Yellowknife Water Treatment Plant Information Session

May 10, 2011

Introduction

- Information Session
- Presentation Outline
  - Background & History
  - Future Water Treatment Plant
  - Water Sources
  - Arsenic
  - Arsenic Removal
- Question Session
- Informal Discussion

Water Supply History

- Piped Water Supply commenced 1948
- Raw Water from Yellowknife Bay
- Concerns raised regarding Arsenic and Sewage
- 1968 onwards Pumphouse 2 and an 8 km Submarine Pipeline utilized

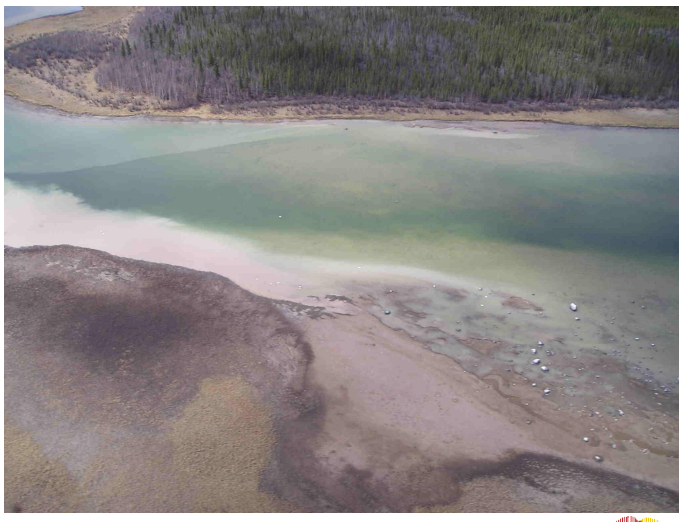
Existing Water Supply System

- Current Water Supply System consists of
  - River Pumphouse / Pipeline
  - Chlorination
  - Fluoridation
  - Distribution / fire pumping
- Yellowknife River water is generally good quality
- Turbidity can increase in spring / summer

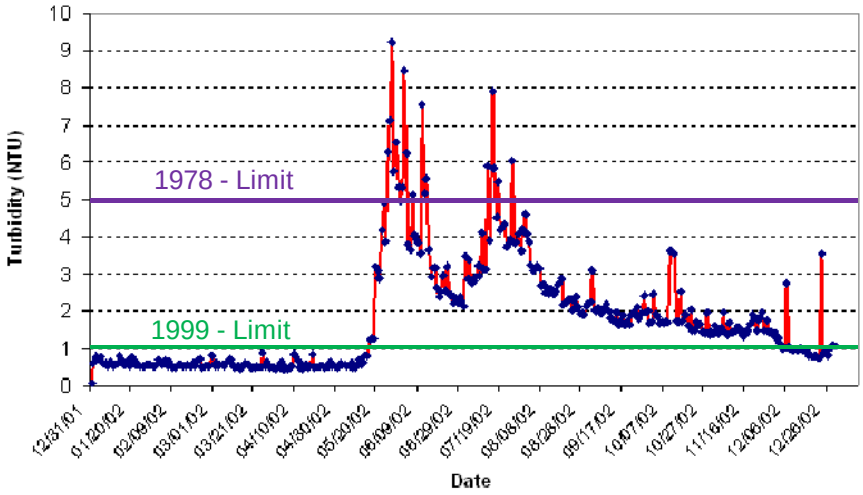
Raw Water Quality Concerns

- High Turbidity events
  - Spring Time
  - Short durations
  - Interferes with disinfection
  - Aesthetic concern (T&O)
- Protection against
  - Pathogens (Cryptosporidium & Giardia)
  - Viruses

Turbidity Events



Yellowknife River Water Turbidity



Water Supply Regulations

- GNWT "Water Supply System Regulations" make the Guidelines for Canadian Drinking Water Quality the "Standard" for Drinking Water Quality
- For a surface water, the Guidelines for Canadian Drinking Water Quality state
  - Filtration is required to reduce turbidity as low as possible
  - Virus inactivation is required for all technologies
  - Pathogen reduction / inactivation is required to reduce illness based upon risk (Giardia and Cryptosporidium)

