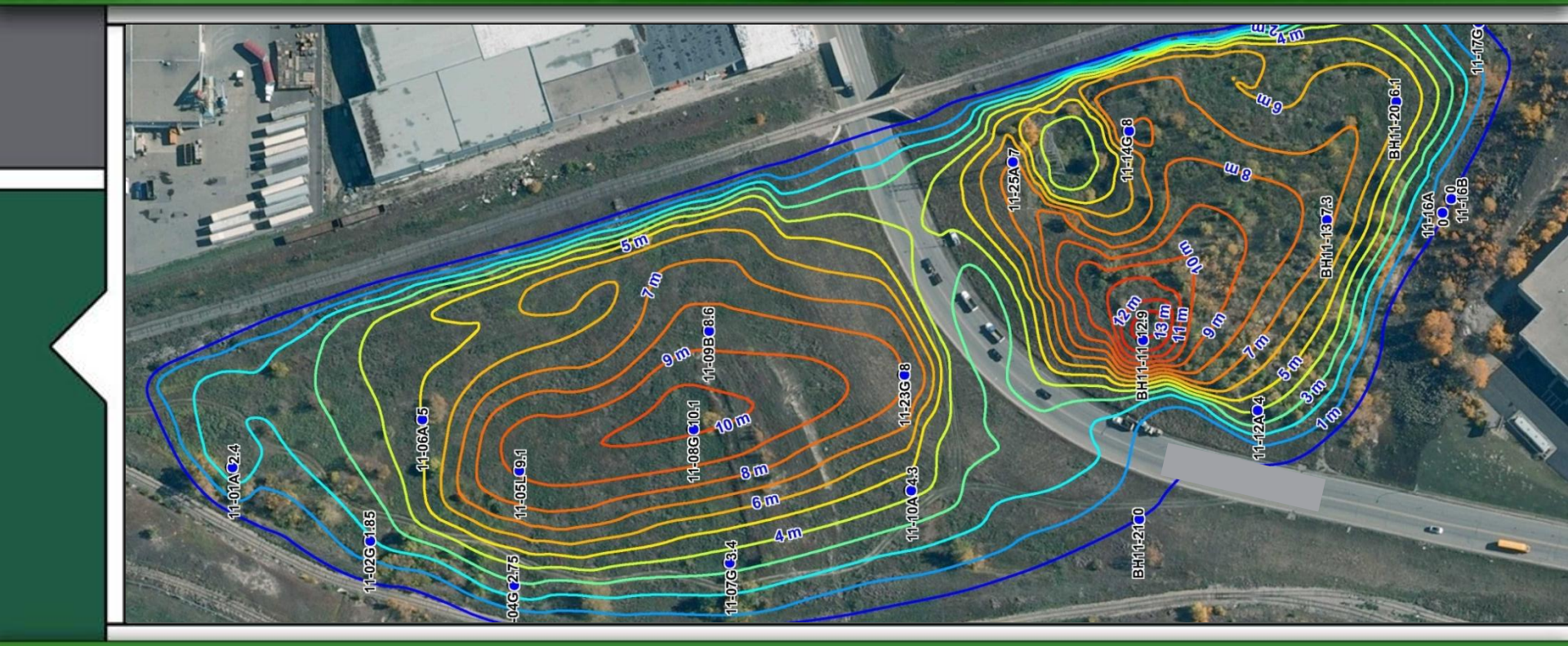
PARSONS

Remediation Technology Symposium (RemTech) 2012

Conceptual Site Models for Environmental Investigations and Remediation



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Outline

- Conceptual Site Model:
  - What
  - Why
  - Key Components
  - Examples
  - Take Home Messages

What Is a Conceptual Site Model (CSM)?

- Realistic but simplified representation of known site conditions necessary for decision-making
- Can include:
  - Tabulated data
  - Graphical data: maps, cross-sections and plots
  - Written summary
    - Remember a picture is worth a thousand words
  - Combination of the above

References

Triad Resource Centre, 2012. Conceptual site model development. http://www.triadcentral.org/mgmt/splan/sitemodel/ (accessed May 02, 2012).

Golder Associates, 2010. Technical Guidance for Contaminated Sites, Groundwater Investigation in Site Assessment. Report No. 07-1412-0162 Submitted to Land Remediation Section, BC MOE. www.env.gov.bc.ca/epd/remediation/reports/pdf/tech-guide-gw.pdf (accessed May 14, 2012)

Why a CSM?

- Summarizes known conditions of a site
- Identifies data gaps
- Improves decision making by allowing:
  - More targeted investigation, monitoring and sampling
  - Better modelling to address data uncertainty and sensitivity
- Documents the rationale for decision making
  - Enables consistent decisions among different professionals

It is also a QA process!

Steps to Develop a CSM

1. Define objective(s)
2. Summarize currently available data in a preliminary CSM
3. Identify data gaps and attempt to rectify
4. Update contents (both objectives and data) as relevant information becomes available

A CSM is a living document!

Use graphical or pictorial data whenever possible!

