5 Appendix B – Issued For Review Design Drawings

APPENDIX B:

Water Supply Capacity Consumption & Conservation Study

RMSi Resource Management Strategies Inc.
Protecting resources for future generations

FSC
ARCHITECTS & ENGINEERS

WATER SUPPLY CAPACITY, CONSUMPTION & CONSERVATION STUDY

Rankin Inlet, NU

GN Project # 09-3009
FSC Project # 2009-1310

April 20, 2010

Prepared for:

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LISTEN. DESIGN. MANAGE.

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1.0 Executive Summary

The implementation of the water efficiency strategy presented in this report will provide the Hamlet of Rankin Inlet with a significant amount of additional water supply capacity and waste water treatment capacity. This capacity, an estimated 597,000 litres per day, can be provided cost-effectively, at least 34% less costly than building new supply infrastructure. In addition, this additional supply capacity through water efficiency can be provided immediately without lengthy design and environmental assessment requirements.

In September 2009 the Government of Nunavut contracted FSC Architects & Engineers in conjunction with Resource Management Strategies Inc. (RMSi) to complete a Water Supply Capacity, Consumption & Conservation Study for the Hamlet of Rankin Inlet. The primary objective was to provide advisory services to optimize the water use in the community to ensure efficient and conservative water use, thereby optimizing the infrastructure and water resource.

Residential Water Use Demand Analysis

An analysis was completed to segregate water use into several categories, so that water use by single family properties, multi family units and the ICI sector could be identified. Customer billing data for the period form August 2006 to August 2009 was compared to:

- Rankin Inlet Business Directory provided by the Canada-Nunavut Business Service Centre
- Rankin Inlet House Numbering system Map, dated April 23rd 2002
- Satellite imaging of Rankin Inlet

The comparison was completed in order to identify the number of properties in each category, and to allocate a volume of use. Properties that were identified as residential housing but listed in the ICI sector was re-categorized as residential for the analysis.

Based on the data provided, a breakdown of the 2009 (Sept. 2008 to Aug. 2009) residential customer billed consumption is shown in the following Table 1.

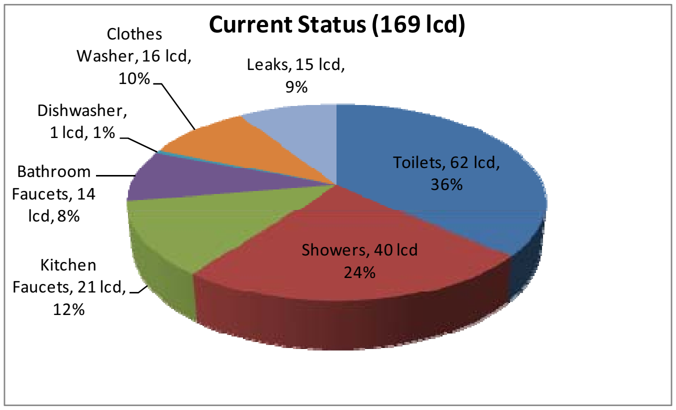
Table 1: Rankin Inlet 2009 Residential Customer Billed Consumption

Category	2009 Billed (litres)	Population 2009 est.	Water Use – Litres per Capita per Day (Lcd)
Residential	111,544,000	2,499	122

The billing analysis indicated that 75% of the overall billed water is to the residential sector. In addition using an estimated 2009 population of 2,499, the residential per capita consumption was 122 litres per capita per day (Lcd). A relatively low residential per capita consumption was expected in Rankin Inlet since there is minimal outdoor water use. However, the excessive water using fixtures and appliances found in the market research would indicate that the residential consumption should be significantly higher than what was indicated from the billing data. It was also observed that the age and technology (remote read) of the residential meters would support lower meter readings than the actual usage and the remote read technology could allow for unauthorized unbilled water use. Both of these factors were confirmed by GN CGS staff as concerns.

Using observations from the market research in addition to factors from the AWWA AWARF 1999 Residential End Uses Study, a residential water balance and a calculated per capita consumption was developed. The results of this calculation provided a residential per capita consumption of 169 Lcd. The water balance is shown below in Figure 1.

Figure 1: Calculated Residential per Capita Consumption and Water Balance



The calculated per capita consumption indicates that the actual residential consumption could be as much as 38% higher than that reported in the billing data. In order to compare this consumption level with other municipalities in Canada, and around the world, the following Figure 2 has been prepared:

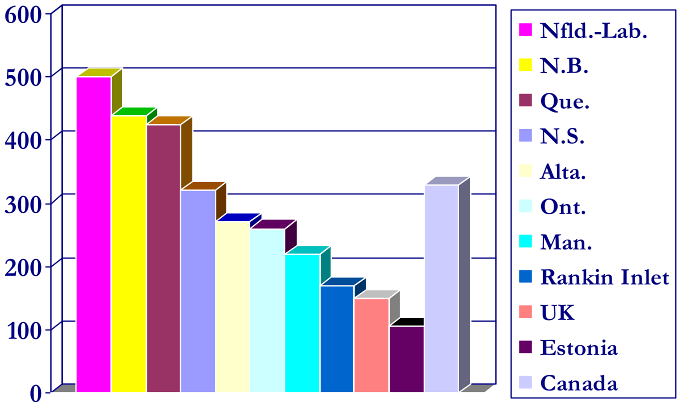


Figure 2: Comparison of Residential Per Capita Demand (lcd)[1]

Prior to 1994, toilet flush volumes were generally 20 litres or greater. The National Building Code or the National Plumbing Code does not address water conservation and as such do not provide required toilet flush volumes. In December 1995, the Government of Nunavut released its 2nd Edition of the Good Building Practices Guidelines. The Guidelines was provided as a supplement to the National Building Code to assist builders and developers with the construction in a northern climate. It is recommended that the GN considers updating the 1995 Guidelines with current proven water efficiency products such as high efficiency toilets and dual flush toilets in addition to lower flow rated showerheads and faucets. Such an update would ensure that all newly constructed homes would be as water efficient as possible.

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[1] Municipal Water Use Survey, Environment Canada, 2004.

Industrial, Commercial and Institutional (ICI) Water Use Demand Analysis

According to the 2009 billing data provided, the industrial, commercial and institutional (ICI) sector represents approximately 25% of Rankin Inlets' bill water consumption. In 2009, the volume of billed water to the ICI sector was 35,128,000 litres, which is 30% more than 26,962,000 litres billed in 2008.

Further investigation of the billing data for 2009 produced the following discrepancies:

- Polar Bear Investments c/0 Nanqu Inn – 7,842,000 litres additional in 2009
- Community & Government Services, Kivalliq – approximately 3,000,000 litres additional in 2009
- Rankin Inlet Airport – approximately 1,500,000 litres additional in 2009

The additional water volume represented by these 3 accounts more than offset the increase in water volume in 2009. In addition, similar to the residential water meters as large mechanical meters get older they tend to under-register due to wear. Due to the discrepancies in the billing data the confidence in the accuracy of the ICI billed water consumption is extremely low.

For the purpose of this analysis, it was assumed that the 2008 ICI billed volume of 26,962,000 litres was more representative and as such used as the corrected 2009 ICI volume.

Further analysis of the ICI billing data indicates that 35% of the customers consume 80% of the overall water for that sector.

AWWA/IWA Water Audit and Water Balance

As part of the Government of Nunavut's (GN) ongoing water loss management program, GN completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance for the Hamlet of Rankin Inlet Water System. The project was completed for a full year from August 2008 to August 2009, based on available billing data. A copy of the report in its entirety can be found in Appendix B of this document.

The gathered data for 2009 was entered into the AWWA – WLCC (Water Loss Control Committee) software program. The results of the analysis are shown as follows:

Parameter	Value for 2009
Current Annual Real Losses (CARL)	145,000,000 litres
Unavoidable Annual Real Losses (UARL)	14,000,000 litres
Infrastructure Leakage Index (ILI)	10.17
System Input Volume	428,000,000 litres
Corrected Billed Water (corrected for estimated accuracy of billing system)	181,000,000 litres
Non-Revenue Water	247,000,000 litres
Volume of Non-Revenue Water - % of System Input Volume	57.7%

The financial results from the IWA software analysis are shown below:

Parameter	**Value**
Annual Cost of Apparent Losses Customer meter under registration Unauthorised consumption – based on estimated customer water and sewer rate of $4.50 per 1,000 litres	$52,215
Annual Cost of Real Losses – Variable Production Cost Based on estimated cost of $0.35 per 1,000 litres	$50,798

In any water system there will be a volume of leakage that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair – this is the Unavoidable Annual Real Losses (UARL). The IWA software uses the physical characteristics of the water distribution system (length of water mains and services, number of connections, average pressure) to make an estimate of UARL. The Current Annual Real Losses (CARL) are also calculated by the software, by taking the water supplied and deducting the calculated authorized consumption and apparent losses, to give CARL. The ratio of UARL to CARL is the Infrastructure Leakage Index (ILI).

The World Bank Target Matrix gives performance category A for an ILI 1 - 2; category B for ILI 2 – 4; category C for ILI 4 – 8; and category D for ILI greater than 8.

The Hamlet of Rankin Inlet Water System's ILI of 10.17 puts them in performance D category – very inefficient use of resources; leakage reduction programs imperative and high priority

Although operational and financial considerations may allow a long term ILI greater than 8.0, such a level of leakage is not an effective utilisation of water as a resource. The priority for the Hamlet of Rankin Inlet Water System should be to develop an active leak detection program to reduce water losses, and reduce the ILI to initially below 8.0, and then progressively reduce it further till it is in performance category B.

Strategy Implementation Plan

The recommended components of the plan include:

Residential Measures

- Visit all homes and apartments and install free of charge HET or dual flush toilets, low flow showerheads, kitchen aerators, bathroom aerators and water efficient clotheswashers. To eliminate toilet leakage in homes, it is recommended that only "flapperless" type toilets be installed. These are proven products and readily available in the market.

Industrial/Commercial/Institutional Measures

- Visit all businesses and institutions and install free of charge HET or dual flush toilets. To eliminate toilet leakage in businesses, it is recommended that only "flapperless" type toilets be installed. These are proven products and readily available in the market.

- Visit commercial kitchens and install free of charge low flow pre-rinse spray valves.
- Complete five (5) comprehensive water audits and offer a capacity buy-back rebate to any facility that implements all or some of the water saving recommendations.

Municipal Measures

- Design and implement five (5) district meter areas. Locate, quantify and repair the leakage within the water distribution system.

Public Education

- Distribution of booklets, leaflets, and fact sheets at community and environmental events.
- Distribution of a water efficiency bulletin in the water bills.
- Displays at community events.
- Develop and maintain a website to educate the public on water efficiency.
- Provide workshops and seminars to the public on water saving techniques both inside and outside the home.

Youth Education

- Develop and deliver a water efficiency education program based on curriculum requirements.
- Develop and facilitate a Children's Water Festival.

For reference individual business cases for each recommended water conservation and efficiency measure are provided in Appendix D of this report.

Table 2: Capital Budget and Water Savings (Litres per average day)

Residential	Water Saving Measure	Number of Product Installed	Total Cost	Total Program Savings (L/d)	Cost per litre
Installation	HET Toilets	768	$ 707,921	96,903	$ 7.31
Installation	Dual Flush Toilets	85	$ 79,434	10,767	$ 7.38
Installation	Low Flow Showerheads	854	$ 103,208	42,246	$ 2.44
Installation	Kitchen Faucets	776	$ 55,096	15,644	$ 3.52
Installation	Bathroom Faucets	854	$ 49,664	18,376	$ 2.70
Installation	Leakage Repair	854	$ -	43,068	$ -
Installation	Clotheswashers	776	$ 970,000	14,356	$ 67.57
Industrial, Commercial, Institutional					
Installation	HET Toilets	357	$ 329,486	16,740	$ 19.68
Installation	Dual Flush Toilets	40	$ 37,850	1,860	$ 20.35
Installation	Pre-Rinse Spray Valves	15	$ 14,500	3,680	$ 3.94
Installation	ICI Audits and Capacity Buy-back	5	$ 72,250	15,000	$ 4.82
Municipal					
Installation	Leakage Reduction	5	$ 275,000	287,500	$ 0.96
Education					
Public Education (5 years)			$ 150,000		
Youth Education (5 years)			$ 180,000		
TOTAL			$ 3,024,408	566,140	$ 5.34

It is recommended that the above capital plan be supported by ongoing monitoring, evaluation and maintenance in order to initially verify the water savings and then to sustain them into the future.

The overall best practices capital program is budgeted at $3,024,408 and is expected to save just over 566,000 litres of water per average day (l/d).

The cost per litre per day for the proposed plan is $5.34. This compares well to the average cost per litre per average day capacity for new infrastructure, which is estimated at $8.00. To add new water and wastewater infrastructure to deliver the equivalent capacity of 566,000 l/d would cost $4.5 million based on the average $8.00 per litre capacity cost.

Although some program measures did not meet the cost analysis, which includes clotheswashers, ICI HET toilets and ICI dual flush toilets, these program alternatives have been included due to the significant savings that they bring to the overall plan. However, it is important to note that even with the inclusion of these programs the overall plan remains more cost-effective than the cost of constructing future water and wastewater supply/treatment capacity.

Due to the difficulty in measuring water savings generated by education, there have been no savings attributed to the Broadscale Public or Youth Education programs in the plan. Technical solutions, such as low flush toilets and low flow showerheads will only achieve a portion of the potential water savings. Education designed to change habits and attitudes or residents towards water use will achieve the remaining savings. The American Water Works Association suggests that education programs can generate up to a 4 to 5% reduction in water demand by long-term education initiatives. In addition, education is necessary to ensure that water savings generated by the capital program are sustained. Since, education should be ongoing, 5 years of costing has been included.

Overall Water Savings

The overall water savings anticipated from the implementation of the recommended strategy is shown in Table 3 below.

Table 3: Overall Water Savings

Sector	litres/day	litres/year
Residential	241,360	88,096,000
ICI	37,280	13,607,000
Municipal	287,500	104,938,000
Total	566,140	206,641,000

The water saving plan will free up 206,641,000 litres/year of water supply capacity. This represents approximately 61% of the total water supplied in 2009.

In addition to providing water supply capacity, the plan will reduce demand on the wastewater system by 101,703,000 litres/year.

Residential

The water savings attributed to the residential sector was compared against 2009 billed consumption and the residential water balance that was developed. Results of this comparison are shown in Table 4.

Table 4: Comparison of Residential Savings and 2009 Residential Consumption based on Billing Data and based on Water Balance

Residential Sector	Per Capita Consumption (Lcd)	Residential Consumption 2009 (litres)	Residential Water Savings (litres)	Percent Savings
As per Billing Data	122	111,544,000	88,096,000	79%
As per Water Balance	169	154,151,000	88,096,000	57%

Industrial, Commercial and Institutional

The water savings attributed to the ICI sector was compared against 2009 corrected billed consumption. Results of this comparison are shown in Table 5.

Table 5: Comparison of ICI Savings and 2009 ICI Billed Consumption

ICI Sector	Corrected ICI Consumption 2009 (litres)	ICI Water Savings (litres)	Percent Savings
As per Billing Data	26,962,000	13,607,000	50%

Municipal

The water savings attributed to the Municipal leakage reduction program was compared against the water loss identified from the AWWA/IWA Water Audit and Water Balance results. Results of this comparison are shown in Table 6.

Table 6: Comparison of Municipal Savings and Water Loss Results

Municipal Sector	Estimated Water Loss 2009 (litres)	Municipal Water Savings (litres)	Percent Savings
As per Billing Data	145,000,000	104,938,000	72%

Energy Savings and Greenhouse Gas Emissions Reductions

The overall energy savings generated from water efficiency is in most cases more significant than the water savings. Water utilities are typically the largest consumer of electricity in a municipality. Electricity is used in the water and wastewater treatment processes but more significantly in the pumping/conveyance of water and wastewater. A recent study[2] completed by the Polis Project on Ecological Governance, University of Victoria evaluated historical data relating to water production and energy consumption from 7 municipalities in Ontario. The study completed case studies on the Town of Collingwood, the Regional Municipality of

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[2] Maas, Carol. Greenhouse Gas and Energy Co-Benefits of Water Conservation, Polis Discussion Series Paper 08-01, November 2008, Polis Project on Ecological Governance, university of Victoria, Victoria, BC.

Durham and the City of Guelph. The study reported, that it takes 0.68 KWh of electricity for every 1,000 litres of water delivered to a customer and then returned through the wastewater process. The findings from this study were used to develop the energy savings and greenhouse gas emission reductions reported below.

Many of the water saving measures recommended in the strategy also reduce energy consumption at the customer's premise. For example, a low flow showerhead reduces not only water but reduces hot water. Oil or electricity has been used by the customer to generate the hot water. Energy savings will also be generated from the faucet aerators, clotheswashers, pre-rinse spray nozzles and the ICI Audit program.

Typically a residential customer who participates in the water efficiency program will see greater dollar savings in their energy bill as compared to their water bill. This is also an important linkage to emphasize when promoting the water efficiency programs to the public.

The reduction of water-use through an efficiency program and the associated energy savings provides significant greenhouse gas reductions. With climate-change in mind, most municipalities have set their own greenhouse gas reduction targets. Water efficiency can be a positive contributor to meeting those targets.

Although the participant's energy savings were not quantified as part of this project, the utility energy savings and greenhouse gas emission reductions are provided in Table 7 below.

Table 7 – Estimated Energy Savings and Associated Greenhouse Gas Emission Reductions

	Water Savings per Year (litres/yr)	Energy Savings per Year	CO2 Reductions per Year (tonnes/yr)
Overall Water Savings	206,641,000	130,022 KWh Electricity	78.0 tonnes

Assuming an electric rate of $ 0.35 per KWh, the Hamlet of Rankin Inlet would reduce its electrical bill by approximately $45,858 per year upon completion of the strategy. In addition, the greenhouse gas emissions reduction is equivalent to removing 14 cars from the road.

2.0 Introduction

Although water conservation and efficiency has been promoted by the Government of Nunavut for many years, the changing landscape has brought water efficiency to the forefront. Water Efficiency is recognised as a utility Best Management Practice (BMP) by the Federation of Canadian Municipalities (FCM), National Research Council (NRC) and the American Water Works Association (AWWA). The benefits of water efficiency are numerous:

- Water efficiency is the most cost effective alternative in generating additional water and wastewater capacity, sometimes as low as 25% of the cost of new infrastructure
- It can defer and sometimes eliminate new infrastructure projects
- Water savings from an efficiency program are quite often immediate, and can assist in bridging the gap in a water supply deficit area prior to the construction of a technical solution
- The pumping stations, tempered water and distribution system consume significant amounts of energy, water efficiency reduces that energy consumption and thus reduces greenhouse gas emissions
- Water efficiency can contribute to lower water and energy bills for residents and businesses

In September 2009 the Government of Nunavut contracted FSC Architects & Engineers in conjunction with Resource Management Strategies Inc. (RMSi) to complete a Water Supply Capacity, Consumption & Conservation Study for the Hamlet of Rankin Inlet. The primary objective was to provide advisory services to optimize the water use in the community to ensure efficient and conservative water use, thereby optimizing the infrastructure and water resource.

Tasks completed by the project team are as follows:

- Residential Market Research
    - Residential Survey
    - Household Audits
- Residential Water Use Demand Analysis
- Industrial, Commercial and Institutional (ICI) Water Use Demand Analysis
- Evaluation of Distribution System Water Loss
    - International Water Association / American Water Works Association (IWA / AWWA) Water Audit and Water Balance
- Development of Specifications for Leak Reduction Equipment
- Identification and Evaluation of Water Efficiency and Conservation Measures
- Water Use and Water Efficiency Report

3.0 Market Research

3.1 Residential Survey

Background

A market research study pertaining to water use habits in the Hamlet of Rankin Inlet was completed on behalf of Government of Nunavut. The study was completed to assist with future planning and improvement of water services for the community.

The survey questionnaire was designed to take approximately 20-30 minutes to complete. The questionnaire was available in Inuktitut and English. Four hundred copies of the survey were distributed to homes through out Rankin Inlet during the week of October 21, 2009 with instructions to return the completed forms to the Hamlet Town Office by October 26, 2009. Ultimately, the deadline was extended to November 5th 2009.

To thank the residents who participated in the survey, a draw was held to win a new laptop computer on November 5th with the results announced on the local radio station.

In total, 62 completed survey responses were received. This statistically valid sample provides a confidence level of 95% +/-6%. All of the information gathered from the survey results were compiled and aggregated.

Observations

Q1. Thank for your participation. Where do you currently obtain water from…?

100% of the respondents indicated that their water was supplied through the municipal water distribution system. None of the respondents indicated that they received their water by truck delivery or that thye had sewage holding tanks on site.

Q2. Do you use water in your home for commercial or business purposes?

None of the respondents used their properties for commercial or business purposes.

Q3. When you think about the environment in Rankin Inlet, what are the top 3 things that come to mind?

When asked about the environment, respondents indicated that they think primarily about water quality/pollution, water conservation and energy efficiency.

Water Quality/Pollution	68%
Water Conservation or Efficiency	67%
Energy Efficiency	60%
Waste Management/Recycling	30%
Air Pollution/Smog	23%
Water Shortages	20%

Poor Drainage	12%
Pesticide Use	8%
Flooding	3%

Q5. Using a scale of 1-10, where '1' means "Not Important" and '10' means "Very Important, how important is it for your household to save water?

Two/thirds of the respondents felt that saving water at home was very important.

Not Important (1-3)	7%
Important (4-7)	26%
Very Important (8-10)	67%

Q6. Compared to 5 years ago, has saving water in your household become ….

Over two/thirds of the respondents indicated that saving water in their household has become more important over the past 5 years.

Much more important	34%
Somewhat more important	36%
Somewhat less important	>1%
Much less important	0%
Has not changed	26%

Q7. Do you…?

Respondent's home ownership/rental arrangement was marginally different from results of 2006 Census

60% of the respondents rent their homes (compared to 69% in 2006 Census)

40% of the respondents own their homes (compared to 31% in 2006 Census)

Q8. How long have you lived at your current address?

Average length of time living in the current premise was 10 years.

Q9. Approximately how old is your home?

Average age of home was 22 years.

Q10. Is your home a…?

Respondents reported that,

Separate House	52%
Apartment	24%
Town House	23%
Duplex	1%

Q11. Using a scale of 1-10, where '1' means "Not At All", and '10' means "A Great Deal". How much has your household changed the way you save water in the past 5 years?

Once again, well over two/thirds of the respondents reported that they have changed the way they save water over the past 5 years. The most common reason for their actions was to save or conserve water, followed by to reduce their water utility bill.

Not at all (1-3)	33%
Somewhat (4-7)	39%
A great deal (8-10)	28%

Q12. Why hasn't your household changed the way you save water?

The most common reason among respondents was that they were not billed for water.

Q13. How does your household currently save water?

Low flow showerheads and full loads of dishwasher/clotheswasher machines were indicated as the most common approaches to saving water. Of interest, a quarter of the respondents indicated that they did not know how to save water. This indicates that a significant educational opportunity exists.

Use Low-flow shower heads	48%
Make sure full load in dishwasher/washing machine	48%
Use Water efficient appliances (washer, dishwasher)	38%
Use Low-flush toilets	30%
Don't know how we save water	26%

Q14. How many bathrooms do you have in your home?

Respondents indicated that on average they have 1.1 bathrooms per house.

Q15. How many bath tubs do you have in your home?

Respondents indicated that on average they have 1.0 bath tubs per house.

Q16. Some appliances and fixtures use more water and/or energy to operate. Do you consider these higher operating costs when making your buying decision?

Yes – 65% No – 35%

SHOWERHEADS

Q17. How many showers are there in the home?

Respondents indicated that on average they have 1.1 showers per house.

Q18. How many are handheld type showerheads?

Respondents indicated that 42% of their showerheads are handheld type while the remaining 58% are fixed type.

Q19. How many showers per day does each person in the house take?

Based on the respondents, the average person in Rankin Inlet has 3.1 showers per week.

Q20. Are you happy with the performance of your shower?

An overwhelming 85% of the respondents indicated that they were happy with the performance of their showerheads. Good flow and pressure were given as the top reasons.

TOILETS

Q21. What do you think a low-flush toilet is?

45% of respondents did not know what a low flush toilet is. Once again, this indicates that an educational opportunity exists.

Don't know	45%
Uses less water than 'older/other' toilets	55%

Q22. What do you think a dual flush toilet is?

Although dual flush toilets are available from local retailers, 59% of respondents did not know what a dual flush toilet is.

Don't know	59%
Use less water than 'older/other' toilets	20%
Two handles for different amounts of water/flush	21%

Q23. How many toilets are there in your home?

Respondents indicated that on average they have 1.1 toilets per house.

Q24. How many 6.0 litre flush toilets are there in your home?

65% of the respondents indicated that they have 6.0 litre flush toilets in their homes. This does not mean that they actually do have 6.0 litre toilets, only that they think they do. As Q.21 pointed out, a high percentage of the residents do not know what low-flush or 6.0 litre flush are. Many people may think they have low flush toilets for a number reasons including poor flushing performance and the need to "double-flush".

Q25. How many dual flush toilets are there in your home?

5% or 3 respondents indicated that they had dual-flush toilets in their homes. This response is considered to have a higher confidence level than Q.24 since dual flush toilets are physically different from regular flush toilets and can be readily identified.

Q26. How old are the toilets in your house?

On average, respondents indicated that their toilets were 11 years old.

Q27. How likely are you to replace a toilet in your home in the next 3 years?

Likely (4-5)	34%
Possibly (3)	22%
Not Likely (1-2)	44%

LEAKS/REPAIRS

Q28. If you have a leak or developed a leak in your faucets or toilet, how would it get repaired?

Two/thirds of the respondents indicated that they would hire a contractor or didn't know who they would get fix a leak. This corresponds very closely to the 60% of respondents who rent their homes. By indicating a contractor, they are most likely referring to the Housing Association.

Family member	11%
Family friend	5%
Contractor you hired	56%
Myself/Spouse	18%
Don't Know	10%

Q29. Do you currently have leaks in any plumbing fixtures in your home, such as a kitchen or bathroom faucet, toilet, shower head, etc.?

23% of respondents indicated that they currently has a leaking fixture. Most common fixture leaking was the kitchen faucet, then the bathroom faucet and then the toilet. Only 27% of those with leaks indicated that they would them fixed right away.

OTHER INDOOR USES

Q30. How many loads of laundry do you wash <u>by hand</u> per week?

Only 19% of the respondents indicating that they wash some of the laundry by hand. Those who wash some of the laundry by hand, on average wash 2.8 loads per week.

Q31. Do you have a washing machine?

An overwhelming 97% of respondents reported that they have a clothes washing machine.

Q32. Is your washing machine a…?

75% of the respondents indicated that they had a top loading clothes washer while 25% reported having the more water efficient front loading style.

Q33. Does you washing machine have an Energy Star label on it?

38% of the respondents indicated that their clothes washer had an Energy Star label on it. This seems extremely high since Energy Star labeling has only been out for a few years. There is a strong possibility the residents are confusing the EnerGuide label as the Energy Star. Perhaps some more research is necessary here, but also it indicates a possible educational opportunity.

Q34. How old is your washing machine?

On average, respondents indicated that their clothes washers were 4.8 years old.

Q35. How likely are you to replace your washing machine in the next 3 years?

Likely (4-5)	28%
Possibly (3)	20%
Not Likely (1-2)	52%

Q36. How likely are you to install a front loading washing machine at that time?

Likely (4-5)	28%
Possibly (3)	43%
Not Likely (1-2)	29%

Q37. How many loads <u>of laundry</u> do you do per week using your washing machine?

On average, respondents indicated that they wash 5.3 loads of laundry per week in the clothes washer.

Q38. How many loads <u>of dishes</u> do you wash by hand per week?

89% of the respondents indicated that they wash some or all of the dishes by hand. Those who wash some or all of the dishes by hand, on average wash 7.7 loads per week.

Q39. Do you have an automatic dishwasher?

Only 25% of respondents reported that they have an automatic dishwasher.

Q40. How many loads of dishes do you wash per week in the washer?

Of those respondents reporting to have an automatic dishwasher, they reported on average have doing 4.6 loads per weeks.

Q41. How old is your dishwasher?

Respondents indicated that the average age of their dishwasher was 4.7 years.

Q42. Do you have any other appliances that use water?

No other water consuming appliance or fixture was reported.

OUTDOOR WATER USE

Q43. Do you use any water outside?

85% of the respondents reported not using any water outside. For the 15% that reported using outside water, the main use was to wash the vehicles.

DEMOGRPAHICS

Respondent to this survey is: Male – 27% Female – 73%

a. **Can you indicate which of the following age groups you fall into?**

18-39 years	37%
40-49 years	29%
50-64 years	26%
65+ years	8%

b. **In total, how many people live in your household, including yourself and any children?**

On average, respondents reported 4.5 persons per household.

c. **Do you have access to the internet in your house?**

67% of respondents reported that they have internet in their homes.

d. **Would you be willing to participate the home visit component of this study?**

37% of the respondents indicated that they would participate in the home visit component of this study.

3.2 Household Audits

Background

To assist with the current market conditions evaluation, the team conducted ten (10) on-site household audits to determine type, repair and condition of water using appliances. During the audits toilet flush volumes were determined and showerhead and faucet flow rates were measured using a calibrated receptacle. Leakage, where visible, was identified and quantified. Makes and models of dishwashers and clothes washers were recorded.

The homeowner was also asked what type of toilets and fixtures they had in their home. (Eg., low flush toilets or regular; low flow showerheads or regular). These questions were asked in order to better understand the homeowner's perception to water efficient appliances and fixtures. For instance in past projects, we have found many homes where customers said that they do not have low-flow showerheads and would never have low-flow showerheads, however, during the actual audit; low-flow showerheads were found. In these cases, it was the homeowner's perception that a low-flow showerhead would provide a very weak, ineffective spray and since theirs did not, it could not be low-flow.

Additional questions were asked pertaining to usage patterns and outdoor water use.

Observations

Demographics

House Style: 60% detached single family
30% townhouse
10% apartments

Showering

- Average flow rate: 12.0 liters per minutes
- 0 (0%) of the showerheads were leaking

Kitchen Faucets

- Average flow rate: 8.1 liters per minutes
- 0 (0%) of the kitchen faucets were leaking

Toilets

- Average flush volume: 12.3 litres per flush
- 2 (20%) of the toilets were leaking

Bathroom Faucets

- Average flow rate: 7.0 liters per minutes
- 0 (0%) of the kitchen faucets were leaking

Dishwashers

- 20% of the homes had automatic dishwashers

Clothes Washer

- 100% of the homes had automatic clothes washers
- 20% of the homes had front loading machines
- 80% of the homes had top loading machines
- 20% of the machines were rated Energy Star

Summary

Showering

The average flow rate of showerhead was 12.1 litres per minute. This is significantly higher (60%) than the currently market available 7.6 litres per minute showerhead. In addition, residents use hot water for showers so any reduction in flowrate will also decrease the energy used to heat the water.

Faucets

Kitchen faucets were generally low flow with an average flow rate of 8.1 litre per minute. All kitchen faucets were threaded, so lower flow aerators could easily be installed. Even though the faucets have relatively low flow rates, 5.7 litre per minute aerators could be installed providing approximately 30% savings.

Bathroom faucets were found to have an average flow rate of 7.0 litres per minute. Once again this is relatively low, however 3.8 litre per minute aerators could easily be installed providing approximately 45% savings.

In addition, residents use hot water in kitchens and bathrooms so any reduction in flowrate of these faucets will also decrease the energy used to heat the water.

Toilets

The average flush volume of the toilets audited was 12.3 litres per flush. During visits to new construction sites and retailers it was observed that 6.0 litre flush toilets are the standard. One retailer also offered dual flush toilets which flush at a low flush with 3.0 litres and flush with 6.0 litres at a high flush for solids. Through performance testing, many toilet models have proven that they flush at 4.8 litres without compromising flushing performance. These toilets are called “High Efficiency Toilets” or HET’s. By replacing the existing toilets in Rankin Inlet with HET toilets, water savings of approximately 60% could be achieved.

Also observed during the audits was that 20% of the toilets were leaking. This level of leakage was expected is a common situation with toilets with flapper valves. After time, due to minerals in the water, chlorine or household cleaners, flappers deform and deteriorate allowing for, quite often, silent leaks. Education and an ongoing maintenance program can help reduce this leakage. Another solution would be the installation of flapper-less toilets. An HET toilet which happens to be flapper-less from one manufacturer has proven to be quite popular in municipal toilet rebate programs throughout North America.

Clothes Washing

All homes surveyed had a clothes washing machine. 20% had water efficient front-loading machines, which have only been readily available in the Ontario market for the past 10 to 15 years. The replacement of top loading washing machines with front loading Energy Star can provide up to 65% in water savings.

Dish Washing

20% of the homes survey had automatic dishwashers. Automatic dishwashers have proven to be an inefficient approach to washing dishes. Most dishwashers available on the market are considered water efficient with some models using as little as 14 litres per load of dishes. Although there are no municipalities offering rebates for the replacement of dishwashers, some municipalities in southern United States of rebates for residents to purchase a dishwasher if they don't already have one. These municipalities have proven through studies that a resident uses more water hand washing dishes as compared to an automatic dishwasher.

Leaks

Only some of the toilets were found to be leaking which is addressed above. All other fixtures and appliances were found to be leak free.

Recommendations to consider during program design

- Low-flow showerhead program
- Low flush toilet program
- Faucet aerator program targeting kitchen and bathroom faucets
- Front loading Energy Star clothes washing machine program

More general education is recommended on all water consuming appliance and fixtures in the home. Educational material could cover all the programs listed above in addition to other water usages not covered by a program.

4.0 Residential Water Use Demand Analysis

An analysis was completed to segregate water use into several categories, so that water use by single family properties, multi family units and the ICI sector could be identified. Customer billing data for the period form August 2006 to August 2009 was compared to:

- Rankin Inlet Business Directory provided by the Canada-Nunavut Business Service Centre
- Rankin Inlet House Numbering system Map, dated April 23rd 2002
- Satellite imaging of Rankin Inlet

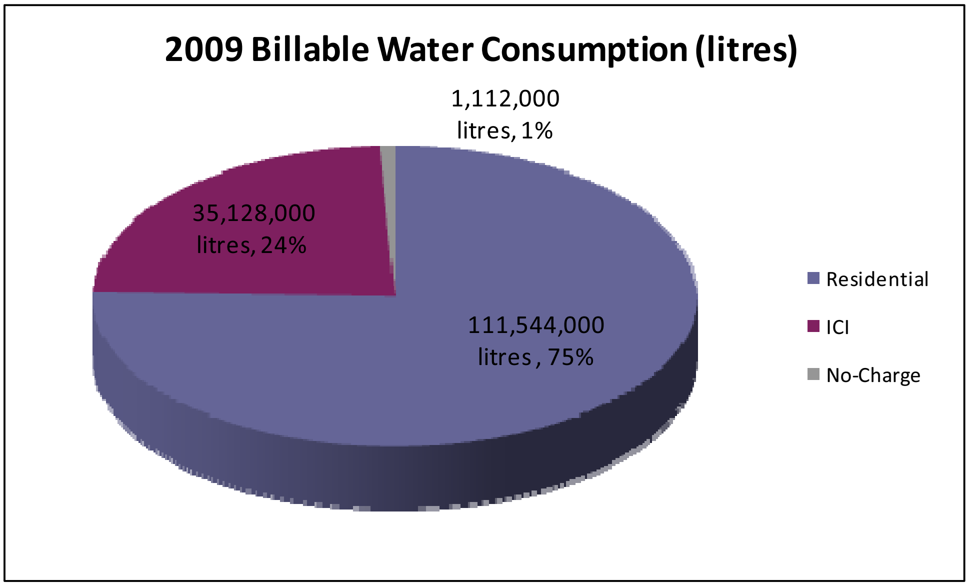
The comparison was completed in order to identify the number of properties in each category, and to allocate a volume of use. Properties that were identified as residential housing but listed in the ICI sector was re-categorized as residential for the analysis.

Based on the data provided, a breakdown of the 2009 (Sept. 2008 to Aug. 2009) customer billed consumption is shown in the following Table 8.

Table 8: Rankin Inlet 2009 Customer Billed Consumption

Category	2009 Billed (litres)	Population 2009 est.	Water Use – Litres per Capita per Day (Lcd)
Residential	111,544,000	2,499	122
ICI	35,128,000		
Not billed	1,112,000		
Total 2009 Billed Consumption	147,784,000		

Figure 3: Breakdown of Billable Water Consumption (litres) 2009



A detailed analysis of the residential sectors follows.

Residential Water Use Demand Analysis

Per Capita Water Use

The residential market sector includes housing which are detached, semi-detached, duplex, row or town and multi-story apartment housing. Each detached premise in this market sector is served with its own water meter. All multi-story apartment building and some multi-unit row housing were serviced by bulk meters, one large meter for all of the units in a facility. For 2009, based on the billing data provided, the Hamlet of Rankin Inlet residential water use was 122 litres per capita per day (Lcd).

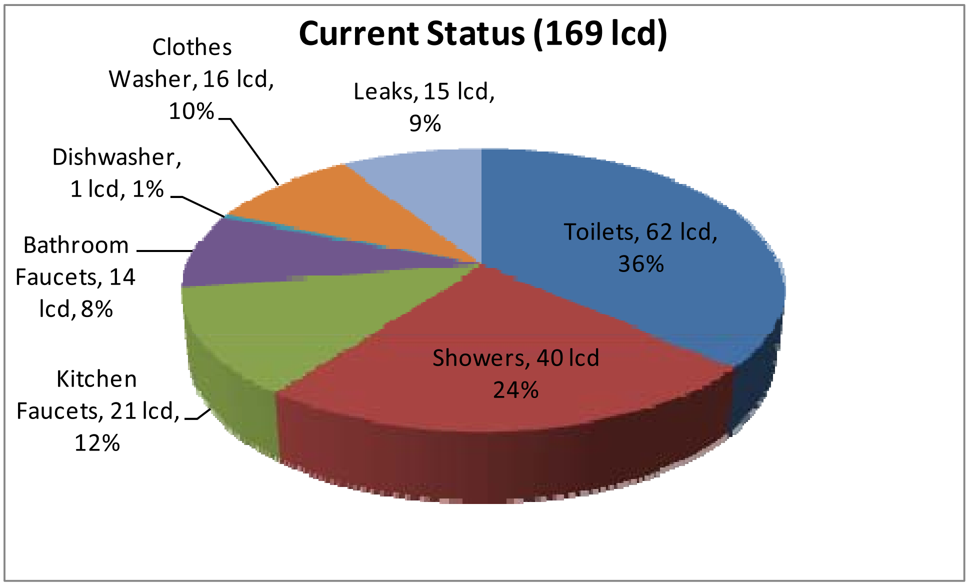
Table 9: 2009 Residential Per Capita Consumption based on Billing Data

Residential Sector	2009 Billable Consumption (litres)	Population 2009 est.	Per Capita Consumption (Lcd)
	111,544,000	2,499	122

The 2008 residential billed consumption at 115,165,000 litres was very similar, actually within 5%, of the 2009 consumption. It should be noted that due to the age and the technology (remote read) of the residential meters that the billed consumption is significantly lower than the actual consumption. This is discussed in more detailed in the Water Loss Mitigation report in the Appendix. Without testing a sample of meters for inaccuracies it is difficult to estimate the losses. As such, a residential water balance was developed as a comparison.

The residential water balance was developed using data from the AWWA AWARF Residential End Uses of Water Study completed in 1999 and local data collected from the market research completed in Rankin Inlet from October 26th to November 5th 2009. The results of the analysis are shown in Figure 4 below:

Figure 4: Calculated Residential per Capita Consumption and Water Balance



The above balance is based on current observations of the condition and efficiency of the existing water consuming fixtures and appliances, and the habits and attitudes of the residents as determined through the market research. The balance indicates that the residential consumption could quite possibly be in the order of 169 lcd in Rankin Inlet under the existing conditions. This consumption is 38% higher than that calculated from the billing data as shown in Table 10.

Table 10: 2009 Comparison of Residential Consumption based on Billing Data and based on Water Balance

Residential Sector	Population 2009 est.	Per Capita Consumption (Lcd)	Residential Consumption 2009 (litres)	Percent Difference
As per Billing Data	2,499	122	111,544,000	
As per Water Balance	2,499	169	154,151,000	+38%

In order to compare this consumption level with other municipalities in Canada, and around the world, the following Figure 5 has been prepared:

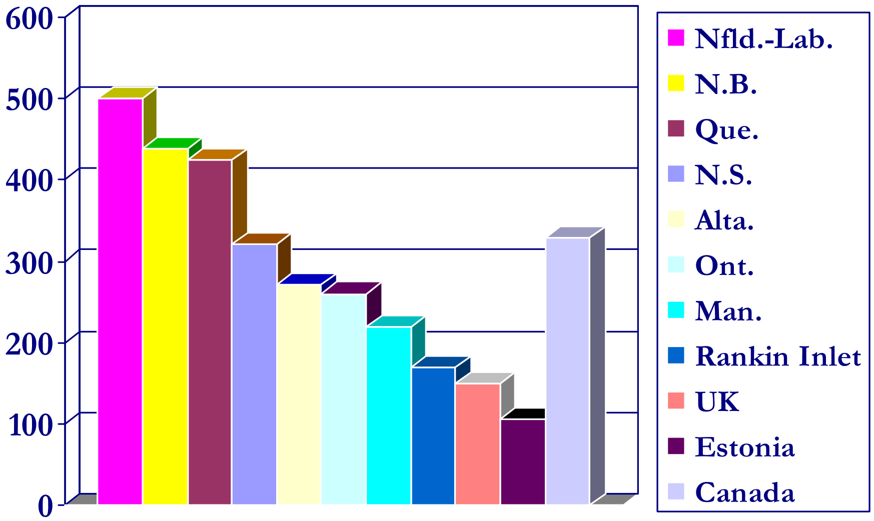


Figure 5: Comparison of Residential Per Capita Demand (lcd)[3]

The Hamlet of Rankin Inlet has one of the lowest residential water demands in Canada even if the 169 Lcd is used for comparison. This is approximately 49% below the national average of 324 Lcd.

Property Types

Based on Statistics Canada 2006 Census data, the following is a breakdown of property types in Rankin Inlet:

Table 11: Breakdown of Housing by Housing Type – Rankin Inlet

Detached	Semi-Detached	Townhouse, Row House	Duplex	Apartments < 5 storeys	Total
409	47	214	12	94	776

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[3] Municipal Water Use Survey, Environment Canada, 2004.

New Construction and the Influence of Building Codes and Guideline on Toilet Flush Volumes

An analysis was completed to identify the number of homes and the corresponding period that the dwellings were constructed. The following Table 12 shows the breakdown of housing construction and the typical flush volume of the toilets:

Table 12: Breakdown of Housing Construction and Typical Toilet Flush Volumes

Period	Toilet Flush Volume	Number of Dwellings Built
Prior to 1981	≥ 20 litre	240
1981 to 1985	≥ 20 litre	145
1986 to 1993	≥ 20 litre	152
1994 to 1995	13.25 litre	38
1996 to 2006	6.0 litre	201

Prior to 1994, toilet flush volumes were generally 20 litres or greater. The National Building Code or the National Plumbing Code does not address water conservation and as such do not provide required toilet flush volumes. In December 1995, the Government of Nunavut released its 2nd Edition of the Good Building Practices Guidelines. The Guidelines was provided as a supplement to the National Building Code to assist builders and developers with the construction in a northern climate.

Recognizing the limited water supply and municipal distribution systems in Nunavut, the Guidelines introduced water conservation requirements as follows:

Section 4.8 Fixtures & Brass
Fixtures are generally required to be low consumption type to conserve water used and waste water produced.

Section 4.8.3 Sinks
All faucets should have flow restrictors to ensure low water use.

Section 4.8.4 Hand Basins
All faucets and showerheads are to have flow restrictors to ensure low water use.

Section 4.8.5 Toilets and Urinals
All toilet fixtures should low consumption type (4 to 9 litres per flush). All urinals are to be low water use type.

5.0 Industrial, Commercial and Institutional (ICI) Water Use Demand Analysis

The industrial, commercial, and institutional (ICI) sector represents approximately 25% of Rankin Inlet's billed water consumption. In 2009, the volume of billed water to the ICI sector was 35,128,000 litres. As indicated in Figure 6 below, this is approximately 23% above the 26,962,000 litres billed in 2008.

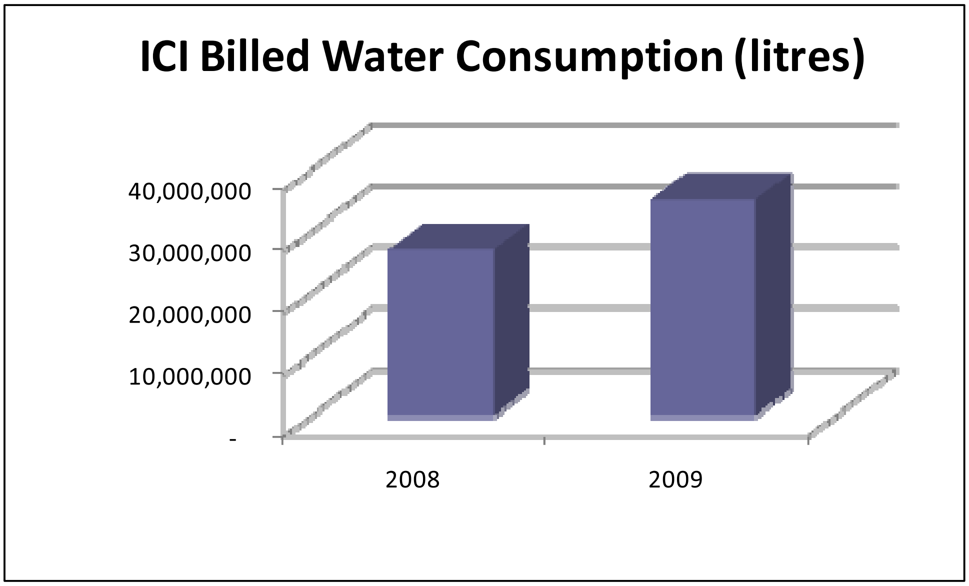


Figure 6: ICI Billed Water Consumption (litres) 2008, 2009

Further investigation of the billing data for 2009 produced the following discrepancies:

- Polar Bear Investments c/0 Nanqu Inn – 7,842,000 litres additional in 2009
- Community & Government Services, Kivalliq – approximately 3,000,000 litres additional in 2009
- Rankin Inlet Airport – approximately 1,500,000 litres additional in 2009

The additional water volume represented by these 3 accounts more than offset the increase in water volume in 2009. In addition, similar to the residential water meters as large mechanical meters get older they tend to under-register due to wear. Due to the discrepancies in the billing data the confidence in the accuracy of the ICI billed water consumption is extremely low.

For the purpose of this analysis, it was assumed that the 2008 ICI billed volume of 26,962,000 litres was more representative and as such used as the corrected 2009 ICI volume.

Further analysis of 2009 billing ICI billing data indicates that 35% of the customers consume 80% of the overall water for that sector. The largest 22 customers collectively used 80% of the total ICI consumption as shown in Figure 7.

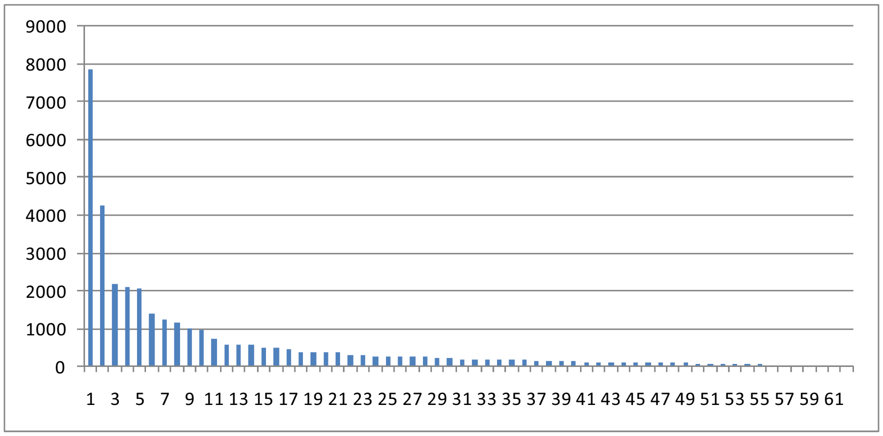
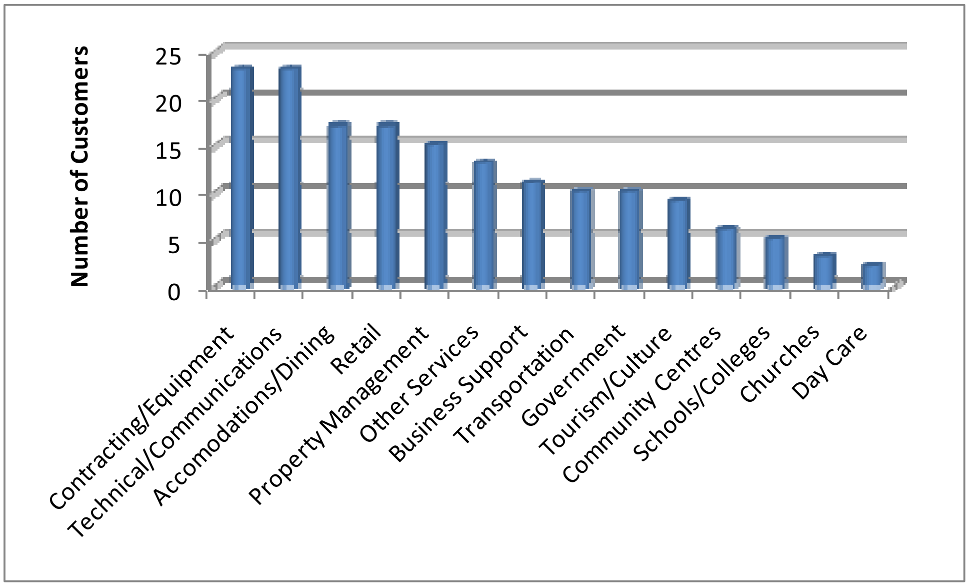


Figure 7: 2009 Annual Billed Water Consumption by Customer

Based on the Canada-Nunavut Business Service Centre directory, Rankin Inlet's ICI customers are collectively segmented in Figure 8.

Figure 8 –ICI Water Customer Sectors by Number of Customer Accounts



6.0 Evaluation of Distribution System Water Loss

6.1 Introduction

The Hamlet of Rankin Inlet water distribution system is complex with a pipework system to deliver tempered water to the customers, which is then returned back to Williamson Lake Water Treatment Plant. In addition, each customer has a looped service pipe with booster pump, to return the tempered water to the water distribution main.

A methodology of water loss reduction was developed after spending time with operations and other staff of both the Hamlet and the Government of Nunavut. Once the methodology had been established, the requirements for the most suitable equipment were made. In this way, the best solution of methodology and equipment was provided.

The methodology included a combination of flow based identification of areas with leakage and other losses, along with methods of acoustic leak detection. This approach forms the core of the AWWA Manual, M36, "Water Audits and Loss Control Programs", which was published in May, 2009. In the M36 manual, this flow based method of identifying areas with leakage is called "District Meter Areas – DMAs". The M36 manual has been completely re-written to include the very latest methodology and equipment, and is considered to be a North American Best Management Practice (BMP).

