - Watson Lake, 300 – 2 Mile, 405 – 2.5 Mile)
- trucked collection from 556 households in Watson Lake. Self haul from 2 Mile and 2.5 Mile
- average solid waste generation was 1.03 tonnes/person /year.
- Estimated design life for solid waste site was at least 50 years for both a burn and no-burn operation.
- A burn operation could extend the design life of the solid waste site.

Total estimated solid waste tonnage for the 2003 population was 2374 tonnes/year. For a 50 year design life, the total tonnage would be 119,000 tonnes. With a population increase to 6000 over the next 20 years, the average population would be 4150 over the 20 year period, with an average annual tonnage of 4274 tonnes/year, or 85490 tonnes over the next 20 years.

With the projected population increase to 6000 over the next 20 years, the existing solid waste site should be able to accommodate the growth and increase in solid waste generation for approximately 28 years, with a no-burn operation. This design life could be extended with a burn operation, as noted in the operational plan.

For more detailed information on the solid waste operational plan refer to the 2003 Solid Waste report.

17.0 Existing Roadways and Drainage System

The existing road network consists of local and minor collector roadways, linked to the local Highway corridors.

The majority of the roadways are surfaced with Bituminous Surface Treatment (BST), while the remainder are gravel surfaced roadways.

Drainage is controlled with the use of roadway ditches, swales, culverts and drainage ditches which discharge to the local Wye Lakes depressions. Some areas have existing ground exfiltration sumps to control localized low area drainage.

Existing roadways are generally in good condition, with some isolated surface breakup in low, wet areas, where sub-grade saturation is occuring.

Existing road and ditch grades are very flat in some areas, resulting in ditch and swale ponding along the roadways. Several ponding areas result in flooding of sewer manholes, and infiltration into the sewer system during high rainfall periods.

In general the area drainage patterns and overland flow paths have been established from previous design and construction. The existing ditches and swales have become blocked by debris and silt build up in many areas, and should be cleaned and regarded to restore surface drainage.

Existing culvert sizes for the main road crossings appear to be sufficiently sized to handle the typical storm collection. In many cases the individual driveway culverts in the roadway ditches are too small, and should be upgraded to match the major culvert size requirements for the particular drainage course.

Additional ground exfiltration sumps could be installed in some isolated low areas to help control ponding in low areas. Exfiltration sumps should only be located in suitable granular soils, and should be engineered to provide a coarse gravel exfiltration bed, and access vault for silt removal maintenance. Sumps should be deep enough to prevent freeze up during spring thaw periods.

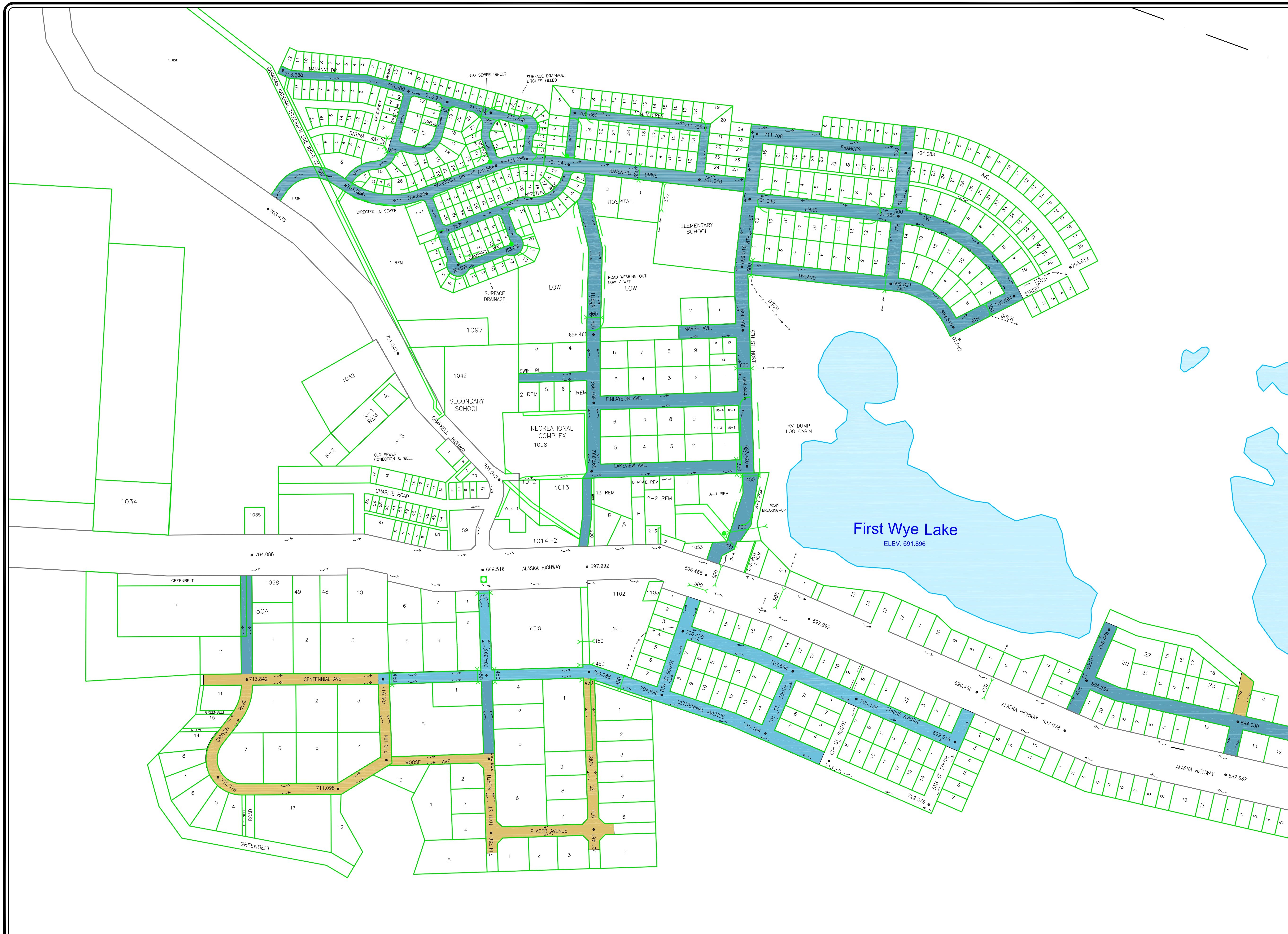
The existing BST road surfaces show typical stress for this type of road surfacing. BST is primarily dust control, with no structural benefit for the surface. Typical life span for BST surfacing is 7 to 10 years, depending on loading and traffic volumes. Annual maintenance including patching of pot holes can extend service life by keeping excess moisture out of the holes and sub-grade, to help prevent further breakup.

