
WaterTech 2017
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Project Team

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Outline

1) Objectives (City Objectives and Project Specific Objectives)
2) Low Impact Development (LID) and Source Control Practices (SCP) defined
3) Approach
4) Phase I – Conceptual Site Model (CSM)
5) Phase II – Field Investigation and CSM Update
6) Phase III – LID Assessment – Time-of-Travel Estimates
7) Summary
8) Next Steps
9) Questions
1) City Objectives - Location

City of Calgary Drinking Water Supply (Raw Water Intake I)
1) City Objectives

• **Source Water Protection**
  - Evaluate stormwater management options.
  - Assess Source Control Practices (SCP) through the application of Low Impact Development (LID).

• **Guidance to Area Structure Plan (ASP) development**
  - A long-range plan with policies guiding land use, subdivision and development decisions.

• **Guidance to Master Drainage Plan (MDP) development**
  - A plan that identifies the stormwater servicing strategy for the subject lands.
1) Project Specific Objectives

- To assist with the City Objectives through:
  
  ▪ Detailed hydrogeologic characterization; and
  
  ▪ Assessment of SCP applicability (runoff infiltration)
    
    – Identification of flow paths
    
    – Time-of-travel calculations
2) LID Defined

“Low Impact Development (LID) is an approach to land development that works with nature to manage stormwater runoff where it falls. LID preserves and recreates natural landscape features, and minimizes hard surfaces to create functional and appealing site drainage. Low impact development treats stormwater as a resource rather than a waste product.”


• To Include a comprehensive LID Manual based on a series of modules

   Module 1 – Geotechnical & Hydrogeological Considerations

   (Tetra Tech, July 2014)
2) SCP Defined

*Stormwater Source Control Practices Handbook*


Specific measures of the LID approach including:

- Better Planning Practices
- Infiltration galleries
- Bio-retention areas
- Grass Swales or Bioswales
- Porous Pavement
3) Study Approach

Three Phases completed between 2014 and 2016, inclusive:

- **Phase I – Preliminary Conceptual Site Model (CSM)**
  - Development of CSM based on existing data
  - Data gap assessment
  - Planning field program

- **Phase II – Field Program and CSM Refinement**
  - Drilling, well installations and testing
  - Hydrogeologic interpretation
  - CSM Refinement

- **Phase III – LID Assessment**
  - Flowpath definition
  - Time-of-travel estimates
  - Ongoing monitoring
4) Phase I – CSM Development

Cross-Section after Moran, 1986

Reservoir (1090 masl)
River (1076 masl)
4) Phase I – CSM Development

Intermittent Loss of flow
4) Phase I – CSM Development

- All 3\textsuperscript{rd} party boreholes and test-pits (black symbols); and

- Tetra Tech wells (white symbols)
5) Phase II - Field Investigations and CSM Update Drilling Program

- **Drilling** - Installed 11 groundwater monitoring wells
  - 6 Paskapoo Formation wells
  - 5 Wells in overlying sediment
- **K Tests** - 6 Hydraulic conductivity tests
- **Manual Water Levels** - 12 water level monitoring events (March 3, 2015 to January 12, 2016)
- **Data Loggers** - Continuous monitoring at 6 wells
- **Sampling** - Two water quality sampling events
- **3rd Party Data**
5) Phase II - Field Investigations and CSM Update

Available Overburden Monitoring Well Locations (Installed by Tetra Tech and others)
5) Phase II - Field Investigations and CSM Update

Available Bedrock Monitoring Well Locations (Installed by Tetra Tech and others)
5) Phase II - Field Investigations and CSM Update
Hydraulic Conductivity Testing and Results

- Pressurized nitrogen
- Real time data logging to ensure an accurate, repeatable test was conducted
- Bedrock (Four Wells):
  - $5.8 \times 10^{-1}$ m/s to $3.2 \times 10^{-6}$ m/s
- Overburden (two wells):
  - $1.4 \times 10^{-5}$ m/s to $1.6 \times 10^{-5}$ m/s
5) Phase II - Field Investigations and CSM Update
Manual Groundwater Measurements

Figure 5 - Manual Hydrograph Data
5) Phase II - Field Investigations and CSM Update

Continuous Water Level Monitoring Locations

Figure 6- Data Logger Hydrograph and Bearspaw Reservoir Data

Water Survey of Canada

Real-Time Hydrometric Data for BOW RIVER NEAR COCHRANE (05BH005) [AB]
5) Phase II - Field Investigations and CSM Update
Temperature vs Time