6.2 Water Supply and Distribution System Operation, and Customer Meters

Lake Nipissar Pump House

Currently water is taken from Lake Nipissar, which is located about two kilometres northwest of the community. Water is abstracted by two submersible pumps located at the end of the two intake pipes. At the Lake Nipissar Pump House, heated water is mixed with the abstracted water, and the resulting tempered water is transmitted to Williamson Lake Storage Tank. Water is heated at the Williamson Lake Pump House, and pumped to the Lake Nipissar Pump House for mixing with the abstracted water.

Williamson Lake Pump House

The watermain from Lake Nipissar enters the Williamson Lake Pump House, and then leaves the building and goes to the outside storage tank. A pipe from the outside storage tank enters the pump house and passes through a control valve which supplies the two wet wells.

The wet wells are approximately 3 metres in diameter, and 8 metres deep. There are two pumps in each wet well, which supply water to the water distribution loops, which are as follows:

- Town Loop 1 (Area 1)
- Town Loop 2 (Area 2)
- Nuvuk Loop (Area 6)
- Area 5
- Town Supply

In the Williamson Lake Pump House, the wet well pumps send water to a common delivery main which has an electromagnetic meter that records the total flow. The pressures in this common delivery main are controlled by a Pressure Reduction Valve (PRV). At the time of the site inspections in early November, 2009, the inlet pressure to the PRV was 85 psi (wet well pump discharge pressure), and the outlet pressure to the PRV was 60 psi (pressure to the distribution system loops). The loops are supplied as follows:

- Area 5 is supplied by a main passing across the top of the building from the common delivery main.
- A pipe is also connected to the common delivery main to supply Kivalliq.
- The common delivery main then leaves the pump house, and in a chamber outside, the supply to Area 6 is connected.
- Water then flows along the Town Supply Main, and after it passes the Hamlet offices, the Area 1 and Area 2 supply mains are connected in a chamber.

The water is then returned to Williamson Lake Pump House from the loops as follows:

- Area 5 enters at the back side of the building
- Areas 1, 2 and 6 are combined in a chamber, then returned to Williamson Lake Pump House in a single main

The return flow is regulated by a thermostatically controlled valve. If the return water temperature falls below a set value, the valve opens to increase the flow of heated water pumped into the mains. The valve closes to reduce the flow if the temperature is higher than a set point.

In the Williamson Lake Pump House there is a diesel fuelled boiler which heats water that is then used to provide:

- Hot water is injected into the wet well pumps common delivery main, just upstream of the Pressure Reduction valve (PRV)
- Hot water is transmitted to Nipissar Lake Pump House

There is also a heat recovery system from the Power Plant that is used to augment the local diesel fuelled boiler.

If high flows occur on the loops (caused by fire fighting, use of hydrants, or other causes), then there are automatic valves on three of the return lines that will open when the water pressure falls to set limits – these valves are normally closed. This effectively increases the available water in the looped systems. The three loops with valves, and the pressure that causes them to operate are as follows:

- Nuvuk Loop – valve starts to open when pressures fall to 26 psi
- New Town Loop (Loops 1 and 2??) - valve starts to open when pressures fall to 26 psi
- Old Town Loop (Town supply?) - valve starts to open when pressures fall to 10 psi

Water Distribution System

Tempered water is pumped to the five loops as described above. The water distribution system consists of older buried Utilidors, and newer shallow buried mains. The older Utilidors consist of 150 mm PVC watermains housed with 150 mm PVC sewer mains, in 600 mm galvanised corrugated metal pipe. The Utilidor is covered with 50mm of rigid polyurethane foam insulation. The new mains are shallow buried and consist of High Density Polyethylene (HDPE) pipe with 50 or 75 mm of polyurethane insulation covered with “Yellow Jacket” and in some cases “Black Jacket”. Most watermains are 200 mm in diameter and are series 160 HDPE.

In order to prevent freezing in the supply pipes to customer properties, each water service has a flow and return pipe, normally located side by side in the ground. Inside the property a pump operates continuously to recirculate the tempered water back into the water main, which then recirculates the water back to Williamson Lake Pump House.

To provide access to the water distribution system, there are chambers located approximately every 100 metres. These chambers contain the connections of various watermains, and also have drain valves and air valves.

Customer Meters

Rankin Inlet has customer water meters which are manufactured by Neptune. The meters are an older style, and when they were installed had a wire fixed from the meter register to the outside of the property. On the end of this wire was fitted a remote register, which has numbers which can be read by the meter reader. This type of remote, or ‘generator remote” works by the meter sending a signal to change the remote register, as the internal meter register changes. They are prone to missing registrations, so that the remote register, which is typically used for billing, records a lower consumption than has actually passed through the water meter.

Some of these old remote registers have been replaced by a more modern “touch pad”, which is simply a device to send a signal to the internal meter register and obtain the reading. So, the actual internal meter reading is gathered.

Furthermore, in the south part of Area 1, new meters with radio read technology have been installed. These meters have a radio transmitter installed either on the meter, of very close to the meter, inside the property. The meters are read with a hand held device, that can receive the meter reading at a distance from the property – it can be driven along each street to obtain the readings if required.

The recorded metered consumption is likely to be less than the actual water produced, for the following reasons:

- Generator remotes recording a lower consumption than the water meter register
- Remote register wires broken
- Customers disconnecting remote wire
- Customers removing water meter and piping through
- Water meter under-registering – most meters under-register as they age

6.3 Water Loss Identification and Reduction Program

The methodology to identify and reduce water loss that is recommended, is a combination of flow based identification of areas with leakage and other losses, along with methods of acoustic leak detection. This approach forms the core of the AWWA Manual, M36, "Water Audits and Loss Control Programs", which was published in May, 2009. In the M36 manual, this flow based method of identifying areas with leakage is called "District Meter Areas – DMAs".

The Rankin Inlet water supply and distribution system is complex with its method of operation including return loops on the distribution mains, and return loops on the customer service lines. There is also the added operational need to maintain water temperatures above a level that will prevent freezing in both the distribution mains and customer services.

District Meter Areas Methodology

It is recommended that the water distribution loops be established as District Meter Areas (DMAs), so that the flows in each individual loop can be monitored, particularly the flows at night, to identify leakage, bleeders and other losses. To achieve this, the flows at the start of each individual loop will have to be metered, and the flows on the return of each loop must also be metered.

In each of these DMA loops, the flow at night, typically between 2.00 am and 4.00 am will be recorded each night. This will then be compared to the "Legitimate Night Usage" or the flow at night that is expected, which is based on the following:

- Length of mains
- Average water pressure
- Number of customer services
- Number of hydrants
- Average number of people per house

With this information, the Legitimate Night Flow can be calculated in a. This legitimate night flow is the sum of flows, or losses from:

- Mains
- Public side of the customer service (main to curb stop)
- Private side of the customer service (curb stop to house)
- Residential night use (usually the largest number)
- Exceptional night use (institutional, commercial, industrial - ICI)

In DMA loops where the measured flow at night is significantly higher than the Legitimate Night Flow, these areas would then be targeted for acoustic leak detection.

It is likely that initially all the loops in Rankin Inlet will have measured flows significantly higher than the Legitimate Night Flow, because of the existence of bleeders, and leaks that may have been running for some time. When DMAs are introduced for the first time in water distribution systems it is common for the flows to be high. The initial tasks are often to identify and eliminate this "backlog" of losses, to reduce water loss to economic levels.

District Meter Area Loops

It is recommended that six DMAs be established, as follows:

Area 5 DMA Loop
Install a flowmeter on the Area 5 supply pipe in Williamson Lake Pump House, between the wet well pumps delivery main, after the existing mag meter; and where the pipe leaves the building at the side.

Install a flowmeter on the Area 5 return pipe, where it enters the Williamson Lake Pump House, before the pipe joins the common return pipe

Nuvuk DMA Loop (Area 6)
In the chamber just outside the entrance door to Williamson Lake Pump House, install a flowmeter on the Area 6 supply pipe

Install a flowmeter on the Area 6 return pipe, which is located in a chamber in the system where the return pipes for Areas 1 and 2 combine – there is then a common return pipe to Williamson Lake Pumphouse for Areas 6, 1, 2.

Town DMA Loop 1 (Area 1)
In a chamber past the Hamlet offices, the water that is transmitted along the Town Supply then feeds Areas 1 and 2. Install a flowmeter on the Area 1 main

Install a flowmeter on the Area 1 return pipe, which is located in a chamber in the system where the return pipes for Areas 1, 2 and 6 combine – there is then a common return pipe to Williamson Lake Pumphouse.

Town DMA Loop 2 (Area 2)
In a chamber past the Hamlet offices, the water that is transmitted along the Town Supply then feeds Areas 1 and 2. Install a flowmeter on the Area 2 main

Install a flowmeter on the Area 2 return pipe, which is located in a chamber in the system where the return pipes for Areas 1, 2 and 6 combine – there is then a common return pipe to Williamson Lake Pumphouse.

Kivalliq DMA Loop
Install a flowmeter on the Kivalliq supply pipe in Williamson Lake Pump House, between the wet well pumps delivery main, after the existing mag meter; and where the pipe leaves the building.

Install a flowmeter on the Kivalliq return pipe, where it enters the Williamson Lake Pump House, before the pipe joins the common return pipe

DMA Town Supply

Because the Town Supply also is the feed pipe for Areas 1 and 2, the DMA flow will be calculated from the flows at other meters, as follows:

Town Supply = Existing common delivery main mag meter, minus metered flows for all other loops.

There is no return for the Town Supply, as it feeds Areas 1 and 2, which have return mains

Mains Between Nipissar Lake Pump House and Williamson Lake Pump House

As a future phase of the flow monitoring program, flow meters could be installed at both ends of the two watermains between Nipissar Lake Pump house and Williamson Lake Pump House

Acoustic Leak Detection

Once the loops with high water losses have been found, the next stage is to identify where the losses are and remove them. In Rankin Inlet the two main areas of losses are bleeders, and leaks on the watermains or services. There are generally two ways to do this, which are:

- For short periods of 5 minutes at night, close small sections of watermain on a loop, and record the drop in flow. For Rankin Inlet distribution system that would involve subtracting the return flow from the supply flow of the loop. ***This method is not recommended*** because when the section of the loop is closed, there would be no water supplied to customers, and hence the recirculation pumps on each customer service pipe would be running dry.
- ***Recommended*** - Use acoustic methods to listen for water loss noises in the loop. This would be a two phased approach of firstly establishing a small area which is "noisy", with at least two fittings, but preferably more, with noise – this gives the "General Area of Losses". Then secondly, from these noisy fittings "Pinpoint the Leak / Losses" – put the cross on the ground for a leak, or identify a customer service or watermain that is bleeding water to waste.

Because the watermains are a mixture of HDPE and PVC, which do not transmit leak noise as well as metallic pipes (cast iron, ductile iron), as many contact points as possible must be used to listen for leak noises. In addition, it is understood that the curb stop valves have a thermal insulating break, which also acts as an acoustic break, so that will make it more difficult to hear leaks from the curb stops.

General Area of Losses

There are a number of methods that are available to find the general area of losses, which are as follows:

- Use acoustic listening devices to manually listen for leaks on contact points on the watermains and services. The contact points are primarily the chambers on the water distribution system that are located approximately every 100m. Typically the devises are a listening stick with an audible sound, and some have noise indicators
- Install leak noise loggers on contact points, which will generally be on the watermains in the manholes. Typically, depending on manufacturer, the noise loggers will be left in place for one to 3 days. The leak noise logger will listen for leaks, and screen out and intermittent water use. The loggers can either be removed and downloaded, or some manufacturers have a radio module on the logger, so that it can be downloaded remotely, and the logger left in place.

- Correlating leak noise loggers can also be used, which go a stage further than a noise logger, and pinpoint the leak from the noises found

Because the watermains are in Utilidors or are insulated, the leak noise may be harder to find, as the characteristics of the leak noise may be muffled. In addition, if any running water is found, it in many cases may be some distance from the location of the actual leak, as the leaking water is travelling along inside the insulation or Utilodor before it is found.

Leak/Losses Pinpointing

Once at least two (but preferably 3 or more) fittings have been identified with a leak noise, the next stage is to pinpoint that leak, and put the cross on the ground for excavation and repair. Leak detection correlators are used to pinpoint the leak, and they operate as follows:

- Accelerometer sensors are attached to two fittings where a leak noise is present – this can be a valve, hydrant, curb stop, tapping etc
- Because the pipe materials are plastic, the leak noise will travel a shorter distance than in metallic pipe. In addition, the normal characteristics of the leak noise at the leak site may be muffled because of the pipe insulation. It is therefore recommended that "Hydrophones" be used. Hydrophones listen for the leak in the body of the water, and can be more successful in plastic pipes correlating leaks. They have to be attached to the pipe at hydrants, or other fittings, so that they are in contact with the water
- The sensors (accelerometers, or hydrophones) are attached to two outstations which transmit the leak noise information to a central processing unit
- The processing unit then analyses the signals, and gives the location of the leak

The process is not as simple as it has been described, as the operator has to enter data about the pipe (diameter, material, distance between leak noise locations), and also can apply a number of filters to obtain a better correlation. Futhermore, it is good practice to complete additional correlations using other contact points that have a leak noise, and in this way several locations of the leak can be established. This process improves the accuracy of the correlation, as the objective is to get the several correlations to give the leak locations close to each other.

The final step is to listen to the located leak from the surface, with a ground microphone, to confirm the location of the leak. Again this may prove more difficult in Rankin Inlet because of the nature of the distribution system which is wrapped / in Utilidors, plus the watermain is deep in some locations.

Bleeders on Customer Services and Distribution System

If the water loss is a bleeder at a water service the pinpointing will indicate a loss at the corporation stop / curb stop of the service. Once this is identified, staff can investigate the bleeder further.

Although customers have to obtain a bleeder permit, all of them may not have done so. Once the bleeder is identified, steps can be taken to assist the customer to correct the problem on the services, and ensure that the recirculation system is put back into operation.

For bleeders on the water distribution system, they will be initially identified as leaks, if they are not already known. Depending on the location and function, the following measures should be considered:

- For all locations, complete a calculation of the approximate volume of water in the mains that are being kept fresh. Then calculate the flow rate required to exchange that volume of water in say 24 hours, or other agreed time period
- Shut off the bleeder, or
- Reduce the flow rate, or
- Install an automatic flushing device, or
- Where possible, for branches left open, install a flowmeter

6.4 Equipment Requirements

Leak Detection Equipment

Acoustic Listening Devices
It is recommended that an electronic listening device be used which includes a listening stick and a ground microphone. The kit also includes a processing unit with display, and headphones.

Leak Noise Loggers
In addition to the acoustic listening equipment, leak noise loggers can be used. They normally come in sets, and depending on manufacturer, can be typically be in sets of 6, 12, 15. The loggers are attached to contact points on the watermains, such as valves and hydrants, and are normally left in position for between one and three days, depending on manufacturer. The options for downloading the loggers include manual retrieval; drive by radio reading; and a fixed network radio system where the data is transmitted to an office computer.

If noise loggers are to be employed, it is recommended that a set of about 12 be used initially to see how applicable they are to the Rankin Inlet water distribution system

Leak Detection Correlators
One leak noise correlator is required to pinpoint the leaks. There are effectively three main types, and their selection depends on customer preference and field conditions. The three main types of processor are:

- Stand alone units for use outside in most elements. Generally robust equipment for use outside
- Hand held PDA small units
- Units where the software is loaded onto laptop computer

It is further recommended that a set of Hydrophones be purchased to correlate for leaks via the body of water in the pipe.

Flow Monitoring Equipment

Most of the existing flowmeters at Lake Nipissar Pump House and Williamson Lake Pump House are Signet paddle wheel flowmeters. In addition, there are two Unimag magnetic flowmeters as follows:

- At Nipissar Lake Pump House, which measures the total flow pumped from the lake
- At Williamson Lake Pump House, which measures the total flow pumped into the distribution system loops – this includes the water consumed, losses, and water recirculated back to the pump house

For each of the distribution loops, in order to measure the volume of water supplied to customers and losses (leakage and bleeders), it will be necessary to measure the flow at the start of each individual loop, and measure the flow on the return of each loop.

As described in section 3.2, some of the flowmeter locations are in the Williamson Lake Pump House, ands some are in chambers in the water distribution system. A site survey will be required to establish the best meter required for the site conditions. The flowmetering options that are recommended are as follows:

Electromagnetic (mag) Flowmeters
An electromagnetic flowmeter, similar to the two existing Unimag mag flowmeters. These meters are powered by mains electricity. For the locations where the meter is installed in the water distribution system chambers, battery powered meters can be used.

Insertion Flowmeters
Insertion magnetic flowmeters are recommended, which are battery powered and have an integral data logger for flow and pressure. These instruments are installed through 2 inch diameter "hot taps" (under pressure tapings), so no isolating of mains, and cutting of pipe is required. These meters will be applicable where there is not sufficient space to install a magnetic flowmeter, or where it is difficult to shut down the watermain.

Clamp on Ultrasonic Flowmeters
At locations where it is not desired to either cut the main to install a magnetic flowmeter, or install a "hot tap", then a clamp on ultrasonic flowmeter can be used.

6.5 Other Items

Instruments Calibration
There are a large number of instruments located at Nipissar Pump House and Williamson Lake Pump House, and consist of flowmeters, temperature monitors, pressure monitors, and other instruments. It was not clear if these instruments are regularly calibrated.

It is recommended that the flowmeters be calibrated annually, and a tag detailing the calibration date be attached to the flowmeter. The frequency of calibration of the other instruments should reviewed, and calibration completed as recommended by the manufacturers.

7.0 Development of Specifications for Leak Reduction Equipment

As part of this assignment, the consultant prepared a specification for leak reduction equipment. The purpose of the specification is to be used in a tendering process by the Government of Nunavut. The specification in its entirety can be found in Appendix A of this report.

8.0 AWWA/IWA Water Audit and Water Balance

Introduction

As part of the Government of Nunavut's (GN) ongoing water loss management program, GN completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance for the Hamlet of Rankin Inlet Water System. The project was completed for a full year from August 2008 to August 2009, based on available billing data. A copy of the report in its entirety can be found in Appendix B of this document.

Completion of an IWA Water Audit and Water Balance is an integral part of the water loss management methodology, in the new AWWA Manual "M36 Water Audits and Loss Control Programs", which was published in May, 2009. An IWA Water Audit and Water Balance is considered to be the North American Best Management Practice (BMP) for water loss management, and is recommended that is completed annually.

The IWA Water Audit and Water Balance quantifies Revenue and Non Revenue Water, and identifies where to reduce water loss and increase revenue.

Summary of Gathered Data

A questionnaire was provided, and data gathered for the 2009 balance (August 2008 to August 2009). At the time of writing the draft report, there is still data that has not been provided by GN, so estimates of the values have been made. Once the data has been received, the analysis can be updated for the final report.

The data was entered into a series of spreadsheets and analysis completed to provided the totals required for the IWA software data entry. A summary of the "Old" Unaccounted For Water (UFW) percentage is shown in the table below. The volume accounted for as part of the IWA balance is included, and deducted from the traditional unaccounted for water volume, as shown in the table:

Item	Total Volume for 2009 (litres)
Total Water Supplied (corrected for accuracy)	427,770,000
Total Billed Consumption (corrected for billing data and meter accuracy)	190,200,000*
IWA Accounted For Water	90,956,000
Unaccounted For Water	146,613,000
Unaccounted For Water (UFW) Percentage	34.3%

* The corrected billed metered consumption derived through a water balance analysis shown in Sections 4 and 5 of this report was 181,143,000 litres in 2009. As part of the IWA analysis, it was estimated that the customer meters were under-registering by 5%, or 9,057,000 litres. This then gave a Total Corrected Billed Consumption of 190,200,000, as shown in the table above.

IWA Software Analysis
The gathered data for 2009 was entered into the AWWA – WLCC (Water Loss Control Committee) software program. The results of the analysis are shown as follows:

Parameter	Value for 2009
Current Annual Real Losses (CARL)	145,000,000 litres
Unavoidable Annual Real Losses (UARL)	14,000,000 litres
Infrastructure Leakage Index (ILI)	10.17
System Input Volume	428,000,000 litres
Revenue Water (corrected for estimated accuracy of billing system)	181,000,000 litres
Non-Revenue Water	247,000,000 litres
Volume of Non-Revenue Water - % of System Input Volume	57.7%

The financial results from the IWA software analysis are shown below:

Parameter	Value
Annual Cost of Apparent Losses Customer meter under registration Unauthorised consumption – based on estimated customer water and sewer rate of $4.50 per 1,000 litres	$52,215
Annual Cost of Real Losses – Variable Production Cost Based on estimated cost of $0.35 per 1,000 litres	$50,798

IWA Software Analysis Summary
In any water system there will be a volume of leakage that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair – this is the Unavoidable Annual Real Losses (UARL). The IWA software uses the physical characteristics of the water distribution system (length of water mains and services, number of connections, average pressure) to make an estimate of UARL. The Current Annual Real Losses (CARL) are also calculated by the software, by taking the water supplied and deducting the calculated authorized consumption and apparent losses, to give CARL. The ratio of UARL to CARL is the Infrastructure Leakage Index (ILI).

The World Bank Target Matrix gives performance category A for an ILI 1 - 2; category B for ILI 2 – 4; category C for ILI 4 – 8; and category D for ILI greater than 8.

The Hamlet of Rankin Inlet Water System's ILI of 10.17 puts them in performance D category – very inefficient use of resources; leakage reduction programs imperative and high priority

Although operational and financial considerations may allow a long term ILI greater than 8.0, such a level of leakage is not an effective utilisation of water as a resource. The priority for the Hamlet of Rankin Inlet Water System should be to develop an active leak detection program to reduce water losses, and reduce the

ILI to initially below 8.0, and then progressively reduce it further till it is in performance category B.

Recommendations

Source Meters

At the Lake Nipissar Pump House there are a number of meters, which include Signet paddle wheel meters and one Unimag electromagnetic. It is recommended that the Unimag meter be set up to record and save the daily total volumes abstracted, and these values be used for the total water abstracted. Locally it has been set up to manually record the total flow in the record book at the pump house.

An on site in-situ test procedure can be completed for some manufactured mag meters, so this should be investigated, to see if it is available for the Unimag meter. Testing could include primary coils/electrodes/circuitry, cables and full electronic check.

Customer Meters

Rankin Inlet has customer water meters which are manufactured by Neptune. The meters are an older style, and when they were installed had a wire fixed from the meter register to the outside of the property. On the end of this wire was fitted a remote register, which has numbers which can be read by the meter reader. This type of remote, or ‘generator remote” works by the internal meter register sending a signal to change the remote register. They are prone to missing registrations, so that the remote register, which is typically used for billing, records a lower consumption than has actually passed through the water meter.

Some of these old remote registers have been replaced by a more modern “touch pad”, which is simply a device to send a signal to the internal meter register and obtain the reading. So, the actual internal meter reading is collected.

Furthermore, in the south part of Area 1, new meters with radio read technology have been installed. These meters have a radio transmitter installed either on the meter, or very close to the meter, inside the property. The meters are read with a hand held device, that can receive the meter reading at a distance from the property – it can be driven along each street to obtain the readings if required.

The recorded metered consumption is likely to be less than the actual water produced, for the following reasons:

- Generator remotes recording a lower consumption than the water meter register
- Remote register wires broken
- Customers disconnecting remote wire
- Customers removing water meter and piping through
- Water meter under-registering – most meters under-register as they age

For the Hamlet of Rankin Inlet, which has relatively old customer meters, the estimated overall customer under-registration was 5%, which represents a loss in billable volume of 9,057,000 litres per year. To determine a more accurate estimate of meter accuracy, it is recommended that a random sample of meters be removed and tested. A sample of 217 meters will give an error margin of 5%, with a 95% confidence level in the data.

Normally this type of random sampling and testing of customer meters is completed for the smaller 5/8" residential meters. Testing these residential meters should typically be repeated every 5 to 10 years, using a statistically valid sample of meters.

For the larger ICI meters, they should be tested more frequently than residential meters, because of the larger volumes being measured and the associated revenue. Testing of ICI meters should be as frequent as once every year for the very large volume meters, and between every 2 to 5 years for the remainder.

Active Leak Detection

The methodology to identify and reduce water loss that is recommended, is a combination of flow based identification of areas with leakage and other losses, along with methods of acoustic leak detection. This approach forms the core of the AWWA Manual, M36, "Water Audits and Loss Control Programs". In the M36 manual, this flow based method of identifying areas with leakage is called "District Meter Areas – DMAs".

The Rankin Inlet water supply and distribution system is complex with its method of operation including return loops on the distribution mains, and return loops on the customer service lines. There is also the added operational need to maintain water temperatures above a level that will prevent freezing in both the distribution mains and customer services.

Leakage can be split into three types; namely:

- Leakage from Reported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Passive Leak Detection and Repair
- Leakage from Unreported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Active Leak Detection and Repair
- Background Leakage (composed of primarily weeps from joints and gaskets rather than holes in pipes) – utility activity often referred to as Active Leakage Reduction

One of the most reliable and long established methodologies to help identify water loss is to split the network into small sectors often referred to as District Meter Areas (DMAs). Where possible areas are designed so that they can be fed through one metered water feed throughout the day and night, although because of fire flow requirements, sometimes two feeds are required.

In these DMAs the flow entering the area, and key pressures are data logged, typically for a seven day period. The estimated legitimate night use is estimated, and compared with the measured night flow, which identifies areas with potential leakage, and the approximate volume of that leakage

By operating the Temporary DMAs, the system backlog leaks can be identified and repaired.

In the process of operating the Temporary DMAs, flow and pressure logged data will be gathered, and along with the number and volume of leakage found, potential areas for converting to Permanent DMAs can be established. If some of the DMAs have high pressure, or significant pressure variations, then they can be considered for Pressure Management.

As summary of the operation of the types of DMAs is provided as follows:

- **Temporary DMAs**, where they are typically operated for a seven day period initially, and the flows at night, between 2.00 and 4.00 am (Minimum Night Flow - MNF) are compared to what flow would be expected from the area. Only in areas of high MNF are leaks looked for in a two step process – step one, narrow the leak down to the General Area of the leak, and step two, Pinpoint the leak (blue cross on the ground). There are a number of methods employed to find the general area of leak, which include night time step testing, when sections of the DMA are closed off for short periods, and the change in flow at the DMA flowmeter inspected for high drops in flow, indicating a potential leak. Another method to find the general area of the leak is to use noise loggers, which listen for leaks. Finally the leak is pinpointed using leak noise correlators, and ground microphones to confirm the location of the leak
- **Permanent DMAs used for Leak Notification**, where the DMA is permanently isolated from the rest of the distribution system, and night time flows monitored on a daily basis. When the Minimum Night Flow (MNF) reaches a predetermined level (Entry Level), then leak detection is completed in that DMA – general area of the leak, and pinpointing the leak. Leak detection and repair is continued until the leakage has been reduced to an acceptable amount (Exit Level), as recorded on the permanent DMA flowmeter
- **Permanent DMAs used for Leak Notification and Pressure Management**, where in addition to the leak detection activities, pressure management is introduced. This is completed by installing a Pressure Reduction Valve (PRV), which is used to control the pressure so the at "off peak" demand times, the pressure is not allowed to increase, and a less variable pressure is delivered to the DMA. This method of operation has the dual benefit of reducing Background Leakage (small leaks that are not economic to find and repair), and also reduces main breaks

District Meter Area Loops

It is recommended that the water distribution loops be established as District Meter Areas (DMAs), so that the flows in each individual loop can be monitored, particularly the flows at night, to identify leakage, bleeders and other losses. To achieve this, the flows at the start of each individual loop will have to be metered, and the flows on the return of each loop must also be metered.

In each of these DMA loops, the flow at night, typically between 2.00 am and 4.00 am will be recorded each night. This will then be compared to the "Legitimate Night Usage" or the flow at night that is expected.

In DMA loops where the measured flow at night is significantly higher than the Legitimate Night Flow, these areas would then be targeted for acoustic leak detection.

It is likely that initially all the loops in Rankin Inlet will have measured flows significantly higher than the Legitimate Night Flow, because of the existence of bleeders, and leaks that may have been running for some time. When DMAs are introduced for the first time in water distribution systems it is common for the flows to be high. The initial tasks are often to identify and eliminate this "backlog" of losses, to reduce water loss to economic levels.

It is recommended that six DMAs be established, as follows:

- Area 5 DMA Loop
- Nuvuk DMA Loop (Area 6)
- Town DMA Loop 1 (Area 1)
- Town DMA Loop 2 (Area 2)
- Kivalliq DMA Loop
- DMA Town Supply

In addition, the mains between Nipissar Lake Pump House and Williamson Lake Pump House should be included in a future phase of the flow monitoring program.

<u>Bleeders on Customer Services and Distribution Mains</u>

If the water loss is a bleeder at a water service the leak pinpointing will indicate a loss at the corporation stop / curb stop of the service. Once this is identified, staff can investigate the bleeder further.

Although customers have to obtain a bleeder permit, all of them may not have done so. Once the bleeder is identified, steps can be taken to assist the customer to correct the problem on the services, and ensure that the recirculation system is put back into operation.

For bleeders on the water distribution system, they will be initially identified as leaks, if they are not already known. Depending on the location and function, the following measures should be considered:

- For all locations, complete a calculation of the approximate volume of water in the mains that are being kept fresh. Then calculate the flow rate required to exchange that volume of water in say 24 hours, or other agreed time period
- Shut off the bleeder, or
- Reduce the flow rate, or
- Install an automatic flushing device, or
- Where possible, for branches left open, install a flowmeter

9.0 Identification and Evaluation of Water Efficiency and Conservation Measures

The following Table 13 provides a comprehensive list of water efficiency alternatives evaluated as part of the Water Consumption and Conservation Study.

9.1 Table 13: Comprehensive List of Water Saving Measures

Indoor Measures	**Common Practice with North American Municipal Programs**	**Description**
Toilet flapper valve replacement	No	This measure is easy to promote and has been used in the past as an alternative to the ULF Toilet program. These flappers require maintenance to ensure water savings are sustained. The early closing flapper can be adjusted to save different amounts of water, but generally save anywhere from 2 to 4 litres/flush. The major issue is that you are altering an engineered product and as such may affect performance and warranty.
Toilet variable flush device	No	These adjustable devices are usually attached to the over flow tube in the toilet tank. The flush device moves up and down with the level of the water in the tank. When the toilet is flushed the device travels down with the water level until it pushes the flapper down causing it to close early thus saving 2 to 4 litres of water per flush.
Toilet tank displacement devices	Yes	Tank displacement devices consist of toilet dams, tank bags or bottles filled with sand. These devices displace the equivalent volume of water in the toilet tank saving usually 2 to 3 litres per flush.
6L toilet installation	Yes	This is a very popular residential water efficiency measure. Many homes still use 20 and 13 litre/flush toilets. This measure would replace those with 6 litre/flush toilets. Early model Ultra Low Flush (or ULF) toilets have faced many customer complaints about quality and reliability. The newer model ULF toilets have taken those complaints into consideration and are much more accepted than the previous models. As with many in-home water efficiency measures ongoing proactive maintenance is the key to sustaining water efficiency and savings. This measure would only apply to homes and buildings built before 2005 when the Good Building Practices Guidelines was introduced in Nunavut.
High Efficiency (HET) toilet	Yes	Relatively new in the North American market and similar to ultra-low flush toilets; high efficiency flush toilets are designed to flush with 4.8 litres of water. Generally these toilets are tamper-proof so that the flush volumes cannot be increased.
Dual flush toilet installation	Yes	The popularity of this residential water efficiency measure is ever increasing. Also popular in Australia, the largest percentage of new toilet installations in Europe and the UK are dual flush toilets. This measure would replace the regular flush (13 to 20 litre flush volume) toilets with dual flush toilet that either flushes 3 litres for liquids or 6 litres for solids. Dual flush toilets are primarily manufactured in Australia and Europe. This measure would only apply to homes and buildings built before 2005 when the Good Building Practices Guidelines was introduced in Nunavut.
Showerhead replacement	Yes	Older showerheads can use as much as 20 litres of water/minute. Low flow models use less than 9.5 litres per minute providing a substantial saving in both water and energy. This measure would only apply to homes and buildings built before 2005 when the Good Building Practices Guidelines was introduced in Nunavut.

Indoor Measures	Common Practice with North American Municipal Programs	Description
Showerhead flow restrictors	No	Flow restrictors are commonly small plastic inserts, which replace the rubber washer in the threaded connector of the showerheads to restrict flow.
Showerheads in-line regulator	No	Requiring a plumber for installation, in-line regulators are fitted into the existing water line to the showerhead. Flow regulators can decrease the flow rate from 20 litres per minute to as low as 5 litres per minute.
Water efficient clothes washer	Yes	Traditional top-loading washing machines use 132 to 240 litres of water per wash. The water efficient front-loading washing machines use 50 to 120 litres of water per wash. This amounts to a 40% reduction in water use. Top loading washing machines have made water-saving improvements in this last few years, but the front loading washers are still recognized as the most water and energy efficient. This measure is often promoted with educational material and incentives, as price is often a limiting factor for most consumers, although the price has been reducing in recent years.
Water efficient dish washer	No	The water savings between older automatic dishwashers and newer models is insignificant. Interestingly, studies have shown that families use less water for dish washing with an automatic washer as compared to hand washing.
Faucet aerator installation	Yes	Faucets can account for 23% of the overall water consumption per capita. Regular faucets can easily flow at 20 litres per minute with some as high as 40 litres per minute. Aerators can bring the flow down below 8.35 litres per minute also providing significant energy savings. Simple threaded devices that add air to the water flowing from a faucet.
Faucet flow restrictor installation	No	Flow restrictors are commonly small plastic inserts, which replace the rubber washer in the threaded connector of the faucet to restrict flow.
Automatic motion sensor faucet	No	There is no evidence that these faucets save water. They are equipped with infrared sensors which sense when the hand is under the tap and when it is pulled away from the tap. This type of faucet is popular in public areas where hygiene can be a concern because the person does not need to touch the tap at any time. Normally found in institutional settings.
Automatic push and touch faucet	No	Push or touch faucets can save a significant amount of water. They work by simply pressing or in the case of the more sophisticated models by touching the faucet to allow water to run. Water will flow for a pre-set time period, which is adjustable. Found mainly in institutions and commercial settings.
Faucet in-line regulator	No	Requiring a plumber for installation, in-line regulators are fitted into the existing water line to the faucet. Flow regulators can decrease the flowrate from 20 litres per minute to as low as 5 litres per minute.
Leakage repair	Yes	The A.W.W.A. (American Water Works Association) Residential End Use Study completed in 1999 concluded that 24 litres/capita/day is associated with indoor home leakage. The recent data logging study indicated that leakage has increased as high as 47 litres/capita/day. The major cause was toilet flappers. Residential audits as well as new water-efficient fixtures can reduce residential leakage. A leakage reduction program for the ICI sector includes auditing, leak detection and repairs.

Indoor Measures	**Common Practice with North American Municipal Programs**	**Description**
Garburator restrictions	No	Garburators, or sink waste disposal units, use water from the kitchen faucet every time they are operated, and can potentially increase organic loads at wastewater treatment plants. The best solution for the environment is to remove these units and encourage composting. Effective methods to encourage this are public education and in some cases offering an incentive for removed garburators. By-laws can also deter newly constructed facilities and homes from installing garburators in the first place.
Hot water recirculation	No	When a hot water faucet is turned on it can sometimes take several seconds to several minutes before hot water actually comes out of the tap. This can waste a lot of water. A hot water recirculating system uses a small pump to decrease the amount of time it takes for hot water to reach the faucet.
Water efficient water softener	No	Water Softeners are common in areas where groundwater is used to service the community. Many people install water softeners to reduce the calcium and magnesium bicarbonates. This is generally an aesthetic preference that many people have. Water softeners need to recharge on a regular basis, sometimes as much as once per day using from 140-400 litres of water at a time. Water-efficient models are available as well as magnetic types of water softeners. These can be encouraged through educational material and incentives.
Humidifier controller	No	Most older style flow through humidifiers can use up to 400 litres/day. This style has water constantly running to help keep the humidifier's mechanism clear of minerals and sediment. This older style of humidifier has an efficiency range of about 20-30%. Efficient models are available that will operate whenever the blower fan is on and not during the cooling season.
Air conditioning condensate	No	The water captured in air conditioning units and dehumidifier units can easily be used for non-potable purposes.
Grey water reuse	No	Grey water is the wastewater from bathing, doing laundry and dishes. This water can be reused to water lawns or flush toilets. Grey water reuse systems are generally not very well accepted in Canada due to fear of cross contamination and hygiene reasons. The biggest barriers against this measure are regulatory and cost effectiveness.
Floor drain primer water	No	In the last 20 years a very common practice in the residential construction industry has been the installation of a bleed line from a tap to drip water into a basement floor drain trap. This was done to keep the drain trap full of water so hazardous gases cannot seep up through the drain into the house. There are drain covers available that will let water drain through but not let gases escape into the house. This can eliminate the constantly flowing bleed line.

Indoor Measures	Common Practice with North American Municipal Programs	Description
Metering and sub-metering	Yes	A water-metering program for all customers is one of the first and most important programs that should be undertaken to account for all water used in a distribution system. Because a metering program can take years to complete it is suggested that high volume users and new development be metered first. Financial planning should accompany a metering program. Sub-metering involves metering individual units in a multi-residential or multi-user location. In apartment buildings, for example, the whole building is usually metered and then the resident only pays a percentage of the monthly bill rather than the actual amount they used. Sub-metering makes water users more aware of how much water they actually use, and in turn, tenants who use less water can benefit from lower water costs.
Household indoor audits	No	An indoor household audit conducted by an experienced water efficiency practitioner can identify cost effective water saving opportunities within the home. The audit itself does not save water but by implementing the recommendations, water savings can be realized. In some cases, the auditor can install the measures during the actual audit thus reducing overall costs.
Commercial food rinse nozzle	Yes	This measure consists of the installation low-flow, high efficiency, high-pressure pre-rinse spray valves typically found in restaurants, cafeterias and institutions. Based on the success of the Rinse & Save program implemented by the California Urban Water Conservation Council in 2003, many municipalities across North America have launched similar programs. In addition to water savings, the pre-rinse valve can provide significant energy savings and greenhouse gas reductions.
Urinal Flush Controls	Yes	Urinals with flush valves can be either adjusted to flush with lower volumes or the flush valves replaced with water efficient, sometime motion sensor type valves. Urinals with tank type flushing can be retrofitted with automatic flush controls that save significant water.
Low Water Urinals	Yes	Waterless urinals described below can save a very large amount of water but are relatively new on the market. Further research is required but some property managers have reported a build up of uric acid deposits in the urinal drains, which can block flushing. Low water urinals, while using some water, provide significant savings while providing enough drain water to prevent the build up of deposits.
Waterless Urinals	No	Waterless urinals can save a very large amount of water each year (upwards of 45,000 gallons). They are designed to operate and function without any water whatsoever while maintaining a sanitary standard. The urine drains through a liquid chemical trap eliminating odours. Ongoing maintenance is required to ensure that the liquid chemical is replenished. Further research is required but some property managers have reported a build up of uric acid deposits in the urinal drains, which can block flushing.
Process water reuse	Yes	Many ICI facilities have water uses that can be met with non-potable water. For many processes, filtered but otherwise untreated water can be used. Rinse water from laundry, car wash rinses and cooling towers could all be used again in the same process, or if applicable, could be used on applications like irrigation.

Indoor Measures	**Common Practice with North American Municipal Programs**	**Description**
Eliminate once through cooling	Yes	Single-pass or once through cooling systems are an excellent opportunity to save water. In systems with single-pass cooling the water is circulated through a piece of equipment once and then disposed of down a drain. These systems can be modified to eliminate the use of water al together. Some municipalities restrict the use of once through cooling with bylaws.
Cooling tower optimization	Yes	Cooling towers help regulate temperature by rejecting heat from air conditioning systems or by cooling hot equipment. Water is lost through evaporation and bleed-off. Often, water from other equipment within a facility can be reused for cooling tower purposes with little or no treatment.
Car wash rinse water reuse	Yes	Depending on the type of recycling system, reclaiming and filtering wash water for reuse reduces the amount of fresh water needed by 50-60% in bay washes, 50-90% in conveyor touch washes, and 20-90% in conveyor touch-less washes. This measure can save a significant amount of water.
ICI audits	Yes	Industrial, commercial and institutional audits are completed by competent consultants with experience in industrial processes and water use. The audits are designed to provide the facility manager with a report of water use in the facility and a list of cost effective water saving measures (previously described above) that can be implemented. Audits in themselves do not save water. The measures implemented as a result of an audit save water. As such, indoor audits provide an excellent delivery mechanism.
Public and Youth Education	Yes	This measure can be targeted at many different sectors such as: residential, ICI (Industrial, Commercial, Institutional), and school programs. It is an attempt to alter people's attitudes and habits about water use in hope that they adopt a water efficient behaviour. Some of the habits that can be affected include; turning faucets off when washing dishes or brushing teeth, fixing leaking fixtures quickly, and reducing lawn-watering frequency. Public education and awareness can also increase the effectiveness of other measures when paired together. For example, most residents will be more willing to install a water-efficient showerhead after a city wide "Water Conservation Week" has taken place. Public education can include school programs, workshops, newspapers and flyers, audits, websites, television and much more.

9.2 Feasibility Screening of Measures

Technical - Some water efficiency measures are not suitable for local conditions and programming. They may not meet local codes, standards or regulations. They may not be performance tested or proven technology. They may not be market ready or available. For instance, replacing an existing toilet flapper valve with a more efficient model alters an engineered product and could negatively affect performance and the toilet's ability to remove waste.

Potential – Is there a large enough potential in the market sector to justify a program? For example, newly constructed homes generally do not have a central humidifier and as such there would be no market for a water efficiency humidifier program in the new construction sector.

Achievable – Once it has been identified that there is a large potential market for a particular measure, is there an expectation that a large percentage will implement the measure based on reasonable incentives and program delivery? For example, although there may be a large potential for the installation of in-line regulators for showers, homeowners would be reluctant to install them since the wall would have to be opened at significant cost and inconvenience.

Social Impact – Once it has been established that there is a significant achievable opportunity for a particular measure, are there any elements of the program that would affect society negatively. For instance, would implementing a particular program affect local employment? Put an undue financial burden on a family?

Environmental Impact – Are there any environmental impacts attributed to a particular measure? For instance if a particular measure used batteries for operating would there be an issue with disposing of the used batteries.

A decision tree, shown in following Figure 9, was developed to illustrate the screening process.

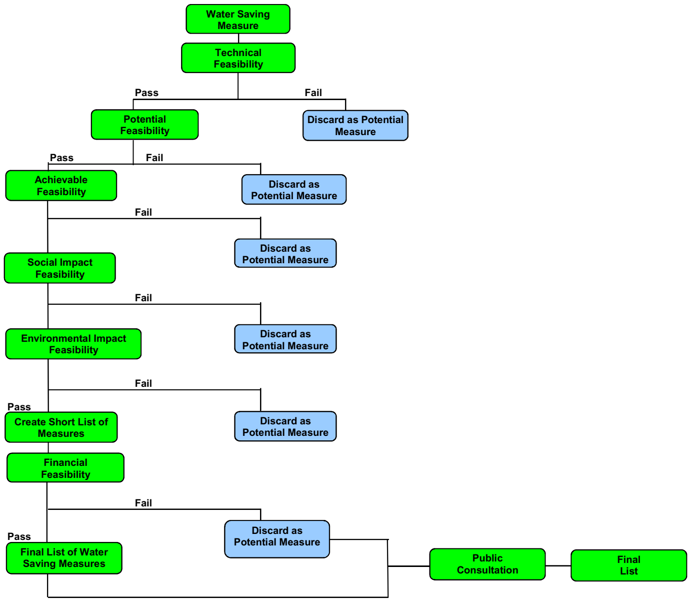


Figure 9: Decision Tree for Screening Water Efficiency Measures

Results of Preliminary Screening

The results of the preliminary screening are shown in the following Table 14. Those measures that passed the screening are highlighted in green.

Table 14: Preliminary Screening Results

Residential Sector	Technical	Potential	Achievable	Social	Environmental
Toilet flapper valve replacement	x	x	x	x	x
Toilet variable flush device	x	x	x	x	x
Toilet tank displacement devices	x	x	x	x	x
6L toilet installation	√	√	x	x	x
High efficiency (HET) toilet installation	√	√	√	√	√
Dual flush toilet installation	√	√	√	√	√
Showerhead replacement	√	√	√	√	√
Showerhead flow restrictors	x	x	x	x	x
Showerheads in-line regulator	√	√	x	x	x
Water efficient clothes washer	√	√	√	√	√
Water efficient dish washer	√	√	x	x	x
Faucet aerator installation	√	√	√	√	√
Faucet flow restrictor installation	x	x	x	x	x
Automatic motion sensor faucet	x	x	x	x	x
Automatic push and touch faucet	√	√	x	x	x
Faucet in-line regulator	√	√	x	x	x
Leakage repair	√	√	√	√	√
Garburator restrictions	x	x	x	x	x
Hot water recirculation	x	x	x	x	x
Water efficient water softener	√	x	x	x	x
Humidifier controller	√	x	x	x	x
Air conditioning condensate recovery	x	x	x	x	x
Grey water reuse	x	x	x	x	x
Floor drain primer water	x	x	x	x	x
Metering and submetering	√	x	x	x	x

Industrial, Commercial and Institutional	Technical	Potential	Achievable	Social	Environmental
Toilet flapper valve replacement	x	x	x	x	x
Toilet variable flush device	x	x	x	x	x
Toilet tank displacement devices	x	x	x	x	x
6L toilet installation	√	√	x	x	x
High efficiency (HET) toilet installation	√	√	√	√	√
Dual flush toilet installation	√	√	√	√	√
Showerhead replacement	√	√	√	√	√
Showerhead flow restrictors	x	x	x	x	x
Showerheads in-line regulator	√	√	x	x	x
Water efficient clothes washer	√	√	√	√	√
Water efficient dish washer	√	√	√	√	√
Faucet aerator installation	√	√	√	√	√
Faucet flow restrictor installation	x	x	x	x	x
Automatic motion sensor faucet	√	x	x	x	x
Automatic push and touch faucet	√	x	x	x	x
Faucet in-line regulator	√	√	x	x	x
Leakage repair	√	√	√	√	√
Garburator restrictions	x	x	x	x	x
Pre-rinse spray valve	√	√	√	√	√
Hot water recirculation	√	√	√	√	√
Water efficient water softener	√	√	√	√	√
Humidifier controller	√	√	√	√	√
Process water	√	√	√	√	√
Cooling tower optimization	√	√	√	√	√
Air conditioning condensate recovery	√	√	√	√	√
Grey water reuse	√	√	√	√	√
Floor drain primer water	√	√	√	√	√
Metering and submetering	√	√	√	√	√

Municipal	Technical	Potential	Achievable	Social	Environmental
Distribution leakage reduction	√	√	√	√	√

For reference, the additional rationale for specific measures not passing the screening process are noted below:

Residential

Toilet flapper valve replacement - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing toilet with a water efficient model is considered the best practice.

Toilet variable flush device - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing toilet with a water efficient model is considered the best practice.

Toilet tank displacement device - Technical

- Alters an engineered product which could adversely affect the product's performance. Can cause operational issues with flush mechanism. Replacement of the existing toilet with a water efficient model is considered the best practice.

6 Litre flush toilet - Achievable

- The HET 4.8 Litre flush toilet has proven to be an effective toilet and is quickly becoming the standard in North America.

Showerhead flow restrictors - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing showerhead with a water efficient model is considered the best practice.

Showerhead in-line regulator - Achievable

- Requires a plumber to cut the existing water line and insert regulator. Difficult to access existing plumbing and as such would have very low uptake.

Water efficient dishwasher - Achievable

- Any dishwasher purchased on the market is Energy Star rated and thus water efficient. Very few households in Rankin Inlet have automatic dishwashers.

Faucet flow restrictor installation - Technical

- Flow restrictor decreases the flow rate and performance of the faucet as compared to an aerator which adds to air to improve performance.

Automatic motion sensor faucet - Technical

- More appropriate for commercial applications for hygienic reasons. No evidence of water savings.

Automatic push and touch faucet - Achievable

- More appropriate for schools and other institutions. Not marketable in a residential sector.

Faucet in-line regulator - Achievable

- Requires a plumber to cut the existing water line and insert regulator. Difficult to access existing plumbing and as such would have very low uptake.

Garburator restrictions - Technical

- Not enough data to justify as a water efficiency measure.

Hot water recirculation - Technical

- Studies have indicated that savings are minimal for this measure.

Water efficient water softeners - Technical

- Not enough data to justify as a water efficiency measure. There are no water softening units in homes in Rankin Inlet.

Humidifier controllers - Technical

- Not enough data to justify as a water efficiency measure. There are no central humidifier units in homes in Rankin Inlet.

Air conditioning condensate recovery - Technical

- Not enough data to justify as a water efficiency measure. There are no air conditioning units in homes in Rankin Inlet.

Grey water reuse - Technical

- Not enough data to justify as a water efficiency measure. Concerns over health and cross connections issues.

Floor drain primer water - Technical

- Not enough data to justify as a water efficiency measure.

Metering and sub metering - Potential

- The Hamlet of Rankin Inlet is fully metered.

Industrial, Commercial and Institutional

Toilet flapper valve replacement - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing toilet with a water efficient model is considered the best practice.

Toilet variable flush device - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing toilet with a water efficient model is considered the best practice.

Toilet tank displacement device - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing toilet with a water efficient model is considered the best practice.

6 Litre flush toilet - Achievable

- The HET 4.8 Litre flush toilet has proven to be an effective toilet and is quickly becoming the standard in North America.

Showerhead flow restrictors - Technical

- Alters an engineered product which could adversely affect the product's performance. Replacement of the existing showerhead with a water efficient model is considered the best practice.

Showerhead in-line regulator - Achievable

- Requires a plumber to cut the existing water line and insert regulator. Difficult to access existing plumbing and as such would have very low uptake.

Faucet flow restrictor installation - Technical

- Flow restrictor decreases the flow rate and performance of the faucet as compared to an aerator which adds to air to improve performance.

Automatic motion sensor faucet - Technical

- More appropriate for commercial applications for hygienic reasons. No evidence of water savings.

Automatic push and touch faucet - Achievable

- More appropriate for schools and other institutions. No evidence of water savings.

Faucet in-line regulator - Achievable

- Requires a plumber to cut the existing water line and insert regulator. Difficult to access existing plumbing and as such would have very low uptake.

Garburator restrictions

- Not enough data to justify as a water efficiency measure.

Table 52: Water Efficiency Measures Short List

Residential Water Efficiency Measures		
High Efficiency (HET) toilet installation	Water efficient clothes washing machines	Showerhead replacement
Dual flush toilet installations	Kitchen faucet aerator installation	Bathroom faucet aerator installation
Leakage repair		
Industrial/Commercial/ Institutional Measures		
High Efficiency (HET) toilet installation	Water efficient clothes washing machines	Commercial food rinse nozzle
Dual flush toilet installations	Water efficient dish washing machines	ICI audits
Municipal		
Distribution leakage reduction		

Financial Feasibility of Water Efficiency Measures

Utilizing a spreadsheet model (see Appendix C), water savings and implementation costs were derived for each measure displayed on the short list. The savings and costs were then used to determine the cost effectiveness of each measure. The cost-effectiveness of a measure, or its cost/benefit ratio, is determined by comparing the program cost to the cost of future infrastructure expansion to deliver a similar quantity of water. The water savings for each measure was determined using a number of resources from engineering estimates to actual verified results from water efficiency programs in North America. Much information was gathered from programs that have been implemented and monitored for the last five to ten years in the Region of Waterloo, Region of York and the City of Toronto.