A BST surface condition, maintenance and replacement plan should be established, whereby road re-surfacing is planned and carried out on a routine basis, with the most critical restoration completed first, with on-going maintenance and replacment for all roads on a rotational basis as determined from the annual condition assessment.

Areas which are showing severe stress due to weak sub-grade, should be sub-excavated and reconstructed with clean granular sub-base materials to provide a structural base for the BST surface.

In areas where local ponding is entering the sewer system, the manholes should be raised to prevent inflow, or the depressions should be drained by improved ditching or drain sump construction.

The existing roadway network is shown on Dwg.'s 007 and 008.



XREFS

LEGEND

300	EXISTING CULVERT/SIZE
	EXISTING DRAINAGE FLOW
	EXISTING DITCH
	BST ROAD SURFACE
	GRAVEL ROAD SURFACE

REVISIONS :

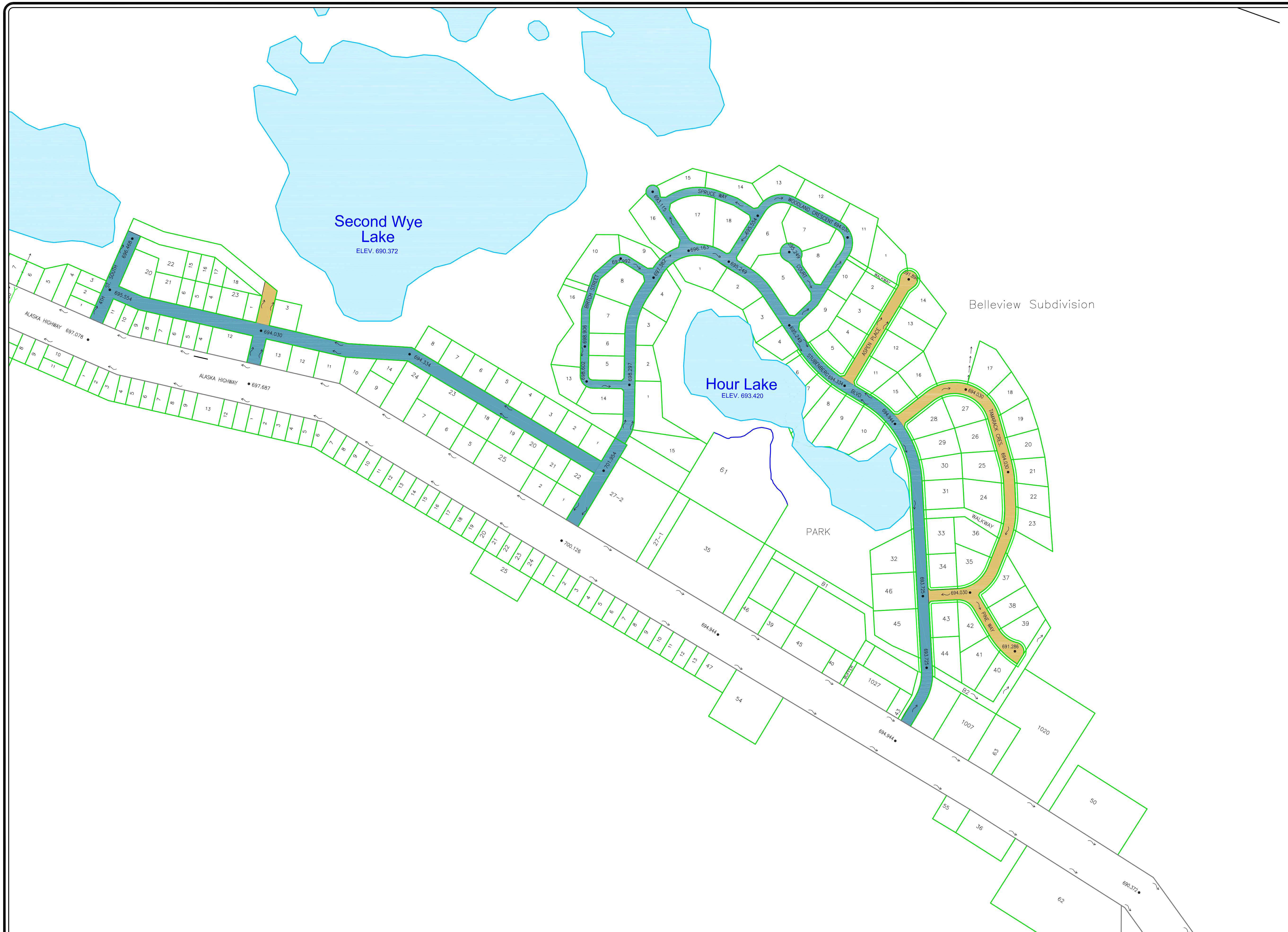
NO.	DATE	ENG.	DESCRIPTION
01	AUG.16 2006	RMS	ISSUED FOR CLIENT REVIEW
02	NOV.20 2006	RMS	ISSUED FOR FINAL REPORT