Actions to meet Regulatory Requirements

- Move to Water Treatment Plant
- Process Piloting Complete
- Preliminary Design Completed
- Membrane Filtration System
  - 20 Million Liters /day
  - Fixed Barrier
  - Low Chemical Use
  - Highly Automated
- Moving Forward with Detailed Design

Raw Water Sources

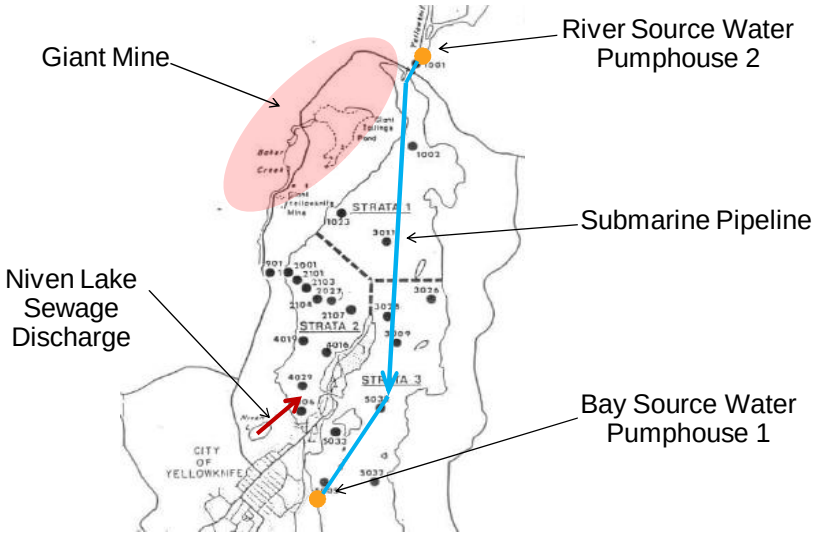
Current Raw Water Source - Yellowknife River

- City's Raw Water Source since 1968
- Stable Water Quality
- Occasional Turbidity Events
- Pumphouse 2 and Submarine Pipeline used to bring water across the Bay
- In service for 43 years
- Pipeline Replacement Date 2020

Alternate Raw Water Source - Yellowknife Bay

- Emergency Source
- Used During Repairs
- Stable Water Quality
- Turbidity Events have less impact
- Intake Structure in Place
- Niven Lake Sewage Discharge Discontinue1981
- Mining Stopped

Orientation of Sources



Raw Water Source Comparisons

River Source Water	Bay Source Water
Availability of raw water depended upon River flow	Raw Water taken directly from the Bay
Stable Water Quality with Turbidity Events	Stable Water Quality, Turbidity Events Less Dramatic
Pumphouse 1, 2 and Submarine Pipeline will required replacement / improvements	Pumphouse 1 only will require equipment replacement
Annual Operational & Maintenance must account for Pumphouse 1, 2 and Submarine Pipeline	Annual Operational & Maintenance must account for Pumphouse 1 only

Arsenic

Sources of Arsenic

- Ore processing at Giant and Con mines released arsenic into air, which settled into water and sediments
- In 1960s Con mine switched to Autoclave process, reducing the release of Arsenic
- Both mines have stopped production recently
- Currently there are high concentrations of Arsenic at the Giant Mine site in terms of surface dust and in water in tailings ponds and below ground.