Depending on the measure and delivery mechanism program costs may include; equipment, installation, rebates, training, program marketing and project management as applicable. Based on related program costs a cost per litre of water per average day saved was determined for each conservation and efficiency alternative. This cost was then compared to the cost of constructing additional infrastructure to gain one litre per average day of additional water and wastewater capacity. It is important to note that calculated cost relating to construction of an additional litre of water and wastewater capacity does not include the cost of debt financing of construction projects. It is also important to note, that this figure does not include the cost of additional infrastructure required for the distribution/conveyance of water and wastewater to and from newly serviced areas such as water/wastewater mains, pumping stations or system reservoirs. In southern Ontario, the combined water and wastewater construction cost per litre per average day of additional capacity ranges from approximately $2.00 to $8.10. Without additional data, the consultant has assumed that the costs in Rankin Inlet are 2 times that of southern Ontario or a range of $4.00 to $16.20. For the purpose of this financial analysis the combined water and wastewater construction cost of $8.00 per litre per average day of additional capacity was utilized.

The outcome of the financial analysis is shown in the following Table 16. The measures that did not pass the financial test are highlighted in yellow.

Table 16: Results of Financial Screening of Water Efficiency Measures

Residential	**Water Efficiency Measure**	**Cost per Participant**	**Savings per Participant (L/d)**	**Cost per litre**
Installation	HET Toilets	$ 1,014	139	$ 7.31
Installation	Dual Flush Toilets	$ 1,024	139	$ 7.38
Installation	Low Flow Showerheads	$ 133	54	$ 2.44
Installation	Kitchen Faucets	$ 71	20	$ 3.52
Installation	Bathroom Faucets	$ 64	24	$ 2.70
Installation	Leakage Repair	$ -	56	$ -
Installation	Clotheswashers	$ 1,250	19	$ 67.57
ICI				
Installation	HET Toilets	$ 7,381	375	$ 19.68
Installation	Dual Flush Toilets	$ 7,631	375	$ 20.35
Installation	Pre-Rinse Spray Valves	$ 1,450	368	$ 3.94
Installation	ICI Audits and Capacity Buy-back	$ 72,250	15,000	$ 4.82
Municipal				
Installation	Leakage Reduction	$ 55,000	57,500	$ 0.96

Recommended List of Measures to Include in Strategy

Three measures including residential clotheswashers, ICI HET toilets and ICI dual flush toilets did not pass the financial screening but are recommended to remain on the short list for inclusion in the strategy. These measures provide substantial water savings and their inclusion provides a comprehensive strategy. As demonstrated in the next section, the inclusion of these three measures does not affect the overall cost-effectiveness of the strategy.

10.0 Strategy Implementation Plan

The recommended components of the plan include:

Residential Measures

- Visit all homes and apartments and install free of charge HET or dual flush toilets, low flow showerheads, kitchen aerators, bathroom aerators and water efficient clotheswashers. To eliminate toilet leakage in homes, it is recommended that only "flapperless" type toilets be installed. These are proven products and readily available in the market.

Industrial/Commercial/Institutional Measures

- Visit all businesses and institutions and install free of charge HET or dual flush toilets. To eliminate toilet leakage in businesses, it is recommended that only "flapperless" type toilets be installed. These are proven products and readily available in the market.
- Visit commercial kitchens and install free of charge low flow pre-rinse spray valves.
- Complete five (5) comprehensive water audits and offer a capacity buy-back rebate to any facility that implements all or some of the water saving recommendations.

Municipal Measures

- Design and implement five (5) district meter areas. Locate, quantify and repair the leakage within the water distribution system.

Public Education

- Distribution of booklets, leaflets, and fact sheets at community and environmental events.
- Distribution of a water efficiency bulletin in the water bills.
- Displays at community events.
- Develop and maintain a website to educate the public on water efficiency.
- Provide workshops and seminars to the public on water saving techniques both inside and outside the home.

Youth Education

- Develop and deliver a water efficiency education program based on curriculum requirements.
- Develop and facilitate a Children's Water Festival.

For reference individual business cases for each recommended water conservation and efficiency measure are provided in Appendix D of this report.

10.1 Table 17: Capital Budget and Water Savings (Litres per average day)

Residential	**Water Saving Measure**	**Number of Product Installed**	**Total Cost**	**Total Program Savings (L/d)**	**Cost per litre**
Installation	HET Toilets	768	$ 707,921	96,903	$ 7.31
Installation	Dual Flush Toilets	85	$ 79,434	10,767	$ 7.38
Installation	Low Flow Showerheads	854	$ 103,208	42,246	$ 2.44
Installation	Kitchen Faucets	776	$ 55,096	15,644	$ 3.52
Installation	Bathroom Faucets	854	$ 49,664	18,376	$ 2.70
Installation	Leakage Repair	854	$ -	43,068	$ -
Installation	Clotheswashers	776	$ 970,000	14,356	$ 67.57
Industrial, Commercial, Institutional					
Installation	HET Toilets	357	$ 329,486	16,740	$ 19.68
Installation	Dual Flush Toilets	40	$ 37,850	1,860	$ 20.35
Installation	Pre-Rinse Spray Valves	15	$ 14,500	3,680	$ 3.94
Installation	ICI Audits and Capacity Buy-back	5	$ 72,250	15,000	$ 4.82
Municipal					
Installation	Leakage Reduction	5	$ 275,000	287,500	$ 0.96
Education					
Public Education (5 years)			$ 150,000		
Youth Education (5 years)			$ 180,000		
TOTAL			$ 3,024,408	566,140	$ 5.34

It is recommended that the above capital plan be supported by ongoing monitoring, evaluation and maintenance in order to initially verify the water savings and then to sustain them into the future.

The overall best practices capital program is budgeted at $3,024,408 and is expected to save just over 566,000 litres of water per average day (l/d).

The cost per litre per day for the proposed plan is $5.34. This compares well to the average cost per litre per average day capacity for new infrastructure, which is estimated at $8.00. To add new water and wastewater infrastructure to deliver the equivalent capacity of 566,000 l/d would cost $4.5 million based on the average $8.00 per litre capacity cost.

Although some program measures did not meet the cost analysis, which includes clotheswashers, ICI HET toilets and ICI dual flush toilets, these program alternatives have been included due to the significant savings that they bring to the overall plan. However, it is important to note that even with the inclusion of these programs the overall plan remains more cost-effective than the cost of constructing future water and wastewater supply/treatment capacity.

Due to the difficulty in measuring water savings generated by education, there have been no savings attributed to the Broadscale Public or Youth Education programs in the plan. Technical solutions, such as low flush toilets and low flow showerheads will only achieve a portion of the potential water savings. Education designed to change habits and attitudes or residents towards water use will achieve the remaining savings. The American Water Works Association suggests that education programs can generate up to a 4 to 5% reduction in water demand by long-term education initiatives. In addition, education is necessary to ensure that water savings generated by the capital program are sustained. Since, education should be ongoing, 5 years of costing has been included.

Included in the costs for the plan are:

- Equipment
- Installation
- Marketing
- Program management and administration
- Project management

A breakdown of the costs by market sector is provided in the table on the following page.

10.2 Table 18: Water Conservation and Efficiency Strategy Costs Breakdown

Residential		**Number Product Installed**	**Equipment & Installation**	**Marketing**	**Program Management & Administration**	**Project Management**	**Total Cost**	**Total Program Savings (L/d)**
Installation	HET Toilets	768	$ 641,572.59	$ 10,476.00	$ 41,904.00	$ 13,968.00	$ 707,920.59	96,903
Installation	Dual Flush Toilets	85	$ 71,285.84	$ 1,164.00	$ 5,432.00	$ 1,552.00	$ 79,433.84	10,767
Installation	Low Flow Showerheads	854	$ 64,408.00	$ 7,760.00	$ 23,280.00	$ 7,760.00	$ 103,208.00	42,246
Installation	Kitchen Faucets	776	$ 25,608.00	$ 7,760.00	$ 15,520.00	$ 6,208.00	$ 55,096.00	15,644
Installation	Bathroom Faucets	854	$ 20,176.00	$ 7,760.00	$ 15,520.00	$ 6,208.00	$ 49,664.00	18,376
Installation	Leakage Repair	854	$ -	$ -	$ -	$ -	$ -	43,068
Installation	Clotheswashers	776	$ 931,200.00	$ 7,760.00	$ 23,280.00	$ 7,760.00	$ 970,000.00	14,356
Industrial, Commercial, Institutional								
Installation	HET Toilets	357	$ 298,238.05	$ 8,928.00	$ 17,856.00	$ 4,464.00	$ 329,486.05	16,740
Installation	Dual Flush Toilets	40	$ 33,137.56	$ 1,488.00	$ 2,480.00	$ 744.00	$ 37,849.56	1,860
Installation	Pre-Rinse Spray Valves	15	$ 3,750.00	$ 3,000.00	$ 7,000.00	$ 750.00	$ 14,500.00	3,680
Installation	ICI Audits and Capacity Buy-back	5	$ 60,500.00	$ -	$ 7,500.00	$ 4,250.00	$ 72,250.00	15,000
Municipal								
Installation	Leakage Reduction	5	$ 250,000.00	$ -	$ 15,000.00	$ 10,000.00	$ 275,000.00	287,500
Education								
Public Education (5 years)							$ 150,000.00	
Youth Education (5 years)							$ 180,000.00	

10.3 Staff Resources

The implementation of the plan would require the following staff resources which has been included in the budget.

Position	Annual Expense
Project Manager (x1), part time	$64,000
Program Coordinator (x2)	$175,000

Responsibilities and duties of recommended staff:

Project Manager – responsible for overall development, implementation, evaluation and reporting of the Water Conservation and Efficiency Strategy. Staff recruitment, training, coaching and evaluation.

Program Co-ordinator – responsible for the development, implementation and evaluation of:

- Residential sector
- Education

Program Co-ordinator – responsible for the development, implementation and evaluation of:

- ICI sector
- Municipal Leakage Program

11.0 Overall Water Savings

Overall

The overall water savings anticipated from the implementation of the recommended strategy is shown in Table 19 below.

Table 19: Overall Water Savings

Sector	litres/day	litres/year
Residential	241,360	88,096,000
ICI	37,280	13,607,000
Municipal	287,500	104,938,000
Total	566,140	206,641,000

The water saving plan will free up 206,641,000 litres/year of water supply capacity. This represents 61% of the total water supplied in 2009.

In addition to providing water supply capacity, the plan will reduce demand on the wastewater system by 101,703,000 litres/year.

Residential

The water savings attributed to the residential sector was compared against 2009 billed consumption and the residential water balance that was developed. Results of this comparison is shown in Table 20.

Table 20: Comparison of Residential Savings and 2009 Residential Consumption based on Billing Data and based on Water Balance

Residential Sector	Per Capita Consumption (Lcd)	Residential Consumption 2009 (litres)	Residential Water Savings (litres)	Percent Savings
As per Billing Data	122	111,544,000	88,096,000	79%
As per Water Balance	169	154,151,000	88,096,000	57%

Industrial, Commercial and Institutional

The water savings attributed to the ICI sector was compared against 2009 billed consumption. Results of this comparison are shown in Table 21.

Table 21: Comparison of ICI Savings and 2009 ICI Billed Consumption

ICI Sector	Corrected ICI Consumption 2009 (litres)	ICI Water Savings (litres)	Percent Savings
As per Billing Data	26,962,000	13,607,000	50%

Municipal

The water savings attributed to the Municipal leakage reduction program was compared against the water loss identified from the AWWA/IWA Water Audit and Water Balance results. Results of this comparison are shown in Table 22.

Table 22: Comparison of Municipal Savings and Water Loss Results

Municipal Sector	Estimated Water Loss 2009 (litres)	Municipal Water Savings (litres)	Percent Savings
As per Billing Data	145,000,000	104,938,000	72%

12.0 Maintenance

Water savings generated from the efficiency program should be viewed in the same manner as constructing a new water treatment facility. If the Hamlet of Rankin Inlet were to design and build new infrastructure to deliver 566,000 l/d, a budget for a maintenance program would be included to ensure that the facility continues to deliver 566,000 l/d in the future. The Hamlet's water conservation and efficiency strategy is no different. If it was designed to save 566,000 l/d, maintenance would be required to sustain the savings into the foreseeable future.

Water efficiency has been identified as a viable cost-effective supply of water. Maintenance will be essential to ensure that the savings are sustained. Each component of the water efficiency strategy should have three basic elements; tracking of activity, savings validation and finally maintenance of products and services provided.

One of the largest components of the proposed conservation and water efficiency strategy, from both a savings and budget perspective, are the programs related to the residential sector. The Hamlet would implement these programs through direct installation in qualifying homes and apartments within the Hamlet.

The maintenance element of the program will ensure that if a water efficiency program participant has a performance problem with the new equipment installed, new replacement parts will be available to the participant.

To sustain water savings within the ICI sector, follow up visits should be scheduled periodically to ensure that the water saving capital equipment that was installed and any procedural changes made as a result of the water efficiency program are still in place, working effectively and saving the same amount of water as originally verified.

Just like a new treatment plant, water efficiency measures have to be maintained. This will be in several formats, including:

- Education of water users
- Tracking of all participants and non-participants
- Customer call centre to respond to enquiries
- Recommendations for replacement products or service

A comprehensive maintenance program is an integral part of the strategy during the capital program and beyond. It is recommended that a customer service representative be established that would field incoming calls regarding the program. A customer with a problem will speak to a program representative directly. The program representative will have access to a database which contains participant information such as name, address, phone numbers, number of showers in the home, number of toilets in the home, products installed, date of installation and name of installer.

The importance of tracking activity from a customer satisfaction perspective, from a product performance perspective to a program performance perspective cannot be over-emphasized. Just like it pays to put that front-end time investment in the development of the scope of work...the same holds true for a tracking system. It is recommended that two levels of tracking, ATS and SRS be developed for the installation activity. ATS or the Activity Tracking System monitors the day-to-day activity. It will be located and maintained by the Hamlet's Water Efficiency Program customer service representative. On a daily basis, all calls received, all installs completed, any maintenance work completed will be tracked in ATS. A number of management reports will be able to be called up at any time or ad hoc queries can be generated. Each month, the information gathered in ATS will be downloaded into SRS, the Summary Reporting System. Just as its name implies, this will be a high level reporting system used for management reports indicating costs, participants, estimated water savings and variance to budgets and forecasts.

Few utilities implement maintenance, monitoring and evaluation programs to the extent that is recommended. Most utilities implement water efficiency capital programs with no thought to sustaining the savings into the long term or without any serious evaluation research. They quite often rely on engineering estimates for calculating savings while not considering the significant number of externalities that effect water savings. The energy sector has done a much better job in monitoring and evaluation but even they fall short on maintenance. Few, if any, energy utilities maintain the savings that they have achieved from their capital programs.

The elements included in the maintenance program would include:

Residential Sector

Significant water savings products will be installed by Rankin Inlet's water conservation and efficiency strategy. These products should be maintained through a "pick-up" service. If a resident or business requires a replacement part they simply stop by the customer service centre that would provide the appropriate parts directly to the customer.

Industrial/Commercial/Institutional Sector

In addition to maintaining the products installed in small commercial businesses it is anticipated that 1 ICI customers will participate in the water saving audits and capacity buy-back program. Over the course of the plan, a consultant who will be similar to a key-account manager will visit each of the facilities periodically. The purpose of the visit will be to ensure that the water measures implemented are still in place and still providing savings as designed. In addition the consultant will meet with the facility staff to ensure proper operating procedures design to achieve maximum savings are being practiced. The budget allows for 1 site visit per year during a five year period.

Distribution Leakage Reduction

It is recommended as good practice to complete an AWWA / IWA Water Audit and Water Balance every year – this is often referred to as the "Top Down" approach to water loss management.

It is also recommended that the temporary District Meter Areas (DMAs) be operated on a regular basis, which can be either every year, or every two to three years. It is also recommended that with the information gathered as part of the operation of the temporary DMAs, that consideration be given to establishing permanent DMAs, for either continuous water loss monitoring, or the next stage of flow modulation to reduce background leakage (small leaks that are nor economic to find and repair). The DMA approach is often referred to as the "Bottom UP" approach.

The maintenance budget has been established to accommodate two (2) DMA maintenance runs in year 3 and three (3) in year 4. This will ensure that no DMA goes without maintenance for more the three years.

The recommended maintenance budget is found in Table 23 below.

Table 23: Recommended Maintenance Budget

Five Year Maintenance Plan	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
	Costs	**Costs**	**Costs**	**Costs**	**Costs**	
Residential	$ 17,107.69	$ 18,215.38	$ 22,646.14	$ 25,969.21	$ 29,292.28	$ 113,230.70
Industrial/Commercial/Institutional	$ 12,437.00	$ 12,874.00	$ 22,122.00	$ 23,433.00	$ 27,704.00	$ 98,570.00
Distribution Leakage Reduction				$ 60,000.00	$ 90,000.00	$ 150,000.00
Total	$ 29,544.69	$ 31,089.38	$ 44,768.14	$ 109,402.21	$ 146,996.28	$ 361,800.70

13.0 Monitoring and Evaluation

It is important to have a monitoring and evaluation program to ensure that the water savings are achieved initially, and that those savings are sustained over time.

In the residential and small commercial markets it is recommended that on-site monitoring be carried out 30 days before the measure installation and 30 days after the measure has been installed. Monitoring can be accomplished with the installation of data loggers on the water meters. These units are small and unobtrusive. The data logging study will verify the actual savings attributed to the water saving measures. This analysis should be completed in the first year of the capital program to verify the expected water savings.

Also of importance is the ongoing monitoring for persistence or sustainability. All products wear out or fail in time. Participants may have the tendency to install a high water consuming device when their water saving device fails. This may happen due to lack of knowledge or the availability of water saving products at retail stores. In order to measure this erosion in savings it is recommended that statistically valid audits of participants be carried out throughout a five year period. The auditor would visit the home or business and inspect the water savings products that were installed. The auditor would observe if the products are still installed, working properly and saving water. Audits could be completed in Year 5.

The Table 24 below provides the monitoring and evaluation by year for the five year period.

Table 24: Monitoring and Evaluation Budget

Five Year Monitoring and Evaluation Plan	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
	Costs	**Costs**	**Costs**	**Costs**	**Costs**	**Costs**
Residential	$ 157,500				$ 30,000	$ 187,500
Industrial, Commercial and Institutional	$ 78,000				$ 7,200	$ 85,200
Total	$ 235,500	$ -	$ -	$ -	$ 37,200	$ 272,700

The Table 25 below provides the activities to be undertaken from the Monitoring and Evaluation plan.

Table 25: Recommended Monitoring and Evaluation Activity

	Number of Participants to be Monitored	Number of Persistence Audits in Year 5
Residential		
HET Toilets	30	125
DF Toilets	15	25
Clothes Washers	30	150
Showers, Faucets, Leakage	30	150
Industrial, Commercial and Institutional		
HET Toilets	20	60
DF Toilets	10	20
Pre Rinse Spray Valves	10	10
Capacity Buy Back	Included in Capital Program	

It is important to note that the long-term costs of water savings monitoring could be drastically reduced with the introduction of automated meter ready (AMR) technology in place of the collection of the Hamlet's current customer water use reading system. The introduction of AMR technologies would provide the utility with enhanced customer water use data (based on the frequency of water use reporting) and added customer services tools to proactively identify private side leakage or meter reading errors. With the introduction of this technology it is expected that the required monitoring program would be less labour intensive for staff and be less intrusive for sites being monitored through the process.

14.0 Energy Savings and Greenhouse Gas Emissions Reductions

The overall energy savings generated from water efficiency is in most cases more significant than the water savings. Water utilities are typically the largest consumer of electricity in a municipality. Electricity is used in the water and wastewater treatment processes but more significantly in the pumping/conveyance of water and wastewater. A recent study[4] completed by the Polis Project on Ecological Governance, University of Victoria evaluated historical data relating to water production and energy consumption from 7 municipalities in Ontario. The study completed case studies on the Town of Collingwood, the Regional Municipality of Durham and the City of Guelph. The study reported, that it takes 0.68 KWh of electricity for every 1,000 litres of water delivered to a customer and then returned through the wastewater process. The findings from this study were used to develop the energy savings and greenhouse gas emission reductions reported below.

Many of the water saving measures recommended in the strategy also reduce energy consumption at the customer's premise. For example, a low flow showerhead reduces not only water but reduces hot water. Oil or electricity has been used by the customer to generate the hot water. Energy savings will also be generated from the faucet aerators, clotheswashers, pre-rinse spray nozzles and the ICI Audit program.

Typically a residential customer who participates in the water efficiency program will see greater dollar savings in their energy bill as compared to their water bill. This is also an important linkage to emphasize when promoting the water efficiency programs to the public.

The reduction of water-use through an efficiency program and the associated energy savings provides significant greenhouse gas reductions. With climate-change in mind, most municipalities have set their own greenhouse gas reduction targets. Water efficiency can be a positive contributor to meeting those targets.

Although the participant's energy savings were not quantified as part of this project, the utility energy savings and greenhouse gas emission reductions are provided in Table 26 below.

Table 26 – Estimated Energy Savings and Associated Greenhouse Gas Emission Reductions

	Water Savings per Year (litres/yr)	Energy Savings per Year	CO2 Reductions per Year (tonnes/yr)
Overall Water Savings	206,641,000	130,022 KWh Electricity	78.0 tonnes

Assuming an electric rate of $ 0.35 per KWh, the Hamlet of Rankin Inlet would reduce its electrical bill by approximately $45,858 per year upon completion of the strategy. In addition, the greenhouse gas emissions reduction is equivalent to removing 14 cars from the road.

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[4] Maas, Carol. Greenhouse Gas and Energy Co-Benefits of Water Conservation, Polis Discussion Series Paper 08-01, November 2008, Polis Project on Ecological Governance, university of Victoria, Victoria, BC.

15.0 Conclusions

Market Research – Residential Surveys

Overall, 62 residential surveys were completed from October 21st to November 5th 2009. When asked about the environment, respondents indicated that they think primarily about water quality/pollution followed very closely by water conservation and efficiency.

When asked why their household has not changed the way it saves water, the most common response was that they were not billed for their water. This is certainly true for the residents who rent their homes from the Rankin Inlet Housing Association. The Statistics Canada 2006 Census indicates that 69% of the households in Rankin Inlet are rented properties. This group, unaffected by a water bill, will require other motivations and incentives to participate in a water efficiency strategy.

In addition to providing information on the habits and attitudes of Rankin Inlet residents, the survey provided quantified data that was used in the potential water savings model.

Market Research – Household Audits

During the week of November 2nd 2009, the project team completed ten (10) household audits in Rankin Inlet. During the audits, it was determined that toilets had an average flush volume of 13.3 litres, showerheads had an average flow rate of 12.0 litres per minute, kitchen faucets had an average flow rate of 8.1 litres per minute and bathroom faucets had an average flow rate of 7.0 litres per minute. It was observed that in general, every water consuming fixture or appliance in the homes in Rankin Inlet provides a water saving opportunity ranging from 30% to 65% reductions. The data collected from the household audits were used in the potential water savings model.

Residential Water Use Demand Analysis

An analysis was completed to segregate water use into several categories, so that water use by single family properties, multi family units and the ICI sector could be identified. Customer billing data for the period form August 2006 to August 2009 was compared to:

- Rankin Inlet Business Directory provided by the Canada-Nunavut Business Service Centre
- Rankin Inlet House Numbering system Map, dated April 23rd 2002
- Satellite imaging of Rankin Inlet

The comparison was completed in order to identify the number of properties in each category, and to allocate a volume of use. Properties that were identified as residential housing but listed in the ICI sector was re-categorized as residential for the analysis.

Based on the data provided, a breakdown of the 2009 (Sept. 2008 to Aug. 2009) residential customer billed consumption is shown in the following Table 27.

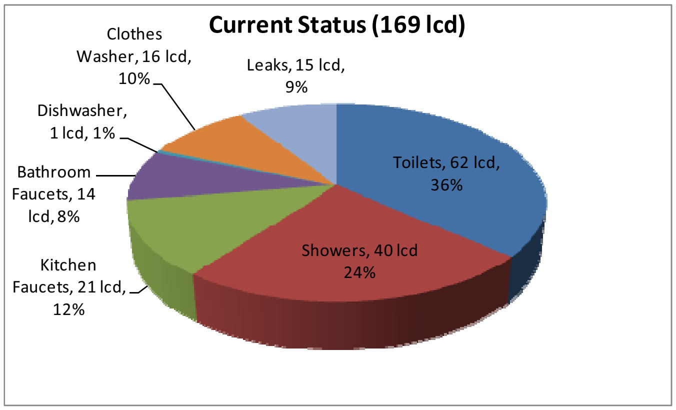
Table 27: Rankin Inlet 2009 Residential Customer Billed Consumption

Category	2009 Billed (litres)	Population 2009 est.	Water Use – Litres per Capita per Day (Lcd)
Residential	111,544,000	2,499	122

The billing analysis indicated that 75% of the overall billed water is to the residential sector. In addition using an estimated 2009 population of 2,499, the residential per capita consumption was 122 litres per capita per day (Lcd). A relatively low residential per capita consumption was expected in Rankin Inlet since there is minimal outdoor water use. However, the excessive water using fixtures and appliances found in the market research would indicate that the residential consumption should be significantly higher than what was indicated from the billing data. It was also observed that the age and technology (remote read) of the residential meters would support lower meter readings than the actual usage and the remote read technology could allow for unauthorized unbilled water use. Both of these factors were confirmed by GN CGS staff as concerns.

Using observations from the market research in addition to factors from the AWWA AWARF 1999 Residential End Uses Study, a residential water balance and a calculated per capita consumption was developed. The results of this calculation provided a residential per capita consumption of 169 Lcd. The water balance is shown below in Figure 10.

Figure 10: Calculated Residential per Capita Consumption and Water Balance



The calculated per capita consumption indicates that the actual residential consumption could be as much as 38% higher than that reported in the billing data. In order to compare this consumption level with other municipalities in Canada, and around the world, the following Figure 11 has been prepared:

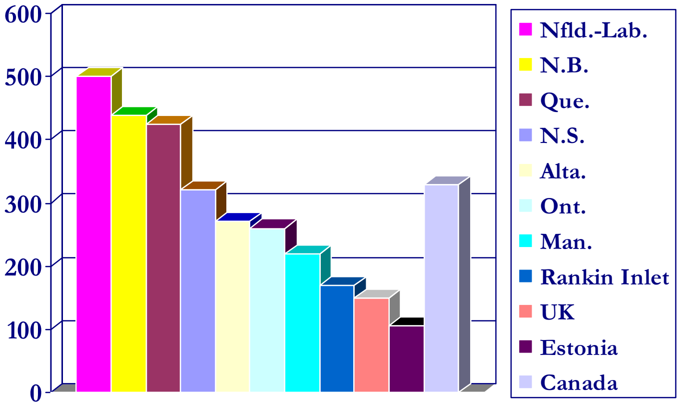


Figure 11: Comparison of Residential Per Capita Demand (lcd)[5]

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[5] Municipal Water Use Survey, Environment Canada, 2004.

Prior to 1994, toilet flush volumes were generally 20 litres or greater. The National Building Code or the National Plumbing Code does not address water conservation and as such do not provide required toilet flush volumes. In December 1995, the Government of Nunavut released its 2nd Edition of the Good Building Practices Guidelines. The Guidelines was provided as a supplement to the National Building Code to assist builders and developers with the construction in a northern climate. It is recommended that the GN considers updating the 1995 Guidelines with current proven water efficiency products such as high efficiency toilets and dual flush toilets in addition to lower flow rated showerheads and faucets. Such an update would ensure that all newly constructed homes would be as water efficient as possible.

Industrial, Commercial and Institutional (ICI) Water Use Demand Analysis

According to the 2009 billing data provided, the industrial, commercial and institutional (ICI) sector represents approximately 25% of Rankin Inlets' bill water consumption. In 2009, the volume of billed water to the ICI sector was 35,128,000 litres, which is 30% more than 26,962,000 litres billed in 2008.

Further investigation of the billing data for 2009 produced the following discrepancies:

- Polar Bear Investments c/0 Nanqu Inn – 7,842,000 litres additional in 2009
- Community & Government Services, Kivalliq – approximately 3,000,000 litres additional in 2009
- Rankin Inlet Airport – approximately 1,500,000 litres additional in 2009

The additional water volume represented by these 3 accounts more than offset the increase in water volume in 2009. In addition, similar to the residential water meters as large mechanical meters get older they tend to under-register due to wear. Due to the discrepancies in the billing data the confidence in the accuracy of the ICI billed water consumption is extremely low.

Further analysis of 2009 billing ICI billing data indicates that 35% of the customers consume 80% of the overall water for that sector. For the purpose of this analysis, it was assumed that the 2008 ICI billed volume of 26,962,000 litres was more representative and as such used as the corrected 2009 ICI volume.

Evaluation of Distribution System Water Loss

It is recommended that the water distribution loops be established as District Meter Areas (DMAs), so that the flows in each individual loop can be monitored, particularly the flows at night, to identify leakage, bleeders and other losses. To achieve this, the flows at the start of each individual loop will have to be metered, and the flows on the return of each loop must also be metered.

In each of these DMA loops, the flow at night, typically between 2.00 am and 4.00 am will be recorded each night. This will then be compared to the "Legitimate Night Usage" or the flow at night that is expected, which is based on the following:

- Length of mains
- Average water pressure
- Number of customer services
- Number of hydrants
- Average number of people per house

With this information, the Legitimate Night Flow can be calculated in a. This legitimate night flow is the sum of flows, or losses from:

- Mains
- Public side of the customer service (main to curb stop)
- Private side of the customer service (curb stop to house)
- Residential night use (usually the largest number)
- Exceptional night use (institutional, commercial, industrial - ICI)

In DMA loops where the measured flow at night is significantly higher than the Legitimate Night Flow, these areas would then be targeted for acoustic leak detection.

It is likely that initially all the loops in Rankin Inlet will have measured flows significantly higher than the Legitimate Night Flow, because of the existence of bleeders, and leaks that may have been running for some time. When DMAs are introduced for the first time in water distribution systems it is common for the flows to be high. The initial tasks are often to identify and eliminate this "backlog" of losses, to reduce water loss to economic levels.

It is recommended that six DMAs be established, as follows:

Area 5 DMA Loop
Install a flowmeter on the Area 5 supply pipe in Williamson Lake Pump House, between the wet well pumps delivery main, after the existing mag meter; and where the pipe leaves the building at the side.

Install a flowmeter on the Area 5 return pipe, where it enters the Williamson Lake Pump House, before the pipe joins the common return pipe

Nuvuk DMA Loop (Area 6)
In the chamber just outside the entrance door to Williamson Lake Pump House, install a flowmeter on the Area 6 supply pipe

Install a flowmeter on the Area 6 return pipe, which is located in a chamber in the system where the return pipes for Areas 1 and 2 combine – there is then a common return pipe to Williamson Lake Pumphouse for Areas 6, 1, 2.

Town DMA Loop 1 (Area 1)
In a chamber past the Hamlet offices, the water that is transmitted along the Town Supply then feeds Areas 1 and 2. Install a flowmeter on the Area 1 main

Install a flowmeter on the Area 1 return pipe, which is located in a chamber in the system where the return pipes for Areas 1, 2 and 6 combine – there is then a common return pipe to Williamson Lake Pumphouse.

Town DMA Loop 2 (Area 2)
In a chamber past the Hamlet offices, the water that is transmitted along the Town Supply then feeds Areas 1 and 2. Install a flowmeter on the Area 2 main

Install a flowmeter on the Area 2 return pipe, which is located in a chamber in the system where the return pipes for Areas 1, 2 and 6 combine – there is then a common return pipe to Williamson Lake Pumphouse.

Kivalliq DMA Loop
Install a flowmeter on the Kivalliq supply pipe in Williamson Lake Pump House, between the wet well pumps delivery main, after the existing mag meter; and where the pipe leaves the building.

Install a flowmeter on the Kivalliq return pipe, where it enters the Williamson Lake Pump House, before the pipe joins the common return pipe

DMA Town Supply
Because the Town Supply also is the feed pipe for Areas 1 and 2, the DMA flow will be calculated from the flows at other meters, as follows:

Town Supply = Existing common delivery main mag meter, minus metered flows for all other loops.

There is no return for the Town Supply, as it feeds Areas 1 and 2, which have return mains

Mains Between Nipissar Lake Pump House and Williamson Lake Pump House
As a future phase of the flow monitoring program, flow meters could be installed at both ends of the two watermains between Nipissar Lake Pump house and Williamson Lake Pump House

Once the loops with high water losses have been found, the next stage is to identify where the losses are and remove them. In Rankin Inlet the two main areas of losses are bleeders, and leaks on the watermains or services. There are generally two ways to do this, which are:

- For short periods of 5 minutes at night, close small sections of watermain on a loop, and record the drop in flow. For Rankin Inlet distribution system that would involve subtracting the return flow from the supply flow of the loop. ***This method is not recommended*** because when the section of the loop is closed, there would be no water supplied to customers, and hence the recirculation pumps on each customer service pipe would be running dry.
- ***Recommended*** - Use acoustic methods to listen for water loss noises in the loop. This would be a two phased approach of firstly establishing a small area which is "noisy", with at least two fittings, but preferably more, with noise – this gives the "General Area of Losses". Then secondly, from these noisy fittings "Pinpoint the Leak / Losses" – put the cross on the ground for a leak, or identify a customer service or watermain that is bleeding water to waste.

Because the watermains are a mixture of HDPE and PVC, which do not transmit leak noise as well as metallic pipes (cast iron, ductile iron), as many contact points as possible must be used to listen for leak noises. In addition, it is understood that the curb stop valves have a thermal insulating break, which also acts as an acoustic break, so that will make it more difficult to hear leaks from the curb stops.

If the water loss is a bleeder at a water service the pinpointing will indicate a loss at the corporation stop / curb stop of the service. Once this is identified, staff can investigate the bleeder further.

Although customers have to obtain a bleeder permit, all of them may not have done so. Once the bleeder is identified, steps can be taken to assist the customer to correct the problem on the services, and ensure that the recirculation system is put back into operation.

For bleeders on the water distribution system, they will be initially identified as leaks, if they are not already known. Depending on the location and function, the following measures should be considered:

- For all locations, complete a calculation of the approximate volume of water in the mains that are being kept fresh. Then calculate the flow rate required to exchange that volume of water in say 24 hours, or other agreed time period
- Shut off the bleeder, or
- Reduce the flow rate, or
- Install an automatic flushing device, or
- Where possible, for branches left open, install a flowmeter

Acoustic Listening Devices
It is recommended that an electronic listening device be used which includes a listening stick and a ground microphone. The kit also includes a processing unit with display, and headphones.

Leak Noise Loggers
In addition to the acoustic listening equipment, leak noise loggers can be used. They normally come in sets, and depending on manufacturer, can be typically be in sets of 6, 12, 15. The loggers are attached to contact points on the watermains, such as valves and hydrants, and are normally left in position for between one and three days, depending on manufacturer. The options for downloading the loggers include manual retrieval; drive by radio reading; and a fixed network radio system where the data is transmitted to an office computer.

If noise loggers are to be employed, it is recommended that a set of about 12 be used initially to see how applicable they are to the Rankin Inlet water distribution system

Leak Detection Correlators
One leak noise correlator is required to pinpoint the leaks. There are effectively three main types, and their selection depends on customer preference and field conditions. The three main types of processor are:

- Stand alone units for use outside in most elements. Generally robust equipment for use outside
- Hand held PDA small units
- Units where the software is loaded onto laptop computer

It is further recommended that a set of Hydrophones be purchased to correlate for leaks via the body of water in the pipe.

For each of the distribution loops, in order to measure the volume of water supplied to customers and losses (leakage and bleeders), it will be necessary to measure the flow at the start of each individual loop, and measure the flow on the return of each loop. As described in section 3.2, some of the flowmeter locations are in the Williamson Lake Pump House, ands some are in chambers in the water distribution system. A site survey will be required to establish the best meter required for the site conditions.

The flowmetering options that are recommended are as follows:

Electromagnetic (mag) Flowmeters
An electromagnetic flowmeter, similar to the two existing Unimag mag flowmeters. These meters are powered by mains electricity. For the locations where the meter is installed in the water distribution system chambers, battery powered meters can be used.

Insertion Flowmeters
Insertion magnetic flowmeters are recommended, which are battery powered and have an integral data logger for flow and pressure. These instruments are installed through 2 inch diameter "hot taps" (under pressure tapings), so no isolating of mains, and cutting of pipe is required. These meters will be applicable where there is not sufficient space to install a magnetic flowmeter, or where it is difficult to shut down the watermain.

Clamp on Ultrasonic Flowmeters
At locations where it is not desired to either cut the main to install a magnetic flowmeter, or install a "hot tap", then a clamp on ultrasonic flowmeter can be used.

It is recommended that the flowmeters be calibrated annually, and a tag detailing the calibration date be attached to the flowmeter. The frequency of calibration of the other instruments should reviewed, and calibration completed as recommended by the manufacturers.

Development of Specifications for Leak Reduction Equipment
As part of this assignment, the consultant prepared a specification for leak reduction equipment. The purpose of the specification is to be used in a tendering process by the Government of Nunavut. The specification in its entirety can be found in Appendix A of this report.

AWWA/IWA Water Audit and Water Balance
As part of the Government of Nunavut's (GN) ongoing water loss management program, GN completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance for the Hamlet of Rankin Inlet Water System. The project was completed for a full year from August 2008 to August 2009, based on available billing data. A copy of the report in its entirety can be found in Appendix B of this document.

The gathered data for 2009 was entered into the AWWA – WLCC (Water Loss Control Committee) software program. The results of the analysis are shown as follows:

Parameter	Value for 2009
Current Annual Real Losses (CARL)	145,000,000 litres
Unavoidable Annual Real Losses (UARL)	14,000,000 litres
Infrastructure Leakage Index (ILI)	10.17
System Input Volume	428,000,000 litres
Revenue Water (corrected for estimated accuracy of billing system)	181,000,000 litres
Non-Revenue Water	247,000,000 litres
Volume of Non-Revenue Water - % of System Input Volume	57.7%

The financial results from the IWA software analysis are shown below:

Parameter	**Value**
Annual Cost of Apparent Losses Customer meter under registration Unauthorised consumption – based on estimated customer water and sewer rate of $4.50 per 1,000 litres	$52,215
Annual Cost of Real Losses – Variable Production Cost Based on estimated cost of $0.35 per 1,000 litres	$50,798

In any water system there will be a volume of leakage that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair – this is the Unavoidable Annual Real Losses (UARL). The IWA software uses the physical characteristics of the water distribution system (length of water mains and services, number of connections, average pressure) to make an estimate of UARL. The Current Annual Real Losses (CARL) are also calculated by the software, by taking the water supplied and deducting the calculated authorized consumption and apparent losses, to give CARL. The ratio of UARL to CARL is the Infrastructure Leakage Index (ILI).

The World Bank Target Matrix gives performance category A for an ILI 1 - 2; category B for ILI 2 – 4; category C for ILI 4 – 8; and category D for ILI greater than 8.

The Hamlet of Rankin Inlet Water System's ILI of 10.17 puts them in performance D category – very inefficient use of resources; leakage reduction programs imperative and high priority

Although operational and financial considerations may allow a long term ILI greater than 8.0, such a level of leakage is not an effective utilisation of water as a resource. The priority for the Hamlet of Rankin Inlet Water System should be to develop an active leak detection program to reduce water losses, and reduce the ILI to initially below 8.0, and then progressively reduce it further till it is in performance category B.

At the Lake Nipissar Pump House there are a number of meters, which include Signet paddle wheel meters and one Unimag electromagnetic. It is recommended that the Unimag meter be set up to record and save the daily total volumes abstracted, and these values be used for the total water abstracted. Locally it has been set up to manually record the total flow in the record book at the pump house.

An on site in-situ test procedure can be completed for some manufactured mag meters, so this should be investigated, to see if it is available for the Unimag meter. Testing could include primary coils/electrodes/circuitry, cables, full electronic check.

For the Hamlet of Rankin Inlet, which has relatively old customer meters, the estimated overall customer under-registration was 5%, which represents a loss in billable volume of 9,057,000 litres per year. To determine a more accurate estimate of meter accuracy, it is recommended that a random sample of meters be removed and tested. A sample of 217 meters will give an error margin of 5%, with a 95% confidence level in the data.

Normally this type of random sampling and testing of customer meters is completed for the smaller 5/8" residential meters. Testing these residential meters should typically be repeated every 5 to 10 years, using a statistically valid sample of meters.

For the larger ICI meters, they should be tested more frequently than residential meters, because of the larger volumes being measured and the associated revenue. Testing of ICI meters should be as frequent as once every year for the very large volume meters, and between every 2 to 5 years for the remainder.

The methodology to identify and reduce water loss that is recommended, is a combination of flow based identification of areas with leakage and other losses, along with methods of acoustic leak detection. This approach forms the core of the AWWA Manual, M36, "Water Audits and Loss Control Programs". In the M36 manual, this flow based method of identifying areas with leakage is called "District Meter Areas – DMAs".

The Rankin Inlet water supply and distribution system is complex with its method of operation including return loops on the distribution mains, and return loops on the customer service lines. There is also the added operational need to maintain water temperatures above a level that will prevent freezing in both the distribution mains and customer services.

Leakage can be split into three types; namely:

- Leakage from Reported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Passive Leak Detection and Repair
- Leakage from Unreported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Active Leak Detection and Repair
- Background Leakage (composed of primarily weeps from joints and gaskets rather than holes in pipes) – utility activity often referred to as Active Leakage Reduction

One of the most reliable and long established methodologies to help identify water loss is to split the network into small sectors often referred to as District Meter Areas (DMAs). Where possible areas are designed so that they can be fed through one metered water feed throughout the day and night, although because of fire flow requirements, sometimes two feeds are required.

In these DMAs the flow entering the area, and key pressures are data logged, typically for a seven day period. The estimated legitimate night use is estimated, and compared with the measured night flow, which identifies areas with potential leakage, and the approximate volume of that leakage.

By operating the Temporary DMAs, the system backlog leaks can be identified and repaired.

In the process of operating the Temporary DMAs, flow and pressure logged data will be gathered, and along with the number and volume of leakage found, potential areas for converting to Permanent DMAs can be established. If some of the DMAs have high pressure, or significant pressure variations, then they can be considered for Pressure Management.

As summary of the operation of the types of DMAs is provided as follows:

- *Temporary DMAs*, where they are typically operated for a seven day period initially, and the flows at night, between 2.00 and 4.00 am (Minimum Night Flow - MNF) are compared to what flow would be expected from the area. Only in areas of high MNF are leaks looked for in a two step process – step one, narrow the leak down to the General Area of the leak, and step two, Pinpoint the leak (blue cross on the ground). There are a number of methods employed to find the general area of leak, which include night time step testing, when sections of the DMA are closed off for short periods, and the change in flow at the DMA flowmeter inspected for high drops in flow, indicating a potential leak. Another method to find the general area of the leak is to use noise loggers, which listen for leaks. Finally the leak is pinpointed using leak noise correlators, and ground microphones to confirm the location of the leak.
- *Permanent DMAs used for Leak Notification*, where the DMA is permanently isolated from the rest of the distribution system, and night time flows monitored on a daily basis. When the Minimum Night Flow (MNF) reaches a predetermined level (Entry Level), then leak detection is completed in that DMA – General Area of the leak, and Pinpointing the leak. Leak detection and repair is continued until the leakage has been reduced to an acceptable amount (Exit Level), as recorded on the permanent DMA flowmeter.
- *Permanent DMAs used for Leak Notification and Pressure Management*, where in addition to the leak detection activities, pressure management is introduced. This is completed by installing a Pressure Reduction Valve (PRV), which is used to control the pressure so the at "off peak" demand times, the pressure is not allowed to increase, and a less variable pressure is delivered to the DMA. This method of operation has the dual benefit of reducing Background Leakage (small leaks that are not economic to find and repair), and also reduces main breaks.

Identification and Evaluation of Water Efficiency and Conservation Measures

Over twenty-five water efficiency measures practised around the world were screened for their applicability in Rankin Inlet. Twelve measures passed the technical, potential, achievable, social, environmental feasibility tests.

Utilizing a spreadsheet model (see Appendix C), water savings and implementation costs were derived for each measure displayed on the short list. The savings and costs were then used to determine the cost effectiveness of each measure. The cost-effectiveness of a measure, or its cost/benefit ratio, is determined by comparing the program cost to the cost of future infrastructure expansion to deliver a similar quantity of water. The water savings for each measure was determined using a number of resources from engineering estimates to actual verified results from water efficiency programs in North America. Much information was gathered from programs that have been implemented and monitored for the last five to ten years in the Region of Waterloo, Region of York and the City of Toronto.

Depending on the measure and delivery mechanism program costs may include; equipment, installation, rebates, training, program marketing and project management as applicable. Based on related program costs a cost per litre of water per average day saved was determined for each conservation and efficiency alternative. This cost was then compared to the cost of constructing additional infrastructure to gain one litre per average day of additional water and wastewater capacity. It is important to note that calculated cost relating to construction of an additional litre of water and wastewater capacity does not include the cost of debt financing of construction projects. It is also important to note, that this figure does not include the cost of additional infrastructure required for the distribution/conveyance of water and wastewater to and from newly serviced areas such as water/wastewater mains, pumping stations or system reservoirs. In southern Ontario, the combined water and wastewater construction cost per litre per average day of additional capacity ranges from approximately $2.00 to $8.10. Without additional data, the consultant has assumed that the costs in Rankin Inlet are 2 times that of southern Ontario or a range of $4.00 to $16.20. For the purpose of this financial analysis the combined water and wastewater construction cost of $8.00 per litre per average day of additional capacity was utilized.

The outcome of the financial analysis is shown in the following Table 28. The measures that did not pass the financial test are highlighted in yellow.

Table 28 Results of Financial Screening of Water Efficiency Measures

Residential	Water Efficiency Measure	Cost per Participant	Savings per Participant (L/d)	Cost per litre
Installation	HET Toilets	$ 1,014	139	$ 7.31
Installation	Dual Flush Toilets	$ 1,024	139	$ 7.38
Installation	Low Flow Showerheads	$ 133	54	$ 2.44
Installation	Kitchen Faucets	$ 71	20	$ 3.52
Installation	Bathroom Faucets	$ 64	24	$ 2.70
Installation	Leakage Repair	$ -	56	$ -
Installation	Clotheswashers	$ 1,250	19	$ 67.57
ICI				
Installation	HET Toilets	$ 7,381	375	$ 19.68
Installation	Dual Flush Toilets	$ 7,631	375	$ 20.35
Installation	Pre-Rinse Spray Valves	$ 1,450	368	$ 3.94
Installation	ICI Audits and Capacity Buy-back	$ 72,250	15,000	$ 4.82
Municipal				
Installation	Leakage Reduction	$ 55,000	57,500	$ 0.96

Three measures including residential clotheswashers, ICI HET toilets and ICI dual flush toilets did not pass the financial screening but are recommended to remain on the short list for inclusion in the strategy. These measures provide substantial water savings and their inclusion provides a comprehensive strategy. As demonstrated in the next section, the inclusion of these three measures does not affect the overall cost-effectiveness of the strategy.

Strategy Implementation Plan

The recommended components of the plan include:

Residential Measures

- Visit all homes and apartments and install free of charge HET or dual flush toilets, low flow showerheads, kitchen aerators, bathroom aerators and water efficient clotheswashers. To eliminate toilet leakage in homes, it is recommended that only "flapperless" type toilets be installed. These are proven products and readily available in the market.

Industrial/Commercial/Institutional Measures

- Visit all businesses and institutions and install free of charge HET or dual flush toilets. To eliminate toilet leakage in businesses, it is recommended that only "flapperless" type toilets be installed. These are proven products and readily available in the market.
- Visit commercial kitchens and install free of charge low flow pre-rinse spray valves.

- Complete five (5) comprehensive water audits and offer a capacity buy-back rebate to any facility that implements all or some of the water saving recommendations.

Municipal Measures

- Design and implement five (5) district meter areas. Locate, quantify and repair the leakage within the water distribution system.

Public Education

- Distribution of booklets, leaflets, and fact sheets at community and environmental events.
- Distribution of a water efficiency bulletin in the water bills.
- Displays at community events.
- Develop and maintain a website to educate the public on water efficiency.
- Provide workshops and seminars to the public on water saving techniques both inside and outside the home.

Youth Education

- Develop and deliver a water efficiency education program based on curriculum requirements.
- Develop and facilitate a Children's Water Festival.

For reference individual business cases for each recommended water conservation and efficiency measures are provided in Appendix D of this report.

15.1 Table 29: Capital Budget and Water Savings (Litres per average day)

Residential	Water Saving Measure	Number of Product Installed	Total Cost	Total Program Savings (L/d)	Cost per litre
Installation	HET Toilets	768	$ 707,921	96,903	$ 7.31
Installation	Dual Flush Toilets	85	$ 79,434	10,767	$ 7.38
Installation	Low Flow Showerheads	854	$ 103,208	42,246	$ 2.44
Installation	Kitchen Faucets	776	$ 55,096	15,644	$ 3.52
Installation	Bathroom Faucets	854	$ 49,664	18,376	$ 2.70
Installation	Leakage Repair	854	$ -	43,068	$ -
Installation	Clotheswashers	776	$ 970,000	14,356	$ 67.57
Industrial, Commercial, Institutional					
Installation	HET Toilets	357	$ 329,486	16,740	$ 19.68
Installation	Dual Flush Toilets	40	$ 37,850	1,860	$ 20.35
Installation	Pre-Rinse Spray Valves	15	$ 14,500	3,680	$ 3.94
Installation	ICI Audits and Capacity Buy-back	5	$ 72,250	15,000	$ 4.82
Municipal					
Installation	Leakage Reduction	5	$ 275,000	287,500	$ 0.96
Education					
Public Education (5 years)			$ 150,000		
Youth Education (5 years)			$ 180,000		
TOTAL			$ 3,024,408	566,140	$ 5.34

It is recommended that the above capital plan be supported by ongoing monitoring, evaluation and maintenance in order to initially verify the water savings and then to sustain them into the future.

The overall best practices capital program is budgeted at $3,024,408 and is expected to save just over 566,000 litres of water per average day (l/d).

The cost per litre per day for the proposed plan is $5.34. This compares well to the average cost per litre per average day capacity for new infrastructure, which is estimated at $8.00. To add new water and wastewater infrastructure to deliver the equivalent capacity of 566,000 l/d would cost $4.5 million based on the average $8.00 per litre capacity cost.

Although some program measures did not meet the cost analysis, which includes clotheswashers, ICI HET toilets and ICI dual flush toilets, these program alternatives have been included due to the significant savings that they bring to the overall plan. However, it is important to note that even with the inclusion of these programs the overall plan remains more cost-effective than the cost of constructing future water and wastewater supply/treatment capacity.

Due to the difficulty in measuring water savings generated by education, there have been no savings attributed to the Broadscale Public or Youth Education programs in the plan. Technical solutions, such as low flush toilets and low flow showerheads will only achieve a portion of the potential water savings. Education designed to change habits and attitudes or residents towards water use will achieve the remaining savings. The American Water Works Association suggests that education programs can generate up to a 4 to 5% reduction in water demand by long-term education initiatives. In addition, education is necessary to ensure that water savings generated by the capital program are sustained. Since, education should be ongoing, 5 years of costing has been included.

Overall Water Savings

The overall water savings anticipated from the implementation of the recommended strategy is shown in Table 30 below.