Quest Engineering Group
P.O. Box 31454, Whitehorse, Yukon Y1A 6K8
Tel: (867) 633 8930 Fax: (867) 633.8933 Email: contact@questengineering.ca

WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL ROAD LAYOUT & SURFACE DRAINAGE SHEET 1 OF 2

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	7 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV. 20, 2006	DWG. NO.:	
PROJECT NO:	6047		007



XREFS

LEGEND

300 EXISTING CULVERT/SIZE

EXISTING DRAINAGE FLOW

EXISTING DITCH

BST ROAD SURFACE

GRAVEL ROAD SURFACE

REVISIONS :

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WATSON LAKE INFRASTRUCTURE ASSESSMENT

OVERALL ROAD LAYOUT & SURFACE DRAINAGE SHEET 2 OF 2

SCALE:	1:8000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	8 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV. 20, 2006	DWG. NO.:	008
PROJECT NO:	6047		

18.0 Proposed Expansion and Future Development

Based on this assessment the following areas have been identified for potential future expansion for residential development.

- Infill — Infill and density increase — Priority 1
- Area 1 — West of Campbell Subdivision, — Priority 2
- Area 2 — North of Frances Avenue, — Priority 3
- Area 3 — South of Centennial Avenue, — Priority 4

The priority level is suggested based on the anticipated ease and cost of expanding the existing services to these areas, and the net benefit achieved by the expansion.

Area 1 is suggested as the next priority as it can be serviced relatively easily by looping the existing watermain through the area. This would also provide improved fire flows, and elimination of a dead end line and bleeder, on Nahanni Drive, which improves the overall water system.

A new sewer lift station would be required, which could also provide service for the remaining un-serviced lots in the west end of the Campbell Subdivision.

Area 2 is the suggested next priority area. It could be serviced along with the completion of services along Frances Avenue. Watermain looping should be possible throughout the expansion area, but may require circulation pump upgrading. A new sanitary lift station may be required due to the lower elevation in the expansion area.

A more detailed economic analysis is required to determine which expansion area would provide the most cost effective development. A conceptual development plan, and utility servicing plan should be prepared for both areas, to provide the basis for the economic analysis. It may be possible to reverse the priority level for these 2 areas, depending on the extent of infrastructure required, and the amount of land which can be serviced.

Area 3 is the next priority area. Area 3 can provide the greatest amount of future development space, but the cost of development will be higher, as a new reservoir will be required. Some of the area may be serviceable by gravity sewer directly to the existing gravity outfall, to avoid additional pumping costs at the existing lift station. This may also extend the service life of the existing lift station. Development within 30 vertical meters of the proposed water reservoir would require water pressure boosting to maintain minimum pressures.