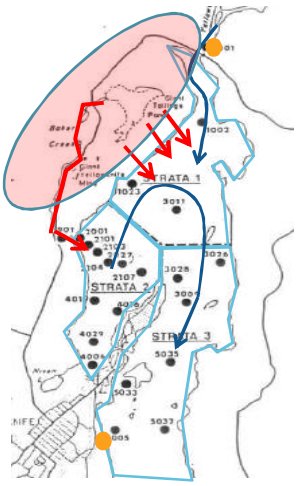
Arsenic Background

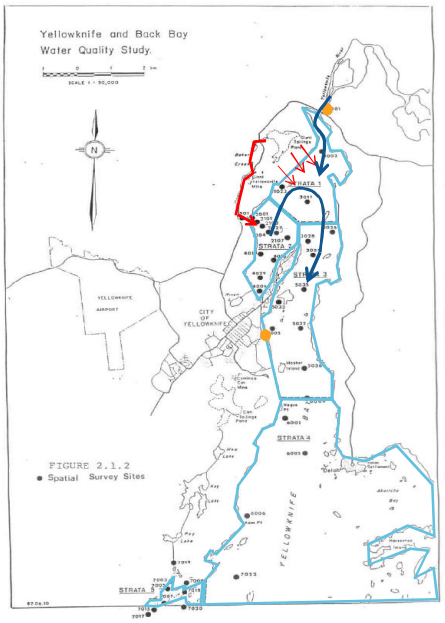
- Arsenic concentration measured parts per billion (ppb)
- 1 part per billion (ppb) = 1 microgram per Liter (µg/L)
- Guidelines for Canadian Drinking Water Quality
  - Maximum Allowable Concentration (MAC) of Total Arsenic in Drinking Water is 10 ppb
  - Reduced from 25 ppb in 2006 following research by the USEPA
  - Prior to that the MAC was set at 50 ppb
- CCME Canadian Water Quality Guideline for the Protection of Aquatic Life
  - Maximum Allowable Concentration 5 ppb

Arsenic Background II

- Sediment Limitations
- Interim Sediment Quality Guideline (ISQG)
  - Protection of Aquatic Life
  - 5,900 ppb (milligrams of Arsenic per kilogram of sediment)
- Probable Effects Limit (PEL)
  - defines the level above which adverse effects are expected to occur frequently **IN AQUATIC LIFE**
  - 17,000 ppb (milligrams of Arsenic per kilograms of sediment)
- Natural levels of Arsenic in soil
  - Yellowknife Average 150,000 ppb
    (Federal Contaminated Site Risk Assessment in Canada, Part I, 2004)

Arsenic Distribution





Arsenic Concentrations Bay Water (ppb) - 1988

- Giant Mine Operating
- Arsenic Concentration falls away

		Stratum 1 (Upper Bay - ppb)	Stratum 2 (Back Bay - ppb)	Stratum 3 (East of Latham Island - ppb)	Stratum 4 (Lower Bay -ppb)
Summer	Max	22	24	12	4
	Mean	2.65	4.65	2.91	1.25
Fall	Max	9	6	5	1
	Mean	3.03	4.81	2.7	1
Winter	Max	25	26	27	1
	Mean	2.12	4.86	2.57	1

Ref: Water Quality Study of Yellowknife Bay: 1987-1988. DRAFT Report, HydroQual Consultants Inc

Arsenic Concentrations Sediments (ppb) - 1988

	Stratum 1 (upper bay)	Stratum 2 (Back Bay)	Stratum 3 (east and south Latham Island)	Stratum 4 (lower bay)
Pre-1980	254,000	388,000	173,000	-
Post-1980	257,000	595,000	137,000	36,000

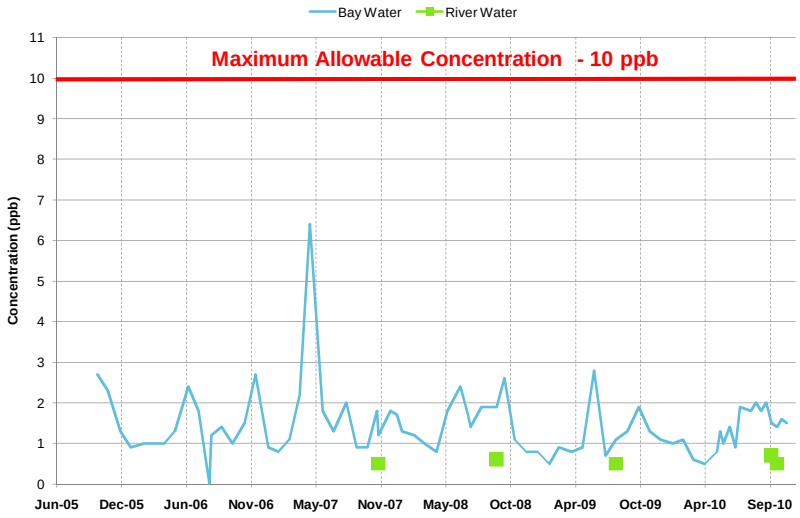
Ref: Water Quality Study of Yellowknife Bay: 1987-1988. DRAFT Report, HydroQual Consultants Inc