Table 30: Overall Water Savings

Sector	litres/day	litres/year
Residential	241,360	88,096,000
ICI	37,280	13,607,000
Municipal	287,500	104,938,000
Total	566,140	206,641,000

The water saving plan will free up 206,641,000 litres/year of water supply capacity. This represents 61% of the total water supplied in 2009.

In addition to providing water supply capacity, the plan will reduce demand on the wastewater system by 101,703,000 litres/year.

Residential

The water savings attributed to the residential sector was compared against 2009 billed consumption and the residential water balance that was developed. Results of this comparison are shown in Table 31.

Table 31: Comparison of Residential Savings and 2009 Residential Consumption based on Billing Data and based on Water Balance

Residential Sector	Per Capita Consumption (Lcd)	Residential Consumption 2009 (litres)	Residential Water Savings (litres)	Percent Savings
As per Billing Data	122	111,544,000	88,096,000	79%
As per Water Balance	169	154,151,000	88,096,000	57%

Industrial, Commercial and Institutional

The water savings attributed to the ICI sector was compared against 2009 billed consumption. Results of this comparison are shown in Table 32.

Table 32: Comparison of ICI Savings and 2009 ICI Billed Consumption

ICI Sector	Corrected ICI Consumption 2009 (litres)	ICI Water Savings (litres)	Percent Savings
As per Billing Data	26,962,000	13,607,000	50%

Municipal

The water savings attributed to the Municipal leakage reduction program was compared against the water loss identified from the AWWA/IWA Water Audit and Water Balance results. Results of this comparison are shown in Table 33.

Table 33: Comparison of Municipal Savings and Water Loss Results

Municipal Sector	Estimated Water Loss 2009 (litres)	Municipal Water Savings (litres)	Percent Savings
As per Billing Data	145,000,000	104,938,000	72%

Maintenance

Water savings generated from the efficiency program should be viewed in the same manner as constructing a new water treatment facility. If the Hamlet of Rankin Inlet were to design and build new infrastructure to deliver 566,000 l/d, a budget for a maintenance program would be included to ensure that the facility continues to deliver 566,000 l/d in the future. The Hamlet's water conservation and efficiency strategy is no different. If it was designed to save 566,000 l/d, maintenance would be required to sustain the savings into the foreseeable future.

Water efficiency has been identified as a viable cost-effective supply of water. Maintenance will be essential to ensure that the savings are sustained. Each component of the water efficiency strategy should have three basic elements; tracking of activity, savings validation and finally maintenance of products and services provided. The elements included in the maintenance program would include:

Residential Sector

Significant water savings products will be installed by Rankin Inlet's water conservation and efficiency strategy. These products should be maintained through a "pick-up" service. If a resident or business requires a replacement part they simply stop by the customer service centre that would provide the appropriate parts directly to the customer.

Industrial/Commercial/Institutional Sector

In addition to maintaining the products installed in small commercial businesses it is anticipated that 1 ICI customers will participate in the water saving audits and capacity buy-back program. Over the course of the plan, a consultant who will be similar to a key-account manager will visit each of the facilities periodically. The purpose of the visit will be to ensure that the water measures implemented are still in place and still providing savings as designed. In addition the consultant will meet with the facility staff to ensure proper operating procedures design to achieve maximum savings are being practiced. The budget allows for 1 site visit per year during a five year period.

Distribution Leakage Reduction

It is recommended as good practice to complete an AWWA / IWA Water Audit and Water Balance every year – this is often referred to as the "Top Down" approach to water loss management.

It is also recommended that the temporary District Meter Areas (DMAs) be operated on a regular basis, which can be either every year, or every two to three years. It is also recommended that with the information gathered as part of the operation of the temporary DMAs, that consideration be given to establishing permanent DMAs, for either continuous water loss monitoring, or the next stage of flow modulation to reduce background leakage (small leaks that are nor economic to find and repair). The DMA approach is often referred to as the "Bottom UP" approach.

The maintenance budget has been established to accommodate two (2) DMA maintenance runs in year 3 and three (3) in year 4. This will ensure that no DMA goes without maintenance for more the three years.

The recommended maintenance budget is found in Table 34 below.

Table 34: Recommended Maintenance Budget

Five Year Maintenance Plan	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
	Costs	**Costs**	**Costs**	**Costs**	**Costs**	
Residential	$ 17,107.69	$ 18,215.38	$ 22,646.14	$ 25,969.21	$ 29,292.28	$ 113,230.70
Industrial/Commercial/Institutional	$ 12,437.00	$ 12,874.00	$ 22,122.00	$ 23,433.00	$ 27,704.00	$ 98,570.00
Distribution Leakage Reduction				$ 60,000.00	$ 90,000.00	$ 150,000.00
Total	$ 29,544.69	$ 31,089.38	$ 44,768.14	$ 109,402.21	$ 146,996.28	$ 361,800.70

Monitoring and Evaluation

In the residential and small commercial markets it is recommended that on-site monitoring be carried out 30 days before the measure installation and 30 days after the measure has been installed. Monitoring can be accomplished with the installation of data loggers on the water meters. These units are small and unobtrusive. The data logging study will verify the actual savings attributed to the water saving measures. This analysis should be completed in the first year of the capital program to verify the expected water savings.

Also of importance is the ongoing monitoring for persistence or sustainability. All products wear out or fail in time. Participants may have the tendency to install a high water consuming device when their water saving device fails. This may happen due to lack of knowledge or the availability of water saving products at retail stores. In order to measure this erosion in savings it is recommended that statistically valid audits of participants be carried out throughout a five year period. The auditor would visit the home or business and inspect the water savings products that were installed. The auditor would observe if the products are still installed, working properly and saving water. Audits could be completed in Year 5.

The Table 35 below provides the monitoring and evaluation by year for the five year period.

Table 35: Monitoring and Evaluation Budget

Five Year Monitoring and Evaluation Plan	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
	Costs	**Costs**	**Costs**	**Costs**	**Costs**	**Costs**
Residential	$ 157,500				$ 30,000	$ 187,500
Industrial, Commercial and Institutional	$ 78,000				$ 7,200	$ 85,200
Total	$ 235,500	$ -	$ -	$ -	$ 37,200	$ 272,700

The Table 36 below provides the activities to be undertaken from the Monitoring and Evaluation plan.

Table 36: Recommended Monitoring and Evaluation Activity

	Number of Participants to be Monitored	Number of Persistence Audits in Year 5
Residential		
HET Toilets	30	125
DF Toilets	15	25
Clothes Washers	30	150
Showers, Faucets, Leakage	30	150
Industrial, Commercial and Institutional		
HET Toilets	20	60
DF Toilets	10	20
Pre Rinse Spray Valves	10	10
Capacity Buy Back	Included in Capital Program	

It is important to note that the long-term costs of water savings monitoring could be drastically reduced with the introduction of automated meter ready (AMR) technology in place of the collection of the Hamlet's current customer water use reading system. The introduction of AMR technologies would provide the utility with enhanced customer water use data (based on the frequency of water use reporting) and added customer services tools to proactively identify private side leakage or meter reading errors. With the introduction of this technology it is expected that the required monitoring program would be less labour intensive for staff and be less intrusive for sites being monitored through the process.

Energy Savings and Greenhouse Gas Emissions Reductions

The overall energy savings generated from water efficiency is in most cases more significant than the water savings. Water utilities are typically the largest consumer of electricity in a municipality. Electricity is used in the water and wastewater treatment processes but more significantly in the pumping/conveyance of water and wastewater. A recent study[6] completed by the Polis Project on Ecological Governance, University of Victoria evaluated historical data relating to water production and energy consumption from 7 municipalities in Ontario. The study completed case studies on the Town of Collingwood, the Regional Municipality of Durham and the City of Guelph. The study reported, that it takes 0.68 KWh of electricity for 1,000 litres of water delivered to a customer and then returned through the wastewater process. The findings from this study were used to develop the energy savings and greenhouse gas emission reductions reported below.

Many of the water saving measures recommended in the strategy also reduce energy consumption at the customer's premise. For example, a low flow showerhead reduces not only water but reduces hot water. Oil or electricity has been used by the customer to generate the hot water. Energy savings will also be generated from the faucet aerators, clotheswashers, pre-rinse spray nozzles and the ICI Audit program.

Typically a residential customer who participates in the water efficiency program will see greater dollar savings in their energy bill as compared to their water bill. This is also an important linkage to emphasize when promoting the water efficiency programs to the public.

The reduction of water-use through an efficiency program and the associated energy savings provides significant greenhouse gas reductions. With climate-change in mind, most municipalities have set their own greenhouse gas reduction targets. Water efficiency can be a positive contributor to meeting those targets.

Although the participant's energy savings were not quantified as part of this project, the utility energy savings and greenhouse gas emission reductions are provided in Table 37 below.

Table 37 – Estimated Energy Savings and Associated Greenhouse Gas Emission Reductions

	Water Savings per Year (litres/yr)	Energy Savings per Year	CO2 Reductions per Year (tonnes/yr)
Overall Water Savings	206,641,000	130,022 KWh Electricity	78.0 tonnes

Assuming an electric rate of $ 0.35 per KWh, the Hamlet of Rankin Inlet would reduce its electrical bill by approximately $45,858 per year upon completion of the strategy. In addition, the greenhouse gas emissions reduction is equivalent to removing 14 cars from the road.

Final Words

The implementation of the water efficiency strategy presented in this report will provide the Hamlet of Rankin Inlet with a significant amount of additional water supply capacity and waste water treatment capacity. This capacity, an estimated 566,000 litres per day, can be provided cost-effectively, at least 34% less costly than building new supply infrastructure. In addition, this additional supply capacity through water efficiency can be provided immediately without lengthy design and environmental assessment requirements.

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[6] Maas, Carol. Greenhouse Gas and Energy Co-Benefits of Water Conservation, Polis Discussion Series Paper 08-01, November 2008, Polis Project on Ecological Governance, university of Victoria, Victoria, BC.

16.0 Resources and References

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APPENDICES

A. Specification for Leak Reduction Equipment

B. AWWA/IWA Water Audit and Water Balance Report

C. Costs and Water Savings Model

D. Individual Program Descriptions

E. Nipissar Lake Volume Study and Environmental Variable Study

APPENDIX A

Specifications for Equipment for Water Loss Reduction

1.0 Introduction

The Government of Nunavut (GN), Department of Community and Government Services, is seeking quotations for Water Loss Reduction Equipment for the Hamlet of Rankin Inlet, Nunavut.

The equipment will be used to identify water loss in Rankin Inlet, and the methodology employed will be as recommended in the American Water Works Association (AWWA) Manual, M36, “Water Audits and Loss Control Programs”, which was published in May, 2009. The methodology is a flow based method of identifying areas with leakage is called “District Meter Areas – DMAs”.

The equipment must be suitable for operation in the cold climate of Rankin Inlet. In addition, warranties, delivery times, after sales support, and training in the use of the equipment are considered to be very important for GN.

2.0 Water Distribution System Description

The water distribution system consists of older buried Utilidors, and newer shallow buried mains. In order to prevent freezing the water distribution system water is tempered by adding heated water, and is recirculated back to Williamson Lake Pump House. If the return water temperature falls below a set limit, further heated water is added.

The older Utilidors consist of 150 mm PVC watermains housed with 150 mm PVC sewer mains, in 600 mm galvanised corrugated metal pipe. The Utilidor is covered with 50mm of rigid polyurethane foam insulation. The new mains are shallow buried and consist of High Density Polyethylene (HDPE) pipe with 50 or 75 mm of polyurethane insulation covered with “Yellow Jacket” and in some cases “Black Jacket”. Most watermains are 200 mm in diameter and are series 160 HDPE.

In order to prevent freezing in the supply pipes to customer properties, each water service has a flow and return pipe, normally located side by side in the ground. Inside the property a pump operates continuously to recirculate the tempered water back into the water main, which then recirculates the water back to Williamson Lake Pump House.

To provide access to the water distribution system, there are chambers located approximately every 100 metres. These chambers contain the connections of various watermains, and also have drain valves and air valves.

Tempered water is pumped to the five loops as follows:

- Town Loop 1 (Area 1)
- Town Loop 2 (Area 2)
- Nuvuk Loop (Area 6)
- Area 5
- Town Supply

In the Williamson Lake Pump House, the wet well pumps send water to a common delivery main which has a mag meter that records the total flow. The pressures in this common delivery main are controlled by a Pressure Reduction Valve (PRV). The loops are supplied as follows:

- Area 5 is supplied by a main passing across the top of the building from the common delivery main.
- A pipe is also connected to the common delivery main to supply Kivalliq.
- The common delivery main then leaves the pump house, and in a chamber outside the supply to Area 6 is connected.
- Water then flows along the Town Supply main, and after it passes the Hamlet offices, the Area 1 and Area 2 supply mains are connected in a chamber.

The water is then returned to Williamson Lake Pump House from the loops as follows:

- Area 5 enters at the back side of the building
- Areas 1, 2 and 6 are combined in a chamber, then returned to Williamson Lake Pump House in a single main

3.0 Methodology Description

3.1 District Meter Area (DMA) Loops

The distribution main loops are to be established as District Meter Areas (DMAs), so that the flows in each individual loop can be monitored, particularly the flows at night, to identify leakage, bleeders and other losses. To achieve this, the flows at the start of each individual loop will have to be metered, and the flows on the return of each loop must also be metered.

In each of these DMA loops, the flow at night, typically between 2.00 am and 4.00 am will be recorded each night. This will then be compared to the "Legitimate Night Usage", or the flow at night that is expected.

The six DMAs to be established, as follows:

<u>Area 5 DMA Loop</u>
Install a flowmeter on the Area 5 supply pipe in Williamson Lake Pump House, between the wet well pumps delivery main, after the existing mag meter; and where the pipe leaves the building at the side.

Install a flowmeter on the Area 5 return pipe, where it enters the Williamson Lake Pump House, before the pipe joins the common return pipe.

Nuvuk DMA Loop (Area 6)

In the chamber just outside the entrance door to Williamson Lake Pump House, install a flowmeter on the Area 6 supply pipe.

Install a flowmeter on the Area 6 return pipe, which is located in a chamber in the system where the return pipes for Areas 1 and 2 combine – there is then a common return pipe to Williamson Lake Pumphouse for Areas 6, 1, 2.

Town DMA Loop 1 (Area 1)

In a chamber past the Hamlet offices, the water that is transmitted along the Town Supply then feeds Areas 1 and 2. Install a flowmeter on the Area 1 main.

Install a flowmeter on the Area 1 return pipe, which is located in a chamber in the system where the return pipes for Areas 1, 2 and 6 combine – there is then a common return pipe to Williamson Lake Pumphouse.

Town DMA Loop 2 (Area 2)

In a chamber past the Hamlet offices, the water that is transmitted along the Town Supply then feeds Areas 1 and 2. Install a flowmeter on the Area 2 main.

Install a flowmeter on the Area 2 return pipe, which is located in a chamber in the system where the return pipes for Areas 1, 2 and 6 combine – there is then a common return pipe to Williamson Lake Pumphouse.

Kivalliq DMA Loop

Install a flowmeter on the Kivalliq supply pipe in Williamson Lake Pump House, between the wet well pumps delivery main, after the existing mag meter; and where the pipe leaves the building.

Install a flowmeter on the Kivalliq return pipe, where it enters the Williamson Lake Pump House, before the pipe joins the common return pipe.

DMA Town Supply

Because the Town Supply also is the feed pipe for Areas 1 and 2, the DMA flow will be calculated from the flows at other meters, as follows:

Town Supply = Existing common delivery main mag meter, minus metered flows for all other loops.

There is no return for the Town Supply, as it feeds Areas 1 and 2, which have return mains.

Mains Between Nipissar Lake Pump House and Williamson Lake Pump House

In the future, flow meters may be installed at both ends of the two watermains between Nipissar Lake Pump house and Williamson Lake Pump House.

3.2 Acoustic Leak Detection

Once the loops with high water losses have been found, the next stage is to identify where the losses are and remove them. In Rankin Inlet the two main areas of losses are bleeders, and leaks on the watermains or services.

Acoustic methods are to be used to listen for water loss noises in the loop. This is a two phased approach of firstly establishing a small area which is "noisy", with at least two fittings, but preferably more, – this gives the "General Area of Losses". Then secondly, from these noisy fittings "Pinpoint the Leak / Losses" – put the cross on the ground for a leak, or identify a customer service or watermain that is bleeding water to waste.

4.0 Equipment Specification

4.1 Leak Detection Equipment

Acoustic Listening Kit – **One Set**

Electronic listening device to include:

- Listening stick
- Ground microphone
- Processing unit with display
- Headphones
- Filter options for different frequency ranges, and different pipe materials
- Rechargeable batteries, with charging unit
- Carrying case

Leak Noise Loggers – **12 number, or standard kits**

Leak Noise Loggers to include:

- Noise loggers
- Carrying case
- Software

Upto three downloading options:

- Manual download
- Radio reading with walk by / drive by unit
- Network to transmit data direct to office computer

Following the use of the noise loggers, additional units may be purchased if they are effective in finding water loss on the Rankin Inlet water distribution system.

Leak Detection Correlators – **One Number**

Leak Detection Correlator to include:

- Processing unit
- Two accelerometers
- Two hydrophones
- Two outstations
- Carrying case
- Software

Three main types of processor will be considered:

- Stand alone units for use outside in most elements. Generally robust equipment for use outside
- Hand held PDA small units
- Units where the software is loaded onto laptop computer

4.2 Flow Monitoring Equipment

Electromagnetic Flowmeters – **upto 14 units**

Electromagnetic flowmeters:

- For pipe diameters between 50 mm (2 inch) and 200 mm (8 inch) diameter
- Mains operated
- Give a battery operated option if available
- Data logger to be included – specify memory and other features
- Pressure monitoring and logging capability, if available
- Provide accuracy, flow range, approvals information

Insertion Flowmeters – **upto 6 units**

Insertion flowmeters:

- For pipe diameters between 50 mm (2 inch) and 300 mm (12 inch) diameter
- Electromagnetic, single point velocity meter
- Battery operated
- Flow data logger to be included – specify memory and other features
- Flow profiling software, if available
- Pipe diameter gauging rod
- Pressure data logger to be included – specify accuracy of pressure sensor
- Communication cables
- Software
- Provide accuracy, flow / pressure range, approvals information
- Include for on site installation of flowmeters at tapings provided by GN

Clamp on Ultrasonic Flowmeters – **upto 14 units**

Clamp on ultrasonic flowmeters:

- For pipe diameters between 50 mm (2 inch) and 300 mm (12 inch) diameter
- Mains operated
- Give a battery operated option if available
- Flow data logger to be included
- Pressure monitoring and logging capability, if available – specify accuracy of pressure sensor
- Communication cables
- Software
- Pipe thickness gauge
- Provide accuracy, flow / pressure range, approvals information
- Include for on site installation

5.0 Training Requirements

GN consider the training of staff in the use of the equipment to be critical. Provide the following training:

- Three days in total at Rankin Inlet for the Leak Detection and Flow Monitoring Equipment – if a different amount of time is required, please indicate and price accordingly
- Training to include classroom instruction and hands on use of the equipment on site
- Provide three sets of training manuals and materials

6.0 Support, Warranties, Delivery Times

Ongoing Support

Indicate the following in the quotation:

- Location of support staff
- Time from support request to response by phone / e mail
- Indicate if support weekdays only, or 7 days per week, and hours available
- Cost of ongoing support

Warranties

- Provide full details of warranties, including

Delivery Times

- Provide time from receipt of order to delivery

Quotation Form

Please provide a menu of equipment prices for specified equipment that GN will select from. It is anticipated that most of the leak detection equipment and up to 14 flowmeters will be purchased. Provide prices, excluding applicable taxes

Leak Detection Equipment

Item Description	Number	Price Each Item	Total Price
Acoustic Listening Kit	1		
Leak Noise Loggers	12		
Leak Detection Correlator	1		

Flow Monitoring Equipment

Item Description	Pipe Diameter	Number	Price Each Item	Total Price
Electromagnetic Flowmeter– Mains Power	50 mm	2		
Electromagnetic Flowmeter– Mains Power	100 mm	2		
Electromagnetic Flowmeter– Mains Power	150 mm	5		
Electromagnetic Flowmeter– Mains Power	200 mm	5		
Electromagnetic Flowmeter–Battery Power	50 mm	2		
Electromagnetic Flowmeter–Battery Power	100 mm	2		
Electromagnetic Flowmeter–Battery Power	150 mm	5		
Electromagnetic Flowmeter–Battery Power	200 mm	5		
Insertion Flowmeter	50 mm to 200 mm	6		
Clamp on Ultrasonic Flowmeter	50 mm to 200 mm	2		
Clamp on Ultrasonic Flowmeter	50 mm to 200 mm	6		
Clamp on Ultrasonic Flowmeter	50 mm to 200 mm	10		
Clamp on Ultrasonic Flowmeter	50 mm to 200 mm	14		

Training

Please provide the cost for training, to include preparation of all materials, three days training at Rankin Inlet (in classroom and on site), and all expenses (travel, accommodation, food etc).

If three days at Rankin Inlet is not appropriate, please provide additional information and quotation as well.

Item Description	Number	Price Each Item	Total Price
Training for 3 days at Rankin Inlet	1		

Information for GN

Sample of Leak Detection Manufacturers

Halma Water Management
Palmer Leak Detection Equipment
http://www.hwm-water.com/

Primayer
Primayer Aqua Technology Solutions
http://www.primayer.co.uk/index.htm

Gutermann International
http://www.gutermann-uk.com/

Fuji Tecom Inc
http://www.fujitecom.com/

Sewerin
http://www.sewerin.com/en/about-us.html

Sample of Flow Monitoring Manufacturers

Elster Metering
http://www.elstermetering.com/

ABB Metering
http://www.abb.com/

Endress + Hauser
http://www.us.endress.com/

Unimag Meter
http://www.emcoflow.com/Documents/SL-UNIMAGNFP-350-01.pdf

Halma Water Management
http://www.hwm-water.com/

Primayer
http://www.primayer.co.uk/index.htm

Appendix B

Government of Nunavut

American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance

For

Hamlet of Rankin Inlet Water System

Final Report

March, 2010

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Executive Summary

Introduction

As part of the Government of Nunavut's (GN) ongoing water loss management program, GN completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance for the Hamlet of Rankin Inlet Water System. The project was completed for a full year from August 2008 to August 2009, based on available billing data. A copy of the report in its entirety can be found in Appendix B of this document.

Completion of an IWA Water Audit and Water Balance is an integral part of the water loss management methodology, in the new AWWA Manual "M36 Water Audits and Loss Control Programs", which was published in May, 2009. An IWA Water Audit and Water Balance is considered to be the North American Best Management Practice (BMP) for water loss management, and is recommended that is completed annually.

The IWA Water Audit and Water Balance quantifies Revenue and Non Revenue Water, and identifies where to reduce water loss and increase revenue.

Summary of Gathered Data

A questionnaire was provided, and data gathered for the 2009 balance (August 2008 to August 2009). At the time of writing the draft report, there is still data that has not been provided by GN, so estimates of the values have been made. Once the data has been received, the analysis can be updated for the final report.

The data was entered into a series of spreadsheets and analysis completed to provided the totals required for the IWA software data entry. A summary of the "Old" Unaccounted For Water (UFW) percentage is shown in the table below. The volume accounted for as part of the IWA balance is included, and deducted from the traditional unaccounted for water volume, as shown in the table:

Item	Total Volume for 2009 (litres)
Total Water Supplied (corrected for accuracy)	427,770,000
Total Billed Consumption (corrected for estimated accuracy of customer meters)	190,200,000
IWA Accounted For Water	90,956,000
Unaccounted For Water	146,613,000
Unaccounted For Water (UFW) Percentage	34.3%

IWA Software Analysis

The gathered data for 2009 was entered into the AWWA – WLCC (Water Loss Control Committee) software program. The results of the analysis are shown as follows:

Parameter	Value for 2009
Current Annual Real Losses (CARL)	145,000,000 litres
Unavoidable Annual Real Losses (UARL)	14,000,000 litres
Infrastructure Leakage Index (ILI)	10.17
System Input Volume	428,000,000 litres
Revenue Water (corrected for estimated accuracy of billing system)	181,000,000 litres
Non-Revenue Water	247,000,000 litres
Volume of Non-Revenue Water - % of System Input Volume	57.7%

The financial results from the IWA software analysis are shown below:

Parameter	Value
Annual Cost of Apparent Losses Customer meter under registration Unauthorised consumption – based on estimated customer water and sewer rate of $4.50 per 1,000 litres	$52,215
Annual Cost of Real Losses – Variable Production Cost Based on estimated cost of $0.35 per 1,000 litres	$50,798

IWA Software Analysis Summary

In any water system there will be a volume of leakage that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair – this is the Unavoidable Annual Real Losses (UARL). The IWA software uses the physical characteristics of the water distribution system (length of water mains and services, number of connections, average pressure) to make an estimate of UARL. The Current Annual Real Losses (CARL) are also calculated by the software, by taking the water supplied and deducting the calculated authorized consumption and apparent losses, to give CARL. The ratio of UARL to CARL is the Infrastructure Leakage Index (ILI).

The World Bank Target Matrix gives performance category A for an ILI 1 - 2; category B for ILI 2 – 4; category C for ILI 4 – 8; and category D for ILI greater than 8.

The Hamlet of Rankin Inlet Water System's ILI of 10.17 puts them in performance D category – very inefficient use of resources; leakage reduction programs imperative and high priority

Although operational and financial considerations may allow a long term ILI greater than 8.0, such a level of leakage is not an effective utilisation of water as a resource. The priority for the Hamlet of Rankin Inlet Water System should be to develop an active leak detection program to reduce water losses, and reduce the ILI to initially below 8.0, and then progressively reduce it further till it is in performance category B.

Recommendations

Source Meters

At the Lake Nipissar Pump House there are a number of meters, which include Signet paddle wheel meters and one Unimag electromagnetic. It is recommended that the Unimag meter be set up to record and save the daily total volumes abstracted, and these values be used for the total water abstracted. Locally it has been set up to manually record the total flow in the record book at the pump house.

An on site in-situ test procedure can be completed for some manufactured mag meters, so this should be investigated, to see if it is available for the Unimag meter. Testing could include primary coils/electrodes/circuitry, cables and full electronic check.

Customer Meters

Rankin Inlet has customer water meters which are manufactured by Neptune. The meters are an older style, and when they were installed had a wire fixed from the meter register to the outside of the property. On the end of this wire was fitted a remote register, which has numbers which can be read by the meter reader. This type of remote, or 'generator remote" works by the internal meter register sending a signal to change the remote register. They are prone to missing registrations, so that the remote register, which is typically used for billing, records a lower consumption than has actually passed through the water meter.

Some of these old remote registers have been replaced by a more modern "touch pad", which is simply a device to send a signal to the internal meter register and obtain the reading. So, the actual internal meter reading is collected.

Furthermore, in the south part of Area 1, new meters with radio read technology have been installed. These meters have a radio transmitter installed either on the meter, or very close to the meter, inside the property. The meters are read with a hand held device, that can receive the meter reading at a distance from the property – it can be driven along each street to obtain the readings if required.

The recorded metered consumption is likely to be less than the actual water produced, for the following reasons:

- Generator remotes recording a lower consumption than the water meter register
- Remote register wires broken
- Customers disconnecting remote wire
- Customers removing water meter and piping through
- Water meter under-registering – most meters under-register as they age

For the Hamlet of Rankin Inlet, which has relatively old customer meters, the estimated overall customer under-registration was 5%, which represents a loss in billable volume of 9,057,000 litres per year. To determine a more accurate estimate of meter accuracy, it is recommended that a random sample of meters be removed and tested. A sample of 217 meters will give an error margin of 5%, with a 95% confidence level in the data.

Normally this type of random sampling and testing of customer meters is completed for the smaller 5/8" residential meters. Testing these residential meters should typically be repeated every 5 to 10 years, using a statistically valid sample of meters.

For the larger ICI meters, they should be tested more frequently than residential meters, because of the larger volumes being measured and the associated revenue. Testing of ICI meters should be as frequent as once every year for the very large volume meters, and between every 2 to 5 years for the remainder.

Active Leak Detection

The methodology to identify and reduce water loss that is recommended, is a combination of flow based identification of areas with leakage and other losses, along with methods of acoustic leak detection. This approach forms the core of the AWWA Manual, M36, "Water Audits and Loss Control Programs". In the M36 manual, this flow based method of identifying areas with leakage is called "District Meter Areas – DMAs".

The Rankin Inlet water supply and distribution system is complex with its method of operation including return loops on the distribution mains, and return loops on the customer service lines. There is also the added operational need to maintain water temperatures above a level that will prevent freezing in both the distribution mains and customer services.

Leakage can be split into three types; namely:

- Leakage from Reported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Passive Leak Detection and Repair
- Leakage from Unreported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Active Leak Detection and Repair
- Background Leakage (composed of primarily weeps from joints and gaskets rather than holes in pipes) – utility activity often referred to as Active Leakage Reduction

One of the most reliable and long established methodologies to help identify water loss is to split the network into small sectors often referred to as District Meter Areas (DMAs). Where possible areas are designed so that they can be fed through one metered water feed throughout the day and night, although because of fire flow requirements, sometimes two feeds are required.

In these DMAs the flow entering the area, and key pressures are data logged, typically for a seven day period. The estimated legitimate night use is estimated, and compared with the measured night flow, which identifies areas with potential leakage, and the approximate volume of that leakage

By operating the Temporary DMAs, the system backlog leaks can be identified and repaired.

In the process of operating the Temporary DMAs, flow and pressure logged data will be gathered, and along with the number and volume of leakage found, potential areas for converting to Permanent DMAs can be established. If some of the DMAs have high pressure, or significant pressure variations, then they can be considered for Pressure Management.

As summary of the operation of the types of DMAs is provided as follows:

- **Temporary DMAs**, where they are typically operated for a seven day period initially, and the flows at night, between 2.00 and 4.00 am (Minimum Night Flow - MNF) are compared to what flow would be expected from the area. Only in areas of high MNF are leaks looked for in a two step process – step one, narrow the leak down to the General Area of the leak, and step two, Pinpoint the leak (blue cross on the ground). There are a number of methods employed to find the general area of leak, which include night time step testing, when sections of the DMA are closed off for short periods, and the change in flow at the DMA flowmeter inspected for high drops in flow, indicating a potential leak. Another method to find the general area of the leak is to use noise loggers, which listen for leaks. Finally the leak is pinpointed using leak noise correlators, and ground microphones to confirm the location of the leak
- **Permanent DMAs used for Leak Notification**, where the DMA is permanently isolated from the rest of the distribution system, and night time flows monitored on a daily basis. When the Minimum Night Flow (MNF) reaches a predetermined level (Entry Level), then

leak detection is completed in that DMA – general area of the leak, and pinpointing the leak. Leak detection and repair is continued until the leakage has been reduced to an acceptable amount (Exit Level), as recorded on the permanent DMA flowmeter
- **Permanent DMAs used for Leak Notification and Pressure Management**, where in addition to the leak detection activities, pressure management is introduced. This is completed by installing a Pressure Reduction Valve (PRV), which is used to control the pressure so the at "off peak" demand times, the pressure is not allowed to increase, and a less variable pressure is delivered to the DMA. This method of operation has the dual benefit of reducing Background Leakage (small leaks that are not economic to find and repair), and also reduces main breaks

District Meter Area Loops

It is recommended that the water distribution loops be established as District Meter Areas (DMAs), so that the flows in each individual loop can be monitored, particularly the flows at night, to identify leakage, bleeders and other losses. To achieve this, the flows at the start of each individual loop will have to be metered, and the flows on the return of each loop must also be metered.

In each of these DMA loops, the flow at night, typically between 2.00 am and 4.00 am will be recorded each night. This will then be compared to the "Legitimate Night Usage" or the flow at night that is expected.

In DMA loops where the measured flow at night is significantly higher than the Legitimate Night Flow, these areas would then be targeted for acoustic leak detection.

It is likely that initially all the loops in Rankin Inlet will have measured flows significantly higher than the Legitimate Night Flow, because of the existence of bleeders, and leaks that may have been running for some time. When DMAs are introduced for the first time in water distribution systems it is common for the flows to be high. The initial tasks are often to identify and eliminate this "backlog" of losses, to reduce water loss to economic levels.

It is recommended that six DMAs be established, as follows:
- Area 5 DMA Loop
- Nuvuk DMA Loop (Area 6)
- Town DMA Loop 1 (Area 1)
- Town DMA Loop 2 (Area 2)
- Kivalliq DMA Loop
- DMA Town Supply

In addition, the mains between Nipissar Lake Pump House and Williamson Lake Pump House should be included in a future phase of the flow monitoring program.

Bleeders on Customer Services and Distribution Mains

If the water loss is a bleeder at a water service the leak pinpointing will indicate a loss at the corporation stop / curb stop of the service. Once this is identified, staff can investigate the bleeder further.

Although customers have to obtain a bleeder permit, all of them may not have done so. Once the bleeder is identified, steps can be taken to assist the customer to correct the problem on the services, and ensure that the recirculation system is put back into operation.

For bleeders on the water distribution system, they will be initially identified as leaks, if they are not already known. Depending on the location and function, the following measures should be considered:

- For all locations, complete a calculation of the approximate volume of water in the mains that are being kept fresh. Then calculate the flow rate required to exchange that volume of water in say 24 hours, or other agreed time period
- Shut off the bleeder, or
- Reduce the flow rate, or
- Install an automatic flushing device, or
- Where possible, for branches left open, install a flowmeter

1.0 Introduction

As part of the Government of Nunavut's (GN) ongoing water loss management program, GN completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance for the Hamlet of Rankin Inlet Water System. The project was performed by Kingsley Blease, and the water balance made for a full year from August 2008 to August 2009, because billing data was available for this time period.

Completion of an IWA Water Audit and Water Balance is an integral part of the water loss management methodology, in the new AWWA Manual "M36 Water Audits and Loss Control Programs", which was published in May, 2009. An IWA Water Audit and Water Balance is considered to be the North American Best Management Practice (BMP) for water loss management, and is recommended that is completed annually.

2.0 IWA Water Audit and Water Balance Methodology

A summary will first be given of the IWA Water Audit and Water Balance Methodology, which identifies the categories of Revenue and Non Revenue Water. Revenue Water can either be metered or non metered, and in the Hamlet of Rankin Inlet Water System it is all metered. There is a range of different types of Non Revenue Water (NRW) that may or may not be significant, and they have been summarised in the following three categories by the IWA methodology:

2.1 Unbilled Authorised Consumption

<u>Unbilled metered, Unbilled unmetered</u>
The following uses are unbilled and can be metered or unmetered, according to local practice:

- Fire fighting
- Flushing of mains and sewers
- Bleeders on watermains and customer services
- Cleaning storage tanks
- Filling water tankers
- Water taken from hydrants
- Street cleaning
- Parks irrigation
- Public fountains
- Frost protection
- Building water for construction

2.2 Apparent Losses

Unauthorised consumption

Theft

- Not opening an account
- Self connecting / disconnecting meter
- Tampering with meter or remote
- Use of false names
- Illegal connections and by passes
- Unauthorised use of fire hydrants

Detecting theft

- Active accounts with no usage
- Inactive accounts with usage
- Periodic review of all inactive accounts
- Meter reader observations
- Inspection of unmetered fire lines
- Review of billing records

Metering inaccuracies

System input meters

- Details of meters, and calibration history

Under / over registration of customer meters

- Any testing of commercial or residential meters

Accounting procedure errors

- Difference between dates of source meter readings and customer readings
- Identify accounts not being billed – quantify reasons why
- Identify active accounts with no consumption for the last 6 months, could be stuck meter, remote problem or theft
- Identify inactive accounts with usage (occupied, but not opened an account, or vacant with leakage)
- Misread meters
- Incorrect estimates
- Stopped meters – particularly compound meters (stuck small side – all usage on large side; stuck large side, with most usage on small side)
- Stopped meters – track monthly revenue changes, versus same month in previous year
- Adjustments to original meter readings
- Unit conversions
- Improper calculations
- Computer programming errors

2.3 Real Losses

Leakage on distribution and transmission mains

- Holes and cracks in mains

- Joints
- Drain valves left open, leaking

Leakage and overflows at storage tanks

- Buried reservoirs structures
- Drain valves left open, leaking
- Overflows

Leakage on service connections up to the point of customer metering

- Holes in service pipes
- Joints

2.4 Definitions

It is the Real Losses that the leak detection techniques target, referred to as Current Annual Real Losses (CARL). Within these Real Losses there is a volume of water that is unavoidable, even with the most comprehensive leak detection program – this is called Unavoidable Annual Real Losses (UARL). So the difference between CARL and UARL, is the Real Losses that is targeted for reduction. This difference, or ratio of CARL to UARL is referred to as the Infrastructure Leakage Index (ILI).

For the management of these Real Losses, there are four areas to look at. They are as follows:

- Active leak detection
- Speed and quality of repairs
- Pressure management
- Pipeline and asset management

3.0 Summary of Gathered Data

The gathered data for the 2009 balance (August 2008 to August 2009), is shown in the Questionnaire in **Appendix A**. The data was entered into a series of spreadsheets which are included as **Appendix B**. At the time of writing the draft report, there is still data that has not been provided by GN, so estimates of the values have been made. Once the data has been received, the analysis can be updated for the final report.

The spreadsheets were developed to match the IWA software data entry pages with the summary and totals shown in the table below. The balance was completed in metric units, hence the recorded volumes are in m3.

No	Balance Item	Total for 2009	Units	Comments
1	Water Supplied	427,770,000	litres	
2	Source Meter Accuracy		litres	Accuracy not known
3	Water Imported	0		
4	Water Exported	0		
5	Billed Metered (corrected for estimated accuracy of billing system)	181,143,000	litres	
6	Billed Unmetered	0	litres	
7	Unbilled Metered	0		
8	Unbilled Unmetered	89,887,000	litres	
9	Unauthorised Consumption	1,069,000	litres	IWA default of 0.25% of water supplied
10	Customer Meter Inaccuracies (under registering)	7,389,000	litres	Estimated at 5% under registration
11	Data Handling Errors			
12	Length of Mains	40	km	Estimated
13	Number of Services	580		Estimated
14	Av Length of Customer Service	15.2	m	Curb stop to house
15	Av Operating Pressure	28	m	(40 psi)
16	Annual Operating Cost	$750,000		Estimated
17	Variable Production Cost	$0.35		Estimated - Per 1,000 litres
18	Customer Rates	$4.50		Estimated - Per 1,000 litres, water and sewer

The "Old" Unaccounted For Water (UFW) percentage is shown in the table below. The volume accounted for as part of the IWA balance is included, and deducted from the traditional unaccounted for water volume, as shown in the table:

Item	**Total Volume for 2009 (litres)**
Total Water Supplied (corrected for accuracy)	427,770,000
Total Billed Consumption (corrected for estimated accuracy of customer meters)	190,200,000
IWA Accounted For Water	90,956,000
Unaccounted For Water	146,613,000
Unaccounted For Water (UFW) Percentage	34.3%

4.0 IWA Software Analysis

The gathered data for 2009 was entered into the AWWA – WLCC (American Water Works Association – Water Loss Control Committee) software program, which is included as **Appendix C**.

All volumes for this program were entered as Megalitres (ML) - 1,000,000 litres.

The Results of the IWA software analysis are shown in the following table:

Parameter	Value for 2009
Current Annual Real Losses (CARL)	145 ML
Unavoidable Annual Real Losses (UARL)	14 ML
Infrastructure Leakage Index (ILI)	10.17
System Input Volume	428 ML
Revenue Water (corrected for estimated accuracy of billing system)	181 ML
Non-Revenue Water	247 ML
Volume of Non-Revenue Water - % of System Input Volume	57.7%

The comparison can be seen between the 'Old" Unaccounted For Water (UFW) percentage, with the IWA accounted for volume included, and the Volume of Non-Revenue Water expressed as a percentage of System Input Volume:

- "Old UFW – 34.3% of System Input Volume
- Volume of Non-Revenue Water – 57.7% of System Input Volume

The financial results from the IWA software analysis are shown below:

Parameter	Value
Annual Cost of Apparent Losses Customer meter under registration Unauthorised consumption – based on estimated customer water and sewer rate of $4.50 per 1,000 litres	$52,215
Annual Cost of Real Losses – Variable Production Cost Based on estimated cost of $0.35 per 1,000 litres	$50,798

The AWWA / IWA software was upgraded in May, 2009, and one of the main upgrades in the new version is the data grading capability. This feature provides a basic validation of the results from the Reporting Worksheet – this is the worksheet where the data is entered. Each of the data inputs on the Reporting Worksheet has an input box to accept a grading value ranged from 1 to 10.

A grading of 10 represents highly reliable, well validated data, while grade of 1 reflects very crude data such as rough estimates. Each grading is identified by specific criteria listed on the Grading Matrix Worksheet, or the auditor may simply hover over the data grading input cell to display the criteria.

Once all the grading cells have been entered, a composite grading score is calculated and displayed at the bottom of the Reporting Worksheet. The composite grading is based upon a scale of 100: this score can then be used to assess a basic validation for the audit. The auditor can determine the status of the utility's data quality by reviewing the Loss Control Planning Worksheet. This worksheet provides planning guidance to the water utility.

Utilities with lower composite grading should focus program efforts on data collection and validation, until data quality becomes more reliable. Utilities with higher composite gradings can trust their data to serve as the basis for budgetary decisions on major loss control initiatives, such as leakage management controls, or wholesale customer meter replacement. Reliable data can also be benchmarked against data from other utilities with reliable data.

For the Hamlet of Rankin Inlet Water System, the composite score was 42, which is a lower composite score, indicating that more accurate data is required. This is to be expected, as some of the data was estimated. When the data is received from GN, then the data quality will improve.

5.0 IWA Software Analysis Summary

In any water system there will be a volume of leakage that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair – this is the Unavoidable Annual Real Losses (UARL). The IWA software uses the physical characteristics of the water distribution system (length of water mains and services, number of connections, average pressure) to make an estimate of UARL. The Current Annual Real Losses (CARL) are also calculated by the software, by taking the water supplied and deducting the calculated authorized consumption and apparent losses, to give CARL. The ratio of UARL to CARL is the Infrastructure Leakage Index (ILI).

The World Bank Target Matrix for ILI shows that the Hamlet of Rankin Inlet Water System's ILI of 10.17 puts them in performance D category – very inefficient use of resources; leakage reduction programs imperative and high priority, as shown in the following table:

ILI Range	Performance Category	Real Loss Management
1-2	A	Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost effective improvement
2-4	B	Potential for marked improvements; consider pressure management, better active leakage control practices, and better network management
4-8	C	Poor leakage record, tolerable only if water is plentiful and cheap; even then, analyse level and nature of leakage and intensify leakage reduction efforts
>8	D	Very inefficient use of resources; leakage reduction programs imperative and high priority

Although operational and financial considerations may allow a long term ILI greater than 8.0, such a level of leakage is not an effective utilisation of water as a resource. The priority for the Hamlet of Rankin Inlet Water System should be to develop an active leak detection program to reduce water losses, and reduce the ILI to initially below 8.0, and then progressively reduce it further till it is in performance category B.

6.0 Recommendations

6.1 Source Meters

At the Lake Nipissar Pump House there are a number of meters, which include Signet paddle wheel meters and one Unimag electromagnetic. It is recommended that the Unimag meter be set up to record and save the daily total volumes abstracted, and these values be used for the total water abstracted. Locally it has been set up to manually record the total flow in the record book at the pump house.

An on site in-situ test procedure can be completed for some manufactured mag meters, so this should be investigated, to see if it is available for the Unimag meter. Testing could include primary coils/electrodes/circuitry, cables, full electronic check

6.2 Customer Meters

Rankin Inlet has customer water meters which are manufactured by Neptune. The meters are an older style, and when they were installed had a wire fixed from the meter register to the outside of the property. On the end of this wire was fitted a remote register, which has numbers which can be read by the meter reader. This type of remote, or 'generator remote" works by the meter sending a signal to change the remote register, as the internal meter register changes. They are prone to missing registrations, so that the remote register, which is typically used for billing, records a lower consumption than has actually passed through the water meter.

Some of these old remote registers have been replaced by a more modern "touch pad", which is simply a device to send a signal to the internal meter register and obtain the reading. So, the actual internal meter reading is gathered.

Furthermore, in the south part of Area 1, new meters with radio read technology have been installed. These meters have a radio transmitter installed either on the meter, or very close to the meter, inside the property. The meters are read with a hand held device, that can receive the meter reading at a distance from the property – it can be driven along each street to obtain the readings if required.

The recorded metered consumption is likely to be less than the actual water produced, for the following reasons:

- Generator remotes recording a lower consumption than the water meter register
- Remote register wires broken
- Customers disconnecting remote wire
- Customers removing water meter and piping through
- Water meter under-registering – most meters under-register as they age

Based on experience, and reference to manufacturer's information, the potential under-registration of customer meters based on age was derived, as shown in the following table:

Age of Meter	**Potential Under – Registration**
Years	**Percentage**
0 to 5	0%
5 to 10	2%

10 to 15	4%
15 to 20	5%
20 to 25	8%
25 +	10%

For the Hamlet of Rankin Inlet, which has relatively old customer meters, the estimated overall customer under-registration was 5%, which represents a loss in billable volume of 9,057,000 litres per year. To determine a more accurate estimate of meter accuracy, it is recommended that a random sample of meters be removed and tested.

The sample should be taken from meters of all ages across the Hamlet of Rankin Inlet Water System, to ensure that it is as representative as possible. Meters that have be changed for maintenance or repair should not be included in the sample, as they may not be representative.

Referring to the following chart, it can be seen that a sample of 217 meters will give an error margin of 5%, with a 95% confidence level in the data.

Simple Random Sample

With a 95% confidence level and 50% estimate of population proportion

Population size – error margin	**Unlimited**	**1,000,000**	**500,000**	**250,000**	**100,000**	**10,000**	**5,000**	**3,500**	**1,000**	**500**	**100**
1%	9,604	9,513	9,423	9,249	8,762	4,899	3,288	2,565	906	475	99
2%	2,401	2,395	2,390	2,378	2,345	1,936	1,622	11,424	706	414	96
3%	1,067	1,066	1,065	1,063	1,056	964	879	818	516	340	91
4%	600	600	600	599	597	566	536	512	375	273	86
5%	384	384	384	384	383	370	357	346	278	217	79
6%	267	267	267	266	266	260	253	248	211	174	73
7%	196	196	196	196	196	192	189	186	164	141	66
8%	150	150	150	150	150	148	146	144	130	115	60
9%	119	119	119	119	118	117	116	115	106	96	54
10%	96	96	96	96	96	95	94	93	88	81	49
11%	79	79	79	79	79	79	78	78	74	68	44
12%	67	67	67	67	67	66	66	65	63	59	40

Reference: Chakrapani: C&K Deal, Market Research: Methods and Canadian Practice, 1992

Normally this type of random sampling and testing of customer meters is completed for the smaller 5/8" residential meters. Testing these residential meters should typically be repeated every 5 to 10 years, using a statistically valid sample of meters.

For the larger ICI meters, they should be tested more frequently than residential meters, because of the larger volumes being measured and the associated revenue. Testing of ICI meters should be as frequent as once every year for the very large volume meters, and between every 2 to 5 years for the remainder.

6.3 Water Loss Identification and Reduction Program

The methodology to identify and reduce water loss that is recommended, is a combination of flow based identification of areas with leakage and other losses, along with methods of acoustic leak detection. This approach forms the core of the AWWA Manual, M36, "Water Audits and Loss Control Programs", which was published in May, 2009. In the M36 manual, this flow based method of identifying areas with leakage is called "District Meter Areas – DMAs".

The Rankin Inlet water supply and distribution system is complex with its method of operation including return loops on the distribution mains, and return loops on the customer service lines. There is also the added operational need to maintain water temperatures above a level that will prevent freezing in both the distribution mains and customer services.

6.3.1 Summary of DMA Methodology

Leakage can be split into three types; namely:

- Leakage from Reported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Passive Leak Detection and Repair
- Leakage from Unreported main breaks, valve and hydrant leaks and service leaks – utility activity often referred to as Active Leak Detection and Repair
- Background Leakage (composed of primarily weeps from joints and gaskets rather than holes in pipes) – utility activity often referred to as Active Leakage Reduction

One of the most reliable and long established methodologies to help identify water loss is to split the network into small sectors often referred to as District Meter Areas (DMAs). Where possible areas are designed so that they can be fed through one metered water feed throughout the day and night, although because of fire flow requirements, sometimes two feeds are required.

In these DMAs the flow entering the area, and key pressures are data logged, typically for a seven day period. The estimated legitimate night use is estimated, and compared with the measured night flow, which identifies areas with potential leakage, and the approximate volume of that leakage

By operating the Temporary DMAs, the system backlog leaks can be identified and repaired.

In the process of operating the Temporary DMAs, flow and pressure logged data will be gathered, and along with the number and volume of leakage found, potential areas for converting to Permanent DMAs can be established. If some of the DMAs have high pressure, or significant pressure variations, then they can be considered for Pressure Management.

As summary of the operation of the types of DMAs is provided as follows:

- Temporary DMAs, where they are typically operated for a seven day period initially, and the flows at night, between 2.00 and 4.00 am (Minimum Night Flow - MNF) are compared to what flow would be expected from the area. Only in areas of high MNF are leaks looked for in a two step process – step one, narrow the leak down to the General Area of the leak, and step two, Pinpoint the leak (blue cross on the ground). There are a number of methods employed to find the general area of leak, which include night time step testing, when sections of the DMA are closed off for short periods, and the change in flow at the DMA flowmeter inspected for high drops in flow, indicating a potential leak. Another method to find the general area of the leak is to use noise loggers, which listen for leaks. Finally the leak is pinpointed using leak noise correlators, and ground microphones to confirm the location of the leak

- Permanent DMAs used for Leak Notification, where the DMA is permanently isolated from the rest of the distribution system, and night time flows monitored on a daily basis. When the Minimum Night Flow (MNF) reaches a predetermined level (Entry Level), then leak detection is completed in that DMA – General Area of the leak, and Pinpointing the leak. Leak detection and repair is continued until the leakage has been reduced to an acceptable amount (Exit Level), as recorded on the permanent DMA flowmeter
- Permanent DMAs used for Leak Notification and Pressure Management, where in addition to the leak detection activities, pressure management is introduced. This is completed by installing a Pressure Reduction Valve (PRV), which is used to control the pressure so the at "off peak" demand times, the pressure is not allowed to increase, and a less variable pressure is delivered to the DMA. This method of operation has the dual benefit of reducing Background Leakage (small leaks that are not economic to find and repair), and also reduces main breaks

6.3.2 District Meter Area Loops

It is recommended that the water distribution loops be established as District Meter Areas (DMAs), so that the flows in each individual loop can be monitored, particularly the flows at night, to identify leakage, bleeders and other losses. To achieve this, the flows at the start of each individual loop will have to be metered, and the flows on the return of each loop must also be metered.

In each of these DMA loops, the flow at night, typically between 2.00 am and 4.00 am will be recorded each night. This will then be compared to the "Legitimate Night Usage" or the flow at night that is expected.

In DMA loops where the measured flow at night is significantly higher than the Legitimate Night Flow, these areas would then be targeted for acoustic leak detection.

It is likely that initially all the loops in Rankin Inlet will have measured flows significantly higher than the Legitimate Night Flow, because of the existence of bleeders, and leaks that may have been running for some time. When DMAs are introduced for the first time in water distribution systems it is common for the flows to be high. The initial tasks are often to identify and eliminate this "backlog" of losses, to reduce water loss to economic levels.