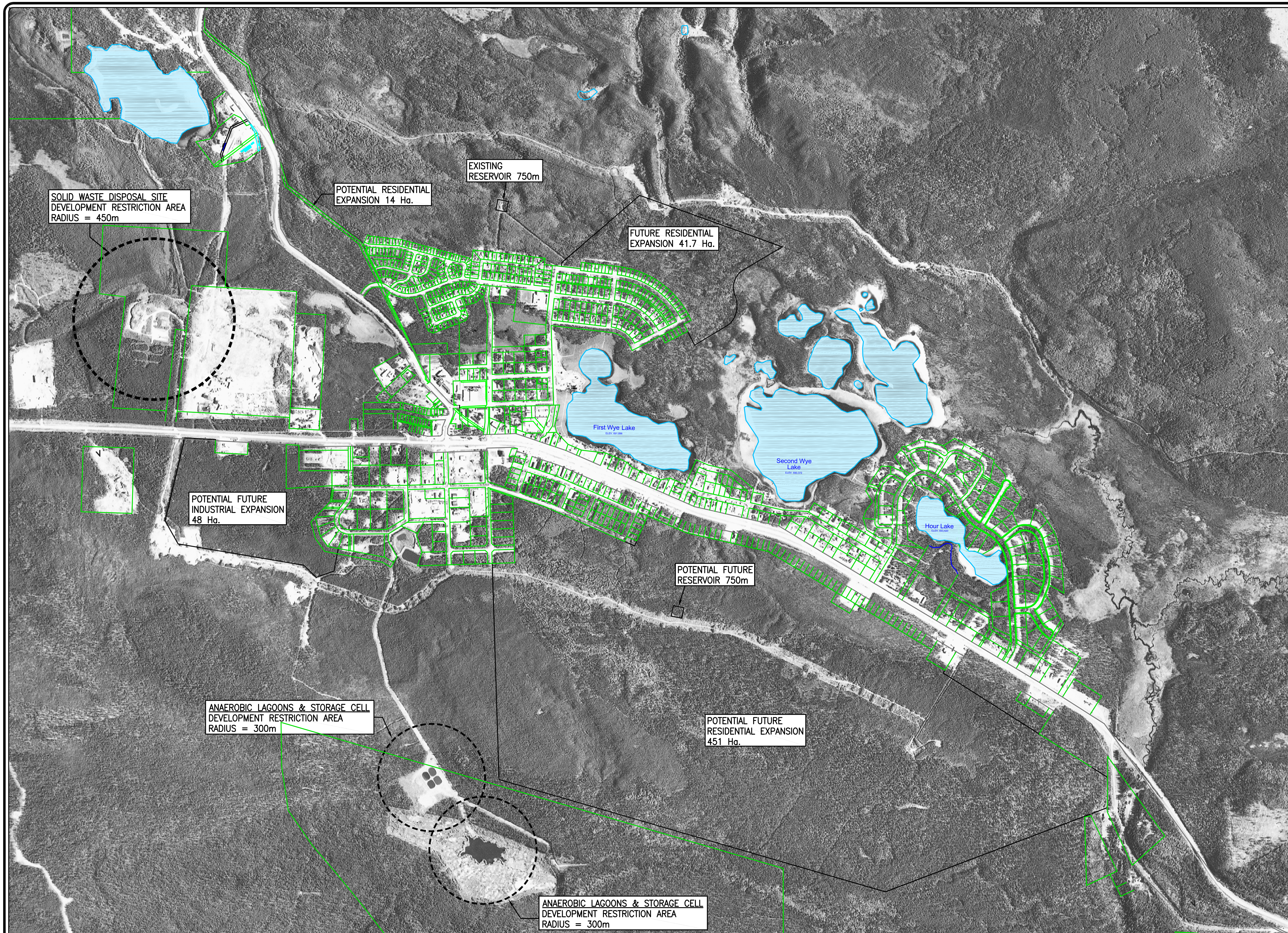
More detailed assessments should be carried out for each of these development areas, including surface mapping, subdivision layout planning, and water, sewer and drainage conceptual designs.

Commercial development can continue along the highway corridors, and expansion of water and sewer services along the east Alaska Highway corridor appears possible. A new lift station will be required due the drop in surface elevation to the east.

Some of the existing industrial area located close to the serviced highway corridor could be considered for commercial development, to meet the long term commercial requirements. It appears easier to expand to the south and west to develop un-serviced industrial land, than it is to develop serviced commercial land.

The overall future development plan shows these proposed development areas and anticipated amount of potential development space.

Potential future development areas are shown on Dwg. 009.



XREFS

REVISIONS :

NO.	DATE	ENG.	DESCRIPTION
01	AUG.16 2006	RMS	ISSUED FOR CLIENT REVIEW
02	NOV.20 2006	RMS	ISSUED FOR FINAL REPORT

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WATSON LAKE INFRASTRUCTURE ASSESSMENT

FUTURE DEVELOPMENT LAYOUT SHEET 1 OF 1

SCALE:	1:20000 @ 11x17		
DRAWN:	S. BAXENDALE	SHEET:	9 OF 9
DESIGNED:	R. SAVAGE	VIEW:	LAYOUT
	NOV. 20, 2006	DWG. NO.:	009
PROJECT NO:	6047		

19.0 Upgrading Requirements and Priorities

The following upgrading and expansion projects are suggested as a guideline for future upgrading and expansion priorities.

Expansion Planning and Conceptual Designs

- confirm expansion needs and priorities with steering committee.
- complete conceptual planning and design for proposed expansion areas 1, 2 and 3. Complete economic analysis for areas 1 and 2 to determine which development should proceed first.
  - Complete detailed terrain mapping
  - Complete subdivision plan layout and engineering analysis
- Complete pre-designs and detailed designs as demand requires
- Construct expansion areas as demand requires.

Water System Improvements and Priorities

- Install additional fire hydrants in residential and commercial areas to improve fire protection.
- Check and repair and/or isolate existing abandoned services to reduce leakage.
- Upgrade water storage requirements immediately to improve fire protection.
  - Construct additional storage capacity at existing reservoir location
  - Construct additional new reservoir as required by expansion demand on the south side of town
- Upgrade water system piping to provide improved fire flows
  - Complete watermain looping on Finlayson, Lakeview and 9th Street
  - Complete pipe upgrade on Alaska Highway east of 8th Street
- Complete pump testing of Well 2005-1. Confirm treatment requirements. Bring Well 2005-1 on-line to provide emergency backup water supply.
- Install well casing seals on existing Wells 1 and 1A to prevent surface water contamination of the aquifer.
- Construct new treatment pumphouse *if required for water treatment*
  - Improve chlorine contact time
  - Provide backup power supply
  - Upgrade booster pump capacity on-line (or provide spare drop-in pump for existing pumphouse)
  - Upgrade circulation pump capacity as required for system expansion
- Expand water system to expansion areas as demand requires
  - Area 1 and Campbell Subdivision expansion
  - Area 2 and Frances Avenue expansion
  - Area 3 and Alaska Highway east expansion
  - Upgrade circulation pump capacities as required