- Natural Background
  - 150,000 ppb

Subsequent Studies

- Jackson 1996
  - Giant Mine Operating
  - Station #8 (Pumphouse 1)
  - 6 Samples Water Samples Taken between Sept '92 and Mar '94
  - All water samples less than 5 ppb (Aquatic Requirement)
- City of Yellowknife
  - Sampling Total Arsenic at Pumphouse 1 since 2005
  - All water samples less than 3 ppb, one exception at 6.5 ppb
  - Drinking Water Limit 10 ppb

Arsenic Concentrations



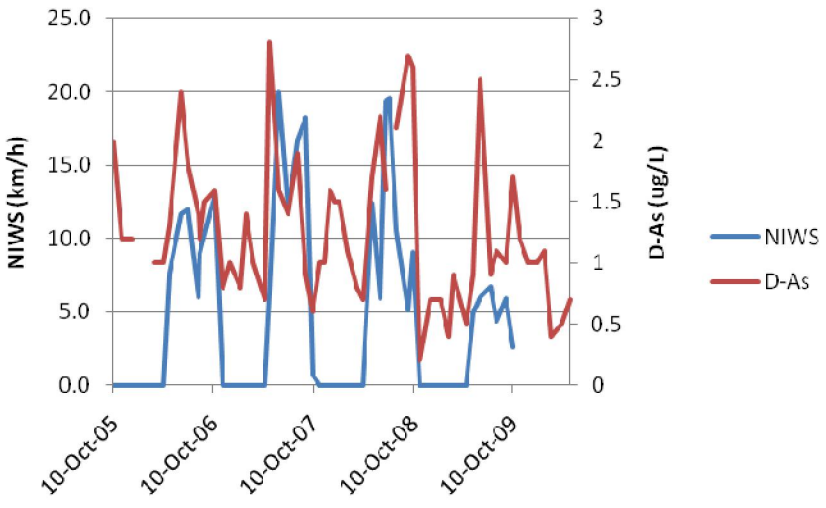
Conclusion of Information Review

- Information on Arsenic within the Bay is limited.
- Last study noted Arsenic concentrations in the Bay Water were below limits
- Yellowknife River and Currents influence the movement of Arsenic within the Bay
- Currents could re-suspend fine particulates and pore water
- Next actions
  - Determine if there is a connection between fluctuating Arsenic Concentration and the local conditions
  - Develop Field study to obtain sediment data closer to the Intake

Arsenic Correlation

- Indication of Weather Influence
- Using
  - City Arsenic Data
  - Weather Records for Airport
- Date reviewed and analyzed
- Filtered for day's where Temperature < -3 ºC
- NIWS – No Ice, Wind Speed

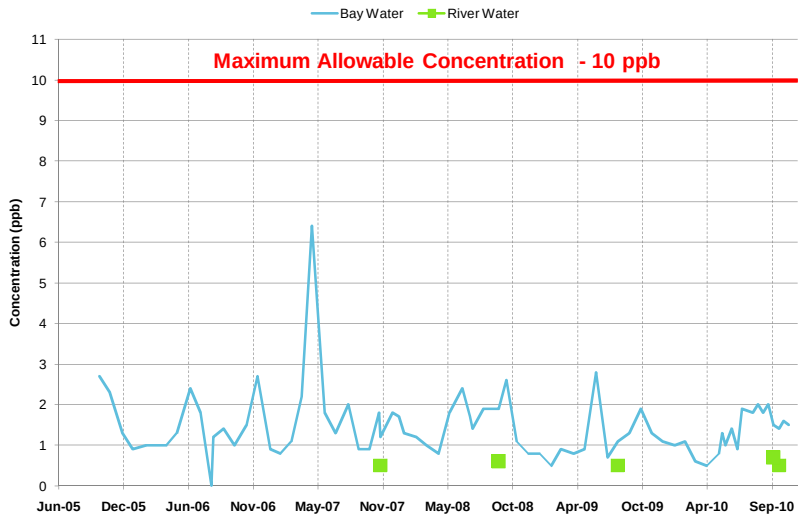
Dissolved Arsenic and Wind Action



Potential of Future Arsenic Event

- Event Basis
  - Arsenic greater than 10 ppb in Bay Raw Water
- Statistical Analysis Completed
- Cause: Release of pore water
- Conclusions
  - Short Term Event of less than 10 days in duration: Unlikely
  - Long Term Event exceeds 0.4 (1.0 is a definite occurrence)