It is recommended that six DMAs be established, as follows:

- Area 5 DMA Loop
- Nuvuk DMA Loop (Area 6)
- Town DMA Loop 1 (Area 1)
- Town DMA Loop 2 (Area 2)
- Kivalliq DMA Loop
- DMA Town Supply

In addition, the mains between Nipissar Lake Pump House and Williamson Lake Pump House should be included in a future phase of the flow monitoring program.

6.3.3 Bleeders on Customer Services and Distribution System

If the water loss is a bleeder at a water service the leak pinpointing will indicate a loss at the corporation stop / curb stop of the service. Once this is identified, staff can investigate the bleeder further.

Although customers have to obtain a bleeder permit, all of them may not have done so. Once the bleeder is identified, steps can be taken to assist the customer to correct the problem on the services, and ensure that the recirculation system is put back into operation.

For bleeders on the water distribution system, they will be initially identified as leaks, if they are not already known. Depending on the location and function, the following measures should be considered:

- For all locations, complete a calculation of the approximate volume of water in the mains that are being kept fresh. Then calculate the flow rate required to exchange that volume of water in say 24 hours, or other agreed time period
- Shut off the bleeder, or
- Reduce the flow rate, or
- Install an automatic flushing device, or
- Where possible, for branches left open, install a flowmeter

APPENDIX A

Government of Nunavut
Hamlet of Rankin Inlet
Water Supply Capacity, Consumption and Conservation Study

IWA Water Balance Questionnaire

Version 1 – November 27, 2009

Version 1 information gathered shown in BLUE
Information Required shown in RED

OPERATIONS DEPT.

A. Water Supplied

For a minimum period of one year, and upto three to five years, if available, the following. Minimum as monthly data, but daily or weekly if available.

1. Water Produced – from Water Treatment Plant (s), Well (s)
2. Any Water Imported from another water system
3. Any Water Exported to a surrounding municipality

Supplied
Based on Signet paddle wheel meter located at the Nipissar Lake Pump House
There is a relatively new electromagnetic (mag) meter at Nipissar Pump House (Unimag), but the flow totals were not recorded. Joe Strickland was arranging for the daily flow totals to be recorded at the pump house.

Accuracy of Source Meters – list the following for each meter:

a. Type (differential pressure, mechanical turbine etc, magnetic flow, clamp on ultrasonic, propeller)
b. Manufacturer
c. Size
d. Age
e. Maintenance / calibration history, and any results

Accuracy information was not available. It is likely that the Unimag meter is recording more accurately than the Signet paddle wheel meter

B. Non-Revenue Water – Unbilled Authorised

1. Flushing of mains and sewers (indicate if data is metered or estimated)

Information required

	MAINS	SEWERS
Avg. # flushed / year		
Avg. flow time		
Avg. flow rate		

2. Cleaning Of Storage Tanks - indicate how data is tracked?

Information required

	STORAGE TANKS
Avg. # cleaned / year	
Avg. size	
Avg. time to clean	

3. Filling Of Water Tankers

Arcene to provide Truck Fill Meter Readings

   a. For metered stations, what is the annual volume of water used?
   b. For un-metered stations, what is the estimated number of fills per year and average tanker size?

   c. Are customers billed on a flat rate or by volume?

4. Water Taken From Hydrants (indicate how data is tracked)

Information required

   a. What is the average number of flow tests per year?

   b. What is the average duration of these tests?

   c. How many areas are tested / year?

   d. What is the average pressure in the tested areas?

   e. What is the average main diameter, material and age?

5. Water Used For Street Cleaning (indicate how data is tracked)

None

	WATER USED FOR STREET CLEANING
# of Trucks	
Avg. Volume of Water / Fill	
Avg. # of Truck Fills / Day	
Avg. # of Operation Days / Year	

6. Frost Protection (if applicable)

   a. What is the average duration of use?

b. What is the average pipe size and material?

7. Building Water For Metered & Un-metered Sites
Information required

a. What is the annual volume of water used for metered building sites?

b. For un-metered building sites, are customers billed on a flat rate or by volume?

c. Please fill in the following chart with the appropriate information for un-metered building sites:

	UN-METERED SITES
Avg. # of Sites / Year	
Avg. # of Connections / Site	
Avg. Size of Supply / Site	
Estimated Avg. Flow / Site	
Estimated Duration / Site	

8. Blow Offs or Bleeders
Arcene to confirm numbers of bleeders for the Utilidors

a. What is the total number of blow offs / year?

b. How many blow offs are permanently running and how many are on a timer?

c. How many of the blow offs are metered?

d. What is the average pipe diameter?

e. What is the estimated flow rate and duration time for the blow offs?

9. Water Main Repairs & Flushing
Information required

a. What is the average number of water main repairs done per year?

b. What is the average diameter of the main?

c. How long are the mains flushed during and after the repairs?

d. Are the flushed water mains metered; if so, what is the average volume of water used per repair?

10. Unavoidable Annual Real Losses (UARL)

a. What is the average water pressure during the day and at night?

Ranges from 30 to 50 psi

b. Provide an estimate on the percentage of leaks reported by customers.

11. Potential For Water Loss Reduction

4 leaks in the summer, equivalent to ¾ inch pipe running full bore

	MAIN LEAKS	SERVICE LEAKS
Avg. # of Leaks / Year		
Avg. Size of Leak		
Avg. Duration of Leak		

12 Financial Data

Information required

a. What is the annual cost of water production and distribution? Include all operations, maintenance, staff salaries, administration, insurance, overhead etc.

b. What is the variable cost of water production? This is normally power for pumping etc and chemicals, but will also include water heating

c. What is the annual cost of leak detection?

d. Provide a list for the unit cost of repairs on each element of the system.

BILLING DEPARTMENT

A. Revenue Water – Billed Authorised – Water Billing Data

Billing Data was provided for three full years, as follows:

- **August 2008 to August 2009**
- **August 2007 to August 2008**
- **August 2006 to August 2007**

Because the IWA Water Audit and Water Balance is completed for a full year, the most recent years data of August 2008 to August 2009 was chosen for the balance

1. Residential Accounts

a. Provide residential billing information for water used in the last 5 years (if possible, show data as bi-monthly, period, or quarterly).

  b. Show any additional information on the residential water use sectors (i.e. how many are multi-residential, single family dwelling).

2. ICI Accounts
   a. Provide ICI billing information for water used in the last 5 years (if possible, show data as bi-monthly, period, or quarterly.

   b. Show any additional information on water use in the ICI sectors (i.e. type of industry, institutional use).

3. What are the water rates for residential and ICI accounts (include fixed charges, wastewater charges, and any other associated charges)?

Information required

4. Are there any billed un-metered accounts? If so, how many are there?

B. Non Revenue Water – Apparent Losses

1. Theft

   a. Provide annual water loss estimates for the types of theft listed below.

THEFT TYPE	ESTIMATED ANNUAL VOLUME LOST
Theft From Hydrants	
Not Opening An Account	
Tampering With Meters	
Use of False Names	
Illegal Connections	

2. Customer Meters

Overview of meter stock provided.

   a. List the manufacturer / size / type, age (number installed by year) and percentage of accuracy for the customer meters.

   b. Provide any details on maintenance and replacement programs for customer meters.

Maintenance completed not known

   c. Details of meter reading system (direct read, touch pad, walk by radio read, drive by radio read, fixed network radio read)

Generator Remote reading system. Small area of radio read meters (South part of Area 1)

FIRE DEPARTMENT

Non-revenue Water – Unbilled Authorised

Information required

1. What is the average number of fires per year (actual or estimated)?

2. What is average duration of a fire?

3. What is the average number of water hydrants / ports used per fire?

4. Does the Fire Department do any hydrant flow tests? If so, what is the average annual number and duration of these tests?

ENGINEERING / INFRASTRUCTURE DEPARTMENT

Water Distribution System Infrastructure

1. Water Mains (list by diameter, length, material, age if available)

   Information required

   a. What are the materials of the main?

   b. What is the average age and diameter for the water main?

   c. What is the total length of the water main?

2. Service Mains

   Information required

   a. What is the total number of active & inactive services?

   b. What is the average age?

   c. List the service materials.

   d. What is the average length of the service to the curb-stop?

   e. What is the average length of the service from the curb-stop to the house?

   50 feet

PARKS DEPARTMENT

Non-Revenue Water – Unbilled Authorised

1. Parks Irrigation

None

a. For metered parks, what is the total volume of water used per year?

b. For un-metered parks:

- What is the total number of irrigation zones?
- What is the number and type of sprinkler heads per zone?
- Average pressure / head?
- Average time that a sprinkler is used per day?
- Average number of days / year that a sprinkler is used?
- Are rain shut offs installed?

3. Public Fountains

None

a. For metered fountains, what is the average volume of water used / year?

b. For un-metered fountains:

- How many are there?
- What's the average size?
- Is the water re-circulated?
- How many days of the year is the fountain operated?

Government of Nunavut - Hamlet of Rankin Inlet
IWA Spreadsheet

Rev2 - March, 2010

IWA Water Balance Summary

Utility	**Government of Nunavut - Hamlet of Rankin Inlet**
Year	**August 2008 to August 2009**

Note: **Balance is for Full Years Data**

No.	Balance Items	Parameter	Total	Units	Comments
1	Water Supplied - Own Sources	volume	427,770	m3	
2	Source Meter Inaccuracy	volume		m3	accuracy not known
3	Water Imported	volume	0		
4	Water Exported	volume	0		
5	Billed Metered	volume	181,143	m3	
6	Billed Unmetered	volume	0	m3	
7	Unbilled Metered	volume	0	m3	
8	Unbilled Unmetered	volume	89,887	m3	
9	Unauthorised Consumption	volume	1,069	m3	IWA default value of 0.25% of supply
10	Customer Meter Inaccuracies	volume	9,057	m3	estimated at 5% under registration
11	Data Handling Errors	volume			Use IWA default
12	Length of Mains	length	40	km	Estimated
13	Number of Services	number	580		Estimated
14	Average Length of Services	length	15.2	m	curb stop to house
15	Average Operating Pressure	pressure	28	m	40 psi
16	Annual Operating Cost	Dollar	$750,000		Estimated
17	Variable Production Cost	Dollar	$350.00		/ Megalitre - Estimated
18	Customer Rates	Dollar	$4.50		/ 1,000 litres - Estimated

Old Unaccounted For Water (UFW)

Total Water Supplied (corrected for accuracy)	427,770
Total Billed Consumption (corrected for accuacy)	190,200
IWA Accounted For Water	90,956
Unaccounted For Water Volume	146,613
Unaccounted For Water Percentage	34.3%

Government of Nunavut - Hamlet of Rankin Inlet

At Nipissar Lake Pump House

	Date				
	2-Apr-07	13-Aug-07	15-Aug-08	14-Aug-09	3-Nov-09
Injection 1, Submersible	26,082	26,082	29,682	33,035	33,721
Injection 2, Submersible	11,740	11,740	15,767	18,599	18,981
Main Flow	3,301,405	3,515,815	4,034,947	4,462,717	4,540,548
Williamson Injection Total	607,752	625,764	647,483	28,347	99,693

At Williamson Lake Pump House

	Date		
	15-Aug-06	18-Aug-07	18-Aug-08
From Nipissar Lake	2,847,381	3,464,638	4,278,710

Main Flow

Aug 07 to Aug 08	**519,132**
Aug 08 to Aug 09	**427,770**

From Nipissar Lake

Aug 06 to Aug 07	**617,257**
Aug 07 to Aug 08	**814,072**
Aug 08 to Aug 09	**698,115**

FOR AUG 08 TO AUG 09, USE	**427,770**

			KB Meter Readings on Mag Meter				
				Date			
17-Aug-09	4-Nov-09			3-Nov-09	4-Nov-09	**6-Nov-09**	
				10.35 am	9.15 am	**10.15 am**	
					units - gallons		
4,976,825	5,070,883		**Mag at Nipissar PH**	8,787,800	9,055,030	**9,586,280**	
			Difference	267,230	gallons	**798,480**	**Difference**
			22 hours, 40 minutes	282,908	gallons per day	**267,386**	**71 hours, 40 minutes**
				1,286	**m3 per day**	**1,215**	
				469,370	**m3 per year**	**443,617**	
				3 to 4 Nov		**3 to 6 nov**	
			Williamson Lake PH				
			Mag - which includes recirulation flow				
				Date			
				3-Nov-09	4-Nov-09	**6-Nov-09**	
				8.50 am	9.50 am	**10.30 am**	
					units - gallons		
				7,223,490	7,969,710	**9,431,080**	
			Difference	746,220	gallons	**2,207,590**	**Difference**
			25 hours	716,371	gallons per day	**719,182**	**73 hours, 40 minutes**
				3,256	**m3 per day**	**3,269**	
				1,188,525	**m3 per year**	**1,193,189**	
				3 to 4 Nov		**3 to 6 nov**	

Government of Nunavut - Hamlet of Rankin Inlet			
Data not provided			
Accuracy not known			

Government of Nunavut - Hamlet of Rankin Inlet				
None				

Government of Nunavut - Hamlet of Rankin Inlet				
None				

Government of Nunavut - Hamlet of Rankin Inlet

Printed on: Nov 03 2009 @ 5:31:17PM

Com Gov/Hamlet Shared	10/08	3/09	7/09	Total
Oomilik Enterprises Acnt:00000280 Unit: 002-71St	85,000.00	33,000.00	58,000.00	**176,000.00**
Oomilik Enterprises Acnt:00000281 Unit: 14/16/18-71St	54,000.00	64,000.00	24,000.00	**142,000.00**
Oomilik Enterprises Acnt:00000923 Unit: 012-71St	46,500.00	48,500.00	51,500.00	**146,500.00**
Total	185,500	145,500	133,500	464,500

Commercial	10/08	3/09	7/09	Total
ATUQTUARVIK CORPORATION Acnt:00000847 Unit: 001-12Av	54,000.00	49,000.00	22,000.00	**125,000.00**
Aurora Northern Contractors Ltd. Acnt:52200000 Unit: 220-66St	45,000.00	62,000.00	150,000.00	**257,000.00**
Aurora Northern Contractors Acnt:00000028 Unit: 234-60St	78,000.00	72,000.00	65,000.00	**215,000.00**
Aurora Northern Contractors Acnt:00000865 Unit: 108-11St	61,000.00	48,000.00	26,000.00	**135,000.00**
Aurora Northern Contractors Acnt:00000971 Unit: 050-15St	61,000.00	13,500.00	23,500.00	**98,000.00**
AURORA NORTHERN CONTRACTORS Acnt:50700000 Unit: 103-	47,500.00	61,000.00	66,000.00	**174,500.00**
Aurora Northern Contractors/3 PLEX Acnt:00000834 Unit: 221/225-6	156,000.00	150,000.00	104,000.00	**410,000.00**

Aurora Northern Contractors/DUPLEX Acnt:00000831 Unit: 003-63A	72,000.00	75,000.00	100,000.00	**247,000.00**		
Aurora Northern Contractors/DUPLEX Acnt:00000832 Unit: 001-63A	91,000.00	45,500.00	64,500.00	**201,000.00**		
B.J.C. Holdings Acnt:00000050 Unit: 050-64Av	80,000.00	40,000.00	50,000.00	**170,000.00**		
Fotheringham Tootoo, Tara Acnt:00000083 Unit: 106-22St	82,000.00	99,000.00	103,500.00	**284,500.00**		
Ikajuqtigiit Limited Acnt:00000139 Unit: 022-3Av	232,000.00	694,000.00	296,000.00	**1,222,000.00**		
Ilagiiktut Limited / 20 UNIT COMPLEX Acnt:00000140 Unit: 111/11	720,000.00	1,280,000.00	720,000.00	**2,720,000.00**		
Ilagiiktut Limited / OLD APT COMPLEX Acnt:00000142 Unit: 135-2	1,736,000.00	1,507,000.00	1,027,000.00	**4,270,000.00**		
Ilagiiktut Limited /5 PLEX Acnt:00000144 Unit: 150/158-4Av	270,000.00	258,500.00	162,500.00	**691,000.00**		
Ilagiiktut Limited Acnt:00000143 Unit: 040-4Av	81,000.00	1,511,000.00	517,000.00	**2,109,000.00**		
Ilagiiktut Limited Acnt:00000145 Unit: 017-3 AVENUE	41,000.00	95,000.00	240,000.00	**376,000.00**		
ILAGIIKTUT LIMITED Acnt:00000955 Unit: 022-15St	36,000.00	8,000.00	36,000.00	**80,000.00**		
ILAGIIKTUT LIMITED/ DUPLEX Acnt:53900000 Unit: 010- 012-	118,000.00	54,000.00	90,000.00	**262,000.00**		
ILAGIIKTUT LIMITED/6 PLEX Acnt:54300003 Unit: 216-226-61 S	324,000.00	324,000.00	262,000.00	**910,000.00**		
ILAGIIKTUT LIMITED/DUPLEX Acnt:00000517 Unit: 016-018-5St	83,000.00	851,000.00	88,000.00	**1,022,000.00**		
ILAGIIKTUT LTD / Ten Plex Acnt:00000509 Unit: 100-118-14TH S	560,000.00	556,000.00	460,000.00	**1,576,000.00**		
ILAGIIKTUT LTD Acnt:00000505 Unit: 014-24St	56,000.00	54,000.00	90,000.00	**200,000.00**		
ILAGIIKTUT LTD Acnt:00000506 Unit: 010-24St	53,000.00	10,000.00	0.00	**63,000.00**		
ILAGIIKTUT LTD Acnt:00000507 Unit: 008-24St	58,000.00	21,000.00	0.00	**79,000.00**		
ILAGIIKTUT LTD Acnt:00000516 Unit: 018-26St	24,000.00	54,000.00	56,000.00	**134,000.00**		
ILAGIIKTUT LTD Acnt:00000624 Unit: 014-5St	31,000.00	28,000.00	19,000.00	**78,000.00**		
KAKIVAK CONSTRUCTION Acnt:53200000 Unit: 245-61ST	54,000.00	23,500.00	13,000.00	**90,500.00**		
Kanaaknaq Invenstments ltd Acnt:53500000 Unit: 243-60St	39,000.00	36,000.00	16,000.00	**91,000.00**		
Kanaaknaq Investment Ltd Acnt:00000171 Unit: 100-21Av	49,000.00	0.00	36,000.00	**85,000.00**		
Kangiqliniq Developments Ltd Acnt:00000174 Unit: 024-4Av	73,000.00	95,000.00	100,000.00	**268,000.00**		
Kativik Ltd Acnt:00000179 Unit: 047-4Av	30,500.00	22,000.00	33,000.00	**85,500.00**		
KEEWATIN AIR LTD /NORMAN GORDON Acnt:00000106 Unit: 1	57,000.00	77,000.00	65,500.00	**199,500.00**		
Keewatin Air Ltd Acnt:00000181 Unit: 219-63St	48,000.00	12,000.00	29,000.00	**89,000.00**		
Keewatin Air Ltd Acnt:00000182 Unit: 200/210-24Av	216,000.00	98,000.00	59,500.00	**373,500.00**		
Keewatin Air Ltd Acnt:00000183 Unit: 108-22Av	47,000.00	37,000.00	35,000.00	**119,000.00**		
Keewatin Air Ltd Acnt:00000184 Unit: 110-22Av	0.00	103,500.00	46,500.00	**150,000.00**		
KISSARVIK COOPERATIVES / DUPLEX Acnt:00000510 Unit: 105	54,000.00	0.00	90,000.00	**144,000.00**		
KISSARVIK COOPERATIVES LTD /4PLEX Acnt:00000512 Unit: 1	121,000.00	726,000.00	542,000.00	**1,389,000.00**		
KISSARVIK COOPERATIVES LTD Acnt:00000494 Unit: 103-13St	54,000.00	54,000.00	75,000.00	**183,000.00**		
KISSARVIK CO-OPERATIVES LTD Acnt:00000514 Unit: 003-12A	39,000.00	63,000.00	59,000.00	**161,000.00**		

KISSARVIK COOPERATIVES LTD Acnt:00000546 Unit: 002-4St	384,000.00	596,000.00	188,000.00	**1,168,000.00**		
Kissarvik Co-operatives Ltd. Acnt:00000200 Unit: 109-24Av	77,000.00	52,000.00	29,000.00	**158,000.00**		
Kissarvik Co-operatives Ltd. Acnt:00000203 Unit: 054-1Av	149,000.00	353,500.00	227,500.00	**730,000.00**		
Kivalliq Arctic Foods Ltd. Acnt:00000190 Unit: 010-3St	36,000.00	54,000.00	88,000.00	**178,000.00**		
Kivalliq Property Maintenance KIVALLIQ NEWS Acnt:00000195 Un	36,000.00	54,000.00	36,000.00	**126,000.00**		
Kivalliq Property Maintenance Acnt:00000196 Unit: 017-2Av	0.00	74,000.00	7,000.00	**81,000.00**		
KIVALLIQ PROPERTY MAINTENANCE Acnt:00000277 Unit: 104	51,000.00	24,000.00	90,000.00	**165,000.00**		
Kudlik Electric Limited Acnt:00000535 Unit: 002-15St	71,000.00	0.00	6,000.00	**77,000.00**		
NANUQ LODGE Acnt:00000126 Unit: 001-1St	164,000.00	138,000.00	155,000.00	**457,000.00**		
NATIK PROJECTS 2007 INC Acnt:00000519 Unit: 206-67St	34,000.00	4,500.00	16,000.00	**54,500.00**		
Northern Stores Inc. Acnt:00000251 Unit: 039-4Av	163,000.00	89,500.00	46,000.00	**298,500.00**		
Northern Stores Inc. Acnt:00000252 Unit: 037-4Av	109,000.00	36,000.00	100,000.00	**245,000.00**		
Northern Stores Inc. Acnt:00000253 Unit: 035-4Av	8,000.00	140,000.00	100,000.00	**248,000.00**		
Northern Stores Inc./4 PLEX Acnt:00000833 Unit: 063/069-64Av	208,000.00	160,000.00	209,000.00	**577,000.00**		
NUNAVUT DEVELOPMENT CORPORATION Acnt:00000156 Unit	54,000.00	54,000.00	90,000.00	**198,000.00**		
Nunnavut Tungavik Inc. Atten. Dept. of Finance Acnt:00000260 Unit:	44,000.00	54,000.00	90,000.00	**188,000.00**		
Oomilik Enterprises Acnt:00000279 Unit: 114-52St	52,000.00	35,500.00	35,000.00	**122,500.00**		
Piruqsaijit Limited Acnt:00000924 Unit: 219-61St	32,000.00	62,500.00	67,500.00	**162,000.00**		
PIRUQSAIJIT LIMITED Acnt:00000925 Unit: 221-61St	77,000.00	82,500.00	73,000.00	**232,500.00**		
Piruqsaijit Limited Acnt:00000927 Unit: 237-61St	61,000.00	58,000.00	25,500.00	**144,500.00**		
Piruqsaijit Limited Acnt:00000928 Unit: 239-61St	41,000.00	106,000.00	92,000.00	**239,000.00**		
Piruqsaijit Limited Acnt:00000929 Unit: 251-61St	75,000.00	76,500.00	85,500.00	**237,000.00**		
Piruqsaijit Limited Acnt:00000930 Unit: 235-61St	84,000.00	53,000.00	72,000.00	**209,000.00**		
Polar Bear Caves Investments:c/o Nanuq Inn Acnt:00000533 Unit: 025	0.00	7,842,000.00	0.00	**7,842,000.00**		
Pulaarvik Kablu Friendship Centre Acnt:00000304 Unit: 015-24St	26,000.00	18,500.00	10,000.00	**54,500.00**		
RBC c/o CBRE GCS Acnt:54200000 Unit: 211-66 St	62,000.00	67,000.00	59,000.00	**188,000.00**		
RCL Branch 169: c/o Margaret Taylor Acnt:00000938 Unit: 200-64St	54,000.00	85,000.00	80,000.00	**219,000.00**		
Red Top Variety Shop Acnt:00000476 Unit: 113-23Av	66,000.00	91,000.00	88,000.00	**245,000.00**		
Sakku Properties Acnt:00000483 Unit: 216-63St	68,000.00	90,000.00	41,000.00	**199,000.00**		
Sakku Properties Acnt:00000845 Unit: 215-63St	0.00	0.00	63,000.00	**63,000.00**		
SAKKU PROPERTIES Acnt:52400000 Unit: 220-63St	44,000.00	75,000.00	100,000.00	**219,000.00**		
Treasures/Tara TooToo-Fotheringham Acnt:00000937 Unit: 116-24Av	154,000.00	202,000.00	176,000.00	**532,000.00**		
Umingmak Supply Ltd. Acnt:00000584 Unit: 028-12Av	38,000.00	15,000.00	42,000.00	**95,000.00**		
Umingmak Supply Ltd. Acnt:00000585 Unit: 112-24St	13,500.00	12,500.00	9,000.00	**35,000.00**		

Total	8,667,500	20,223,000	8,633,500	37,524,000		

FE Gov/Hamlet Shared	**10/08**	**3/09**	**7/09**	**Total**		
Community & Government Services Sewage Trt. Plt. Acnt:00000093 U	48,000.00	35,000.00	25,000.00	**108,000.00**		
Total	48,000	35,000	25,000	108,000		

Full Economic	**10/08**	**3/09**	**7/09**	**Total**		
COMMUNITY & GOVERNMENT SERVICES Arctic College Acnt:	54,000.00	0.00	0.00	**54,000.00**		
CANADIAN BROADCASTING CORPORATION-LISA POWERS A	39,000.00	36,000.00	38,000.00	**113,000.00**		
COMMUNITY & GOVERNMENT SERVICES / LEO USSAK Acnt:0	316,000.00	1,443,000.00	426,000.00	**2,185,000.00**		
Community & Government Services /RSO Acnt:00000303 Unit: 013-4	100,000.00	392,000.00	90,000.00	**582,000.00**		
Community & Government Services CHILD. GRP HOME Acnt:00000	71,000.00	187,000.00	134,500.00	**392,500.00**		
Community & Government Services DAY CARE Acnt:00000956 Unit	106,000.00	1,181,000.00	100,000.00	**1,387,000.00**		
COMMUNITY & GOVERNMENT SERVICES KIVALLIQ HALL A	340,000.00	226,000.00	3,672,000.00	**4,238,000.00**		
COMMUNITY & GOVERNMENT SERVICES MUI Acnt:00000186	271,000.00	215,500.00	106,500.00	**593,000.00**		
Community & Government Services Acnt:00000094 Unit: 25-71 NUV	478,000.00	0.00	0.00	**478,000.00**		
Community & Government Services Acnt:00000101 Unit: 008-1St	11,000.00	0.00	0.00	**11,000.00**		
Community & Government Services Acnt:00000198 Unit: 106/108-52	216,000.00	365,500.00	380,500.00	**962,000.00**		
Community & Government Services Acnt:00000199 Unit: 011-4St	225,000.00	100,000.00	54,000.00	**379,000.00**		
COMMUNITY & GOVERNMENT SERVICES/ALAITTUQ Acnt:00	162,000.00	254,000.00	100,000.00	**516,000.00**		
COMMUNITY AND GOVERNMENT SERVICES Acnt:00000187 U	82,500.00	83,000.00	6,500.00	**172,000.00**		
COMMUNITY AND GOVERNMENT SERVICES Acnt:00000980 U	303,000.00	672,000.00	50,000.00	**1,025,000.00**		
D.I.A.N.D. Acnt:00000060 Unit: 107-22St	32,000.00	72,000.00	70,000.00	**174,000.00**		

D.I.A.N.D. Acnt:00000061 Unit: 103-22St	9,000.00	2,000.00	16,000.00	**27,000.00**		
Hamlet of Rankin Inlet (Airport) Acnt:00000114 Unit: 390	1,813,000.00	150,000.00	111,000.00	**2,074,000.00**		
IBSL LEASING LTD / ROCKLAND BLDG Acnt:00000493 Unit: 04	46,000.00	750,000.00	56,000.00	**852,000.00**		
IBSL LEASING LTD Acnt:00000489 Unit: 110/112-54St	108,000.00	67,000.00	120,000.00	**295,000.00**		
IBSL LEASING LTD Acnt:00000491 Unit: 120-52St	67,000.00	91,000.00	137,000.00	**295,000.00**		
IBSL LEASING LTD Acnt:00000496 Unit: 105-24St	24,000.00	16,000.00	22,500.00	**62,500.00**		
IBSL LEASING LTD Acnt:00000511 Unit: 102-21Av	75,000.00	91,000.00	9,300.00	**175,300.00**		
IBSL LEASING LTD Acnt:00000515 Unit: 018-4Av	16,000.00	84,000.00	56,000.00	**156,000.00**		
IBSL LEASING LTD Acnt:00000966 Unit: 106/108-54St	54,000.00	64,000.00	155,000.00	**273,000.00**		
IBSL LEASING LTD Acnt:53700000 Unit: 43-4Av	0.00	36,000.00	36,000.00	**72,000.00**		
NUNAVUT HOUSING CORPORATION (4 UNITS) Acnt:00000518	108,000.00	91,000.00	88,000.00	**287,000.00**		
NUNAVUT HOUSING CORPORATION / 10 PLEX Acnt:00000556	67,000.00	413,000.00	228,000.00	**708,000.00**		
NUNAVUT HOUSING CORPORATION /4 UNITS Acnt:00000557 U	108,000.00	95,000.00	21,000.00	**224,000.00**		
NUNAVUT HOUSING CORPORATION /5 Plex Acnt:00000558 Uni	35,000.00	25,000.00	25,000.00	**85,000.00**		
NUNAVUT HOUSING CORPORATION Acnt:00000403 Unit: 027-2	30,000.00	54,000.00	97,000.00	**181,000.00**		
NUNAVUT HOUSING CORPORATION Acnt:52700000 Unit: 215-6	73,000.00	1,000.00	0.00	**74,000.00**		
NUNAVUT HOUSING CORPORATION Acnt:53000000 Unit: 229-6	46,000.00	11,000.00	500.00	**57,500.00**		
NUNAVUT HOUSING CORPORATION Acnt:53300000 Unit: 247-6	56,000.00	75,000.00	65,500.00	**196,500.00**		
Nunavut Housing Corporation/6 PLEX Acnt:00000934 Unit: 018/028-	313,000.00	259,000.00	240,000.00	**812,000.00**		
Nunavut Housing Corporation/6 PLEX Acnt:00000935 Unit: 030/040-	324,000.00	193,000.00	218,000.00	**735,000.00**		
NUNAVUT HOUSING CORPORTATION Acnt:00000936 Unit: 223-	53,000.00	40,000.00	500.00	**93,500.00**		
NUNAVUT HOUSING CORPORTATION Acnt:52900000 Unit: 227-	22,000.00	60,000.00	1,000.00	**83,000.00**		
Nunavut Power Corporation Acnt:00000262 Unit: 010-4Av.1	55,000.00	77,000.00	233,000.00	**365,000.00**		
Nunavut Power Corporation Acnt:00000263 Unit: 006-1Av	63,000.00	150,000.00	100,000.00	**313,000.00**		
Nunavut Power Corporation Acnt:00000264 Unit: 007-12St	7,000.00	11,000.00	8,000.00	**26,000.00**		
Nunavut Power Corporation Acnt:00000266 Unit: 003-12St	24,000.00	0.00	0.00	**24,000.00**		
Nunavut Power Corporation Acnt:00000267 Unit: 005-12St	4,000.00	16,000.00	17,000.00	**37,000.00**		
Nunavut Power Corporation Acnt:00000270 Unit: 010-4Av	100,000.00	100,000.00	28,000.00	**228,000.00**		
R.C.M. Police Acnt:00000305 Unit: 007-11	36,000.00	0.00	62,000.00	**98,000.00**		
R.C.M. Police Acnt:00000306 Unit: 116-24St	0.00	2,000.00	0.00	**2,000.00**		
R.C.M. Police Acnt:00000307 Unit: 005-11	40,000.00	27,000.00	23,000.00	**90,000.00**		
R.C.M. Police Acnt:00000308 Unit: 005-15St	51,000.00	31,000.00	41,000.00	**123,000.00**		
R.C.M. Police Acnt:00000309 Unit: 001-11	58,000.00	30,000.00	30,000.00	**118,000.00**		
R.C.M. Police Acnt:00000310 Unit: 007-15St	24,000.00	0.00	0.00	**24,000.00**		

R.C.M. Police Acnt:00000311 Unit: 003-11	13,000.00	25,000.00	17,000.00	**55,000.00**		
R.C.M. Police Acnt:00000841 Unit: 009-15St	64,000.00	0.00	36,000.00	**100,000.00**		
Rankin Inlet Housing Assoc. /4PLEX Acnt:00000416 Unit: 124-24Av	78,000.00	296,500.00	252,500.00	**627,000.00**		
Rankin Inlet Housing Association (18 UNITS)/DUPLEX Acnt:000004	54,000.00	250,000.00	0.00	**304,000.00**		
Rankin Inlet Housing Association (9 PLEX) Acnt:00000442 Unit: 147	486,000.00	494,000.00	364,000.00	**1,344,000.00**		
Rankin Inlet Housing Association (Duplex) Acnt:00000313 Unit: 007-	36,000.00	0.00	0.00	**36,000.00**		
Rankin Inlet Housing Association (Duplex) Acnt:00000339 Unit: 016-	56,000.00	91,000.00	100,500.00	**247,500.00**		
Rankin Inlet Housing Association / 4 PLEX Acnt:00000430 Unit: 129-	59,000.00	305,500.00	380,000.00	**744,500.00**		
Rankin Inlet Housing Association / 4 PLEX Acnt:00000431 Unit: 168/	116,000.00	188,000.00	132,000.00	**436,000.00**		
Rankin Inlet Housing Association / DUPLEX Acnt:00000432 Unit: 17	93,000.00	851,500.00	1,052,000.00	**1,996,500.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000019 Unit: 2	0.00	99,000.00	0.00	**99,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000020 Unit: 2	105,000.00	70,000.00	68,000.00	**243,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000071 Unit: 2	0.00	81,000.00	0.00	**81,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000155 Unit: 2	53,000.00	95,000.00	90,000.00	**238,000.00**		
Rankin Inlet Housing Association Acnt:00000314 Unit: 005-14St	56,000.00	73,000.00	49,000.00	**178,000.00**		
Rankin Inlet Housing Association Acnt:00000315 Unit: 006-13St	87,000.00	71,000.00	99,000.00	**257,000.00**		
Rankin Inlet Housing Association Acnt:00000316 Unit: 008-13St	54,000.00	54,000.00	100,000.00	**208,000.00**		
Rankin Inlet Housing Association Acnt:00000317 Unit: 010-13St	71,000.00	72,000.00	90,000.00	**233,000.00**		
Rankin Inlet Housing Association Acnt:00000318 Unit: 009-14St	63,000.00	99,000.00	93,000.00	**255,000.00**		
Rankin Inlet Housing Association Acnt:00000319 Unit: 012-13St	54,000.00	0.00	0.00	**54,000.00**		
Rankin Inlet Housing Association Acnt:00000320 Unit: 014-13St	54,000.00	69,000.00	101,000.00	**224,000.00**		
Rankin Inlet Housing Association Acnt:00000321 Unit: 016-13St	61,000.00	64,500.00	80,300.00	**205,800.00**		
Rankin Inlet Housing Association Acnt:00000322 Unit: 018-13St	90,000.00	115,000.00	88,000.00	**293,000.00**		
Rankin Inlet Housing Association Acnt:00000324 Unit: 014-12St	90,000.00	68,000.00	65,000.00	**223,000.00**		
Rankin Inlet Housing Association Acnt:00000325 Unit: 013-13St	92,000.00	93,000.00	73,000.00	**258,000.00**		
Rankin Inlet Housing Association Acnt:00000326 Unit: 011-13St	88,000.00	89,000.00	63,500.00	**240,500.00**		
Rankin Inlet Housing Association Acnt:00000327 Unit: 020-13St	88,000.00	72,000.00	73,000.00	**233,000.00**		
Rankin Inlet Housing Association Acnt:00000328 Unit: 020-14St	103,000.00	64,500.00	58,500.00	**226,000.00**		
Rankin Inlet Housing Association Acnt:00000329 Unit: 020-12Av	54,000.00	81,000.00	90,000.00	**225,000.00**		
Rankin Inlet Housing Association Acnt:00000330 Unit: 006-14Av	89,000.00	81,000.00	76,000.00	**246,000.00**		
Rankin Inlet Housing Association Acnt:00000331 Unit: 022-12Av	35,000.00	36,000.00	27,000.00	**98,000.00**		
Rankin Inlet Housing Association Acnt:00000332 Unit: 009-13St	62,000.00	57,000.00	102,000.00	**221,000.00**		
Rankin Inlet Housing Association Acnt:00000333 Unit: 017-15St	49,000.00	81,000.00	96,000.00	**226,000.00**		
Rankin Inlet Housing Association Acnt:00000334 Unit: 014-14St	39,000.00	64,000.00	90,000.00	**193,000.00**		

Rankin Inlet Housing Association Acnt:00000335 Unit: 100-22St	81,000.00	91,000.00	75,000.00	**247,000.00**		
Rankin Inlet Housing Association Acnt:00000336 Unit: 018-14St	82,000.00	48,500.00	70,000.00	**200,500.00**		
Rankin Inlet Housing Association Acnt:00000337 Unit: 013-14St	32,000.00	111,000.00	40,000.00	**183,000.00**		
Rankin Inlet Housing Association Acnt:00000338 Unit: 022-14St	54,000.00	0.00	0.00	**54,000.00**		
Rankin Inlet Housing Association Acnt:00000340 Unit: 012-12Av	53,000.00	54,000.00	72,000.00	**179,000.00**		
Rankin Inlet Housing Association Acnt:00000341 Unit: 021-14St	54,000.00	49,000.00	111,000.00	**214,000.00**		
Rankin Inlet Housing Association Acnt:00000342 Unit: 019-14St	54,000.00	0.00	0.00	**54,000.00**		
Rankin Inlet Housing Association Acnt:00000343 Unit: 015-14St	50,000.00	54,000.00	19,000.00	**123,000.00**		
Rankin Inlet Housing Association Acnt:00000344 Unit: 016-14St	75,000.00	41,500.00	18,500.00	**135,000.00**		
Rankin Inlet Housing Association Acnt:00000345 Unit: 106-13St	54,000.00	54,000.00	54,000.00	**162,000.00**		
Rankin Inlet Housing Association Acnt:00000346 Unit: 017-13Av	96,000.00	24,000.00	45,000.00	**165,000.00**		
Rankin Inlet Housing Association Acnt:00000347 Unit: 015-13Av	52,000.00	42,000.00	48,000.00	**142,000.00**		
Rankin Inlet Housing Association Acnt:00000348 Unit: 011-13Av	80,000.00	83,000.00	75,000.00	**238,000.00**		
Rankin Inlet Housing Association Acnt:00000349 Unit: 006-13Av	96,000.00	45,000.00	100,000.00	**241,000.00**		
Rankin Inlet Housing Association Acnt:00000350 Unit: 010-13Av	97,000.00	54,000.00	67,000.00	**218,000.00**		
Rankin Inlet Housing Association Acnt:00000351 Unit: 013-13Av	52,000.00	51,000.00	50,000.00	**153,000.00**		
Rankin Inlet Housing Association Acnt:00000352 Unit: 018-13Av	54,000.00	32,000.00	24,000.00	**110,000.00**		
Rankin Inlet Housing Association Acnt:00000353 Unit: 014-14Av	112,000.00	63,000.00	49,000.00	**224,000.00**		
Rankin Inlet Housing Association Acnt:00000355 Unit: 102-13St	85,000.00	45,000.00	49,000.00	**179,000.00**		
Rankin Inlet Housing Association Acnt:00000356 Unit: 007-12Av	90,000.00	68,000.00	110,000.00	**268,000.00**		
Rankin Inlet Housing Association Acnt:00000357 Unit: 101-22Av	66,000.00	54,000.00	19,000.00	**139,000.00**		
Rankin Inlet Housing Association Acnt:00000358 Unit: 017-14St	81,000.00	81,000.00	58,400.00	**220,400.00**		
Rankin Inlet Housing Association Acnt:00000359 Unit: 104-22St	77,000.00	58,000.00	38,500.00	**173,500.00**		
Rankin Inlet Housing Association Acnt:00000360 Unit: 012-13Av	56,000.00	45,000.00	35,000.00	**136,000.00**		
Rankin Inlet Housing Association Acnt:00000361 Unit: 115-14St	75,000.00	46,000.00	36,000.00	**157,000.00**		
Rankin Inlet Housing Association Acnt:00000362 Unit: 005-13St	54,000.00	87,000.00	67,500.00	**208,500.00**		
Rankin Inlet Housing Association Acnt:00000363 Unit: 002-12St	65,000.00	45,000.00	51,000.00	**161,000.00**		
Rankin Inlet Housing Association Acnt:00000364 Unit: 008-12St	54,000.00	0.00	0.00	**54,000.00**		
Rankin Inlet Housing Association Acnt:00000365 Unit: 010-12St	68,000.00	37,000.00	27,000.00	**132,000.00**		
Rankin Inlet Housing Association Acnt:00000366 Unit: 017-12St	36,000.00	62,000.00	36,000.00	**134,000.00**		
Rankin Inlet Housing Association Acnt:00000367 Unit: 009-12Av	54,000.00	28,000.00	120,000.00	**202,000.00**		
Rankin Inlet Housing Association Acnt:00000368 Unit: 018-14Av	89,000.00	39,000.00	90,000.00	**218,000.00**		
Rankin Inlet Housing Association Acnt:00000369 Unit: 111-14St	80,000.00	92,000.00	72,000.00	**244,000.00**		
Rankin Inlet Housing Association Acnt:00000371 Unit: 119-14St	74,000.00	35,000.00	35,000.00	**144,000.00**		

Rankin Inlet Housing Association Acnt:00000372 Unit: 021-14Av	84,000.00	54,000.00	45,000.00	**183,000.00**		
Rankin Inlet Housing Association Acnt:00000373 Unit: 008-14Av	58,000.00	85,000.00	105,000.00	**248,000.00**		
Rankin Inlet Housing Association Acnt:00000374 Unit: 010-14Av	90,000.00	48,000.00	35,000.00	**173,000.00**		
Rankin Inlet Housing Association Acnt:00000376 Unit: 007-13St	54,000.00	59,000.00	98,000.00	**211,000.00**		
Rankin Inlet Housing Association Acnt:00000384 Unit: 250-61St	79,000.00	91,000.00	100,000.00	**270,000.00**		
Rankin Inlet Housing Association Acnt:00000385 Unit: 246-61St	39,000.00	53,000.00	39,000.00	**131,000.00**		
Rankin Inlet Housing Association Acnt:00000386 Unit: 118-52St	58,000.00	64,500.00	67,000.00	**189,500.00**		
Rankin Inlet Housing Association Acnt:00000387 Unit: 107-23St	59,000.00	51,000.00	93,000.00	**203,000.00**		
Rankin Inlet Housing Association Acnt:00000388 Unit: 103-21Av	31,000.00	0.00	0.00	**31,000.00**		
Rankin Inlet Housing Association Acnt:00000391 Unit: 103-22Av	45,000.00	66,500.00	55,500.00	**167,000.00**		
Rankin Inlet Housing Association Acnt:00000392 Unit: 025-21St	35,500.00	18,000.00	18,000.00	**71,500.00**		
Rankin Inlet Housing Association Acnt:00000393 Unit: 023-21St	22,000.00	51,000.00	59,000.00	**132,000.00**		
Rankin Inlet Housing Association Acnt:00000394 Unit: 019-21St	66,000.00	14,500.00	55,500.00	**136,000.00**		
Rankin Inlet Housing Association Acnt:00000395 Unit: 017-21St	32,000.00	84,500.00	63,000.00	**179,500.00**		
Rankin Inlet Housing Association Acnt:00000396 Unit: 015-21St	66,000.00	91,000.00	19,000.00	**176,000.00**		
Rankin Inlet Housing Association Acnt:00000397 Unit: 014-21St	82,000.00	106,000.00	91,500.00	**279,500.00**		
Rankin Inlet Housing Association Acnt:00000398 Unit: 016-21St	73,000.00	38,000.00	48,000.00	**159,000.00**		
Rankin Inlet Housing Association Acnt:00000399 Unit: 018-21St	69,000.00	122,000.00	69,000.00	**260,000.00**		
Rankin Inlet Housing Association Acnt:00000400 Unit: 020-21St	90,000.00	0.00	24,000.00	**114,000.00**		
Rankin Inlet Housing Association Acnt:00000406 Unit: 104-24St	54,000.00	0.00	0.00	**54,000.00**		
Rankin Inlet Housing Association Acnt:00000407 Unit: 103-25St	99,000.00	56,500.00	51,000.00	**206,500.00**		
Rankin Inlet Housing Association Acnt:00000411 Unit: 167-24Av	97,000.00	66,000.00	45,000.00	**208,000.00**		
Rankin Inlet Housing Association Acnt:00000418 Unit: 136-54St	49,000.00	188,000.00	98,000.00	**335,000.00**		
Rankin Inlet Housing Association Acnt:00000422 Unit: 130-54St	74,000.00	86,000.00	88,000.00	**248,000.00**		
Rankin Inlet Housing Association Acnt:00000423 Unit: 210-64St	49,000.00	89,000.00	100,000.00	**238,000.00**		
Rankin Inlet Housing Association Acnt:00000427 Unit: 169-24Av	81,000.00	54,000.00	0.00	**135,000.00**		
Rankin Inlet Housing Association Acnt:00000429 Unit: 162-24Av	64,000.00	67,000.00	51,000.00	**182,000.00**		
Rankin Inlet Housing Association Acnt:00000433 Unit: 101-21Av	63,000.00	59,000.00	54,000.00	**176,000.00**		
Rankin Inlet Housing Association Acnt:00000434 Unit: 182-24Av	54,000.00	35,000.00	35,000.00	**124,000.00**		
Rankin Inlet Housing Association Acnt:00000435 Unit: 186-24Av	54,000.00	64,000.00	56,000.00	**174,000.00**		
Rankin Inlet Housing Association Acnt:00000436 Unit: 188-24Av	61,000.00	73,000.00	98,500.00	**232,500.00**		
Rankin Inlet Housing Association Acnt:00000437 Unit: 190-24Av	71,000.00	37,000.00	24,000.00	**132,000.00**		
Rankin Inlet Housing Association Acnt:00000438 Unit: 011-26St	84,000.00	79,000.00	65,000.00	**228,000.00**		
Rankin Inlet Housing Association Acnt:00000439 Unit: 171-24Av	69,000.00	91,000.00	90,000.00	**250,000.00**		

Rankin Inlet Housing Association Acnt:00000440 Unit: 180-24Av	83,000.00	53,000.00	42,000.00	**178,000.00**		
Rankin Inlet Housing Association Acnt:00000441 Unit: 165-24Av	61,000.00	91,000.00	56,000.00	**208,000.00**		
Rankin Inlet Housing Association Acnt:00000443 Unit: 104-24Av	62,000.00	91,000.00	77,500.00	**230,500.00**		
Rankin Inlet Housing Association Acnt:00000444 Unit: 106-24Av	73,000.00	73,000.00	43,000.00	**189,000.00**		
Rankin Inlet Housing Association Acnt:00000445 Unit: 108-24Av	81,000.00	81,500.00	63,500.00	**226,000.00**		
Rankin Inlet Housing Association Acnt:00000446 Unit: 112-24Av	72,000.00	75,000.00	76,000.00	**223,000.00**		
Rankin Inlet Housing Association Acnt:00000447 Unit: 115-24Av	92,000.00	54,000.00	90,000.00	**236,000.00**		
Rankin Inlet Housing Association Acnt:00000448 Unit: 109-24St	36,000.00	0.00	0.00	**36,000.00**		
Rankin Inlet Housing Association Acnt:00000450 Unit: 109-22St	49,000.00	87,000.00	79,000.00	**215,000.00**		
Rankin Inlet Housing Association Acnt:00000451 Unit: 108-22St	49,000.00	54,000.00	102,000.00	**205,000.00**		
Rankin Inlet Housing Association Acnt:00000452 Unit: 173/189-24Av	472,000.00	331,000.00	336,000.00	**1,139,000.00**		
Rankin Inlet Housing Association Acnt:00000453 Unit: 108-23Av	77,000.00	92,500.00	33,000.00	**202,500.00**		
Rankin Inlet Housing Association Acnt:00000454 Unit: 014-26St	82,000.00	54,000.00	59,000.00	**195,000.00**		
Rankin Inlet Housing Association Acnt:00000455 Unit: 109-22Av	69,000.00	59,500.00	0.00	**128,500.00**		
Rankin Inlet Housing Association Acnt:00000456 Unit: 184-24Av	81,000.00	260,000.00	87,000.00	**428,000.00**		
Rankin Inlet Housing Association Acnt:00000457 Unit: 105-22Av	41,000.00	56,000.00	56,000.00	**153,000.00**		
Rankin Inlet Housing Association Acnt:00000458 Unit: 100-23Av	87,000.00	95,000.00	90,000.00	**272,000.00**		
Rankin Inlet Housing Association Acnt:00000459 Unit: 113-22Av	66,000.00	30,000.00	26,000.00	**122,000.00**		
Rankin Inlet Housing Association Acnt:00000460 Unit: 106-23Av	74,000.00	91,000.00	90,000.00	**255,000.00**		
Rankin Inlet Housing Association Acnt:00000461 Unit: 111-22Av	52,000.00	57,000.00	98,000.00	**207,000.00**		
Rankin Inlet Housing Association Acnt:00000462 Unit: 112-23Av	54,000.00	88,500.00	0.00	**142,500.00**		
Rankin Inlet Housing Association Acnt:00000463 Unit: 104-22Av	52,000.00	36,000.00	90,000.00	**178,000.00**		
Rankin Inlet Housing Association Acnt:00000464 Unit: 102-22Av	69,000.00	60,500.00	72,500.00	**202,000.00**		
Rankin Inlet Housing Association Acnt:00000465 Unit: 100-22Av	49,000.00	123,000.00	105,000.00	**277,000.00**		
Rankin Inlet Housing Association Acnt:00000466 Unit: 028-21St	63,000.00	42,000.00	55,000.00	**160,000.00**		
Rankin Inlet Housing Association Acnt:00000467 Unit: 026-21St	65,000.00	115,000.00	119,500.00	**299,500.00**		
Rankin Inlet Housing Association Acnt:00000468 Unit: 104-23Av	66,000.00	36,000.00	88,000.00	**190,000.00**		
Rankin Inlet Housing Association Acnt:00000469 Unit: 012-26St	67,000.00	108,000.00	89,000.00	**264,000.00**		
Rankin Inlet Housing Association Acnt:00000470 Unit: 010-26St	52,000.00	102,000.00	92,000.00	**246,000.00**		
Rankin Inlet Housing Association Acnt:00000472 Unit: 120-22Av	33,000.00	91,000.00	90,000.00	**214,000.00**		
Rankin Inlet Housing Association Acnt:00000473 Unit: 117-22Av	56,000.00	54,500.00	78,000.00	**188,500.00**		
Rankin Inlet Housing Association Acnt:00000474 Unit: 115-22Av	71,000.00	89,000.00	90,000.00	**250,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000530 Unit: 2	0.00	89,000.00	83,000.00	**172,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000559 Unit: 9	165,000.00	120,000.00	127,000.00	**412,000.00**		