- Drill additional water well(s) to meet increased demand of expansion

Sewer System Improvements and Priorities

- Review operation and lift station capacity
  - Upgrade lift station pumps if required
- Provide standby power or storage at lift station as required
- Expand sewer system to expansion areas
  - Install additional lift stations as required
- Upgrade lift station, forcemain and gravity outfall as required for long term expansion
- Upgrade anaerobic cells as required for long term expansion
- Upgrade long term storage as required for future expansion

Roads and Drainage Improvements and Priorities

- Raise sewer manhole tops to prevent flooding
- Install drainage sumps in depressions as required
- Improve ditching, culverts and outfalls as required
- Improve road sub-grade structures as required
- Implement BST condition assessment / maintenance plan
- Expand road network to expansion areas as required.

Solid Waste Operations

- Update solid waste management plan as required
- Implement burn operational plan if required to extend waste site life span.

The planning and upgrading recommendations and priorities have been developed based on the system deficiencies and long term growth requirements.

Depending on the rate of growth, the direction of expansion and the changes in development type and density, the upgrading recommendations and priorities may need to be reviewed to determine if they are still applicable.

Order-of-magnitude cost estimates for the recommended conceptual planning and system upgrades are provided to assist with long term budget planning.

Note: (cost estimates to be provided after review of 1st Draft and confirmation of recommendations and priorities.)

20.0 Order of Magnitude Costs and Project Priority Levels

Project	Estimated Cost	Priority High	Priority Med.	Priority Low
Conceptual Plans, Areas 1 and 2	$75000		#	
Conceptual Plan, Area 3	$150000			#
Check/Isolate Abandoned Water Services	$150000	#		
Install Fire Hydrants to improve protection	$90000	#		
Construct new water storage reservoir	$1,354,000	#		
Construct New Water Mains, Lakeview	$175000	#		
9th, Rec Centre	$160000	#		
Finlayson	$100000		#	
Alaska Highway	$200000		#	
Marsh	$150000			#
Complete Well 2005-1 pump testing / treatment	$75000	#		
Construct casing seals for existing wells 1 and 1A	$25000 each	#		
Bring Well 2005-1 on line as emergency backup	$10000	#		
Construct Treatment Facility (if required)	$1,170,000			
Expand Water System to expansion areas	$ to be determined		#	
Drill Additional Water Wells	$75000 each			#
Existing Lift Station Pump Upgrade	$200000	#		
Standby Generator at Lift Station (reduced cost if portable unit can be used)	$325000		#	
Expand Sewer System as required	$ to be determined		#	
Upgrade forcemain, outfall and treatment lagoons as required.	$ to be determined			#
Raise Manholes / Eliminate Infiltration	$ to be determined	#		
Install additional drainage Sumps and Improve Road drainage	$ to be determined		#	

20.0 Report Certification

Richard M. Savage, RET, LL(Eng)
Project Manager, Project Engineer
Quest Engineering Group

Professional Engineer's Seal

Appendix A

Overall Plans

Overall Plans (A1 Size Plans Appended Seperately)

- Existing Development Overall Plans (001 & 002)
- Water System Overall Plans (003 & 004)
- Sewer System Overall Plans (005 & 006)
- Roads and Drainage Overall Plans (007 & 008)
- Future Development Overall Plan (009)

Appendix B

Order of Magnitude Cost Estimates

Watson Lake Infrastructure Assessment

Order of Magnitude Cost Estimates

Watermains - Supply and Installation c/w valve, hydrants, trenching/backfi $500 / lm

Lakeview Avenue	9th to 8th	350 lm @ $500 /m	$175,000
9th St.	Lakeview to Finlayson	160 lm @ $500/m	$80,000
Rec Centre Fire Flow upgrade		160 lm @ $500 / m	$80,000
Finlayson	9th to 8th	200 m @ $500 /m	$100,000
9th St.	Finlayson to Marsh	160 lm @ $500 /m	$80,000
Marsh	9th to 8th	300 lm @ $500 /m	$150,000
Alaska Highway upgrade to 250/300		400 lm @ $500/m	$200,000
Total Watermain upgrades			**$865,000**

Hydrant Upgrades in Commercial and Residential Areas

Supply hydrants	12 @ 2500/each	$30,000
Install hydrants	12 @ $5000 /each	$60,000
Total Hydrant Upgrades		**$90,000**

Abandoned Services to Be Isolated and/or Repaired

Install new CC's at main, repair as required, c/w trenching/backfill	30 @ $5000/each	$150,000
Total Service Upgrades		**$150,000**

Well Development and/or Drilling of new Wells

Develop Well 2005-1 to determine if treatment is necessary	1 @ $75000	$75,000
Drill new wells for emergency backup	2 @ $75000/each	$150,000
Total for Well Development and drilling		**$225,000**

New Reservior Construction **3000 cu.m. reservior**

Size	30 x 30 x 4 m depth		3600 cu.m. total capacity 3150 cu.m. working capacity
Wall Areaa	30 x4 x 4	480 sq.m.	