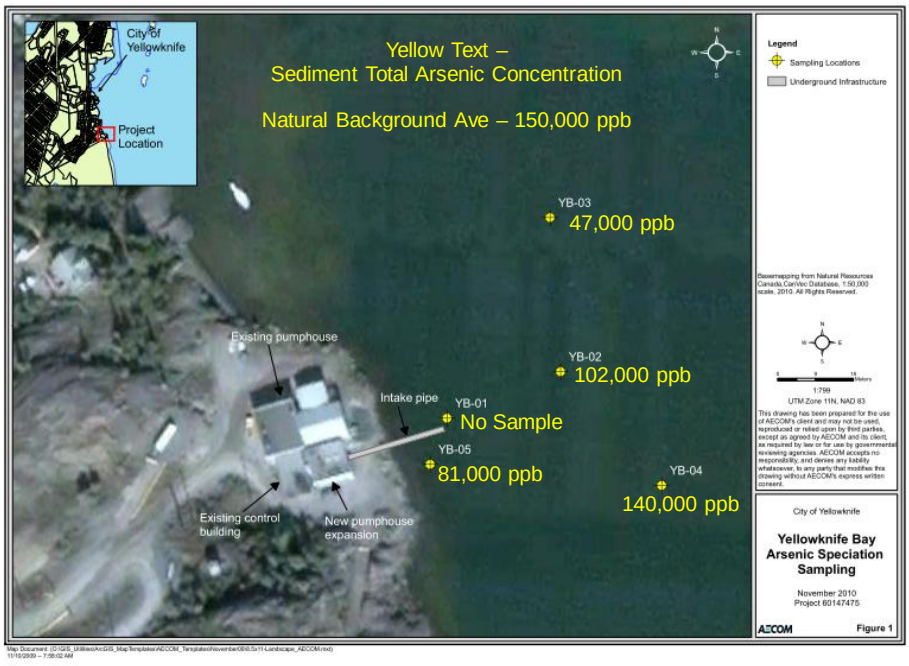
Arsenic Concentrations



2010 Sediment Sampling

- Update sediment concentration around the intake
- 1988 Samples: 173,000 / 137,000 ppb

Sample Location	Water Total Arsenic Concentration (ppb)	Water Dissolved Arsenic Concentration (ppb)	Sediment Total Arsenic Concentration (ppb)
YB-01	1.0	0.93	-
YB-02	0.96	1	102,000
YB-03	0.96	0.89	47,000
YB-04	1.4	1.1	140,000
YB-05	1.1	1.1	81,000



Arsenic "Remobilization"

- Andrade et al (2010)
- Sediment Core Analysis charts mining activity
- Cores showed mobility following deposition
- Analysis of pore water showed Arsenic movement towards the sediments / water body interface
- Reducing Environment in winter promotes creation of Dissolve Arsenic
- Supports the inference between Wind speed and Arsenic concentrations in Bay Water

Giant Mine Factor

- Significant Source of Arsenic
- Development of Remediation Plan Ongoing
- Tailings Ponds Water Arsenic Concentration: 20,000 ppb
- Tailing Ponds Concept
  - Discharge Treated Tailings Water to North End of the Bay
  - Application of Diffuser
  - Dilution Design of 80:1
  - Dispersion Analysis demonstrates 5 ppb limit for the protection of aquatic life is achievable (Giant Mine Remediation Project - Developer's Assessment Report , 2010)

Giant Mine – What if……..