RANKIN INLET HOUSING ASSOCIATION Acnt:00000583 Unit: 2	54,000.00	97,000.00	100,000.00	**251,000.00**		
Rankin Inlet Housing Association Acnt:00000799 Unit: 213-63St	71,000.00	109,000.00	98,000.00	**278,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000903 Unit: 2	75,000.00	31,000.00	27,000.00	**133,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:00000967 Unit: 2	78,000.00	49,000.00	46,000.00	**173,000.00**		
Rankin Inlet Housing Association Acnt:00000978 Unit: 210/214-61St	169,000.00	153,500.00	160,500.00	**483,000.00**		
RANKIN INLET HOUSING ASSOCIATION Acnt:52000000 Unit: 2	72,000.00	95,000.00	100,000.00	**267,000.00**		
Rankin Inlet Housing Association Acnt:53600000 Unit: 056-64Av	64,000.00	95,000.00	98,000.00	**257,000.00**		
Rankin Inlet Housing Association/ 3 PLEX Acnt:00000836 Unit: 209/	162,000.00	155,500.00	0.00	**317,500.00**		
Rankin Inlet Housing Association/ 3 PLEX Acnt:00000840 Unit: 210/	177,000.00	133,500.00	136,500.00	**447,000.00**		
Rankin Inlet Housing Association/ 4 PLEX Acnt:00000378 Unit: 126/	200,000.00	417,500.00	433,500.00	**1,051,000.00**		
Rankin Inlet Housing Association/ 4 PLEX Acnt:00000389 Unit: 134/	172,000.00	476,500.00	86,500.00	**735,000.00**		
Rankin Inlet Housing Association/ 4 PLEX Acnt:00000837 Unit: 232/	224,000.00	229,000.00	326,000.00	**779,000.00**		
Rankin Inlet Housing Association/ 4 PLEX Acnt:00000839 Unit: 216/	218,000.00	268,000.00	284,000.00	**770,000.00**		
Rankin Inlet Housing Association/ DUPLEX Acnt:00000828 Unit: 21	115,000.00	58,000.00	64,500.00	**237,500.00**		
Rankin Inlet Housing Association/3 PLEX Acnt:00000390 Unit: 115/1	108,000.00	85,000.00	97,500.00	**290,500.00**		
Rankin Inlet Housing Association/3 PLEX Acnt:00000835 Unit: 215/2	147,000.00	151,500.00	0.00	**298,500.00**		
Rankin Inlet Housing Association/4 PLEX Acnt:00000420 Unit: 114/1	216,000.00	212,000.00	275,000.00	**703,000.00**		
Rankin Inlet Housing Association/4 PLEX Acnt:00000425 Unit: 142/1	162,000.00	670,500.00	845,000.00	**1,677,500.00**		
Rankin Inlet Housing Association/4 PLEX Acnt:00000428 Unit: 124/1	144,000.00	300,000.00	239,000.00	**683,000.00**		
Rankin Inlet Housing Association/4 PLEX Acnt:00000838 Unit: 224/2	196,000.00	533,000.00	200,000.00	**929,000.00**		
Rankin Inlet Housing Association/4Plex Acnt:00000471 Unit: 004-26	68,000.00	90,000.00	124,000.00	**282,000.00**		
Rankin Inlet Housing Association/DUPLEX Acnt:00000401 Unit: 110	88,000.00	337,000.00	203,000.00	**628,000.00**		
Rankin Inlet Housing Association/DUPLEX Acnt:00000415 Unit: 132	45,000.00	187,000.00	90,000.00	**322,000.00**		
Rankin Inlet Housing Association/DUPLEX Acnt:00000421 Unit: 126	123,000.00	121,500.00	120,500.00	**365,000.00**		
Rankin Inlet Housing Association/DUPLEX Acnt:00000826 Unit: 223	149,500.00	64,000.00	68,500.00	**282,000.00**		
Rankin Inlet Housing Association/DUPLEX Acnt:00000827 Unit: 219	118,500.00	310,500.00	143,500.00	**572,500.00**		
Total	19,832,000	24,819,500	22,231,000	66,882,500		
No Charge	**10/08**	**3/09**	**7/09**	**Total**		
Hamlet of Rankin Inlet Acnt:00000115 Unit: 018-4St	0.00	62,000.00	0.00	**62,000.00**		
Hamlet of Rankin Inlet Acnt:00000116 Unit: 122-4Av	232,000.00	146,000.00	157,000.00	**535,000.00**		
Hamlet of Rankin Inlet Acnt:00000122 Unit: 127-53St	49,000.00	189,000.00	56,000.00	**294,000.00**		
Hamlet of Rankin Inlet Acnt:50200000 Unit: 020-11Av	90,000.00	89,000.00	42,000.00	**221,000.00**		

Total	371,000	486,000	255,000	1,112,000		
Residential	**10/08**	**3/09**	**7/09**	**Total**		
NOKKITOK, MARGARET FOR Nokkitok, Emilia Acnt:00000249 U	72,000.00	107,000.00	127,500.00	**306,500.00**		
ABUAN, CYNTHIA E. Acnt:00000073 Unit: 010-11Av	47,000.00	33,000.00	25,000.00	**105,000.00**		
Adams, Sandy Acnt:00000002 Unit: 203-66St	39,000.00	59,000.00	37,000.00	**135,000.00**		
ADAMS, STEPHANIE Acnt:52600000 Unit: 213-61St	54,000.00	78,500.00	90,000.00	**222,500.00**		
Adams, Tommy Acnt:00000003 Unit: 113-51St	59,000.00	88,000.00	98,000.00	**245,000.00**		
Adams, Willie Jr. and Donna Acnt:00000004 Unit: 002-11St	67,000.00	38,000.00	49,000.00	**154,000.00**		
Airut, Oscar&Lisa Acnt:00000007 Unit: 053-62Av	84,000.00	57,000.00	54,000.00	**195,000.00**		
AJAJA PAIRIVIK SOCIETY Acnt:00000164 Unit: 213-64St	69,000.00	69,000.00	102,500.00	**240,500.00**		
Akerolik, Andrew Acnt:00000010 Unit: 004-12Av	51,000.00	29,000.00	54,000.00	**134,000.00**		
Akerolik, Ernest & Nancy Acnt:00000631 Unit: 216-65St	82,000.00	62,000.00	70,000.00	**214,000.00**		
Akerolik, Timothy Acnt:00000011 Unit: 113-24St	61,000.00	54,000.00	129,000.00	**244,000.00**		
AKSALNIK, INUKSHUK & KYLE SHEPPARD Acnt:00000968 Uni	37,000.00	54,000.00	88,000.00	**179,000.00**		
Aksalnik, Margo Acnt:00000012 Unit: 016-15St	61,000.00	49,000.00	37,000.00	**147,000.00**		
Aliyak, Mariah Acnt:00000013 Unit: 206-64St	31,000.00	26,000.00	32,000.00	**89,000.00**		
Aliyak, Samson Acnt:00000014 Unit: 209-63St	50,000.00	27,000.00	36,500.00	**113,500.00**		
AMAROK, TONY AND LINSDEY Acnt:00000550 Unit: 102-21St	1,000.00	13,000.00	26,000.00	**40,000.00**		
ANAWAK, GERALD/JENNIFER FLUEGAR Acnt:00000983 Unit: 2	54,000.00	54,000.00	56,000.00	**164,000.00**		
ANAWAK, STACY Acnt:00000206 Unit: 233-60St	75,000.00	86,000.00	89,000.00	**250,000.00**		
Anderson, Stan / DUPLEX/SM Acnt:00000921 Unit: 142-24Av	108,000.00	50,000.00	32,000.00	**190,000.00**		
Angalik, Emelia Acnt:00000021 Unit: 208-64St	48,000.00	67,000.00	58,000.00	**173,000.00**		
Angidlik, Kerry & Simon Acnt:00000022 Unit: 057-62Av	86,000.00	73,000.00	87,000.00	**246,000.00**		
Angidlik, Luke & Mary Acnt:00000023 Unit: 015-12St	56,000.00	67,000.00	80,000.00	**203,000.00**		
Angoshadluk, Moses & MaryRose Acnt:00000816 Unit: 062-64Av	78,000.00	80,500.00	87,000.00	**245,500.00**		
Aupaluktuq, Jane Acnt:00000027 Unit: 006-12Av	54,000.00	51,000.00	43,000.00	**148,000.00**		

AUTUT, ALIISA & CEDRIC Acnt:54300004 Unit: 91-65 AVENUE	54,000.00	54,000.00	54,000.00	**162,000.00**		
Autut, Cecilia Acnt:00000029 Unit: 110-22St	37,000.00	0.00	36,000.00	**73,000.00**		
Autut, Danny Acnt:00000030 Unit: 036-15St	39,000.00	34,000.00	30,000.00	**103,000.00**		
Autut, Marcel Acnt:00000031 Unit: 213-66St	43,000.00	28,000.00	39,000.00	**110,000.00**		
Ayaruak, Sarah Acnt:00000035 Unit: 105-25St	66,000.00	54,000.00	88,000.00	**208,000.00**		
BALAJI, RAMAMANI Acnt:51100000 Unit: 150-24Av	37,000.00	36,000.00	24,000.00	**97,000.00**		
BEARDSALL, KEN Acnt:00000904 Unit: 235-60St	62,000.00	66,000.00	54,000.00	**182,000.00**		
BEATON, RYAN Acnt:00000289 Unit: 054-62Av	47,000.00	54,000.00	90,000.00	**191,000.00**		
Benoit, Anne-Hannah Acnt:00000037 Unit: 052-64Av	82,000.00	0.00	100,000.00	**182,000.00**		
Berry, Leonie Acnt:00000038 Unit: 003-24St	79,000.00	52,000.00	50,000.00	**181,000.00**		
BOUTHILLIER, JOCELYN Acnt:51400000 Unit: 016-24ST	54,000.00	90,000.00	80,000.00	**224,000.00**		
BRIGHAM, DAWN Acnt:05230000 Unit: 214-65St	40,000.00	23,000.00	15,000.00	**78,000.00**		
BROWN, ARNIE Acnt:00000811 Unit: 217-66St	84,000.00	85,000.00	77,000.00	**246,000.00**		
Brown, Jake & Edith Acnt:00000822 Unit: 084-64Av	76,000.00	67,000.00	66,000.00	**209,000.00**		
Brown, Levinia Acnt:00000041 Unit: 201-51St	80,000.00	43,000.00	94,000.00	**217,000.00**		
Brown, Rosemary Acnt:00000042 Unit: 101-22St	35,000.00	19,000.00	12,000.00	**66,000.00**		
BRUCE, HERMAN/DUPLEX/SM Acnt:51200000 Unit: 138-24AV	49,000.00	75,000.00	90,000.00	**214,000.00**		
Bruce, Tommy Acnt:00000879 Unit: 121-53St	59,000.00	41,000.00	15,000.00	**115,000.00**		
Chislett, Jerry Acnt:00000051 Unit: 016-26St	64,000.00	75,000.00	76,000.00	**215,000.00**		
Clark, Donald Acnt:00000052 Unit: 102-24St	51,000.00	54,000.00	56,000.00	**161,000.00**		
CLARK, KELLY Acnt:00000541 Unit: 214-67St	36,000.00	31,500.00	30,500.00	**98,000.00**		
CONNELLY, Richard Acnt:00000084 Unit: 109-21Av	62,000.00	114,000.00	92,000.00	**268,000.00**		
CONNELLY, RICHARD Acnt:00000551 Unit: 152-24Av	45,000.00	0.00	94,000.00	**139,000.00**		
Connelly, Robert Acnt:00000056 Unit: 028-11Av	33,000.00	23,000.00	20,000.00	**76,000.00**		
COOPER, YVONNE Acnt:51000000 Unit: 207-24Av	56,000.00	40,000.00	24,000.00	**120,000.00**		
CURLEY, JACQUELINE Acnt:00000564 Unit: 112-23 St.	24,000.00	28,000.00	21,000.00	**73,000.00**		
Curley, Sebastian Acnt:00000058 Unit: 104-21Av	78,000.00	56,500.00	42,500.00	**177,000.00**		
Curley, Tagak Acnt:00000948 Unit: 051-62Av	70,000.00	35,000.00	39,000.00	**144,000.00**		
David, Teresita Acnt:00000062 Unit: 026-15St	61,000.00	53,500.00	45,000.00	**159,500.00**		
Dean, Bert & Bernadette Acnt:00000063 Unit: 103-24St	56,000.00	37,000.00	33,000.00	**126,000.00**		
DIAS, SHAWNA Acnt:52800000 Unit: 225-61ST	47,000.00	126,000.00	88,000.00	**261,000.00**		
DUGUAY, BRIAN Acnt:50000000 Unit: 104-21St	14,000.00	11,000.00	8,000.00	**33,000.00**		
Eccles, Selma Acnt:00000066 Unit: 113-53St	62,000.00	51,500.00	35,500.00	**149,000.00**		
EECHERK, ANDY Acnt:00000069 Unit: 118-22Av	50,000.00	43,000.00	38,000.00	**131,000.00**		

FAULKNER, STEVEN & KIMBERLEY Acnt:00000544 Unit: 219-6	73,000.00	40,000.00	19,000.00	**132,000.00**		
Fitzpatrick, Bob Acnt:00000074 Unit: 202-64St	77,000.00	63,000.00	29,000.00	**169,000.00**		
Fleischhacker, Larry Acnt:00000075 Unit: 109-13St	41,000.00	24,000.00	40,000.00	**105,000.00**		
Flynn, Darren Acnt:05380000 Unit: 105-13StA	54,000.00	56,000.00	80,000.00	**190,000.00**		
FORBES, AARON Acnt:00000076 Unit: 014-11Av	46,000.00	18,000.00	15,000.00	**79,000.00**		
Ford, Beverly Acnt:00000077 Unit: 109-23St	59,000.00	102,000.00	90,000.00	**251,000.00**		
FORD, PALLULAAQ Acnt:00000299 Unit: 249-61St	66,000.00	40,000.00	36,500.00	**142,500.00**		
FREDLUND, BENJI Acnt:00000477 Unit: 049-62Av	75,000.00	89,000.00	57,000.00	**221,000.00**		
FREDLUND, DAVID Acnt:54300002 Unit: 240-60th Street	50,000.00	111,500.00	50,500.00	**212,000.00**		
Gamble, John Acnt:00000087 Unit: 019-15St	39,000.00	0.00	54,000.00	**93,000.00**		
Gawor, Bill Acnt:00000089 Unit: 028-15St	57,000.00	22,000.00	4,000.00	**83,000.00**		
Glad Tidings Arctic Mission: Kay Gordon Acnt:00000090 Unit: 121-2	41,000.00	54,000.00	7,500.00	**102,500.00**		
Glad Tidings Fellowship /RON DEWER Acnt:00000053 Unit: 008-13	39,000.00	45,000.00	66,000.00	**150,000.00**		
Gordon, Mark & Irene Acnt:00000817 Unit: 064-64Av	70,000.00	49,000.00	46,000.00	**165,000.00**		
GORDON, NANCY Acnt:00000124 Unit: 214-63St	0.00	72,000.00	42,000.00	**114,000.00**		
Gordon, Tommy Acnt:00000107 Unit: 003-26St	84,000.00	59,000.00	66,000.00	**209,000.00**		
Graham, Mary Acnt:00000108 Unit: 038-15St	56,000.00	71,000.00	72,000.00	**199,000.00**		
Graves, Alma Acnt:00000866 Unit: 010-15St	45,000.00	29,000.00	18,000.00	**92,000.00**		
GREEN, JOYCE Acnt:54300000 Unit: 105-13StB	36,000.00	36,000.00	50,000.00	**122,000.00**		
GREEN, STEPHEN Acnt:00000230 Unit: 024-11Av	61,000.00	25,000.00	26,000.00	**112,000.00**		
HAPANAK, DICK Acnt:50400000 Unit: 018-15St	24,000.00	0.00	0.00	**24,000.00**		
HICKES, MARTHA Acnt:00000128 Unit: 004-11St	36,000.00	24,000.00	36,000.00	**96,000.00**		
HICKES, LOUISE Acnt:00000658 Unit: 020-15St	29,000.00	61,000.00	41,900.00	**131,900.00**		
HIDALGO JOSE D Acnt:00000130 Unit: 006-15St	81,000.00	38,000.00	53,000.00	**172,000.00**		
HIDALGO, CAROLINA AND JOEY Acnt:00000250 Unit: 021-4St	165,000.00	190,500.00	54,000.00	**409,500.00**		
Hidalgo, Carolina Acnt:00000129 Unit: 107-24St	58,000.00	35,000.00	12,000.00	**105,000.00**		
Hill, Beverly Acnt:00000131 Unit: 112-21St	28,000.00	56,000.00	89,000.00	**173,000.00**		
I.N.P.H.C. / (5 PLEX) Acnt:00000137 Unit: 130/138-14St	195,000.00	270,000.00	72,000.00	**537,000.00**		
I.N.P.H.C. Acnt:00000136 Unit: 128-14St	54,000.00	24,000.00	88,000.00	**166,000.00**		
IGNERDJUK MOSES & SABINA Acnt:00000224 Unit: 014-11St	48,000.00	48,000.00	48,000.00	**144,000.00**		
Iguptak, Jackie Acnt:00000138 Unit: 009-26St	70,000.00	56,500.00	76,500.00	**203,000.00**		
IKAKHIK, DARREN Acnt:54000000 Unit: 006-11St	61,000.00	57,000.00	49,500.00	**167,500.00**		
Irwin, Kathleen Acnt:00000149 Unit: 217-64St	69,000.00	36,000.00	100,000.00	**205,000.00**		
ISMAIL, AHMED Acnt:51500000 Unit: 021-21St	12,000.00	24,000.00	45,500.00	**81,500.00**		

Issaluk, Mrs. Acnt:00000910 Unit: 040-15St	50,000.00	36,000.00	90,000.00	**176,000.00**		
Ittinuar, David Acnt:00000152 Unit: 004-12St	90,000.00	82,000.00	67,000.00	**239,000.00**		
Ittinuar, Harry Acnt:00000153 Unit: 016-11St	39,000.00	47,000.00	56,000.00	**142,000.00**		
Ittinuar, Johnny Acnt:00000154 Unit: 022-13St	63,000.00	54,000.00	40,000.00	**157,000.00**		
JACKIE UGJUK/DUPLEX/SM Acnt:00000874 Unit: 140-24Av	54,000.00	65,000.00	56,000.00	**175,000.00**		
Janes, Robert Acnt:00000157 Unit: 040-21St	51,000.00	50,000.00	38,500.00	**139,500.00**		
Jones, Les Acnt:00000159 Unit: 208-63St	50,000.00	25,000.00	26,500.00	**101,500.00**		
K.R. Manson Ltd Acnt:00000160 Unit: 017-24St	32,500.00	21,000.00	17,000.00	**70,500.00**		
Kabluitok, Patrick Acnt:00000161 Unit: 199-24Av	92,000.00	91,000.00	69,000.00	**252,000.00**		
KAKUKTINNINQ, FAITH Acnt:00000939 Unit: 217-61St	24,000.00	36,000.00	0.00	**60,000.00**		
KALASERK, CRYSTAL Acnt:00000913 Unit: 032-15St	25,000.00	54,000.00	98,000.00	**177,000.00**		
Kalaserk, Joan Acnt:00000165 Unit: 029-21St	43,000.00	35,000.00	30,000.00	**108,000.00**		
Kaludjak, Joeffrey Acnt:00000977 Unit: 223-67St	40,000.00	36,000.00	0.00	**76,000.00**		
Kaludjak, Pasha Acnt:00000169 Unit: 003-14Av	39,000.00	48,000.00	41,000.00	**128,000.00**		
KALUDJAK, PATRICK & MADELINE Acnt:00000001 Unit: 107-2	71,500.00	47,500.00	43,500.00	**162,500.00**		
KANGIQLINIQ DEVELOPMENT LTD Acnt:00000147 Unit: 020-4A	0.00	24,000.00	0.00	**24,000.00**		
Kappi, Leonie Acnt:00000175 Unit: 008-15St	28,000.00	20,500.00	17,500.00	**66,000.00**		
KARLIK, GABRIAL & KATHY Acnt:50300000 Unit: 014-15St	36,000.00	34,000.00	20,000.00	**90,000.00**		
Kasaluak, Johnny Acnt:00000864 Unit: 114-24Av	41,000.00	132,000.00	99,000.00	**272,000.00**		
Kataujaq Society Acnt:00000178 Unit: 107-51St	50,500.00	67,500.00	27,500.00	**145,500.00**		
Komaksiutiksak, Lisa-Ann &Titaaq Acnt:00000209 Unit: 048-64Av	65,000.00	73,000.00	61,000.00	**199,000.00**		
Kowmuk, Simeon Acnt:00000211 Unit: 010-11St	59,000.00	36,000.00	57,000.00	**152,000.00**		
KOWTAK, GLORIA Acnt:51300000 Unit: 103-23Av	24,000.00	24,000.00	24,000.00	**72,000.00**		
KRESKY, LISA Acnt:00000902 Unit: 114-21St	36,000.00	36,000.00	56,000.00	**128,000.00**		
KUSUGAK JODY & WARREN Acnt:00000528 Unit: 023-15St	54,000.00	49,000.00	44,000.00	**147,000.00**		
KUSUGAK, GEOFF AND DENISE Acnt:00000168 Unit: 126-52St	44,000.00	63,000.00	53,000.00	**160,000.00**		
Kusugak, Jean Acnt:00000214 Unit: 008-11St	49,000.00	36,000.00	54,000.00	**139,000.00**		
KUSUGAK, JOHNNY Acnt:00000975 Unit: 082-64Av	59,000.00	45,000.00	47,000.00	**151,000.00**		
Kusugak, Jose Acnt:00000215 Unit: 125-53St	64,000.00	52,000.00	56,500.00	**172,500.00**		
Kusugak, Lorne Acnt:00000216 Unit: 141-24Av	76,000.00	57,500.00	51,000.00	**184,500.00**		
KUSUGAK, PUJJUUT AND ADRIANA Acnt:00000239 Unit: 015-2	3,000.00	27,500.00	27,500.00	**58,000.00**		
Kusugak, Sandra Acnt:00000217 Unit: 017-14Av	44,000.00	36,000.00	90,000.00	**170,000.00**		
KWEDZO, FORSON Acnt:00000979 Unit: 60-64Av	74,000.00	48,500.00	48,500.00	**171,000.00**		
LEGERE, JOY & FELIKS GAWOR Acnt:00000191 Unit: 048-15St	49,000.00	26,000.00	18,000.00	**93,000.00**		

LINDELL, JACKSON Acnt:00000210 Unit: 106-11St	61,000.00	54,000.00	56,000.00	**171,000.00**		
MACCALLUM, JEREMIAH Acnt:00000151 Unit: 034-15St	31,000.00	41,000.00	36,500.00	**108,500.00**		
MacCallum, Cecilia Acnt:00000793 Unit: 215-66St	54,000.00	28,500.00	25,000.00	**107,500.00**		
MacCallum, Naomi Acnt:53400000 Unit: 231-60St	80,000.00	69,000.00	68,000.00	**217,000.00**		
MACKENZIE, RICHARD AND LAURA Acnt:00000772 Unit: 083-6	74,000.00	89,000.00	84,000.00	**247,000.00**		
Makayak, Noah Acnt:00000218 Unit: 117-25St	39,000.00	70,000.00	50,000.00	**159,000.00**		
Makkigak, LUCY Acnt:00000219 Unit: 212-63St	0.00	0.00	10,500.00	**10,500.00**		
Makpah, Celestino Acnt:00000220 Unit: 055-62Av	43,000.00	31,000.00	34,000.00	**108,000.00**		
Makpah, Raymond&Hilarie Acnt:00000882 Unit: 122-14St	40,000.00	54,000.00	90,000.00	**184,000.00**		
Makpah, Susan Acnt:00000221 Unit: 076-64Av	43,000.00	42,000.00	56,500.00	**141,500.00**		
MAKPAH, TRISHA Acnt:00000562 Unit: 215-67 STREET	55,000.00	39,500.00	37,500.00	**132,000.00**		
MAKTAR, RACHEL JENNIFER Acnt:00000970 Unit: 244-61St	61,000.00	80,000.00	59,000.00	**200,000.00**		
Maley, Shawn Acnt:00000222 Unit: 006-12St	61,000.00	46,500.00	37,500.00	**145,000.00**		
MANCHUR, SHELDON Acnt:53100000 Unit: 231-61ST	12,000.00	23,000.00	19,500.00	**54,500.00**		
Manitok, Paul Acnt:00000223 Unit: 205-24Av	69,000.00	72,500.00	53,500.00	**195,000.00**		
Manson, Kenneth Acnt:00000225 Unit: 102-23St	52,000.00	24,000.00	21,000.00	**97,000.00**		
Manson, Kenneth Acnt:00000226 Unit: 111-24St	56,000.00	40,000.00	27,000.00	**123,000.00**		
MARSHMAN AMANDA Acnt:00000788 Unit: 218-66St	24,000.00	36,000.00	36,000.00	**96,000.00**		
Mercer, Holly Acnt:00000829 Unit: 213-65St	75,000.00	40,000.00	36,000.00	**151,000.00**		
Mercer, Raymond & Charmaine Acnt:00000843 Unit: 105-53St	44,000.00	80,000.00	47,000.00	**171,000.00**		
Merritt, Dorothy Acnt:00000232 Unit: 106-23St	59,000.00	54,000.00	92,000.00	**205,000.00**		
MILLER, RANDY Acnt:00000047 Unit: 241-60St	29,000.00	6,000.00	14,000.00	**49,000.00**		
Misheralak, Moses&Linda Acnt:00000237 Unit: 232-60St	81,000.00	56,000.00	56,000.00	**193,000.00**		
MOORE, LESLIE Acnt:00000878 Unit: 100-21St	46,000.00	58,000.00	37,000.00	**141,000.00**		
MOREY, WALTER/KISSARVIK COOP Acnt:00000212 Unit: 034-4	66,000.00	117,000.00	39,000.00	**222,000.00**		
NAKOOLAK, GORDON Acnt:00000870 Unit: 248-61St	75,000.00	68,000.00	65,000.00	**208,000.00**		
Nauya, Vital Acnt:00000244 Unit: 105-21Av	42,000.00	7,500.00	2,500.00	**52,000.00**		
NICHOL, DARRIN Acnt:00000213 Unit: 205-51St	64,000.00	64,000.00	54,000.00	**182,000.00**		
Ningeogan, David & Anne Acnt:00000247 Unit: 208-67St	79,000.00	50,000.00	61,000.00	**190,000.00**		
Nukapiak, Christine & Eric Acnt:00000256 Unit: 109-53St	56,000.00	69,000.00	66,000.00	**191,000.00**		
NUNA M & T Acnt:51900000 Unit: 124-54St	54,000.00	171,000.00	110,000.00	**335,000.00**		
Oingonn, Manasie & Julie Acnt:00000271 Unit: 111-53St	61,000.00	35,000.00	18,000.00	**114,000.00**		
Okpatauyak, Joe & Clara Acnt:00000272 Unit: 223-63St	59,000.00	75,000.00	58,000.00	**192,000.00**		
Okpatauyak, Simon Acnt:00000273 Unit: 101-25St	77,000.00	89,000.00	76,000.00	**242,000.00**		

Onalik, Janet Acnt:00000274 Unit: 012-11Av	39,000.00	80,000.00	44,000.00	**163,000.00**		
Onalik, Naanasee Acnt:00000275 Unit: 106-24St	50,000.00	13,000.00	3,000.00	**66,000.00**		
Oolooyuk, Bobby Acnt:00000276 Unit: 144-54St	81,000.00	91,000.00	100,000.00	**272,000.00**		
OOLOOYUK, DAVID Acnt:50800000 Unit: 115-25ST	51,000.00	31,000.00	22,000.00	**104,000.00**		
OOLOOYUK, LISA Acnt:00000278 Unit: 210-63St	38,000.00	33,000.00	31,000.00	**102,000.00**		
OUTCHIKAT, SHAWNEE Acnt:00000110 Unit: 241-61St	45,000.00	89,500.00	47,500.00	**182,000.00**		
PANIGONIAK, CHARLIE Acnt:00000285 Unit: 056-62Av	85,000.00	55,000.00	57,500.00	**197,500.00**		
Panika, RICHARD Acnt:00000286 Unit: 225-63St	54,000.00	0.00	36,000.00	**90,000.00**		
PANIYUK, NOAH & LYNDA Acnt:00000587 Unit: 127-14St	57,000.00	53,000.00	49,000.00	**159,000.00**		
Papik, Cecelia Acnt:00000287 Unit: 054-64Av	90,000.00	44,000.00	56,000.00	**190,000.00**		
Patterk, John Acnt:50900000 Unit: 109-25St	62,000.00	38,000.00	40,000.00	**140,000.00**		
PETRYSHEN, DAVE Acnt:50600000 Unit: 032-12AV	71,000.00	55,000.00	47,000.00	**173,000.00**		
PFLUGER, GERRY Acnt:00000193 Unit: 124-52St	43,000.00	34,500.00	31,500.00	**109,000.00**		
Pilakapsi, Aaron & Tootoo, Corrine Acnt:00000290 Unit: 210-67St	63,000.00	32,500.00	31,500.00	**127,000.00**		
Pilakapsi, Catherine Acnt:00000291 Unit: 102-24Av	54,000.00	23,000.00	17,500.00	**94,500.00**		
PILAKAPSI, DEBBIE Acnt:00000292 Unit: 207-63St	61,000.00	54,000.00	63,000.00	**178,000.00**		
Pilakapsi, Hannah Acnt:00000294 Unit: 212-67St	54,000.00	14,000.00	60,000.00	**128,000.00**		
Pimentel, Emerlinda C. Acnt:50500000 Unit: 030-15St	31,000.00	56,000.00	24,500.00	**111,500.00**		
PORTER, BRENTON Acnt:00000065 Unit: 104-23ST	48,000.00	29,000.00	18,000.00	**95,000.00**		
POWELL, ESTHER Acnt:00000645 Unit: 088-64Av	65,000.00	77,000.00	87,000.00	**229,000.00**		
RBC c/o CBRE GCS Acnt:00000931 Unit: 100-24Av	36,000.00	54,000.00	90,000.00	**180,000.00**		
Roach, Ron & Goretti Acnt:00000478 Unit: 004-13Av	80,000.00	42,000.00	90,000.00	**212,000.00**		
Roman Catholic Mission Acnt:00000085 Unit: 102-4Av	31,000.00	20,000.00	16,000.00	**67,000.00**		
Roman Catholic Mission Acnt:00000086 Unit: 104-4Av	22,000.00	11,500.00	7,000.00	**40,500.00**		
ROY, PETER Acnt:00000176 Unit: 012-15St	88,000.00	54,000.00	47,000.00	**189,000.00**		
Rudd, Chris Acnt:00000480 Unit: 107-21Av	49,000.00	57,000.00	61,000.00	**167,000.00**		
Ruediger, Ralph Acnt:00000481 Unit: 215-64St	40,000.00	29,000.00	34,000.00	**103,000.00**		
SABOURIN, DONNA Acnt:00000261 Unit: 216-66St	54,000.00	91,000.00	53,000.00	**198,000.00**		
SABOURIN, PAULINE Acnt:00000684 Unit: 203-51St	51,000.00	50,000.00	56,000.00	**157,000.00**		
SACULLES MELANIE & MAX MCDONALD Acnt:51600000 Unit:	12,000.00	7,500.00	12,500.00	**32,000.00**		
SACULLES, CAMILLO & IMELDA DAVID Acnt:00000118 Unit: 1	48,000.00	31,000.00	25,000.00	**104,000.00**		
SADIWA, WINILDA Acnt:00000078 Unit: 018-11Av	81,000.00	47,000.00	43,000.00	**171,000.00**		
Sammurtok, Alex Acnt:00000485 Unit: 145-24Av	64,000.00	123,000.00	93,000.00	**280,000.00**		
SAMMURTOK, KARYNA & MINGERIAK KOLOLA Acnt:000005	90,000.00	45,000.00	51,000.00	**186,000.00**		

SAMMURTOK, MELODIE Acnt:00000632 Unit: 068-64Av	37,000.00	54,000.00	56,000.00	**147,000.00**		
SAMMURTOK, TOM Acnt:00000039 Unit: 009-12St	51,000.00	23,000.00	28,000.00	**102,000.00**		
San Leasing Ltd / DUPLEX Acnt:00000487 Unit: 105-23St.1	61,000.00	0.00	0.00	**61,000.00**		
Sandy, Eddie Acnt:00000521 Unit: 212-64St	37,000.00	27,000.00	32,000.00	**96,000.00**		
Sandy, James Acnt:00000522 Unit: 122-52St	57,000.00	64,000.00	90,000.00	**211,000.00**		
SANERTANUT, FRANCES Acnt:00000127 Unit: 022-11Av	52,000.00	89,000.00	84,000.00	**225,000.00**		
Sanertanut, Paul & Lucy Acnt:00000524 Unit: 197-24Av	64,000.00	59,000.00	41,000.00	**164,000.00**		
SANGUIN, KEVIN Acnt:00000954 Unit: 239-60St	54,000.00	45,000.00	36,000.00	**135,000.00**		
Sateana, Danny Acnt:00000526 Unit: 236-60St	57,000.00	31,000.00	34,000.00	**122,000.00**		
Sateana, James Acnt:00000527 Unit: 030-12Av	44,000.00	81,000.00	62,000.00	**187,000.00**		
Sateana, Steven & Roxanne Acnt:00000529 Unit: 237-60St	69,000.00	124,500.00	136,000.00	**329,500.00**		
SAYLES, STEVE Acnt:00000972 Unit: 042-15St	49,000.00	7,500.00	8,500.00	**65,000.00**		
Schindel, Brian & Vivian Acnt:00000900 Unit: 217-63St	75,000.00	59,000.00	39,000.00	**173,000.00**		
Sharp, Keith Acnt:00000537 Unit: 002-24St	64,000.00	43,500.00	29,500.00	**137,000.00**		
SHARP, PELAGIE Acnt:00000539 Unit: 117-21Av	53,000.00	93,000.00	90,000.00	**236,000.00**		
SHEARMAN, RALPH Acnt:00000049 Unit: 108-21St	34,000.00	20,000.00	15,000.00	**69,000.00**		
Shirley, Susan Acnt:00000540 Unit: 111-25St	49,000.00	35,000.00	20,000.00	**104,000.00**		
Shouldice, Michael Acnt:00000943 Unit: 113-25St	51,000.00	46,000.00	51,000.00	**148,000.00**		
SIGURDSON, MRS Acnt:00000868 Unit: 115-21Av	47,000.00	77,000.00	41,000.00	**165,000.00**		
SIGURDSON, PAKAK Acnt:00000166 Unit: 126-14St	47,000.00	53,000.00	35,000.00	**135,000.00**		
Siksik, Steven & Nancy Acnt:00000957 Unit: 013-12St	52,000.00	36,000.00	53,000.00	**141,000.00**		
SMITH CIELO Acnt:00000235 Unit: 214-66St	47,000.00	22,000.00	38,000.00	**107,000.00**		
SMITH, ALLAN Acnt:00000132 Unit: 024-15St	54,000.00	75,000.00	72,000.00	**201,000.00**		
SMITH, PATRICK Acnt:50100000 Unit: 016-11AV	0.00	0.00	24,000.00	**24,000.00**		
Smith, Tammy Acnt:00000553 Unit: 026-11Av	36,000.00	0.00	0.00	**36,000.00**		
Smutylo, Dale Acnt:00000554 Unit: 102-23Av	47,000.00	21,000.00	8,000.00	**76,000.00**		
SOLOMON, MARY-ANN Acnt:00000555 Unit: 108-23St	36,000.00	35,000.00	13,500.00	**84,500.00**		
Strickland, Joe Acnt:51700000 Unit: 116-52St	58,000.00	44,500.00	34,000.00	**136,500.00**		
Strickland, Rick Acnt:00000556 Unit: 111-51St	16,000.00	9,000.00	9,000.00	**34,000.00**		
SUBGUT, GIBSON Acnt:00000248 Unit: 012-11St	54,000.00	39,000.00	36,000.00	**129,000.00**		
TAGOONA, PATRICK Acnt:52100000 Unit: 209-66ST	8,000.00	6,000.00	35,000.00	**49,000.00**		
Taipana, John & Cecilia Acnt:00000820 Unit: 080-64Av	71,000.00	51,000.00	92,000.00	**214,000.00**		
Taparti, Louis / DUPLEX /SM Acnt:00000560 Unit: 144-24Av	87,000.00	64,000.00	32,000.00	**183,000.00**		
Tartak, Joe Acnt:00000561 Unit: 105-51St	69,000.00	29,000.00	59,000.00	**157,000.00**		

Tattuinee, Jerome & Marianne Acnt:00000562 Unit: 216-64St	54,000.00	33,000.00	46,000.00	**133,000.00**		
TATTUINEE, KONO Acnt:00000896 Unit: 243-61St	54,000.00	65,000.00	76,000.00	**195,000.00**		
TATTUINEE, KYLE Acnt:05550000 Unit: 090-64 Av	95,000.00	67,000.00	69,000.00	**231,000.00**		
Tattuinee, Louie Acnt:00000563 Unit: 116-22Av	40,000.00	24,000.00	28,000.00	**92,000.00**		
Tatty, Bill & Mary Acnt:00000710 Unit: 208-62St	49,000.00	79,000.00	90,000.00	**218,000.00**		
TATTY, CHARLENE Acnt:00000818 Unit: 066-64Av	51,000.00	54,000.00	54,000.00	**159,000.00**		
Tatty, Elsa Acnt:00000564 Unit: 204-64St	61,000.00	95,000.00	109,000.00	**265,000.00**		
Tatty, Eric Acnt:00000965 Unit: 086-64Av	36,000.00	54,000.00	56,000.00	**146,000.00**		
TATTY, HAMISH Acnt:00000567 Unit: 013-14Av	58,000.00	61,000.00	46,000.00	**165,000.00**		
Tatty, John Acnt:00000566 Unit: 011-14Av	42,000.00	28,000.00	27,000.00	**97,000.00**		
TATTY, ROSS Acnt:00000563 Unit: 140-14 STREET	54,000.00	36,000.00	60,000.00	**150,000.00**		
Tatty, Simeoni Acnt:00000568 Unit: 125-24Av	39,000.00	25,000.00	23,000.00	**87,000.00**		
Tatty, Toota Acnt:00000571 Unit: 148-24Av	64,000.00	54,000.00	56,000.00	**174,000.00**		
THORNE, TEENA / STEVEN HARTMAN Acnt:00000538 Unit: 114	64,000.00	90,000.00	57,000.00	**211,000.00**		
Tiktak, Noah & Okatsiak, Margaret Acnt:00000570 Unit: 100-23St	70,500.00	42,000.00	35,000.00	**147,500.00**		
TODD, JASON /DUPLEX Acnt:51800000 Unit: 140/142-54St	84,000.00	83,000.00	69,000.00	**236,000.00**		
Tongola, Sandy Acnt:00000523 Unit: 120-14St	45,000.00	24,000.00	56,000.00	**125,000.00**		
Tootoo, Barney Acnt:00000572 Unit: 119-21Av	77,000.00	52,000.00	56,500.00	**185,500.00**		
TOOTOO, DOROTHY Acnt:00000245 Unit: 046-15St	43,000.00	27,000.00	21,000.00	**91,000.00**		
TOROMONT ARCTIC LTD Acnt:01071489 Unit: 107-13ST	54,000.00	24,000.00	44,000.00	**122,000.00**		
TOWTONGIE, HARRY Acnt:00000561 Unit: 47-62 AVENUE	8,000.00	18,000.00	21,500.00	**47,500.00**		
TOWTONGIE, HARRY Acnt:00000573 Unit: 230-60St	54,000.00	54,000.00	100,000.00	**208,000.00**		
Towtongie, Harry Acnt:00000919 Unit: 114-24St	66,000.00	54,000.00	56,000.00	**176,000.00**		
TOWTONGNIE, NECO Acnt:00000559 Unit: 110-24St	71,000.00	60,000.00	47,000.00	**178,000.00**		
TUCKTOO, DALLAS Acnt:52500000 Unit: 211-61ST	54,000.00	53,000.00	46,500.00	**153,500.00**		
TULUGAK, DAVID & MARLENE Acnt:00000576 Unit: 122-54St	65,000.00	64,000.00	120,000.00	**249,000.00**		
TULUGAK, SANDRA Acnt:00000579 Unit: 192-24Av	81,000.00	54,000.00	1,500.00	**136,500.00**		
Tulugak, Jeff Acnt:00000578 Unit: 203-24Av	67,000.00	121,000.00	36,000.00	**224,000.00**		
Tungilik, Theresie Acnt:00000581 Unit: 021-15St	39,000.00	20,000.00	23,000.00	**82,000.00**		
TUTANUAK, RONNIE & RITA Acnt:00000914 Unit: 146-24Av	54,000.00	91,000.00	100,000.00	**245,000.00**		
Tutanuak, Samson Acnt:00000582 Unit: 011-12St	54,000.00	35,000.00	100,000.00	**189,000.00**		
ULUADLUAK, MANDY Acnt:00000513 Unit: 107-22Av	80,000.00	74,000.00	76,000.00	**230,000.00**		
USSAK, JOSEPHINE Acnt:00000984 Unit: 044-15St	32,000.00	80,000.00	83,000.00	**195,000.00**		
Wallace, John Acnt:00000618 Unit: 102-22St	52,000.00	47,000.00	31,000.00	**130,000.00**		

Wallace, Tracy Acnt:00000619 Unit: 106-22Av	41,000.00	72,000.00	75,000.00	**188,000.00**		
White, Boyd Acnt:00000620 Unit: 106-21St	7,000.00	4,000.00	21,000.00	**32,000.00**		
White, Larry Acnt:00000621 Unit: 026-12Av	61,000.00	66,000.00	67,000.00	**194,000.00**		
WHITE, MELANIE Acnt:00000819 Unit: 070-64Av	54,000.00	54,000.00	36,000.00	**144,000.00**		
Wiebe, Lyle Acnt:00000622 Unit: 129-53St	48,000.00	30,000.00	36,500.00	**114,500.00**		
WILKERSON, STUART Acnt:00000812 Unit: 012-12St	23,000.00	16,000.00	21,000.00	**60,000.00**		
Williams, Paul & Nowyah Acnt:00000623 Unit: 221-63St	61,000.00	26,000.00	50,000.00	**137,000.00**		
YAREMA, MARGARET & MIKE Acnt:00000231 Unit: 015-14Av	56,000.00	50,000.00	52,000.00	**158,000.00**		
Zawadski, Brian & Putulik, Maggie Acnt:00000630 Unit: 207-66St	70,000.00	47,000.00	71,000.00	**188,000.00**		
Total	14,604,000	13,626,500	13,462,400	41,692,900		
						OnTap - Wa

Water Usage Report By Month

Community & Government Services Department

From: AUG-15-2008 To: AUG-15-2009

TOTAL FOR YEAR (Aug 2008 to Aug 2009)			
	litres		**Check**
Com Gov/Hamlet Shared	464,500		**176,000.00**
Commercial	37,524,000		**142,000.00**
FE Gov/Hamlet Shared	108,000		**146,500.00**
Full Economic	66,882,500		
No Charge	1,112,000		
Residential	41,692,900		
TOTAL FOR YEAR (Aug 2008 to Aug 2009)	147,783,900	litres	
	147,784	**m3**	
population	2,500		
water use per person per day	162	lcd	
			125,000.00
			257,000.00
			215,000.00
			135,000.00
			98,000.00
			174,500.00
			410,000.00

					247,000.00			
					201,000.00			
					170,000.00			
					284,500.00			
					1,222,000.00			
					2,720,000.00			
					4,270,000.00			
					691,000.00			
					2,109,000.00			
					376,000.00			
					80,000.00			
					262,000.00			
					910,000.00			
					1,022,000.00			
					1,576,000.00			
					200,000.00			
					63,000.00			
					79,000.00			
					134,000.00			
					78,000.00			
					90,500.00			
					91,000.00			
					85,000.00			
					268,000.00			
					85,500.00			
					199,500.00			
					89,000.00			
					373,500.00			
					119,000.00			
					150,000.00			
					144,000.00			
					1,389,000.00			
					183,000.00			
					161,000.00			

					1,168,000.00			
					158,000.00			
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					188,000.00			
				TOTAL	**147,783,900.00**			
ter Distribution System								

UPDATE MARCH 2010

SECTOR	VOLUME PER YEAR (m3)
Residential	154,151
ICI	26,962
Total	**181,143**

Government of Nunavut - Hamlet of Rankin Inlet				
None				

Government of Nunavut - Hamlet of Rankin Inlet				
None				

Government of Nunavut - Hamlet of Rankin Inlet

Area of Use	Volume	Units
Bleeders on dead end of Utilidors	17,280,000	gallons
Bleeders at customer homes	2,430,000	gallons
Flushing of watermains		gallons
Fighting fires		gallons
Total	19,710,000	gallons
Total	**89,877**	**m3**
conversion 219.3 gallons per m3		

Comments
From Oct to May (8 months), and bleed into the sewer system. Waiting for data from Arcene
Assume 10 number / 3/4 inch pipe equivalent - 5 gpm each 24 hours per day
10 approved in 2008. There are also other that are not approved
Assume 25 number running from on average January to September (9 months) at 1/4 gpm

Government of Nunavut - Hamlet of Rankin Inlet

Theft				
Use IWA default of 0.25%				
	1,069	**m3**		

Government of Nunavut - Hamlet of Rankin Inlet

Typical customer water meter under-registration

Customer Meter Age	Estimated Under-
Years	Percentage
5 to 10	1% to 2%
10 to 15	2% to 4%
15 to 20	3% to 5%
20 to 25	5% to 8%
25+	6% to 10%+

Assume meters 15 to 25 years old - estimated under-registration of 5%

Government of Nunavut - Hamlet of Rankin Inlet				
Use IWA Default				

Government of Nunavut - Hamlet of Rankin Inlet				
Data not provided				
Population	2358			
Number of properties	580	approximate		
Assume	**40 km**	**For flow and return mains**		

Government of Nunavut - Hamlet of Rankin Inlet		
Data not provided		
Number of Customer Accounts		
Number of services	**580**	**Estimate**

Government of Nunavut - Hamlet of Rankin Inlet			
Main to curb stop			
Curb stop to house	50 ft	**15.24**	**m**

Government of Nunavut - Hamlet of Rankin Inlet

Average	psi	**m**
From	30	21
To	50	35
Average	40	**28**
conversion 1 psi is 0.7 m		

Government of Nunavut - Hamlet of Rankin Inlet		
Data not provided		
Canadian example for municipality of 600 services is $250,000		
Assume	**$750,000.00**	**Three times average**
Item	**Cost**	**Comment**
Total	$0	
Operation and Maintenance		
Salaries, benefits, insurance, administration, overhead		
Total	**$0**	

Government of Nunavut - Hamlet of Rankin Inlet

Data not provided

Cost per m3	Assumptions
0.20	Power and chemicals - typical Canadian $0.10, so double for Rankin Inlet
0.15	Heating water added to produce tempered water - estimate
0.35	total
Cost per ML	
$350.00	

Government of Nunavut - Hamlet of Rankin Inlet

Data not provided

Not Known

Canadian rates, on average $1.50 per m3 - water and sewer

Assume	**$4.50**	**per m3**	**Three times Canadian average rate**

AWWA WLCC Free Water Audit Software: Reporting Worksheet

WAS v4.0

Back to Instructions

? Click to access definition

Water Audit Report for: Regional Municipality of Peel
Reporting Year: 2008 | 1/2008 - 12/2008

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

All volumes to be entered as: MEGALITRES (THOUSAND CUBIC METRES) PER YEAR

WATER SUPPLIED << Enter grading in column 'E'

Volume from own sources:	?	7	213,977.000	Megalitres/yr (or ML/Yr)
Master meter error adjustment:	?	4	0.000	ML/Yr
Water imported:	?	n/a	0.000	ML/Yr
Water exported:	?	7	26,457.500	ML/Yr
WATER SUPPLIED:			187,519.500	ML/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:		Value:
Billed metered:	?	7	163,665.000	ML/Yr			
Billed unmetered:	?	2	433.900	ML/Yr			
Unbilled metered:	?	8	1,768.400	ML/Yr			
Unbilled unmetered:	?	5	230.100	ML/Yr		○ ●	230.100
AUTHORIZED CONSUMPTION:	?		166,097.400	ML/Yr			

Use buttons to select percentage of water supplied **OR** value

					Pcnt:		Value:
WATER LOSSES (Water Supplied - Authorized Consumption)			21,422.100	ML/Yr			
Apparent Losses							
Unauthorized consumption:	?	5	886.800	ML/Yr		○ ●	886.800
Customer metering inaccuracies:	?	7	2,851.000	ML/Yr		○ ●	2,851.000
Systematic data handling errors:	?		0.000	ML/Yr			

Systematic data handling errors are likely, please enter a non-zero value; otherwise grade = 5

Apparent Losses:	?		3,737.800	ML/Yr

Choose this option to enter a percentage of billed metered consumption. This is NOT a default value ?