Roof/Floor area	30 x 30 x 2	1800 sq.m.	
total Surface area		2300 sq.m.	
Wall concrete	480 x .2	96 cu.m.	
Roof/floor conc.	1800 x .3	540 cu.m.	
Total concrete		650 cu.m.	
Total Forming	2300x2	4600 sq.m.	

Clearing / grubbing	50x50 = 2500 sq.m. @ $5 /sq.m.	$12,500
excavation/backfill	40x40x4 = 6400 cu.m. @ $20 / cu.m.	$128,000
fencing	40x4 = 160 lm @ $100/m	$16,000
forming	4600 sq.m. @ 100/sq.m.	$460,000
concrete	650 cu.m. @ 500/cu.m.	$325,000
piping / controls	lump sum @ 100000	$100,000
Total		$1,041,500
Total c/w 30 % contingencies		**$1,353,950**

New Pumphouse / Treatment Facility

Pumphouse / treatment Building Upgrade	$250,000
Storge / retention tank	$100,000
Treatment Train Package	$250,000
Standby Generator	$150,000
Pumps/piping/controls	$150,000
Total	$900,000
Total c/w 30% contingency	**$1,170,000**

Sewer Lift Station Upgrades

Pump and control upgrades	$150,000
Standby Generator and Building	$250,000
Total	$400,000
Total c/w 30% contingency	**$520,000**

New Lift Station Packages, c/w Standby Generators for new developments

Package Duplex lift stations, c/w standby generators and buildings, each	**$500,000**

Land Development Cost / Order of Magnitude / Cost per Lo

Assumptions
- lots have 20 m frontage average
- lots have separate services (100 san / 20 water)
- roads are rural section with ditches and culverts, no curb/gutter/sidewalk
- roads have BST surface

r/w width = 25 m, average service length = 12.5 m

Per lot cost / double loaded roadways	
clear/grub/strip @ 250 /m x 20 m	$5,000
watermain @ 500/m x 20 m	$10,000
sewermain @ 400/m x 20 m	$8,000
services @ 400/m x 12.5 m	$5,000
roads @ 500/m x 20 m	$10,000
total / lot	$38,000
Total c/w 30% contingency / lot	$49,400
Cost / hectare @ 8 units per gross hectare, 8 x 4940(	**$395,200**