- Tailings Pond Breach
- Water Discharged into Baker Creek / Back Bay
- Initial Giant Mine work applied a dilution ratio of 200:1 from Baker Creek to South Yellowknife Bay (SWK Consulting, 2009)
- Arsenic Concentration Drops
  - 20,000 ppb to 100 ppb at the Intake
- In the event of a release there would likely NOT be enough time to
  - Procure, install and commission arsenic removal equipment,
  - Commission previously installed equipment

Arsenic Removal

Arsenic Treatment Options

- Coagulation
- Sorption Process
- Ion Exchange
- High Pressure Membrane Filtration
- Assessment Factors
  - Local Situation
  - Chemical Involvement
  - Complexity
  - Waste Generation
  - Cost

Adsorption Filters

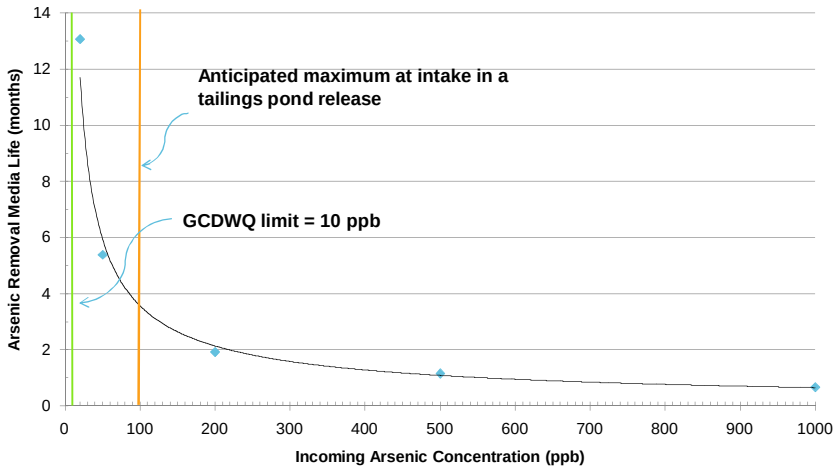
- Iron Based Media
- Adheres to the Surface
- Potential Pre-oxidation
- Packaged System
- Arsenic Locked into Media

- Backwash Waste contains no Arsenic
- Once “Full” media can be regenerate or disposed of.

Adsorption Filters II

- Media meets US EPA's Toxicity Characteristic Leaching Procedure (TCLP)
- Passive System.
- Also removes other components
  - Phosphates
  - Silica
  - Vanadium
- Performance
  - Initial Outlet Concentration below detection limit
  - Break through as Media "used"

Estimate Media Life



Low Probability Scenario – Tailings Pond Failure

- Tailings Ponds Dam Failure
- 20,000 ppb water release into Baker Creek / Back Bay
- Concentration at Bay Intake 100 ppb
- Passive Arsenic Removal System in Place
- Reduces Arsenic Concentration to below 10 ppb
- Arsenic Removal System provides 3 to 4 months of treatment
- Pre-arranged Media Replacement Program Activated

Conclusions and Recommendations

Conclusions

- Yellowknife is moving towards a Water Treatment Plant
- Existing Submarine Pipeline is undersized for the future capacity
- Circumstances for moving to the River have changed
- Opportunity to address any lingering issued with Bay Water within the Water Treatment Process.
- Since 2005, the Arsenic Concentrations in the Bay Water are less than Drink Water Maximum Allowable Concentrations (10 ppb)

Conclusion II

- The concentration of Arsenic in the Bay varies through out the year, influenced by
  - Arsenic Remobilization
  - Pore Water
  - Wind Speed / Ice Cover
  - Currents
- Long Term Elevation of Arsenic above 10 ppb is possible
- Low Probability Events at Giant Mine could significantly increase Arsenic Concentration in the Bay Water
- Technology is available to address these issues

Economic Influence

- Yellowknife River Option
  - Upgrades to Pumphouse 1 & 2
  - Replacement of 8 km submarine pipeline
  - $10 million Capital Cost (+ 100% / - 20%)
  - Additional costs for fish habitat compensation, assessments etc. Total additional costs not defined at this time
  - $250,000 Annual Operation and Maintenance Costs
- Yellowknife Bay Option
  - Upgrades to Pumphouse 1
  - $3.0 million Capital Cost (+50% / - 20%)
  - $80,000 Annual Operation and Maintenance Costs

Recommendation

- Based upon the information to date and an engineering basis
- AECOM has recommended that the City of Yellowknife moves ahead with the design of a Water Treatment Plant that:
  - Utilizes Yellowknife Bay as the Raw Water Source, and
  - Includes an Arsenic Treatment Stage to address the annual variations in Arsenic Concentrations and presence of Giant Mine.

Thank You

Any Questions?