Real Losses

Real Losses = Water Losses - Apparent Losses:	?		17,684.300	ML/Yr
WATER LOSSES:			21,422.100	ML/Yr

NON-REVENUE WATER

NON-REVENUE WATER:	?		23,420.600	ML/Yr

= Total Water Loss + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains:	?	8	4,161.0	kilometers	
Number of active AND inactive service connections:	?	9	287,905		
Connection density:			69	conn./km main	
Average length of customer service line:	?	5	16.0	metres	(pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	6	58.4	metres (head)	

COST DATA

Total annual cost of operating water system:	?	3	$100,000,000	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	10	$0.64	$/1000 litres
Variable production cost (applied to Real Losses):	?	10	$642.00	$/Megalitre

Retail costs are less than (or equal to) production costs; please review and correct if necessary

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume of Water Supplied:	12.5%	
Non-revenue water as percent by cost of operating system:	15.0%	
Annual cost of Apparent Losses:	$2,399,668	
Annual cost of Real Losses:	$11,353,321	

Operational Efficiency Indicators

Apparent Losses per service connection per day:	35.57	litres/connection/day
Real Losses per service connection per day*:	168.29	litres/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per meter (head) pressure:	2.88	litres/connection/day/m
? Unavoidable Annual Real Losses (UARL):	8,960.91	cubic meters/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	1.97	

* only the most applicable of these two indicators will be calculated

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 64 out of 100 *****

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Volume from own sources
2: Master meter error adjustment
3: Billed unmetered

For more information, click here to see the Grading Matrix worksheet

APPENDIX C

Residential

Toilet Replacement (HET)

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Particpants	776			
Number of Participants	698	138.75		
Number of Toilets/Participant	1.1			
Equipment and Installation	$ 918.63			$ 641,572.59
Marketing	$ 15.00			$ 10,476.00
Program Management	$ 60.00			$ 41,904.00
Project Management	$ 20.00			$ 13,968.00
Total per Participant	$ 1,013.63			
Total for Program	$ 707,920.59	96,903	$ 7.31	$ 707,920.59

Toilet Replacement (Dual Flush)

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Particpants	776			
Number of Participants	78	138.75		
Number of Toilets/Participant	1.1			
Equipment and Installation	$ 918.63			$ 71,285.84
Marketing	$ 15.00			$ 1,164.00
Program Management	$ 70.00			$ 5,432.00
Project Management	$ 20.00			$ 1,552.00
Total per Participant	$ 1,023.63			
Total for Program	$ 79,433.84	10,767	$ 7.38	$ 79,433.84

Showerhead Replacement

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	776	54		
Number of Participants	776			
Number of Showerheads/Participant	1.1			
Equipment	$ 33.00			$ 25,608.00
Installation	$ 50.00			$ 38,800.00
Marketing	$ 10.00			$ 7,760.00
Program Management	$ 30.00			$ 23,280.00
Project Management	$ 10.00			$ 7,760.00
Total per Participant	$ 133.00			
Total for Program	$ 103,208.00	42,246	$ 2.44	$ 103,208.00

Kitchen Faucet Aerator Replacement

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	776	20		
Number of Participants	776			
Number of Faucets/Participant	1.0			
Equipment	$ 13.00			$ 10,088.00
Installation	$ 20.00			$ 15,520.00
Marketing	$ 10.00			$ 7,760.00
Program Management	$ 20.00			$ 15,520.00
Project Management	$ 8.00			$ 6,208.00
Total per Participant	$ 71.00			
Total for Program	$ 55,096.00	15,644	$ 3.52	$ 55,096.00

Bathroom Faucet Aerator Replacement

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	776	24		
Number of Participants	776			
Number of Faucets/Participant	1.1			
Equipment	$ 6.00			$ 4,656.00
Installation	$ 20.00			$ 15,520.00
Marketing	$ 10.00			$ 7,760.00
Program Management	$ 20.00			$ 15,520.00
Project Management	$ 8.00			$ 6,208.00
Total per Participant	$ 64.00			
Total for Program	$ 49,664.00	18,376	$ 2.70	$ 49,664.00

Leakage Repair

Single Family		Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants		776	56		
Number of Participants		776			
Number of Leak/Participant		1.1			
Equipment	assume flapperless HET toilets	$ -			$ -
Installation	installed at no extra cost	$ -			$ -
Marketing		$ -			$ -
Program Management		$ -			$ -
Project Management		$ -			$ -
Total per Participant		$ -			
Total for Program		$ -	43,068	$ -	$ -

Water Efficient Clothes Washing

Single Family	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	776			
Number of Participants	776	19		
Equipment and Delivery	$ 1,200.00			$ 931,200.00
Marketing	$ 10.00			$ 7,760.00
Program Management	$ 30.00			$ 23,280.00
Project Management	$ 10.00			$ 7,760.00
Total per Participant	$ 1,250.00			
Total for Program	$ 970,000.00	14,356	$ 67.57	$ 970,000.00

Industrial/Commerical/Institutional

Toilet Replacement (HET)

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	62	375		
Number of Participants	44.64			
Number of Toilets/Participant	8.0			
Equipment and Installation	$ 6,680.96			$ 298,238.05
Marketing	$ 200.00			$ 8,928.00
Program Management	$ 400.00			$ 17,856.00
Project Management	$ 100.00			$ 4,464.00
Total per Participant	$ 7,380.96			
Total for Program	$ 329,486.05	16,740	$ 19.68	$ 329,486.05

Toilet Replacement (Dual Flush)

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	62	375		
Number of Participants	4.96			
Number of Toilets/Participant	8.0			
Equipment and Installation	$ 6,680.96			$ 33,137.56
Marketing	$ 300.00			$ 1,488.00
Program Management	$ 500.00			$ 2,480.00
Project Management	$ 150.00			$ 744.00
Total per Participant	$ 7,630.96			
Total for Program	$ 37,849.56	1,860	$ 20.35	$ 37,849.56

Pre-Rinse Spray Nozzle

	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of Participants	10	368		
Number of Participants	10			
Number of Nozzles/Participant	1.5			
Equipment	$ 225.00			$ 2,250.00
Installation	$ 150.00			$ 1,500.00
Marketing	$ 300.00			$ 3,000.00
Program Management	$ 700.00			$ 7,000.00
Project Management	$ 75.00			$ 750.00
Total per Participant	$ 1,450.00			
Total for Program	$ 14,500.00	3,680	$ 3.94	$ 14,500.00

ICI Audit and Capacity Buy-Back	Per Participant	Water Savings (lpd)	Cost per litre/day		
Number of Participants (Audits)	5				5
Implementation Rate	0.15				
Number of Implementation Participants	0.75				
Average Savings Per Implementation	20,000	litres per day			
Average Cost of Audit	$ 5,500.00				$ 27,500.00
Monitoring and Verification	$ 3,000.00				$ 3,000.00
Capacity Buy-back	$ 2.00	per litre per day savings			$ 30,000.00
Program Management	$ 1,500.00				$ 7,500.00
Project Management	$ 1,000.00				$ 4,250.00
Total Cost Audit Participant	$ 34,000.00				$ 72,250.00
Total for Audit/Implementation Participant	$ 38,250.00				
Total	$ 72,250.00				$ 4.82
Cost per Participant	$ 96,333.33	15,000	$ 4.82		

Distribution Leakage Reduction

Leakage Reduction	Per Participant	Water Savings (lpd)	Cost per litre/day	
Potential Number of DMAs	5	57,500		
Number of DMAs per year	5			
Field Work Cost	$ 30,000.00			$ 150,000.00
Cost to repair leak per DMA	$ 20,000.00			$ 100,000.00
Program Management	$ 3,000.00			$ 15,000.00
Project Management	$ 2,000.00			$ 10,000.00
Total per Participant	$ 55,000.00			
Total for Program	$ 275,000.00	287,500	$ 0.96	$ 275,000.00

Per Participant Costing

Residential		**Equipment & Installation**	**Marketing**	**Program Management & Administration**	**Project Management**	**Cost per Participant**	**Savings per Participant (L/d)**	**Cost per litre**
Installation	HET Toilets	$ 918.63	$ 15.00	$ 60.00	$ 20.00	$ 1,013.63	138.75	$ 7.31
Installation	Dual Flush Toilets	$ 918.63	$ 15.00	$ 70.00	$ 20.00	$ 1,023.63	138.75	$ 7.38
Installation	Low Flow Showerheads	$ 83.00	$ 10.00	$ 30.00	$ 10.00	$ 133.00	54	$ 2.44
Installation	Kitchen Faucets	$ 33.00	$ 10.00	$ 20.00	$ 8.00	$ 71.00	20	$ 3.52
Installation	Bathroom Faucets	$ 26.00	$ 10.00	$ 20.00	$ 8.00	$ 64.00	24	$ 2.70
Installation	Leakage Repair	$ -	$ -	$ -	$ -	$ -	56	$ -
Installation	Clotheswashers	$ 1,200.00	$ 10.00	$ 30.00	$ 10.00	$ 1,250.00	19	$ 67.57
Industrial, Commercial, Institutional								
Installation	HET Toilets	$ 6,680.96	$ 200.00	$ 400.00	$ 100.00	$ 7,380.96	375	$ 19.68
Installation	Dual Flush Toilets	$ 6,680.96	$ 300.00	$ 500.00	$ 150.00	$ 7,630.96	375	$ 20.35
Installation	Pre-Rinse Spray Valves	$ 375.00	$ 300.00	$ 700.00	$ 75.00	$ 1,450.00	368	$ 3.94
Installation	ICI Audits and Capacity Buy-back	$ -	$ -	$ -	$ -	$ 72,250.00	15,000	$ 4.82
Municipal								
Installation	Leakage Reduction	$ 50,000.00	$ -	$ 3,000.00	$ 2,000.00	$ 55,000.00	57,500	$ 0.96

Total Program Costing

Residential		Number Product Installed	Equipment & Installation	Marketing	Program Management & Administration	Project Management	Total Cost	Total Program Savings (L/d)	Cost per litre	Utility Electrical Savings (KWh/yr)	Utility Electric Bill Savings ($/yr)	CO2 Reductions (tonnes/yr)
Installation	HET Toilets	768	$ 641,572.59	$ 10,476.00	$ 41,904.00	$ 13,968.00	$ 707,920.59	96,903	$ 7.31	24,051	$ 8,482.90	14.4
Installation	Dual Flush Toilets	85	$ 71,285.84	$ 1,164.00	$ 5,432.00	$ 1,552.00	$ 79,433.84	10,767	$ 7.38	2,672	$ 942.54	1.6
Installation	Low Flow Showerheads	854	$ 64,408.00	$ 7,760.00	$ 23,280.00	$ 7,760.00	$ 103,208.00	42,246	$ 2.44	10,485	$ 3,698.19	6.3
Installation	Kitchen Faucets	776	$ 25,608.00	$ 7,760.00	$ 15,520.00	$ 6,208.00	$ 55,096.00	15,644	$ 3.52	3,883	$ 1,369.49	2.3
Installation	Bathroom Faucets	854	$ 20,176.00	$ 7,760.00	$ 15,520.00	$ 6,208.00	$ 49,664.00	18,376	$ 2.70	4,561	$ 1,608.61	2.7
Installation	Leakage Repair	854	$ -	$ -	$ -	$ -	$ -	43,068	$ -	10,689	$ 3,770.18	6.4
Installation	Clotheswashers	776	$ 931,200.00	$ 7,760.00	$ 23,280.00	$ 7,760.00	$ 970,000.00	14,356	$ 67.57	3,563	$ 1,256.73	2.1
Industrial, Commercial, Institutional												
Installation	HET Toilets	357	$ 298,238.05	$ 8,928.00	$ 17,856.00	$ 4,464.00	$ 329,486.05	16,740	$ 19.68	4,155	$ 1,465.42	2.5
Installation	Dual Flush Toilets	40	$ 33,137.56	$ 1,488.00	$ 2,480.00	$ 744.00	$ 37,849.56	1,860	$ 20.35	462	$ 162.82	0.3
Installation	Pre-Rinse Spray Valves	15	$ 3,750.00	$ 3,000.00	$ 7,000.00	$ 750.00	$ 14,500.00	3,680	$ 3.94	913	$ 322.15	0.5
Installation	ICI Audits and Capacity Buy-back	5	$ 60,500.00	$ -	$ 7,500.00	$ 4,250.00	$ 72,250.00	15,000	$ 4.82	3,723	$ 1,313.10	2.2
Municipal												
Installation	Leakage Reduction	5	$ 250,000.00	$ -	$ 15,000.00	$ 10,000.00	$ 275,000.00	287,500	$ 0.96	60,864	$ 21,466.64	36.5
Education												
Public Education (5 years)							$ 150,000.00					
Youth Education (5 years)							$ 180,000.00					
			Equipment/Installation	Marketing	Prog. Mngmt	Proj. Mngmt.	Total Cost	Total Savings				
			$ 2,399,876.05	$ 13,416.00	$ 174,772.00	$ 63,664.00	$ 3,024,408.05	566,140	$ 5.34	130,022	$ 45,858.79	78.0

Residential	Water Efficiency Measure	Cost per Participant	Savings per Participant (L/d)	Cost per litre
Installation	HET Toilets	$ 1,014	139	$ 7.31
Installation	Dual Flush Toilets	$ 1,024	139	$ 7.38
Installation	Low Flow Showerheads	$ 133	54	$ 2.44
Installation	Kitchen Faucets	$ 71	20	$ 3.52
Installation	Bathroom Faucets	$ 64	24	$ 2.70
Installation	Leakage Repair	$ -	56	$ -
Installation	Clotheswashers	$ 1,250	19	$ 67.57
ICI				
Installation	HET Toilets	$ 7,381	375	$ 19.68
Installation	Dual Flush Toilets	$ 7,631	375	$ 20.35
Installation	Pre-Rinse Spray Valves	$ 1,450	368	$ 3.94
Installation	ICI Audits and Capacity Buy-back	$ 72,250	15,000	$ 4.82
Municipal				
Installation	Leakage Reduction	$ 55,000	57,500	$ 0.96

Residential	Water Saving Measure	Number of Product Installed	Total Cost	Total Program Savings (L/d)	Cost per litre
Installation	HET Toilets	768	$ 707,921	96,903	$ 7.31
Installation	Dual Flush Toilets	85	$ 79,434	10,767	$ 7.38
Installation	Low Flow Showerheads	854	$ 103,208	42,246	$ 2.44
Installation	Kitchen Faucets	776	$ 55,096	15,644	$ 3.52
Installation	Bathroom Faucets	854	$ 49,664	18,376	$ 2.70
Installation	Leakage Repair	854	$ -	43,068	$ -
Installation	Clotheswashers	776	$ 970,000	14,356	$ 67.57
Industrial, Commercial, Institutional					
Installation	HET Toilets	357	$ 329,486	16,740	$ 19.68
Installation	Dual Flush Toilets	40	$ 37,850	1,860	$ 20.35
Installation	Pre-Rinse Spray Valves	15	$ 14,500	3,680	$ 3.94
Installation	ICI Audits and Capacity Buy-back	5	$ 72,250	15,000	$ 4.82
Municipal					
Installation	Leakage Reduction	5	$ 275,000	287,500	$ 0.96
Education					
Public Education (5 years)			$ 150,000		
Youth Education (5 years)			$ 180,000		
TOTAL			$ 3,024,408	566,140	$ 5.34

RESIDENTIAL - Maintenance

Residential		Cost per Participant	Participants (Capital)	Year 1 Maintenance (1%)	Year 1 Annual Cost	Year 2 Maintenance (2%)	Year 2 Annual Cost	Year 3 Maintenance (3%)	Year 3 Annual Cost	Year 4 Maintenance (3%)	Year 4 Annual Cost	Year 5 Maintenance (3%)	Year 5 Annual Cost	Total
Indoor	Showerheads	$ 33.00	854	8.54	$ 281.82	17.1	$ 563.64	51.24	$ 1,690.92	76.86	$ 2,536.38	102.48	$ 3,381.84	
	Kitchen Faucet Aerators	$ 13.00	776	7.76	$ 100.88	15.5	$ 201.76	46.56	$ 605.28	69.84	$ 907.92	93.12	$ 1,210.56	
	Bathroom Aerators	$ 6.00	854	8.54	$ 51.24	17.1	$ 102.48	51.24	$ 307.44	76.86	$ 461.16	102.48	$ 614.88	
	Clotheswashers	$ 35.00	779											
	Program Mngmt/Admin				$ 8,000.00		$ 8,000.00		$ 8,000.00		$ 8,000.00		$ 8,000.00	
Total					$ 8,433.94		$ 8,867.88		$ 10,603.64		$ 11,905.46		$ 13,207.28	$ 53,018.20
Toilet Flappers	HET Toilets	$ 75.00	768	7.68	$ 576.00	15.4	$ 1,152.00	46.08	$ 3,456.00	69.12	$ 5,184.00	92.16	$ 6,912.00	
	Dual Flush Toilets	$ 115.00	85	0.85	$ 97.75	1.7	$ 195.50	5.1	$ 586.50	7.65	$ 879.75	10.2	$ 1,173.00	
	Program Mngmt/Admin				$ 8,000.00		$ 8,000.00		$ 8,000.00		$ 8,000.00		$ 8,000.00	
					$ 8,673.75		$ 9,347.50		$ 12,042.50		$ 14,063.75		$ 16,085.00	$ 60,212.50
Total														
					$ 17,107.69		$ 18,215.38		$ 22,646.14		$ 25,969.21		$ 29,292.28	$ 113,230.70
TOTAL RESIDENTIAL														

INDUSTRIAL/COMMERCIAL/INSTITUTIONAL

		Cost per Participant	Participants (Capital)	Year 1 Maintenance (1%)	Year 1 Annual Cost	Year 2 Maintenance (2%)	Year 2 Annual Cost	Year 3 Maintenance (3%)	Year 3 Annual Cost	Year 4 Maintenance (3%)	Year 4 Annual Cost	Year 5 Maintenance (3%)	Year 5 Annual Cost	Total
Large Volume Industrial/Commercial/Institutional														
	Pre-Rinse Spray Valves	$ 150.00	30	0.3	$ 45.00	0.6	$ 90.00	1.8	$ 270.00	2.7	$ 405.00	10	$ 1,500.00	
	Program Mngmt/Admin				$ 6,000.00		$ 6,000.00		$ 6,000.00		$ 6,000.00		$ 8,000.00	
					$ 6,045.00		$ 6,090.00		$ 6,270.00		$ 6,405.00		$ 9,500.00	$ 34,310.00
Total														
Toilet Flappers	HET Toilets	$ 75.00	446	4.46	$ 334.50	8.9	$ 669.00	26.76	$ 2,007.00	40.14	$ 3,010.50	53.52	$ 4,014.00	
	Dual Flush Toilets	$ 115.00	50	0.5	$ 57.50	1.0	$ 115.00	3	$ 345.00	4.5	$ 517.50	6	$ 690.00	
	Program Mngmt/Admin				$ 6,000.00		$ 6,000.00		$ 6,000.00		$ 6,000.00		$ 6,000.00	
					$ 6,392.00		$ 6,784.00		$ 8,352.00		$ 9,528.00		$ 10,704.00	$ 41,760.00
Total														
		$ 1,500.00	1		$ -		$ -	1	$ 1,500.00	1	$ 1,500.00	1	$ 1,500.00	
ICI Audit and Capacity Buyback	Program Mngmt/Admin								$ 6,000.00		$ 6,000.00		$ 6,000.00	
					$ -		-		$ 7,500.00		$ 7,500.00		$ 7,500.00	$ 22,500.00
Total														
TOTAL INDUSTRIAL/COMMERCIAL/INSTITUTIONAL					$ 12,437.00		$ 12,874.00		$ 22,122.00		$ 23,433.00		$ 27,704.00	$ 98,570.00

Five Year Maintenance Plan	**Year 1 Costs**	**Year 2 Costs**	**Year 3 Costs**	**Year 4 Costs**	**Year 5 Costs**	**Total**
Residential	$ 17,107.69	$ 18,215.38	$ 22,646.14	$ 25,969.21	$ 29,292.28	$ 113,230.70
Industrial/Commercial/Institutional	$ 12,437.00	$ 12,874.00	$ 22,122.00	$ 23,433.00	$ 27,704.00	$ 98,570.00
Distribution Leakage Reduction				$ 60,000.00	$ 90,000.00	$ 150,000.00
Total	$ 29,544.69	$ 31,089.38	$ 44,768.14	$ 109,402.21	$ 146,996.28	$ 361,800.70

Residential		End-Use Monitoring Sample Size	End-use Monitoring one month pre, one post	Persistance Audits Sample Size	Persistance Audits Year 5 150 sample	Total
	HET Toilets	30	$ 45,000.00	125	$ 8,750.00	
	Dual Flush Toilets	15	$ 22,500.00	25	$ 1,750.00	
	Clothes Washer	30	$ 45,000.00	150	$ 10,500.00	
	Showers,Faucets,	30	$ 45,000.00	150	$ 9,000.00	
TOTAL RESIDENTIAL INDOOR			$ 157,500.00		$ 30,000.00	$ 187,500.00
Industrial/Commercial/Institutional						
	Pre-rinse spray valves	10	$ 15,000.00	10	$ 800.00	
	HET Toilets	20	$ 42,000.00	60	$ 4,800.00	
	Dual Flush Toilets	10	$ 21,000.00	20	$ 1,600.00	
TOTAL INDUSTRIAL/COMMERCIAL/INSTITUTIONAL			$ 78,000.00		$ 7,200.00	$ 85,200.00
			$ 235,500.00		$ 37,200.00	
				$ 157,500.00	15,000	

Five Year Monitoring and Evaluation Plan	
	Costs
Residential	$ 187,500.00
Industrial, Commercial and Institutional	$ 85,200.00
Total	$ 272,700.00

Five Year Monitoring and Evaluation Plan	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
	Costs	**Costs**	**Costs**	**Costs**	**Costs**	**Costs**
Residential	$ 157,500				$ 30,000	$ 187,500
Industrial, Commercial and Institutional	$ 78,000				$ 7,200	$ 85,200
Total	$ 235,500	$ -	$ -	$ -	$ 37,200	$ 272,700

APPENDIX D

Program Descriptions

Table of Contents

Toilet Replacement - HET

Residential

Incentive	Free Supply and Installation
Savings Per Participant	139 litres per average day
Cost Per Participant	$1,014.00
Number of Participants	698
Number of Toilets	768
Program Costs	$707,920
Program Savings (litres per average day)	96,903
Cost per Litre per Average Day Saved	$7.31
Monitoring Cost	$53,750

Program Description

Through a mass campaign, all residential toilets would be replaced with High Efficiency toilets (HETs) or Dual Flush toilets. A contractor, selected through a tendering process would go door to door replacing the existing toilets with the new HET toilets. It is assume that 90% of the participant would select and HET toilet while 10% would select the dual flush models. Toilets would be purchased and shipped in bulk ensuring the lowest cost possible. Existing toilets would be removed and scrapped.

It is recommended that the toilets selected for this campaign be EPA WaterSense approved to ensure sustained water savings and a high level of customer satisfaction amongst program participants.

Assumptions

Savings

- Current housing stock is 776 units[1]
- Assume 90% of the participants would select an HET toilet model and 10% would select a dual flush model[2]
- 698 participants
- 3.7 persons per household[1]
- 1.1 toilets per household[3]
- 5 flushes per person per day[4]
- Average flush volume per existing toilet is 12.3 litres[5]
- Average flush volume per replaced toilet is 4.8 litres[6]

Savings per Participant = (Existing toilet flush volume – Replaced toilet flush volume)
x number of flushes per person per day
x number of persons per household

Savings per Participant = (12.3 – 4.8) x 5.0 x 3.7 = 139 litres per average day

Costs per Participant

- Assume 1.1 toilets per participant
- Equipment cost is $535.12
- Installation cost is $300.00
- Marketing cost is $15.00
- Program management cost is $60.00
- Project management cost is $20.00

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.

[2] Assumption.

[3] Rankin Inlet, Customer Survey, RMSi, October 2009.

[4] American Water Works Association, Research Foundation. Residential End Uses of Water Study. 1999.

[5] Rankin Inlet, Household Audits, RMSi, October 2009.

[6] US Environmental Protection Agency, WaterSense Program, 2009.

Toilet Replacement – Dual Flush

Residential

Incentive	Free Supply and Installation
Savings Per Participant	139 litres per average day
Cost Per Participant	$1,023.00
Number of Participants	78
Number of Toilets	85
Program Costs	$79,434
Program Savings (litres per average day)	10,767
Cost per Litre per Average Day Saved	$7.38
Monitoring Cost	$24,250

Program Description

Through a mass campaign, all residential toilets would be replaced with High Efficiency toilets (HETs) or Dual Flush toilets. A contractor, selected through a tendering process would go door to door replacing the existing toilets with the new HET toilets. It is assume that 90% of the participant would select and HET toilet while 10% would select the dual flush models. Toilets would be purchased and shipped in bulk ensuring the lowest cost possible. Existing toilets would be removed and scrapped.

It is recommended that the toilets selected for this campaign be EPA WaterSense approved to ensure sustained water savings and a high level of customer satisfaction amongst program participants.

Assumptions

Savings

- Current housing stock is 776 units[1]
- Assume 10% of the participants would select a dual flush toilet model and 10% [2]
- 78 participants
- 3.7 persons per household[1]
- 1.1 toilets per household[3]
- 5 flushes per person per day[4]
- Average flush volume per existing toilet is 12.3 litres[5]
- Average flush volume per replaced toilet is 4.8 litres[6]

Savings per Participant = (Existing toilet flush volume – Replaced toilet flush volume)
x number of flushes per person per day
x number of persons per household

Savings per Participant = (12.3 – 4.8) x 5.0 x 3.7 = 139 litres per average day

Costs per Participant

- Assume 1.1 toilets per participant
- Equipment cost is $535.12
- Installation cost is $300.00
- Marketing cost is $15.00
- Program management cost is $70.00
- Project management cost is $20.00

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.

[2] Assumption.

[3] Rankin Inlet, Customer Survey, RMSi, October 2009.

[4] American Water Works Association, Research Foundation. Residential End Uses of Water Study. 1999.

[5] Rankin Inlet, Household Audits, RMSi, October 2009.

[6] US Environmental Protection Agency, WaterSense Program, 2009.

Clothes Washer Replacement

Residential

Incentive	Free Supply and Delivery
Savings Per Participant	19 litres per average day
Cost Per Participant	$1,250.00
Number of Participants	776
Number of Clothes Washers	776
Program Costs	$970,000
Program Savings (litres per average day)	14,356
Cost per Litre per Average Day Saved	$67.57
Monitoring Cost	$55,500

Program Description

Through a mass campaign, all residential clothes washers would be replaced with water efficient front loading models. Water efficient clothes washers would be purchased and shipped in bulk ensuring the lowest cost possible. Washers would be delivered to each home and the existing machines removed for scrap.

It is recommended that the clothes washers selected for this campaign be Energy Star rated to ensure sustained water savings and a high level of customer satisfaction amongst program participants. Significant energy savings can be attributed to water efficient clothes washers. Not only do they use less hot water, the machines themselves are inherently energy efficient. Energy providers may be interested in partnering in this program.

Assumptions

Savings

- Current housing stock is 776 units[1]
- 3.7 persons per household[1]
- 0.204 wash cycles per person per day[2]
- Average consumption per cycle of existing clothes washer is 79 litres[3]
- Average consumption per cycle of replaced clothes washer is 55.5 litres [4]

Savings per Participant = (Existing clothes washer volume – Replaced clothes washer volume)
x number of cycles per person per day x number of persons per household

Savings per Participant = (80 – 55.5) x 0.204 x 3.7 = 19 litres per average day

Costs per Participant

- Equipment cost is $1,200.00
- Marketing cost is $10.00
- Program management cost is $30.00
- Project management cost is $10.00

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.
[2] Rankin Inlet, Customer Survey, RMSi, October 2009.
[3] Rankin Inlet, Household Audits, RMSi, October 2009.
[4] Based on analysis of Energy Star Canada listing, 2008.

Low Flow Showerheads

Residential

Incentive	Free Supply and Installation
Savings Per Participant	54 litres per average day
Cost Per Participant	$133
Number of Participants	776
Number of Showerheads	854
Program Costs	$103,208
Program Savings (litres per average day)	42,246
Cost per Litre per Average Day Saved	$2.44
Monitoring Cost	$18,000

Program Description

Low flow showerheads would be installed in all homes in Rankin Inlet through a mass campaign. Low flow showerheads save approximately 60% of the water during a shower while maintaining good shower performance. In addition to reducing water bills, low flow showers contribute to lower energy bills due to the less hot water used. Through a mass campaign, all showerheads would be replaced with water efficient low flow models. Water efficient showerheads would be purchased and shipped in bulk ensuring the lowest cost possible. An installing contractor would be selected by a tendering process. Existing showerheads would be removed for scrap.

Due to the inherit energy savings attributed to low flow showerheads, energy providers may be interested in partnering in this program.

Assumptions

Savings

- Current housing stock is 776 units[1]
- 3.7 persons per household[1]
- 1.1 showerheads per household[2]
- 0.44 showers per person per day[2]
- Average length of shower is 7.6 minutes[3]
- Average flow rate per existing showerhead is 12.0 litres per minute[4]
- Average flow rate per replaced showerhead is 7.6 litres per minute[5]

Savings per Participant = (Existing shower flow rate – Replaced shower flow rate)
x number of showers per person per day x average length of shower
x number of persons per household

Savings per Participant = (12.0-7.6) x 0.44 x 7.6 x 3.7 = 54 litres per average day

Costs per Participant

- Assume 1.1 showerheads per participant
- Equipment cost is $33.00
- Installation cost is $50.00
- Marketing cost is $10.10
- Program management cost is $30.00
- Project management cost is $10.00

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.

[2] Rankin Inlet, Customer Survey, RMSi, October 2009.

[3] American Water Works Association, Research Foundation. Residential End Uses of Water Study. 1999.

[4] Rankin Inlet, Household Audits, RMSi, October 2009.

[5] Showerhead manufacturer data, 2009.

Kitchen Faucet Aerators **Residential**

Incentive	Free Supply and Installation	
Savings Per Participant	20 litres per average day	
Cost Per Participant	$71.00	
Number of Participants		776
Number of Kitchen Faucets		776
Program Costs		$55,096
Program Savings (litres per average day)		15,644
Cost per Litre per Average Day Saved		$3.52
Monitoring Cost		$18,000

Program Description

Low flow kitchen faucet aerators would be installed in all homes in Rankin Inlet through a mass campaign. Through a mass campaign, low flow aerators would be installed on all kitchen faucets. Water efficient aerators would be purchased and shipped in bulk ensuring the lowest cost possible. An installing contractor would be selected by a tendering process. Existing aerators would be removed for scrap.

In addition to reducing water bills, low flow faucet aerators contribute to lower energy bills due to the less hot water used. Energy providers may be interested in partnering in this program.

Assumptions

Savings

- Current housing stock is 776 units[1]
- 3.7 persons per household[1]
- 1 kitchen faucet per household[2]
- Average length of use is 8.4 minutes per day[3]
- Average flow rate per existing kitchen faucet is 11.8 litres per minute[4]
- Average flow rate per replaced faucet is 5.7 litres per minute[5]

Savings per Participant = (Existing faucet flow rate – Replaced faucet flow rate)
x average length of use per day

Savings per Participant = (8.1 – 5.7) x 8.4 = 20 litres per average day

Costs per Participant

- Equipment cost is $13.00
- Installation cost is $20.00
- Marketing cost is $10.00
- Program management cost is $20.00
- Project management cost is $8.00

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.

[2] Rankin Inlet, Customer Survey, RMSi, October 2009.

[3] Regional Municipality of Waterloo. Water Efficiency Master Plan Update Research Study, May 24, 2006.

[4] Rankin Inlet, Household Audits, RMSi, October 2009.

[5] Faucet aerator manufacturer data, 2009.

Bathroom Aerators **Residential**

Incentive	Free Supply and Installation
Savings Per Participant	24 litres per average day
Cost Per Participant	$64.00
Number of Participants	776
Number of Bathroom Aerators	854
Program Costs	$49,664
Program Savings (litres per average day)	18,376
Cost per Litre per Average Day Saved	$2.70
Monitoring Cost	$18,000

Program Description

Low flow bathroom faucet aerators would be installed in all homes in Rankin Inlet through a mass campaign. Through a mass campaign, low flow aerators would be installed on all bathroom faucets. Water efficient aerators would be purchased and shipped in bulk ensuring the lowest cost possible. An installing contractor would be selected by a tendering process. Existing aerators would be removed for scrap.

In addition to reducing water bills, low flow faucet aerators contribute to lower energy bills due to the less hot water used. Energy providers may be interested in partnering in this program.

Assumptions

Savings

- Current housing stock is 776 units[1]
- 3.7 persons per household[1]
- 1.1 bathroom faucets per household[2]
- Average length of use is 2.0 minutes per person per day[3]
- Average flow rate per existing bathroom faucet is 7.0 litres per minute[4]
- Average flow rate per replaced faucet is 3.8 litres per minute[5]

Savings per Participant = (Existing faucet flow rate – Replaced faucet flow rate)
x average length of use per day

Savings per Participant = (7.0 – 3.8) x 2.0 x 3.7 = 24 litres per average day

Costs per Participant

- Equipment cost is $6.00
- Installation cost is $20.00
- Marketing cost is $10.00
- Program management cost is $20.00
- Project management cost is $8.00

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.
[2] Rankin Inlet, Customer Survey, RMSi, October 2009.
[3] Assumption.
[4] Rankin Inlet, Household Audits, RMSi, October 2009.
[5] Faucet aerator manufacturer data, 2009.

Leakage Repair Residential

Incentive	None Required
Savings Per Participant	56 litres per average day
Cost Per Participant	Included in toilet program
Number of Participants	776
Number of Leaks	776
Program Costs	$0
Program Savings (litres per average day)	43,068
Cost per Litre per Average Day Saved	$0.00
Monitoring Cost	Included in toilet program

Program Description

Leaks in homes can account for up to 13.7%[2] of the total household usage. It has been assumed that toilet flapper leakage is equivalent to 10% of the total household usage. Flappers wear out or deteriorate over time causing water from the cistern to leak down the toilet drain. In many cases these leaks are silent and as such undetected. It is suggested that the Municipality selects a flapperless toilet model for its toilet replacement program. This approach will eliminate existing and future flapper leakage. Flapperless toilets, which cost no more than other toilets, are available in HET models and are EPA WaterSense approved.

Assumptions

Savings

- Current housing stock is 776 units[1]
- 3.7 persons per household[1]
- 15.0 litres per day per person of leakage[2]

Savings per Participant = Existing leakage rate per person per day x number of persons per household

Savings per Participant = 15.0 x 3.7 = 56 litres per average day

Costs per Participant

- No additional costs incurred. Need only to specify flapperless toilets when purchasing for the toilet replacement program.

References

[1] Statistics Canada, 2006 Census, Community Profile, Rankin Inlet.

[2] Assume toilet flapper leakage is equivalent to approximately 10% of household use or 15.0 lpd.

Toilet Replacement - HET Industrial, Commercial, Institutional

Incentive	Free Supply and Installation
Savings Per Participant	375 litres per average day
Cost Per Participant	$7,381.00
Number of Participants	45
Number of Toilets	357
Program Costs	$329,486
Program Savings (litres per average day)	16,740
Cost per Litre per Average Day Saved	$19.68
Monitoring Cost	$46,800

Program Description

Through a mass campaign, all toilets in the Industrial, Commercial and Institutional sector would be replaced with High Efficiency toilets (HETs) or Dual Flush toilets. A contractor, selected through a tendering process would go door to door replacing the existing toilets with the new HET toilets. It is assume that 90% of the participant would select and HET toilet while 10% would select the dual flush models. Toilets would be purchased and shipped in bulk ensuring the lowest cost possible. Existing toilets would be removed and scrapped.

It is recommended that the toilets selected for this campaign be EPA WaterSense approved to ensure sustained water savings and a high level of customer satisfaction amongst program participants.

Assumptions

Savings

- 62 business units[1]
- 80% of businesses would qualify and 90% would select the HET models[2]
- 8 toilets per building[2]
- 5 flushes per person per day[3]
- 10 persons on premise per day assumed[2]
- Average flush volume per existing toilet is 12.3 litres[4]
- Average flush volume per replaced toilet is 4.8 litres[5]

Savings per Participant = (Existing toilet flush volume – Replaced toilet flush volume)
x number of flushes per person per day
x number of persons on premise per day

Savings per Participant = (12.3 – 4.8) x 5.0 x 10 = 375 litres per average day

Costs per Participant

- Assume 8 toilets per participant
- Equipment cost is $4,280.96
- Installation cost is $2,400.00
- Marketing cost is $200.00
- Program management cost is $400.00
- Project management cost is $100.00

References

[1] Water Billing Data, Rankin Inlet, 2009.
[2] Assumption.
[3] American Water Works Association, Research Foundation. Residential End Uses of Water Study. 1999.
[4] Rankin Inlet, Household Audits, RMSi, October 2009.
[5] US Environmental Protection Agency, WaterSense Program, 2009.

Toilet Replacement – Dual Flush Industrial, Commercial, Institutional

Incentive	Free Supply and Installation
Savings Per Participant	375 litres per average day
Cost Per Participant	$7,631.00
Number of Participants	5
Number of Toilets	40
Program Costs	$37,850
Program Savings (litres per average day)	1,860
Cost per Litre per Average Day Saved	$20.35
Monitoring Cost	$22,600

Program Description

Through a mass campaign, all toilets in the Industrial, Commercial and Institutional sector would be replaced with High Efficiency toilets (HETs) or Dual Flush toilets. A contractor, selected through a tendering process would go door to door replacing the existing toilets with the new HET toilets. It is assume that 90% of the participant would select and HET toilet while 10% would select the dual flush models. Toilets would be purchased and shipped in bulk ensuring the lowest cost possible. Existing toilets would be removed and scrapped.

It is recommended that the toilets selected for this campaign be EPA WaterSense approved to ensure sustained water savings and a high level of customer satisfaction amongst program participants.

Assumptions

Savings

- 62 business units[1]
- 80% of business would qualify and 10% would select the Dual Flush models[2]
- 8 toilets per building[2]
- 5 flushes per person per day[3]
- 10 persons on premise per day assumed[2]
- Average flush volume per existing toilet is 12.3 litres[4]
- Average flush volume per replaced toilet is 4.8 litres[5]

Savings per Participant = (Existing toilet flush volume – Replaced toilet flush volume)
x number of flushes per person per day
x number of persons on premise per day

Savings per Participant = (12.3 – 4.8) x 5.0 x 10 = 375 litres per average day

Costs per Participant

- Assume 8 toilets per participant
- Equipment cost is $4,280.96
- Installation cost is $2,400.00
- Marketing cost is $300.00
- Program management cost is $500.00
- Project management cost is $150.00

References

1 Water Billing Data, Rankin Inlet, 2009.

2 Assumption.

3 American Water Works Association, Research Foundation. Residential End Uses of Water Study. 1999.

4 Rankin Inlet, Household Audits, RMSi, October 2009.

5 US Environmental Protection Agency, WaterSense Program, 2009.

Pre-Rinse Spray Valves

Industrial, Commercial, Institutional

Incentive	Free Supply and Installation
Savings Per Participant	368 litres per average day
Cost Per Participant	$1,450
Number of Participants	10
Number of Nozzles	15
Program Costs	$14,500
Program Savings (litres per average day)	3,680
Cost per Litre per Average Day Saved	$3.94
Monitoring Cost	$15,800

Program Description

Pre-rinse spray valves would be provided and installed free of charge in approximately 10 businesses with cafeterias and commercial kitchens. Low flow pre-rinse spray valves have a flow rate of 6 litres per minute while maintaining good cleaning performance. In addition to reducing water bills, low flow pre-rinse spray valves contribute to lower energy bills due to the less hot water used.

Assumptions

Savings

- 10 potential units[1]
- 1.5 valves per business[2]
- 245 litres per valve per day savings[3]

Savings per Participant = savings per valve x number of valves replaced

Savings per Participant = 245 x 1.5 = 368 litres per average day

Costs per Participant

- Assume 1.5 valves per participant
- Equipment cost is $225.00
- Installation cost is $150.00
- Marketing cost is $300.00
- Program management cost is $700.00
- Project management cost is $75.00

References

[1] Potential developed from Rankin Inlet Business Directory, Canada-Nunavut Business Service Centre, 2009.

[2] Assumption.

[4] Regional Municipality of Waterloo. Pre-rinse Spray Valve Research Study. January 2005.

Audit and Capacity Buyback — Industrial, Commercial, Institutional

Incentive	$2.00 per litre per average day saved
Savings Per Participant	15,000 litres per day
Cost Per Participant	$72,250
Number of Participants	1.0
Program Costs	$72,250
Program Savings (litres per average day)	15,000
Cost per Litre per Average Day Saved	$4.82
Monitoring Cost	Included above

Program Description

A rebate or capacity-buyback of $2.00 per litre per average day would be provided to large volume industrial clients who replace inefficient processes with water efficient processes. The capacity buyback would be available to any client who participated in the ICI Water Audit program. Five audits would be completed and it is anticipated that 1.0 of the audited clients will implement water saving measures. Savings would have to be verified before the capacity-buyback is paid.

Assumptions

Savings

- Target 5 facilities[1]
- Average 15,000 litres per day savings per participant[2]

Savings per Participant = Savings per participant as referenced above

Savings per Participant = 15,000 litres per day

Costs per Participant

- 5 audits to be completed
- 1.0 of those audited clients will implement water savings
- Average savings per participant per day is 15,000 litres
- Capacity buyback is $2.00 per litre per average day saved
- Average cost of an audit is $5,500.00
- Average cost for monitoring and verification is $3,000.00
- Program management cost is $1,500.00
- Project management cost is $1,000.00

References

[1] Based on Rankin Inlet billing data, 2009.

[2] Based on results from York Region's Industrial Audit Program from 1998 to 2004.

Distribution Leakage Reduction **Municipal**

Incentive	
Savings Per District Meter Area	57,500 litres per average day
Cost Per District Meter Area	$55,000
Number of District Meter Areas	5
Program Costs	$275,000
Program Savings (litres per average day)	287,500
Cost per Litre per Average Day Saved	$0.96
Monitoring Cost	included

Program Description

Active Leak Detection Overview

Over the last 10 years, there has been considerable progress in the development of practices and techniques to identify and reduce losses in water distribution systems. There are in essence three types of leaks associated with a water distribution system, which are:

1. Reported leaks, which come to the surface, and are repaired
2. Unreported leaks, which do not surface, but are economic to repair (larger leaks). These leaks are best found using District Meter Areas (DMAs)
3. Background leakage, which do not surface, and are not economic to repair (very small leaks). These leaks can be reduced by flow modulation, using Permanent DMAs

The methods of leak detection fall into two main categories, namely "passive" and "active" leak detection, which can conveniently be defined as follows:

Passive leak detection

Repair of reported leaks

Active leak detection

Traditional leak detection sounding survey and leak pinpointing
Temporary flow monitoring, using the District Meter Area (DMA) methodology
Permanent flow monitoring, using permanent DMAs

District Meter Area Approach

The approach used to complete leak detection using District Meter Areas is as follows:

1. Conduct initial meetings and site inspections with Hamlet staff.
2. Design of DMAs based on meetings with Hamlet staff and review of water distribution system map
3. Identification of associated valve closures and potential flow metering locations.
4. The Hamlet completes the tapings for the temporary flow meters, including installing any chambers.
5. Set up DMAs and data log the flows for 7 days.
6. Identify the recorded Night Flow, establish Legitimate Night Flow (or Background Leakage), and Identify Potential Leakage.
7. Identify DMAs where leakage is evident and complete methods to find the general area of the leak (step-testing) within the DMA.

8. Pinpoint the leaks using acoustic leak detection and correlation methods and report on the locations for a directed repair program.
9. The Hamlet repairs the identified leaks
10. Repeat DMA operation after the identified leaks have been repaired, to confirm leakage reduction.
11. Report on the findings of the program with procedures for an ongoing Water Loss Management Program to be undertaken by the Hamlet staff.

Assumptions

Savings

- 5 Temporary District Meter Areas (DMAs) to be completed
- Average 57,500 litres per day savings per DMA
- 287,500 litres per day in saving from the completion of 5 DMAs

Costs per Participant

- 5 Temporary DMAs to be completed
- Average cost for implementing a temporary DMA is $30,000 which includes design, installation of temporary flowmeter and data logging for 7 days, step testing and leak pinpointing, and verifying savings after the leak repair
- Estimated average cost for repairing leaks in each DMA is $20,000 per DMA
- Note, providing insertion points, operation of all valves, repairing leaks would be the responsibility of the Hamlet
- Program management cost is $3,000 per DMA
- Project management cost is $2,000 per DMA

Broad-scale Public Education

Annual Cost	$30,000
Total 5 Year Cost	$150,000

Program Description

Technical solutions can only go so far in achieving overall water savings. Education that changes habits and attitudes towards water use is needed to finish the job. An important element of the Hamlet's water efficiency program has been public outreach and education. These activities are intended to educate and change the water-use attitudes of Rankin Inlet's residents. Activities that could be undertaken include:

- Literature including booklets, leaflets and flyers
- Two water efficiency bulletins distributed in the water bills annually
- Display booths at community events
- Displays at the Hamlet Administration Office
- Presentations at service clubs, community and youth groups
- Hamlet of Rankin Inlet Water Efficiency website

In addition to traditional education and communication strategies, it is recommended that the City develop and pursue a community based social marketing (CBSM) approach to education. Highly effective in the solid waste education programs during the past decade, CBSM techniques are being introduced more and more into water conservation and efficiency programs across North America.

Youth Education

Annual Cost	$36,000
Total 5 Year Cost	$180,000

Program Description

It is intended that the Hamlet develops an educational program that meets current Curriculum standards and can be delivered by the Hamlet's elementary school teachers. The program and supporting materials would be developed to support the current curriculum at the Grade 7 and 8 levels - specifically targeting Geography and Science expectations, but incorporating language, art and mathematics activities. An interactive website could be developed where teachers can direct their students for assistance on projects or to have fun completing a water quiz. A poster drawing contest resulting in an annual calendar could be held every year.

In addition to the Grade 7 & 8 program, it is suggested that the Hamlet considers hosting a Children's Water Festival. Students will learn about water and the environment in the out-of-doors at an annual Children's Water Festival. The festival can be held over one day where Grade 3 to 5 students learn by participating in over 40 curriculum based activities about water and the environment. Children's Water Festivals are held around the world. For more information about this opportunity please visit the Children's Water Education Council website at www.cwec.ca.

FSC
ARCHITECTS & ENGINEERS

J. KENT
April 20/10

PERMIT TO PRACTICE
FSC ARCHITECTS AND ENGINEERS
(5107 NWT LTD.)
Signature
Date 20/APRIL/2010
PERMIT NUMBER: P0457
The Association of Professional Engineers,
Geologists and Geophysicists of the NWT / NU

Nipissar Lake Volume Study and Environmental Variable Study

Rankin Inlet, NU

GN Project # 09-3009
FSC Project # 2009-1310

April 20, 2010

Prepared for:

The Office of the Regional Director
Kivalliq Region
Dept. of Community and Government Services
Government of Nunavut
Delivered to Project Management/O&M Building
P.O. Bag #002, Rankin Inlet, Nunavut X0C 0G0
Attn: Dawn Brigham, Project Officer

Prepared by:

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LISTEN. DESIGN. MANAGE.

FSC
ARCHITECTS & ENGINEERS

FSC File: 2009-1310
April 20, 2010

Government of Nunavut
Dept. of Community & Government Services
Public Works Building, PO Bag 002
Rankin Inlet, Nunavut X0C 0G0

Attn: Dawn Brigham, Project Officer

Re: Water Supply Capacity, Consumption & Conservation Study

Dear Ms. Brigham,

Please find attached our Final Report on the volume calculation of Nipissar Lake and the affecting climatic variables.

You asked the following questions of an earlier draft; our answers follow your questions.

When will Nipissar Lake fail to be an adequate water source for Rankin Inlet? *Ans: As early as 2015*

What is the maximum consumption rate per day Nipissar Lake can provide? *Ans: 854,000 litres/day*

When do you estimate Rankin will reach the maximum consumption rate? *Ans: It has been reached now.*

Please contact us should you have any questions regarding this report.

Sincerely,

FSC ARCHITECTS & ENGINEERS

Kevin Hodgins, P. Eng., Principal
Civil Engineering

Table of Contents

1 Definitions

LCPD	Litres per capita per day, the total daily volume of water supplied to the community divided by the population of the community.
Evapotranspiration	Discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces and by transpiration from plants.
ILI	Infrastructure Leakage Index, ratio of CARL/UARL.
Apparent Losses	Volume of water from unauthorised consumption (theft) and metering inaccuracies (calibration and accounting errors).
CARL	Current Annual Real Losses, the water supplied and deducting the calculated authorized consumption and apparent losses.
UARL	Unavoidable Annual Real Losses, volume of leakage within the CARL that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair.
Minimum Pumping Volume	Volume of Nipissar Lake required to submerge pumping equipment for withdrawal.
Maximum Annual Withdrawal Rate	Estimated recharge rate to Nipissar Lake from inputs such as precipitation, and is therefore the restricting volume of water that can be withdrawn without forcing the overall annual Lake volume to decrease.

2 Understanding of Project

In this report FSC has three important tasks that were asked for in the RFP. These were:

1. Determine the volume of Nipissar Lake and calculate any losses compared to the Bathymetry and Topographical survey that was completed in 1995 by Vista Engineering.

2. Complete an environmental assessment of climate variables affecting the Nipissar Lake watershed capacity and report on how these might be affecting the long-term storage potential of the reserve.

3. Complete a review of historical precipitation and evapo-transpiration rates to establish if the current volume reduction of Nipissar Lake is a result of climatic variables or municipal consumption/wastage.

3 Volume Calculations

To accurately calculate the current volume of Nipissar Lake, a survey was completed of the water level on September 26, 2009. This information was used to determine the volume of Nipissar Lake.

To make sure that the volume calculation in 2009 was consistent with the Vista survey done in 1995, the two drawings were compared to each other. Vista's original reference point could not be located at the time of FSC's 2009 survey. FSC's reference point (TBM 1) was generated from Canada Control Markers (CCMs) established for the fuel project.

A scan of the mapping from the Vista 1995 survey was inserted into the current base drawing as provided by the Government of Nunavut and scaled to match existing features such as roadways and lake outlines. However, Vista's mapping is from 1994 and this older technology now shows as very pixilated, rather than as smooth line.

The shoreline from the FSC 2009 survey fit neatly into the outline of the lake from the earlier Vista mapping. The reference point (TBM 1) established in the FSC 2009 survey was noted to fall slightly above a contour line from the Vista survey mapping.

The elevation of the reference point was 12.72 m and the contour line from the Vista survey map was approximately 15.00 m.

As the elevations did not match exactly, a correction factor of 2.36 m (i.e. + 0.08 m) was selected to consider the pixilated nature of the mapping and the slightly elevated location of FSC TBM 1.

The correction factor was then applied to the bathymetric survey elevations and several major contours were traced from the scanned mapping. These major contours were used to estimate the total volume of the lake.

The current volume of the Lake is 2,809,259.60 cubic meters. Appendix A contains drawings for more detail.

Table 3.1: Nipissar Lake Volume

Survey	Volume
1995 survey	3,469,780.00 m^3
2009 survey	2,809,259.60 m^3
Difference	- 660,520.40 m^3

4 Climate Variables

Rankin Inlet is located in the continuous permafrost mid-Arctic region of the Canadian Shield, on the west coast of Hudson Bay. Topographic relief is low. The regional terrain consists of a high proportion of bedrock, glacial till, clay, outwash gravels and peat forming the scattered soil in the region. Vegetation is of the tundra type.

Climatic data in the Rankin Inlet area is characterized, in the terms of long-term normals, by the published data from Environment Canada between the year of 1981 and 2008. A summary of this data as well as information from the 1996 Stanley Report is provided below.

Table 4.1: Climatic Data

Climatic Parameter	**Average Value**	
	2009 Report	**1996 Report**
Annual Rainfall	180.39643 mm	146 mm
Annual Snowfall	128.7393 cm	113 cm
Annual Precipitation	305.425 mm	259 mm [1]
Days with Snow	77.8	66
Days with Rain	46.9	36
Daily Average Temperature	-11 C °C	- 11.6 °C
Daily Maximum Temperature	-7.3 °C	- 7.9 °C
Daily Minimum Temperature	-14.7 °C	- 15.2 °C°C
Start Date of Snowcover	mid October	mid October
Finish Date of Snowcover	mid June	mid June
Average Snow Depth	16 cm	No data
Lake freeze over Date	mid October	mid October
Lake Ice-Free Date	mid July	mid July
Lake Ice Thickness	Approx 200 cm	200 cm

Based on the comparison between the climatic parameters of the 1996 report and the 2009 report, there is a slight difference between the two sets of data. The 2009 data shows an 18 % increase in days with snow. This same data shows an increase of 30 % of days with rain. This information is constant with the annual rainfall and snowfall being greater then in the 1996 Report. Because the rainfall and snowfall have increased from the earlier report, an increase into the potential input into Nipissar Lake may occur.

The temperature difference between the 2009 report and the 1996 report vary on an average of 5% between the Daily Average, Daily Maximum and the Daily Minimum. The 2009 report temperatures are

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[1] The Stanley report of 1996 used mean annual precipitation from Chesterfield Inlet for their data. This report used mean annual precipitation from Rankin Inlet. Rankin inlet and Chesterfield Inlet are only 80 km apart and for the basis for this report the geographic difference will be considered irrelevant. The 1996 Report chose Chesterfield Inlet because of the similarity to Rankin Inlet.

all warmer then the 1996 report temperatures. The slight increase could lead to move evaporation in the warmer months and thus more water loss.

Because of the short time span that this report looks at temperature, the difference could be based on the lack of data for the area. To see a 5% increase in temperature in 27 years appears to be very dramatic. Global climate change has seen only a fraction of a degree increase over the last century.

The start and finish dates of snowcover are the same from the 2009 report to the 1996 report. Although this date varies from year to year, snowcover can be generally expected in mid October. This has not changed from the earlier Stanley report. The same can be said about the lake freezing dates.