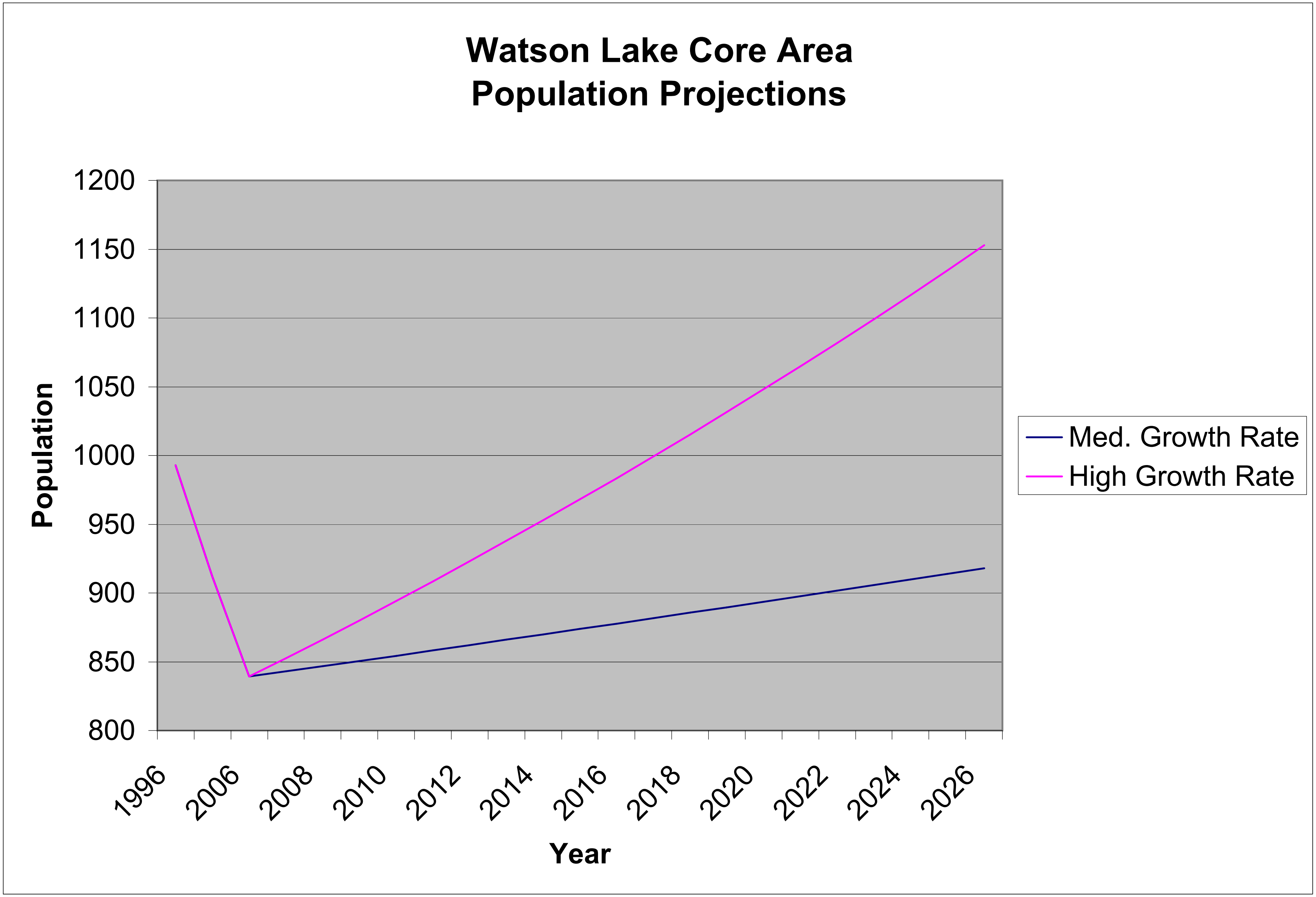
Appendix C

Population Statistics and Projections

Watson Lake Population Statistics and Projections (Current to 20 year growth horizon)

Year	Census Data	Health Data	Ratio (census/health	
1996	993	1791	0.554439	
2001	912	1648	0.553398	
2006	839	1515	0.553918	Calculated Estimates

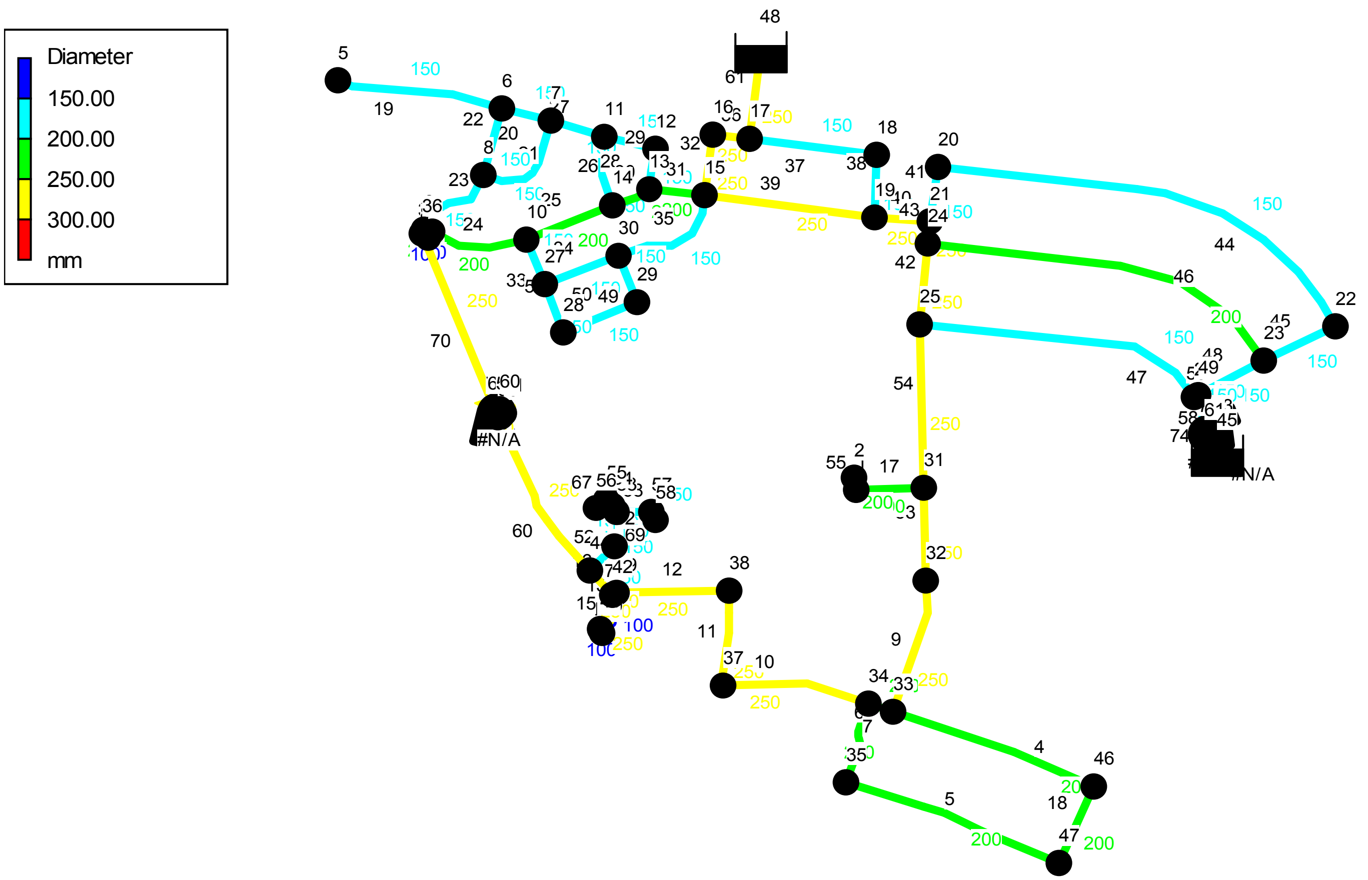
Growth Projections	Low	Med	High	Low	Med	High
Ave. Annual Growth	-0.60%	0.45%	1.60%	-0.60%	0.45%	1.60%
2007	834	843	853	1506	1522	1539
2008	829	847	866	1497	1529	1,564
2009	824	851	880	1488	1536	1,589
2010	819	854	894	1479	1542	1,614
2011	814	858	909	1470	1549	1,640
2012	809	862	923	1461	1556	1,666
2013	805	866	938	1453	1563	1,693
2014	800	870	953	1444	1570	1,720
2015	795	874	968	1435	1577	1,748
2016	790	878	984	1427	1585	1,776
2017	785	882	999	1418	1592	1,804
2018	781	886	1,015	1409	1599	1,833
2019	776	890	1,032	1401	1606	1,862
2020	771	894	1,048	1393	1613	1,892
2021	767	898	1,065	1384	1621	1,922
2022	762	902	1,082	1376	1628	1,953
2023	758	906	1,099	1368	1635	1,984
2024	753	910	1,117	1359	1643	2,016
2025	749	914	1,135	1351	1650	2,048
2026	744	918	1,153	1343	1657	2,081