- Quaternary
- Shallow Bedrock
- Deep Bedrock
- Shallow Bedrock

Line colors and legend:
- 15AW01-D
- 15AW01-A
- 15AW02
- 15AW06
- 15AW08-D
- 15AW06-A
Approximate Water Level in Bearspaw Reservoir
5) Phase II - Field Investigations and CSM Update
5) Phase II - Field Investigations and CSM Update

October 2, 2015

January 5 to 7, 2016
Water Quality Trends

- Dynamic mixing of meteoric groundwater, reservoir water, and regional groundwater
- No appreciable seasonal changes in chemistry
- Similarity of shallow bedrock water chemistry with Bearspaw Reservoir water quality
- Deep bedrock and Quaternary strata groundwater chemistry differs from Bearspaw Reservoir
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Topography
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Top of Paskapoo Formation Elevation Contour
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Tertiary Undivided Sand and Gravel
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Laterally Extensive Silt-dominant Layer
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Clay-dominant Layer North
Sand-dominant Layer South
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Clay-dominant Layer overlying Sand (South)
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Sand-dominant Layer overlying Clay (South)
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Undifferentiated material (Fill)
5) Phase II - Field Investigations and CSM Update
Geologic Interpretation – Compilation
Two possible flow systems in the unconsolidated material overlying the bedrock:

- **Flow along bedrock surface**
  - Sand and gravel in north and middle portion of the site;
  - Silt in south portion of the site.

- **Perched flow along clay surface in upper sand**
  - South portion of the site.
5) Phase II - Field Investigations and CSM Update - Hydrostratigraphic Interpretation Shallow Flow Path on Paskapoo Surface (North)
5) Phase II - Field Investigations and CSM Update
Hydrostratigraphic Interpretation Shallow Flow Path on
Paskapoo Surface (South)
5) Phase II - Field Investigations and CSM Update
Hydrostratigraphic Interpretation Perched Flow Path (Sand overlying Clay)
6) Phase III SCP Assessment – Time-of-Travel Estimates
Analytical Methods

• **Advective Flow**
  - Time-of-Travel based on the groundwater flow velocity

• **Advective-Dispersive Flow**
  - Most conservative estimate of travel time
  - Analyzed for concentration in groundwater is 0.16 the initial concentration (measurable amount)

• **Alberta Tier 2 Model**
  - Provides an estimated concentration that will reach the reservoir
  - Uses advection, dispersion, and sorption to estimate velocity of the contaminant
6) Phase III SCP Assessment – Time-of-Travel Estimates
Analytical Methods

Alberta Tier 2 Model

- PCofC
  - Chloride
  - Herbicides
    - 2,4-D (2,4-Dichlorophenoxyacetic acid)
    - Dicamba (Banvel; 3,6-dichloro-2-methoxybenzoic acid)
    - Glyphosate (N-(phosphonomethyl)glycine)
    - MCPA (2-methyl-4-chlorophenoxyacetic acid)
    - MCPP (Mecoprop, methylchlorophenoxypropionic acid)

- 5 interpreted flow paths
- Cross-sections for each flow path
- Used field hydraulic conductivity where available
- Used estimated literature values where conductivity was unknown
6) Phase III SCP Assessment – Time-Of-Travel Estimates
Horizontal Flow Paths
6) Phase III SCP Assessment – Time-of-Travel Estimates
Flow Path T-T’
6) Phase III SCP Assessment – Time-Of-Travel Estimates
Horizontal Flow Paths
6) Phase III SCP Assessment – Time-of-Travel Estimates
Flow Path T-T’
7) Summary

SCP / LID Assessment

- **Northwestern Area**
  - Horizontal flow towards the reservoir over short distances.
  - Local sand and gravel and bedrock active hydraulic connection to the Reservoir.
  - Therefore, SCP applications appear to be inadequate for this area

- **Southeastern Area**
  - West - Groundwater flow toward the Reservoir along short flow paths, and short time of travel estimates.
  - East - surface water infiltration down to low permeability clay, lateral flow along the surface of clay away from the Reservoir.
  - Therefore, SCP applications may be appropriate for this area

- **Qualifier**
  - Detailed SCP investigations including lithological classification, infiltration tests, and/or pumping tests will be required for proposed stormwater infiltration locations.
8) Next Steps

Ongoing Work

• Continuous monitoring at select locations for temperature data, groundwater elevations, surface water elevations, and chemistry data to further understand the seasonal variations, and assist in constraining the degree of groundwater and surface water interaction.
9) Questions?