4.1 PRECIPITATION

Based on the information shown below in Table 4.2, and the Original Stanley data from 1996, the average precipitation shows an increase from the 1996 numbers. The percentage of increase is shown in the table below.

Table 4.2: Precipitation Increases

Item	Percent Increase
Rainfall	+ 24 %
Snowfall	+ 14%
Precipitation	+ 18 %

The amount of rainfall in Rankin Inlet has increased from an average of 146 mm annually to an average of 180 mm annually. This average would mean an increase of available input into Nipissar Lake. The amount of snowfall has also increased 14%, which would mean more snow to be deposited into the watershed area and into the lake in the spring when it melts.

The Stanley Report acquired their parameters for Rankin Inlet from Weather data from 1981 to 1994, a period of only 14 years. For this report, Environment Canada provided information from 1981 to 2008, a period of 28 years. Because of the increased amount of weather data the 2009 parameters will be more historically accurate. Having twice the data set may help to explain why there is such an apparent increase in Rainfall, Snowfall and Precipitation. Additionally, if data from Environment Canada was chosen for years 1981–1994, and compared to that for years 1995-2008, very little difference would be noticed. This is summarized in the table 4.3 below.

Table 4.3: Overall Precipitation Amounts

Years	1981-1994	1995-2008
Rainfall	181.5 mm	179.2 mm
Snowfall	126.6 cm	130.8 cm
Precipitation	302.7 mm	308.1 mm

Table 4.4: Ranking Inlet Annual Precipitation

Year	Total Rain (mm)	Total Snow (cm)	Total Precip. (mm)
1981	199	101.1	297.8
1982	171	108.7	277.3
1983	233.9	97.2	323.4
1984	174.9	102.5	262.2
1985	255.7	209.5	449.2
1986	168.8	103.5	270.1
1987	161.4	189.4	352.5
1988	110.3	117.4	221.4
1989	133.4	68.5	198.1
1990	253.4	162.6	399.9
1991	228.6	165.8	387.8
1992	139.8	113.7	253.2
1993	191.4	121.8	313.2
1994	120	111.1	231.5
1995	197.8	73.6	271.2
1996	159.2	96.2	254.6
1997	139.9	99.6	240.6
1998	189.8	102.6	289.8
1999	268.4	120.6	388
2000	133.3	108	241.7
2001	230.4	145.8	371.8
2002	174.2	115	287.8
2003	158.4	146.8	303.6
2004	156.8	180.4	337.2
2005	163	257.8	417
2006	222.6	152.6	373.6
2007	161.9	92.5	243.2
2008	153.8	140.4	294.2
Average	**180.4**	**128.7**	**305.4**

Looking at the historical precipitation rates from 1981 to 2008 we see dry years and wet years with an average of 180 mm. There are no obvious trends that state historical precipitation is on the increase or decrease. So we must conclude that it is relatively stable. The increased percentage from the 1996 Stanley Report can be explained by the lack of climatic data and the fact that the 1996 report.

4.2 EVAPOTRANSPIRATION

Evapotranspiration is based on evaporation and vegetation. The vegetation in the watershed area has remained constant since 1996 so there would be no difference between then and now.

The rate of evaporation is primarily a function of temperature, pressure, wind speed and direction, relative humidity and surface area. All of these factors interplay.

For the purpose of this study, we will assume that for now and in the future, inflow to the lake and losses from the lake remains stable and evapotranspiration is not a factor in the analysis.

5 AWWA - IWA Water Audit

The Government of Nunavut completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit and Water Balance for the Hamlet of Rankin Inlet Water System.

The information determined from the audit was previously used in the Rankin Inlet, Water Consumption and Conservation Study, Draft Report, December 4, 2009 completed by FSC Architects & Engineers and Resource Management Strategies Inc.

The study explained that the World Bank Target Matrix provides performance categories according to a Infrastructure Leakage Index (ILI) shown in Table 5.1. The ILI is based on the ratio of Unavoidable Annual Real Losses (UARL) and Current Annual Real Losses (CARL).[2]

The CARL is the volume of water remaining after the calculated authorized consumption and apparent losses are subtracted from the total water supplied to the community.

An apparent loss is any volume of water from unauthorized consumption (ex. theft) and metering inaccuracies (ex. calibration and accounting errors).

The UARL is volume of leakage within the CARL that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair.

Table 5.1: ILI Performance Categories

ILI Range	Performance Category	Real Loss Management
1 – 2	A	Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost effective improvement
2 – 4	B	Potential for marked improvements; consider pressure management, better active leakage control practices, and better network management
4 – 8	C	Poor leakage record, tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensify leakage reduction efforts
>8	D	Very inefficient use of resources; leakage reduction programs imperative and high priority.

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[2] *Rankin Inlet, Water Consumption and Conservation Study, Draft Report, December 4, 2009, FSC Architects & Engineers, Resource Management Strategies Inc.*

6 Results and Discussion

6.1 COMPARISON WITH AWWA - IWA WATER AUDIT

The volume of Nipissar Lake has approximately decreased by 660,520 cubic meters over the past 15 years. As we are not considering climate to be a factor in this exercise, then an increase in population and water usage is the primary cause for the drop in Nipissar Lake.

The Town of Rankin Inlet is currently drawing more water from Nipissar Lake then water is recharged through natural precipitation and other sources. Using the two known water volumes of Nipissar Lake for 1994 and 2009, an average lake decrease of 44,035 m^3/year of water was determined. The same procedure was completed in determining an annual water usage of 355,824 m^3/year for Rankin Inlet.

The difference between the annual lake decrease and annual water usage is the estimated annual volume of water from recharge to the lake. This volume of water is approximately 311,789 m^3/year, and is therefore the maximum rate Rankin Inlet can withdrawal without forcing the lake to continue to deplete.

The second column in Table 6.1 represents the total water supplied to Rankin Inlet, which corresponds to an ILI of 12.62, placing them in performance D category. As stated in the RMSi/FSC Study, being in this category means the Hamlet of Rankin Inlet water system is operating with a very inefficient use of resources; making leakage reduction programs imperative and a high priority.[2]

Table 6.1 also shows the required management and reduction of the Unaccounted for Water in order to meet performance categories A, B, and C. The reduction of the Unaccounted for Water is not simply the reassigning of the water volume to a different water use sector; rather it is the elimination of that loss. Determining how to eliminate the Unaccounted for Water in Rankin Inlet's water system is beyond the scope of this project.

Table 6.1: Water Consumption Data for 2009 Population of 2499

Item	Current Water Use Sector[3] (m^3)	Category C Performance (m^3)	Category B Performance (m^3)	Category A Performance (m^3)
Total Billed Consumption	155,173	155,173	155,173	155,173
IWA Accounted For Water	90,956	90,956	90,956	90,956
Unaccounted for Water	181,640	*112,000*	*56,000*	*28,000*
Total Water Supplied	427,770	358,129	302,129	274,129
LCPD	**469**	**393**	**331**	**301**

Table 6.1 further shows that Rankin Inlet has already surpassed the maximum withdrawal rate Nipissar Lake can provide without continuing to decrease in volume. If the Unaccounted for Water were reduced to meet category B performance or better, Rankin Inlet could meet the maximum withdrawal rate of Nipissar Lake with its current population in 2009.

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[3] *Rankin Inlet, Water Consumption and Conservation Study, Draft Report, December 4, 2009, FSC Architects & Engineers, Resource Management Strategies Inc.*

However, as the population increases, water use increases correspondingly. Therefore, there will come a point where the Unaccounted for Water cannot be decreased any further and Rankin Inlet's water consumption rate will once again be greater than the Nipissar Lake maximum annual withdrawal rate of 311,789 m^3/year.

Figures 6.1 to 6.3 depict the projected water volume decrease in Nipissar Lake corresponding to population increases and the management of the Unaccounted for Water. All data and calculations are found in spreadsheets in Appendix B.

The objective of this exercise was to portray visually the effect of:

- Managing the Unaccounted for Water loss;
- When the lake would continue to be depleted; and
- When it will fail completely.

The projected year when Nipissar Lake will fall below the current volume can be estimated when each line intersects the Current Lake Volume line. The years at which this occurs is summarized in Table 6.2.

Table 6.2: Projected Year of Lake Depletion Below Current Volume

Population Increase	Category D Performance (Current)	Category C Performance	Category B Performance	Category A Performance
2.04%	Immediate	Immediate	2011	2019
2.5%	Immediate	Immediate	2011	2017
3.0%	Immediate	Immediate	2011	2016

The projected year when Nipissar Lake will completely fail to be an adequate source of water for Rankin Inlet can be estimated as the location when each line intersects the Minimum Pumping Volume line. The years at which this occurs is summarized in Table 6.3.

Table 6.3: Projected Year of Failure of Nipissar Lake as Adequate Water Source

Population Increase	Category D Performance (Current)	Category C Performance	Category B Performance	Category A Performance
2.04%	2022	2027	2033	2038
2.5%	2021	2025	2031	2033
3.0%	2020	2024	2028	2031

For example, if the current consumption of water continues as is (Category D), and a population increase of 2.04% is realized, Figure 6.1 suggests that Nipissar Lake will fail to be an adequate source of water as early as 2022. However, water quality and the ability to pump water from under the ice will have impacted production at least 5 years before that in 2017.

Figure 6.1: Lake Volume with 2.04% Population Increase

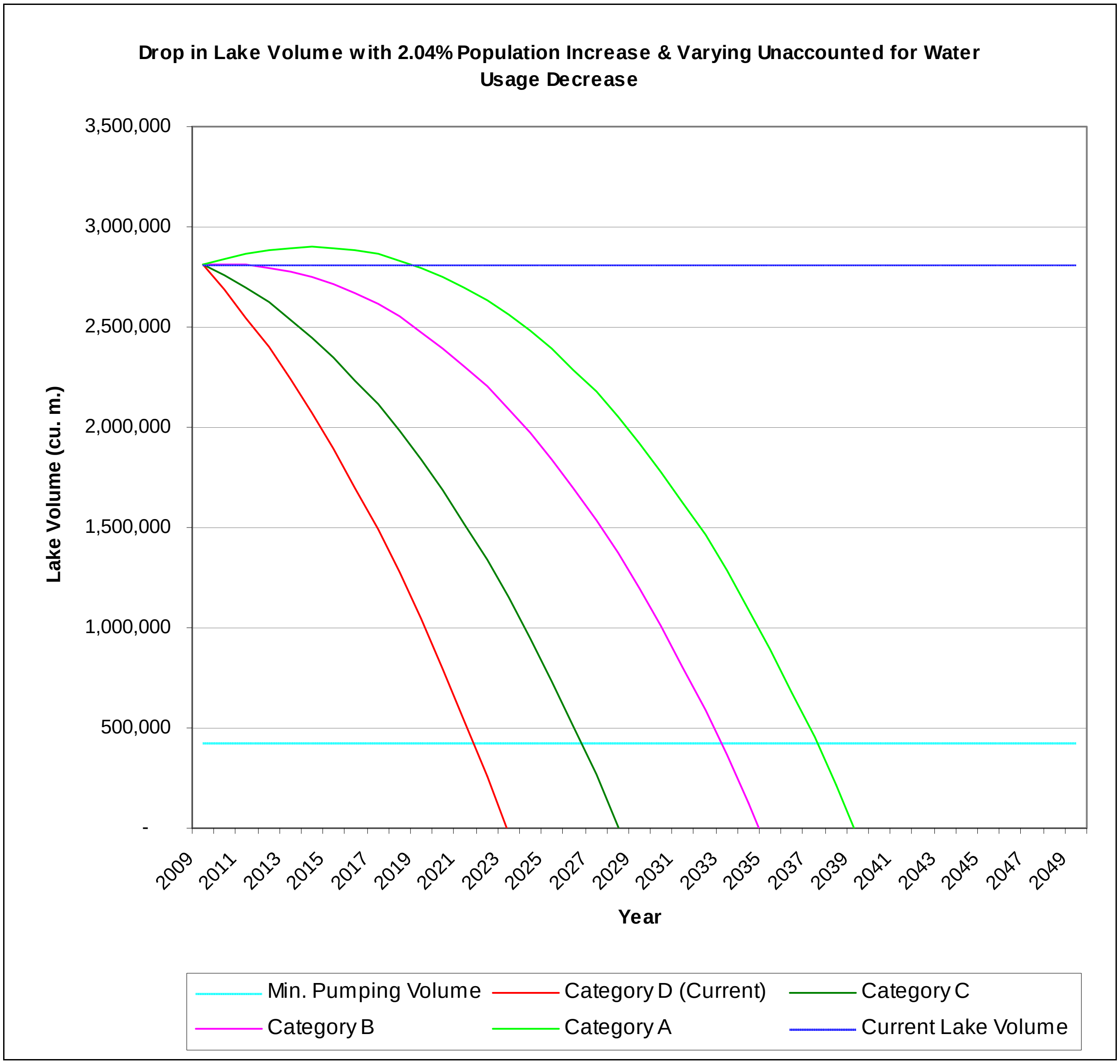


Figure 6.2: Lake Volume with 2.5% Population Increase

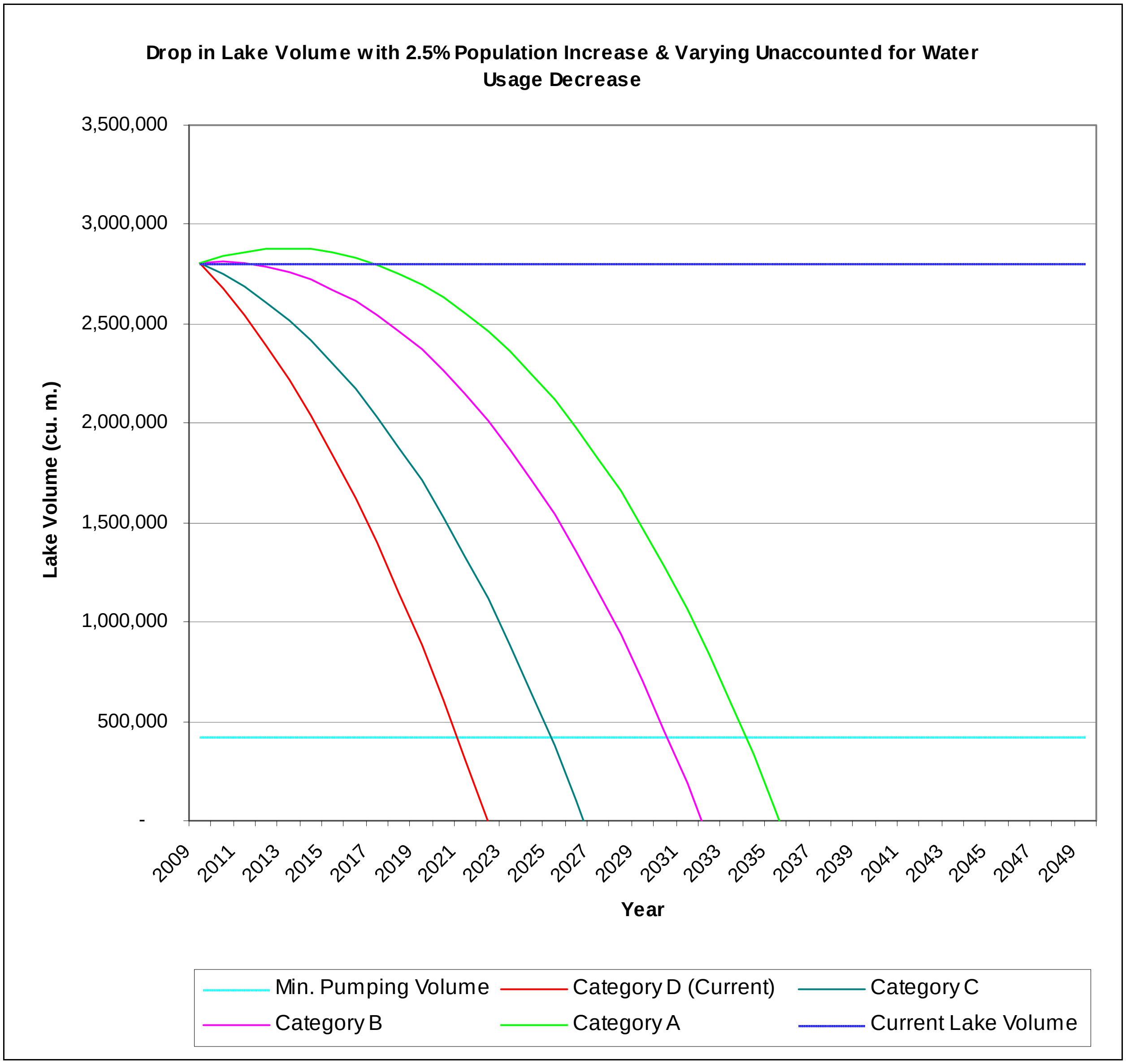
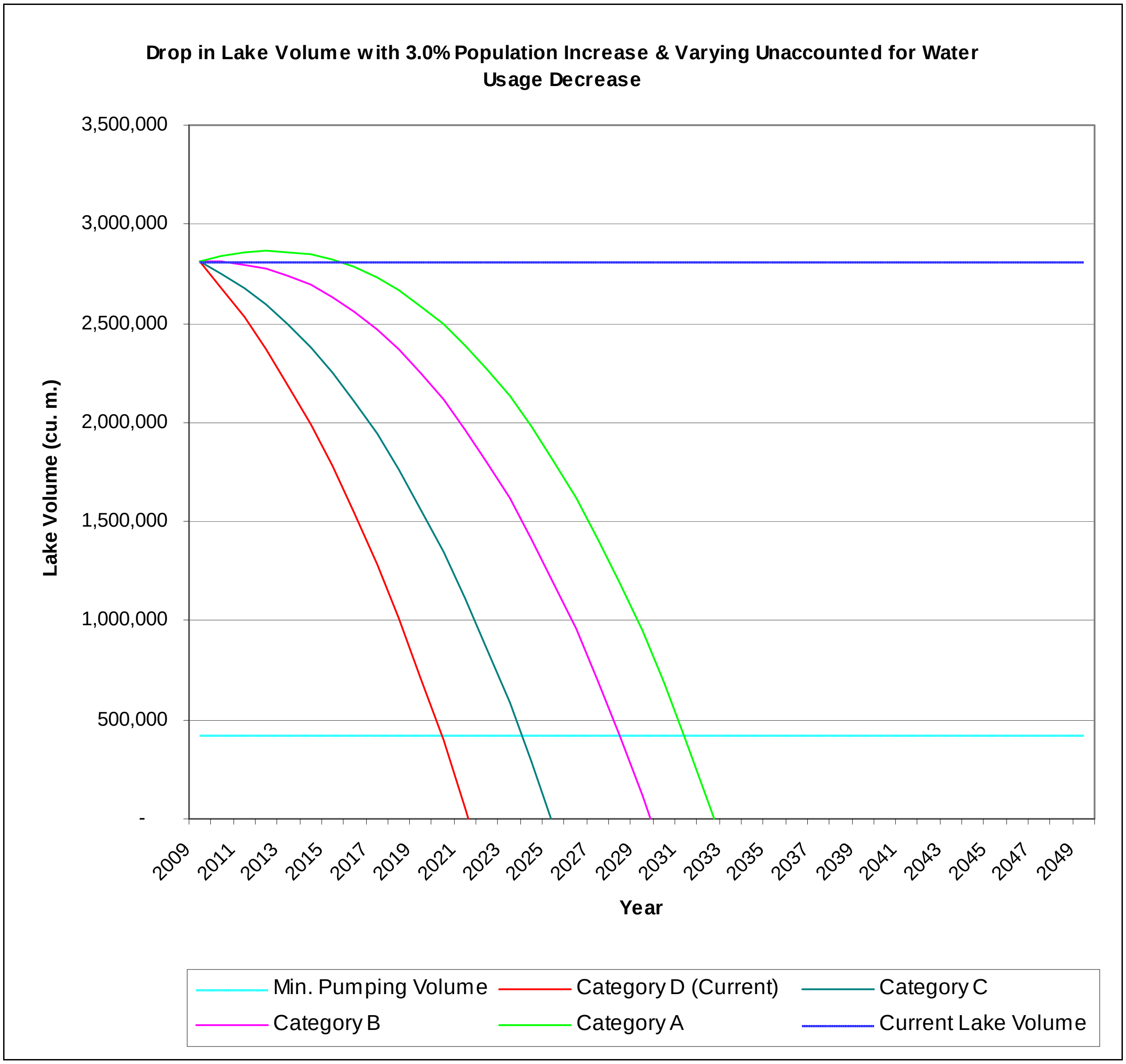


Figure 6.3: Lake Volume with 3.0% Population Increase



6.2 COMPARISON TO MACA PLANNING STANDARDS

MACA developed design usage rates for specific populations that have stood the test of time for planning purposes; the MACA usage rate for Rankin Inlet at its current 2009 population is found to be 344 LCPD.

Comparing the MACA planning rate (344 LCPD) to the proposed Category B Performance usage rate (331 LCPD) for the year 2009 suggests that continuing population increases will continue to deplete the water storage in Nipissar Lake regardless of conservation and the further elimination of the Unaccounted for Water.

This then suggests that meeting the Category B Performance or better will delay but not eliminate the need to recharge Nipissar Lake artificially.

7 Conclusions

1. The maximum rate that Nipissar Lake can provide without forcing the Lake to continue to deplete is estimated to be 311,789 m^3/year (854,000 litres/day).

2. Rankin Inlet has already surpassed the maximum withdrawal rate Nipissar Lake can provide without forcing the Lake to continue to deplete. The following table summarizes the projected year Nipissar Lake will begin to decrease from its current volume:

Population Increase	Category D Performance (Current)	Category C Performance	Category B Performance	Category A Performance
2.04%	Immediate	Immediate	2011	2019
2.5%	Immediate	Immediate	2011	2017
3.0%	Immediate	Immediate	2011	2016

3. The projected year when Nipissar Lake will fail completely can be estimated as the location when each line intersects the Minimum Pumping Volume line in Figures 6.1 to 6.3.

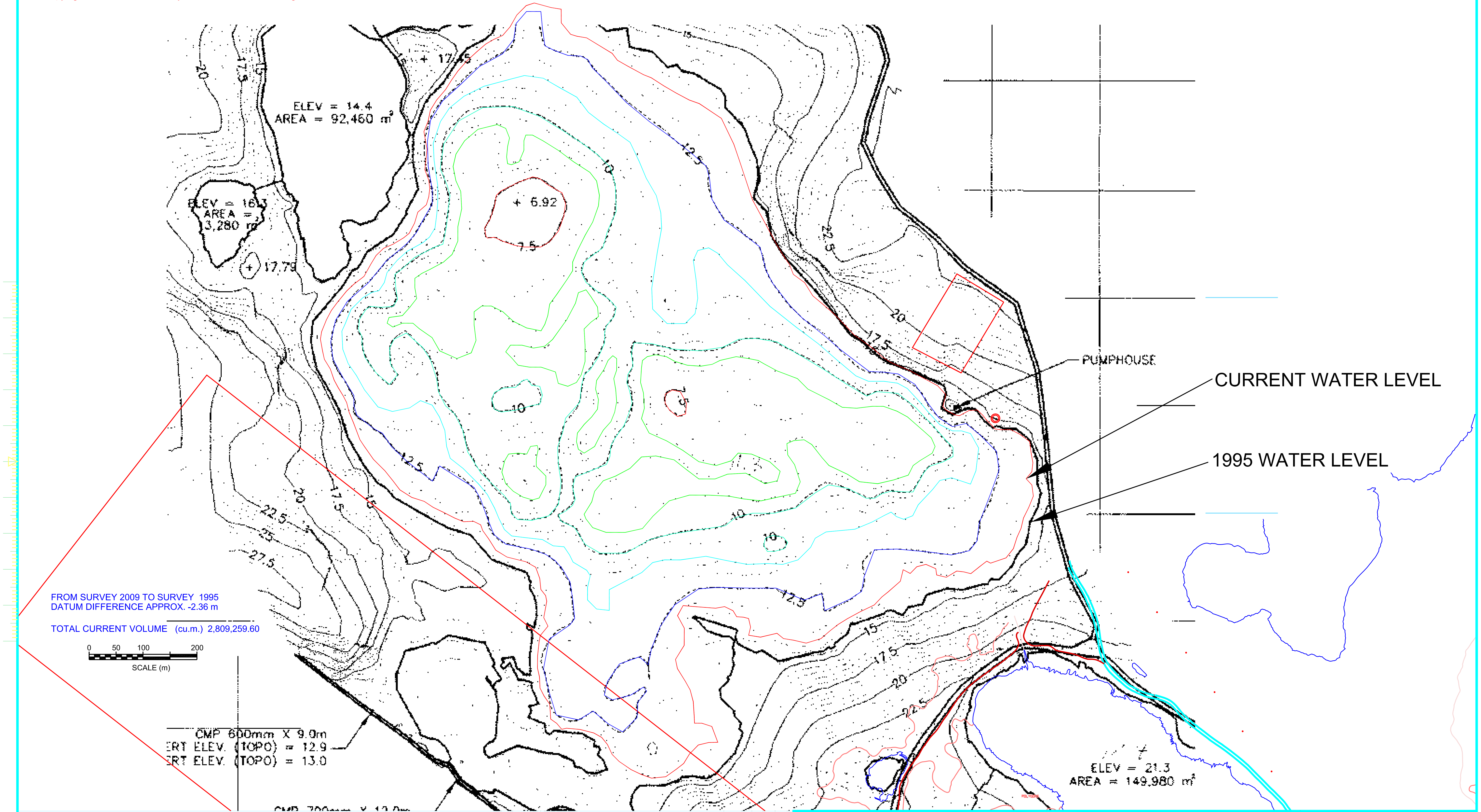
4. With the current consumption of water, and with a population increase of 2.04% realized, Figure 6.1 suggests that Nipissar Lake will fail completely as early as 2022. However, water quality and the ability to pump water from under the ice will have impacted production at least 5 years before that in 2017. The worst-case scenario for a 3.0% population increase is the year 2015, at which time water quality is expected to degrade.

5. If the Unaccounted for Water were reduced to meet Category B performance or better ($\leq$ 331 LCPD), Rankin Inlet could meet the maximum withdrawal rate of Nipissar Lake with its current 2009 population.

6. According to MACA design usage rates, Rankin Inlet requires 344 LCPD using its current 2009 population. This is a higher usage rate then that of Category B Performance, and therefore suggests that reducing the Unaccounted for Water to meet Category B Performance may be moot.

7. Continuing population increases will continue to deplete the water storage in Nipissar Lake regardless of conservation and the further elimination of unaccounted water. This then suggests that meeting the Category B Performance or better will delay but not eliminate the need to recharge Nipissar Lake artificially within the next five years.

Appendix A: Drawings



FROM SURVEY 2009 TO SURVEY 1995
DATUM DIFFERENCE APPROX. -2.36 m

TOTAL CURRENT VOLUME (cu.m.) 2,809,259.60

PROJECT TITLE	CLIENT PROJECT NO.	FSC PROJECT NO.
NIPISSAR LAKE VOLUME STUDY	-	2009--1310

ARCHITECTS & ENGINEERS
4910 - 53rd Street, P.O. Box 1777
Yellowknife, NT, X1A 2P4, Canada
T 867.920.2882 | F 867.920.4319

LOCATION RANKIN INLET, NU	DRAWN BY IGM	CHECKED BY CP
DRAWING TITLE NIPISSAR LAKE BATHYMETRIC AND VOLUME	SCALE 2009--1310	DATE 2010 JAN
	DRAWING NO.	OF __

Appendix B: Spreadsheet Data & Calculations

Population Increase Rate 2.04%
Water Management Category A
Water Use (LPCD) 196

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,749	2,809,260
2010	2550	301	279,716	2,841,333
2011	2602	302	286,685	2,866,437
2012	2655	303	293,783	2,884,443
2013	2709	304	301,051	2,895,181
2014	2765	306	308,494	2,898,476
2015	2821	307	316,115	2,894,151
2016	2879	308	323,918	2,882,022
2017	2938	310	331,909	2,861,902
2018	2998	311	340,091	2,833,600
2019	3059	312	348,468	2,796,921
2020	3121	313	357,046	2,751,664
2021	3185	315	365,829	2,697,624
2022	3250	316	374,822	2,634,591
2023	3317	317	384,030	2,562,351
2024	3384	319	393,457	2,480,683
2025	3454	320	403,109	2,389,363
2026	3524	321	412,992	2,288,160
2027	3596	322	423,110	2,176,839
2028	3670	324	433,469	2,055,160
2029	3745	325	444,074	1,922,874
2030	3821	326	454,933	1,779,730
2031	3899	327	466,049	1,625,470
2032	3979	329	477,430	1,459,829
2033	4060	330	489,081	1,282,537
2034	4143	331	501,009	1,093,317
2035	4228	333	513,221	891,885
2036	4314	334	525,722	677,952
2037	4402	335	538,520	451,221
2038	4492	336	551,621	211,389
2039	4584	338	565,033	- 41,855
2040	4678	339	578,762	- 308,828

2041	4773	340	592,817	-	589,856
2042	4871	342	607,205	-	885,272
2043	4970	343	621,933	-	1,195,415
2044	5072	344	637,009	-	1,520,635
2045	5175	345	652,441	-	1,861,287
2046	5281	347	668,239	-	2,217,737
2047	5389	348	684,409	-	2,590,358
2048	5499	349	700,962	-	2,979,530
2049	5611	351	717,905	-	3,385,646

Population Increase Rate	2.04%
Water Management	Category B
Water Use (LPCD)	216

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,749	2,809,260
2010	2550	331	308,286	2,812,762
2011	2602	333	315,939	2,808,613
2012	2655	334	323,761	2,796,641
2013	2709	335	331,771	2,776,660
2014	2765	337	339,973	2,748,476
2015	2821	338	348,371	2,711,894
2016	2879	340	356,971	2,666,712
2017	2938	341	365,777	2,612,724
2018	2998	343	374,794	2,549,719
2019	3059	344	384,026	2,477,482
2020	3121	345	393,479	2,395,792
2021	3185	347	403,159	2,304,422
2022	3250	348	413,069	2,203,142
2023	3317	350	423,216	2,091,715
2024	3384	351	433,606	1,969,898
2025	3454	352	444,243	1,837,445
2026	3524	354	455,134	1,694,100
2027	3596	355	466,284	1,539,605
2028	3670	357	477,700	1,373,693
2029	3745	358	489,388	1,196,094
2030	3821	359	501,354	1,006,529
2031	3899	361	513,605	804,713
2032	3979	362	526,147	590,354
2033	4060	364	538,988	363,156
2034	4143	365	552,133	122,812
2035	4228	367	565,590	- 130,989
2036	4314	368	579,367	- 398,567
2037	4402	369	593,471	- 680,249
2038	4492	371	607,909	- 976,369
2039	4584	372	622,689	- 1,287,269
2040	4678	374	637,820	- 1,613,300

2041	4773	375	653,309	-	1,954,819
2042	4871	376	669,164	-	2,312,195
2043	4970	378	685,395	-	2,685,801
2044	5072	379	702,010	-	3,076,021
2045	5175	381	719,017	-	3,483,249
2046	5281	382	736,426	-	3,907,887
2047	5389	383	754,247	-	4,350,345
2048	5499	385	772,488	-	4,811,044
2049	5611	386	791,160	-	5,290,416

Population Increase Rate	2.04%
Water Management	Category C
Water Use (LPCD)	256

Year	Population	LCPD	Cu. M./ Year	Volume of Lake
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,749	2,809,260
2010	2550	393	365,427	2,755,621
2011	2602	394	374,446	2,692,964
2012	2655	396	383,716	2,621,037
2013	2709	398	393,210	2,539,616
2014	2765	399	402,930	2,448,475
2015	2821	401	412,884	2,347,380
2016	2879	403	423,077	2,236,092
2017	2938	404	433,513	2,114,367
2018	2998	406	444,200	1,981,957
2019	3059	408	455,142	1,838,604
2020	3121	409	466,346	1,684,047
2021	3185	411	477,818	1,518,018
2022	3250	413	489,563	1,340,244
2023	3317	414	501,590	1,150,443
2024	3384	416	513,903	948,329
2025	3454	418	526,510	733,608
2026	3524	419	539,418	505,980
2027	3596	421	552,633	265,136
2028	3670	423	566,163	10,761
2029	3745	424	580,016	- 257,465
2030	3821	426	594,198	- 539,874
2031	3899	428	608,717	- 836,802
2032	3979	429	623,582	- 1,148,595
2033	4060	431	638,800	- 1,475,606
2034	4143	433	654,380	- 1,818,197
2035	4228	434	670,329	- 2,176,737
2036	4314	436	686,657	- 2,551,605
2037	4402	438	703,373	- 2,943,189
2038	4492	439	720,485	- 3,351,885
2039	4584	441	738,002	- 3,778,098
2040	4678	443	755,935	- 4,222,243

2041	4773	444	774,292	-	4,684,746
2042	4871	446	793,084	-	5,166,041
2043	4970	448	812,320	-	5,666,572
2044	5072	449	832,011	-	6,186,794
2045	5175	451	852,168	-	6,727,173
2046	5281	453	872,802	-	7,288,186
2047	5389	454	893,922	-	7,870,320
2048	5499	456	915,542	-	8,474,072
2049	5611	458	937,671	-	9,099,955

Population Increase Rate 2.04%
Water Management Category D (Current)
Water Use (LPCD) 306

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,749	2,809,260
2010	2550	469	436,488	2,684,561
2011	2602	471	447,580	2,548,770
2012	2655	473	458,661	2,401,898
2013	2709	475	470,008	2,243,679
2014	2765	477	481,628	2,073,840
2015	2821	479	493,526	1,892,103
2016	2879	481	505,709	1,698,183
2017	2938	483	518,184	1,491,788
2018	2998	485	530,958	1,272,620
2019	3059	487	544,037	1,040,372
2020	3121	489	557,429	794,732
2021	3185	491	571,141	535,379
2022	3250	493	585,181	261,987
2023	3317	495	599,556	- 25,780
2024	3384	497	614,275	- 328,266
2025	3454	499	629,344	- 645,821
2026	3524	501	644,773	- 978,804
2027	3596	503	660,569	- 1,327,585
2028	3670	505	676,742	- 1,692,538
2029	3745	507	693,300	- 2,074,049
2030	3821	509	710,252	- 2,472,512
2031	3899	511	727,607	- 2,888,330
2032	3979	513	745,375	- 3,321,916
2033	4060	515	763,566	- 3,773,693
2034	4143	517	782,188	- 4,244,092
2035	4228	519	801,253	- 4,733,556
2036	4314	521	820,770	- 5,242,537
2037	4402	523	840,750	- 5,771,498
2038	4492	525	861,204	- 6,320,913
2039	4584	527	882,143	- 6,891,267
2040	4678	529	903,578	- 7,483,056

2041	4773	531	925,521	-	8,096,788
2042	4871	533	947,983	-	8,732,982
2043	4970	535	970,976	-	9,392,169
2044	5072	537	994,514	-	10,074,894
2045	5175	539	1,018,608	-	10,781,712
2046	5281	541	1,043,271	-	11,513,194
2047	5389	543	1,068,517	-	12,269,922
2048	5499	545	1,094,359	-	13,052,491
2049	5611	547	1,120,810	-	13,861,513

Population Increase Rate 2.50%
Water Management Category A
Water Use (LPCD) 196

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2561	301	280,982	2,840,066
2011	2626	302	289,818	2,862,037
2012	2691	304	298,599	2,875,227
2013	2758	306	307,638	2,879,378
2014	2827	307	316,942	2,874,224
2015	2898	309	326,520	2,859,494
2016	2971	310	336,377	2,834,905
2017	3045	312	346,524	2,800,170
2018	3121	313	356,968	2,754,991
2019	3199	315	367,717	2,699,063
2020	3279	316	378,781	2,632,070
2021	3361	318	390,168	2,553,691
2022	3445	320	401,888	2,463,592
2023	3531	321	413,950	2,361,430
2024	3619	323	426,364	2,246,855
2025	3710	324	439,140	2,119,504
2026	3803	326	452,288	1,979,005
2027	3898	327	465,819	1,824,975
2028	3995	329	479,744	1,657,020
2029	4095	331	494,074	1,474,735
2030	4197	332	508,821	1,277,703
2031	4302	334	523,996	1,065,495
2032	4410	335	539,612	837,672
2033	4520	337	555,682	593,779
2034	4633	338	572,217	333,351
2035	4749	340	589,232	55,908
2036	4868	342	606,740	- 239,043
2037	4989	343	624,756	- 552,010
2038	5114	345	643,293	- 883,514
2039	5242	346	662,366	- 1,234,090
2040	5373	348	681,991	- 1,604,292

2041	5507	349	702,183	-	1,994,685
2042	5645	351	722,958	-	2,405,854
2043	5786	352	744,333	-	2,838,399
2044	5931	354	766,326	-	3,292,935
2045	6079	356	788,952	-	3,770,099
2046	6231	357	812,231	-	4,270,541
2047	6387	359	836,181	-	4,794,933
2048	6546	360	860,821	-	5,343,965
2049	6710	362	886,170	-	5,918,346

Population Increase Rate 2.50%
Water Management Category B
Water Use (LPCD) 216

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2561	331	309,682	2,811,366
2011	2626	333	319,392	2,803,764
2012	2691	335	329,069	2,786,484
2013	2758	337	339,030	2,759,243
2014	2827	338	349,283	2,721,749
2015	2898	340	359,838	2,673,700
2016	2971	342	370,702	2,614,788
2017	3045	344	381,884	2,544,693
2018	3121	345	393,393	2,463,088
2019	3199	347	405,240	2,369,638
2020	3279	349	417,432	2,263,994
2021	3361	351	429,982	2,145,802
2022	3445	352	442,897	2,014,693
2023	3531	354	456,190	1,870,292
2024	3619	356	469,871	1,712,211
2025	3710	357	483,950	1,540,050
2026	3803	359	498,440	1,353,399
2027	3898	361	513,352	1,151,836
2028	3995	363	528,698	934,927
2029	4095	364	544,490	702,226
2030	4197	366	560,741	453,274
2031	4302	368	577,465	187,598
2032	4410	369	594,675	- 95,288
2033	4520	371	612,384	- 395,883
2034	4633	373	630,607	- 714,701
2035	4749	375	649,358	- 1,052,270
2036	4868	376	668,653	- 1,409,134
2037	4989	378	688,506	- 1,785,851
2038	5114	380	708,935	- 2,182,996
2039	5242	382	729,954	- 2,601,161
2040	5373	383	751,581	- 3,040,954

2041	5507	385	773,834	-	3,502,999
2042	5645	387	796,729	-	3,987,939
2043	5786	388	820,286	-	4,496,436
2044	5931	390	844,522	-	5,029,169
2045	6079	392	869,458	-	5,586,837
2046	6231	394	895,112	-	6,170,161
2047	6387	395	921,506	-	6,779,877
2048	6546	397	948,660	-	7,416,748
2049	6710	399	976,596	-	8,081,555

Population Increase Rate 2.50%
Water Management Category C
Water Use (LPCD) 256

Year	Population	LCPD	Cu. M./ Year	Volume of Lake
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2561	393	367,082	2,753,966
2011	2626	395	378,538	2,687,217
2012	2691	397	390,007	2,608,999
2013	2758	399	401,813	2,518,975
2014	2827	401	413,966	2,416,798
2015	2898	403	426,474	2,302,113
2016	2971	405	439,350	2,174,552
2017	3045	407	452,603	2,033,738
2018	3121	409	466,244	1,879,283
2019	3199	411	480,284	1,710,788
2020	3279	413	494,735	1,527,842
2021	3361	415	509,608	1,330,023
2022	3445	417	524,915	1,116,897
2023	3531	420	540,670	888,016
2024	3619	422	556,884	642,922
2025	3710	424	573,571	381,140
2026	3803	426	590,744	102,185
2027	3898	428	608,417	- 194,442
2028	3995	430	626,605	- 509,258
2029	4095	432	645,321	- 842,791
2030	4197	434	664,583	- 1,195,584
2031	4302	436	684,403	- 1,568,198
2032	4410	438	704,800	- 1,961,209
2033	4520	440	725,788	- 2,375,208
2034	4633	442	747,386	- 2,810,805
2035	4749	444	769,609	- 3,268,626
2036	4868	446	792,477	- 3,749,314
2037	4989	448	816,007	- 4,253,532
2038	5114	450	840,219	- 4,781,962
2039	5242	452	865,131	- 5,335,304
2040	5373	454	890,763	- 5,914,278

2041	5507	456	917,136	-	6,519,625
2042	5645	458	944,272	-	7,152,108
2043	5786	460	972,191	-	7,812,510
2044	5931	462	1,000,915	-	8,501,636
2045	6079	464	1,030,468	-	9,220,315
2046	6231	466	1,060,874	-	9,969,400
2047	6387	469	1,092,155	-	10,749,766
2048	6546	471	1,124,338	-	11,562,314
2049	6710	473	1,157,447	-	12,407,972

Population Increase Rate 2.50%
Water Management Category D (Current)
Water Use (LPCD) 306

Year	Population	LCPD	Cu. M./ Year	Volume of Lake
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2561	469	438,464	2,682,584
2011	2626	472	452,471	2,541,902
2012	2691	475	466,180	2,387,511
2013	2758	477	480,292	2,219,007
2014	2827	479	494,818	2,035,978
2015	2898	482	509,770	1,837,997
2016	2971	484	525,161	1,624,625
2017	3045	487	541,002	1,395,412
2018	3121	489	557,307	1,149,894
2019	3199	492	574,090	887,593
2020	3279	494	591,363	608,020
2021	3361	497	609,141	310,668
2022	3445	499	627,438	- 4,981
2023	3531	501	646,269	- 339,461
2024	3619	504	665,650	- 693,322
2025	3710	506	685,596	- 1,067,129
2026	3803	509	706,123	- 1,461,463
2027	3898	511	727,248	- 1,876,922
2028	3995	514	748,988	- 2,314,122
2029	4095	516	771,361	- 2,773,694
2030	4197	519	794,384	- 3,256,288
2031	4302	521	818,076	- 3,762,575
2032	4410	523	842,456	- 4,293,242
2033	4520	526	867,544	- 4,848,997
2034	4633	528	893,360	- 5,430,568
2035	4749	531	919,924	- 6,038,702
2036	4868	533	947,258	- 6,674,171
2037	4989	536	975,384	- 7,337,766
2038	5114	538	1,004,324	- 8,030,301
2039	5242	540	1,034,102	- 8,752,614
2040	5373	543	1,064,740	- 9,505,565

2041	5507	545	1,096,265	-	10,290,041
2042	5645	548	1,128,700	-	11,106,952
2043	5786	550	1,162,071	-	11,957,234
2044	5931	553	1,196,406	-	12,841,851
2045	6079	555	1,231,732	-	13,761,794
2046	6231	558	1,268,075	-	14,718,080
2047	6387	560	1,305,467	-	15,711,758
2048	6546	562	1,343,935	-	16,743,904
2049	6710	565	1,383,510	-	17,815,625

Population Increase Rate 3.00%
Water Management Category A
Water Use (LPCD) 196

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2574	301	282,353	2,838,696
2011	2651	303	293,249	2,857,236
2012	2731	305	303,912	2,865,113
2013	2813	307	314,950	2,861,952
2014	2897	309	326,377	2,847,364
2015	2984	311	338,207	2,820,946
2016	3073	312	350,452	2,782,283
2017	3166	314	363,128	2,730,944
2018	3261	316	376,249	2,666,485
2019	3358	318	389,830	2,588,443
2020	3459	320	403,888	2,496,344
2021	3563	322	418,438	2,389,695
2022	3670	324	433,498	2,267,986
2023	3780	325	449,085	2,130,691
2024	3893	327	465,216	1,977,263
2025	4010	329	481,912	1,807,140
2026	4130	331	499,191	1,619,739
2027	4254	333	517,072	1,414,456
2028	4382	335	535,577	1,190,667
2029	4513	337	554,727	947,729
2030	4649	339	574,545	684,973
2031	4788	340	595,052	401,711
2032	4932	342	616,272	97,228
2033	5080	344	638,230	- 229,213
2034	5232	346	660,950	- 578,374
2035	5389	348	684,460	- 951,045
2036	5551	350	708,785	- 1,348,041
2037	5718	352	733,954	- 1,770,206
2038	5889	354	759,995	- 2,218,412
2039	6066	355	786,938	- 2,693,561
2040	6248	357	814,813	- 3,196,586

2041	6435	359	843,653	-	3,728,450
2042	6628	361	873,490	-	4,290,151
2043	6827	363	904,358	-	4,882,720
2044	7032	365	936,291	-	5,507,222
2045	7243	367	969,327	-	6,164,761
2046	7460	369	1,003,503	-	6,856,474
2047	7684	370	1,038,856	-	7,583,541
2048	7914	372	1,075,427	-	8,347,179
2049	8152	374	1,113,258	-	9,148,648

Population Increase Rate	3.00%
Water Management	Category B
Water Use (LPCD)	216

Year	Population	LCPD	Cu. M./ Year	Volume of Lake
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2574	331	311,193	2,809,856
2011	2651	334	323,172	2,798,472
2012	2731	336	334,923	2,775,339
2013	2813	338	347,088	2,740,040
2014	2897	340	359,681	2,692,148
2015	2984	342	372,718	2,631,219
2016	3073	344	386,213	2,556,796
2017	3166	346	400,182	2,468,403
2018	3261	348	414,642	2,365,550
2019	3358	350	429,609	2,247,731
2020	3459	353	445,101	2,114,419
2021	3563	355	461,136	1,965,072
2022	3670	357	477,732	1,799,128
2023	3780	359	494,910	1,616,008
2024	3893	361	512,688	1,415,109
2025	4010	363	531,087	1,195,812
2026	4130	365	550,128	957,472
2027	4254	367	569,835	699,427
2028	4382	369	590,228	420,988
2029	4513	371	611,332	121,444
2030	4649	373	633,172	- 199,938
2031	4788	375	655,771	- 543,920
2032	4932	377	679,157	- 911,288
2033	5080	379	703,355	- 1,302,854
2034	5232	381	728,394	- 1,719,460
2035	5389	383	754,303	- 2,161,973
2036	5551	386	781,110	- 2,631,295
2037	5718	388	808,847	- 3,128,353
2038	5889	390	837,546	- 3,654,110
2039	6066	392	867,238	- 4,209,558
2040	6248	394	897,958	- 4,795,727

2041	6435	396	929,740	-	5,413,678
2042	6628	398	962,622	-	6,064,511
2043	6827	400	996,639	-	6,749,361
2044	7032	402	1,031,831	-	7,469,404
2045	7243	404	1,068,238	-	8,225,853
2046	7460	406	1,105,901	-	9,019,965
2047	7684	408	1,144,862	-	9,853,037
2048	7914	410	1,185,165	-	10,726,413
2049	8152	412	1,226,856	-	11,641,480

Population Increase Rate	3.00%
Water Management	Category C
Water Use (LPCD)	256

Year	Population	LCPD	Cu. M./ Year	Volume of Lake
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2574	393	368,873	2,752,176
2011	2651	396	383,019	2,680,946
2012	2731	398	396,946	2,595,789
2013	2813	401	411,363	2,496,215
2014	2897	403	426,289	2,381,715
2015	2984	406	441,739	2,251,765
2016	3073	408	457,733	2,105,821
2017	3166	410	474,290	1,943,320
2018	3261	413	491,427	1,763,682
2019	3358	415	509,166	1,566,305
2020	3459	418	527,527	1,350,567
2021	3563	420	546,531	1,115,825
2022	3670	423	566,201	861,412
2023	3780	425	586,560	586,642
2024	3893	428	607,630	290,801
2025	4010	430	629,436	- 26,846
2026	4130	432	652,004	- 367,061
2027	4254	435	675,360	- 730,631
2028	4382	437	699,530	- 1,118,372
2029	4513	440	724,542	- 1,531,125
2030	4649	442	750,426	- 1,969,762
2031	4788	445	777,210	- 2,435,183
2032	4932	447	804,926	- 2,928,320
2033	5080	450	833,606	- 3,450,137
2034	5232	452	863,282	- 4,001,631
2035	5389	454	893,989	- 4,583,830
2036	5551	457	925,760	- 5,197,801
2037	5718	459	958,634	- 5,844,646
2038	5889	462	992,647	- 6,525,504
2039	6066	464	1,027,837	- 7,241,552
2040	6248	467	1,064,246	- 7,994,009

2041	6435	469	1,101,914	-	8,784,135
2042	6628	472	1,140,885	-	9,613,231
2043	6827	474	1,181,202	-	10,482,644
2044	7032	476	1,222,911	-	11,393,766
2045	7243	479	1,266,060	-	12,348,037
2046	7460	481	1,310,697	-	13,346,945
2047	7684	484	1,356,873	-	14,392,029
2048	7914	486	1,404,640	-	15,484,880
2049	8152	489	1,454,051	-	16,627,143

Population Increase Rate	3.00%
Water Management	Category D (Current)
Water Use (LPCD)	306

Year	**Population**	**LCPD**	**Cu. M./ Year**	**Volume of Lake**
1994	1845	450	303,041	3,469,780
1995	1883	450	309,232	3,464,452
1996	1921	450	315,550	3,453,688
1997	1960	450	321,997	3,437,376
1998	2000	450	328,575	3,415,403
1999	2041	450	335,288	3,387,653
2000	2083	450	342,138	3,354,008
2001	2126	450	349,128	3,314,349
2002	2169	450	356,260	3,268,551
2003	2213	450	363,539	3,216,490
2004	2259	450	370,966	3,158,037
2005	2305	450	378,545	3,093,063
2006	2352	450	386,278	3,021,433
2007	2400	450	394,170	2,943,012
2008	2449	459	410,704	2,857,661
2009	2499	469	427,770	2,809,260
2010	2574	469	440,603	2,680,446
2011	2651	473	457,827	2,534,407
2012	2731	476	474,474	2,371,722
2013	2813	479	491,708	2,191,803
2014	2897	482	509,548	1,994,044
2015	2984	485	528,017	1,777,817
2016	3073	488	547,134	1,542,471
2017	3166	491	566,924	1,287,336
2018	3261	494	587,409	1,011,716
2019	3358	496	608,612	714,893
2020	3459	499	630,560	396,122
2021	3563	502	653,276	54,635
2022	3670	505	676,787	- 310,363
2023	3780	508	701,122	- 699,696
2024	3893	511	726,307	- 1,114,214
2025	4010	514	752,373	- 1,554,798
2026	4130	517	779,349	- 2,022,358
2027	4254	520	807,266	- 2,517,834
2028	4382	523	836,156	- 3,042,202
2029	4513	526	866,054	- 3,596,467
2030	4649	529	896,993	- 4,181,671
2031	4788	532	929,009	- 4,798,891
2032	4932	534	962,139	- 5,449,241
2033	5080	537	996,420	- 6,133,871
2034	5232	540	1,031,892	- 6,853,974
2035	5389	543	1,068,596	- 7,610,781
2036	5551	546	1,106,573	- 8,405,565
2037	5718	549	1,145,867	- 9,239,643
2038	5889	552	1,186,523	- 10,114,377
2039	6066	555	1,228,587	- 11,031,175
2040	6248	558	1,272,107	- 11,991,492

2041	6435	561	1,317,132	-	12,996,835
2042	6628	564	1,363,714	-	14,048,761
2043	6827	567	1,411,906	-	15,148,877
2044	7032	570	1,461,761	-	16,298,849
2045	7243	572	1,513,337	-	17,500,398
2046	7460	575	1,566,693	-	18,755,302
2047	7684	578	1,621,887	-	20,065,400
2048	7914	581	1,678,983	-	21,432,594
2049	8152	584	1,738,046	-	22,858,851