Watson Lake Core Area
Population Projections
Population
1200
1150
1100
1050
1000
950
900
850
800
1996
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
Year
Med. Growth Rate
High Growth Rate

Appendix D

Water Model Pipe Networks

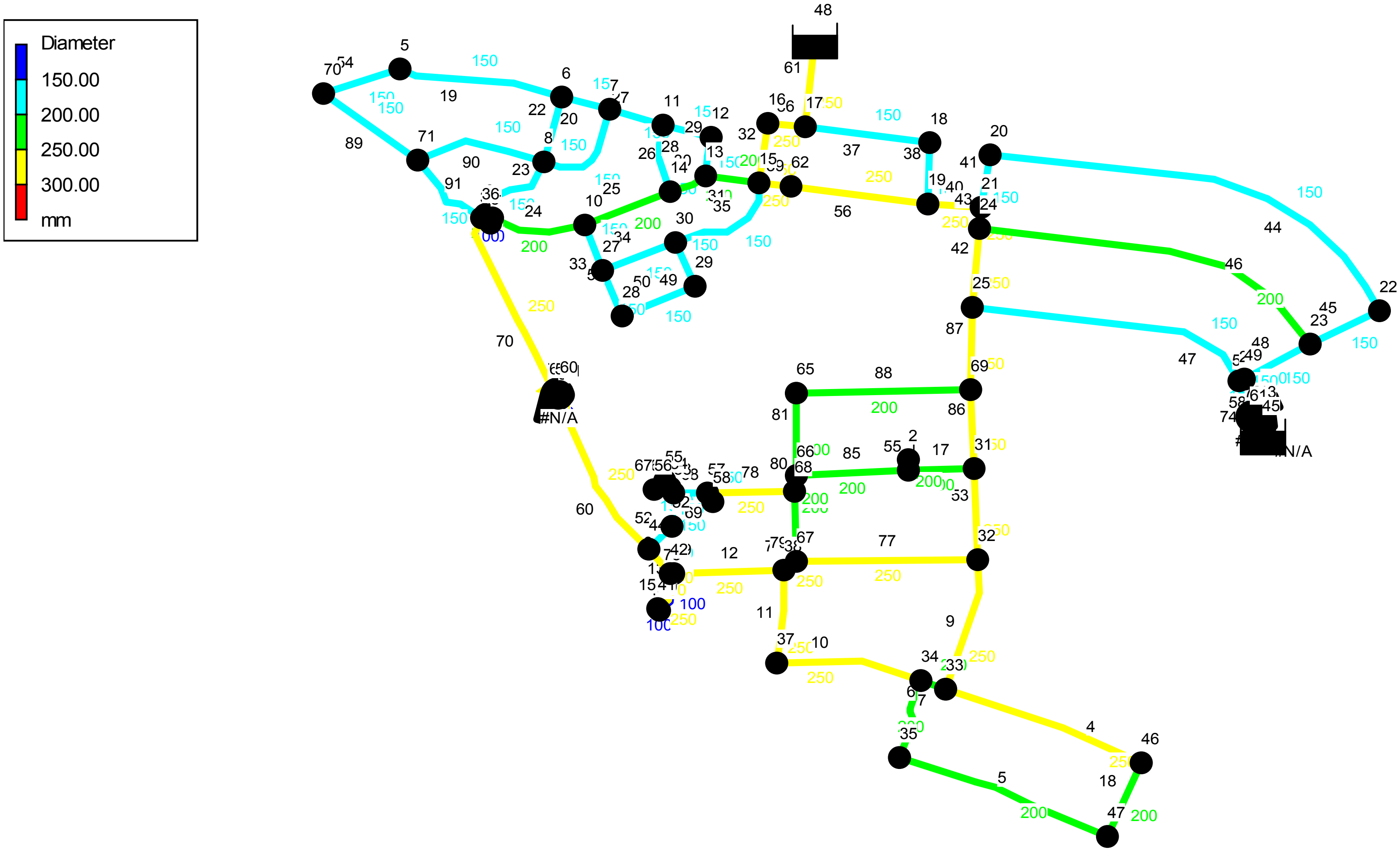
Watson Lake Water System



Existing Pipe Network Sizes

Day 1, 12:00 A

Watson Lake Water System



Upgraded Water System Pipe Network Sizes