Principal Components of a CSM

- Objective(s) of the CSM
- Site information
- Geologic setting
- Hydrogeologic data
- Contaminant data
- Exposure pathways and receptors
- Remediation criteria
- Applicable remedies (if required)

Typical Objectives of a CSM

- Determine sampling locations to identify source and extent of impact:
  - E.g., metallic lead (soil), gasoline (soil, liquid & air)
  - Can be initial or follow-up sampling locations
- Determine potential risks:
  - E.g., DUA, vapour inhalation
- Facilitate numerical modelling
  - E.g., bail test, groundwater flow, contaminant flow and transport, LNAPL distribution and mobility
- Evaluate or design remedies
  - E.g., extent of excavation, placement of extraction wells, vapour management

Site Information

- Location
- Climate:
  - Site access (drill rig access)
  - Restriction on applicable technology (SVE in the Arctic)
- Land use, onsite and adjacent area:
  - Zoning
  - Utilities, including rights-of-way
  - Pipeline
  - Railroad

Geologic & Hydrogeologic Data

- Stratigraphy:
  - Use of cross-sections
- Geologic boundaries:
  - Coarse and fine contrasts, confining layers, bedrock, fractures, channels, etc.
- Groundwater:
  - Water table or potentiometric surface, flow directions, seasonal variation, tidal fluctuation
  - Lateral and vertical gradients
  - Confined or unconfined aquifer, discharge or recharge
- Surface water:
  - Natural water bodies, dugouts, surface drainage

Contaminant Data

- Nature of contaminants:
  - Properties in the appropriate temperature range
  - Potential impacts to environment
- Distribution in three dimensions:
  - Up, down and all around
- Transport pathways and receptors
- Applicable criteria
- Possible remedies (if required)

Examples

- CSM Example 1:
  - DUA Assessment

Example 1: DUA Assessment

- Objective:
  To determine if the DUA (domestic use aquifer, aka potable water) pathway is applicable

Some basic requirements:

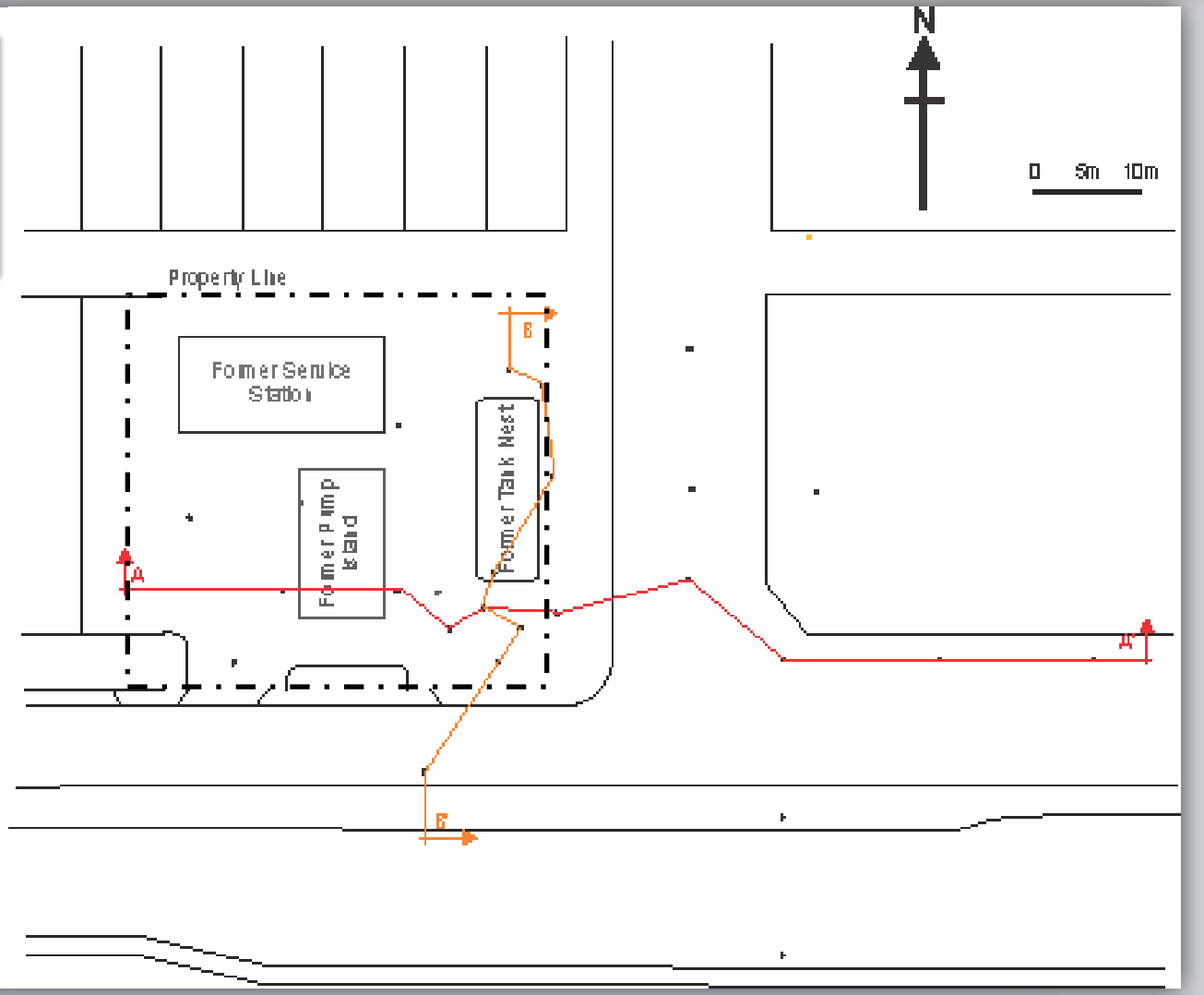
1. Need to determine:
   a) If shallow (surficial) stratum is a DUA, otherwise:
   b) Can the shallow stratum act as a separation layer to a possible DUA at depth
2. Alberta ESRD requires determining hydraulic conductivities within the same formation at a minimum of three locations for an average size site

References

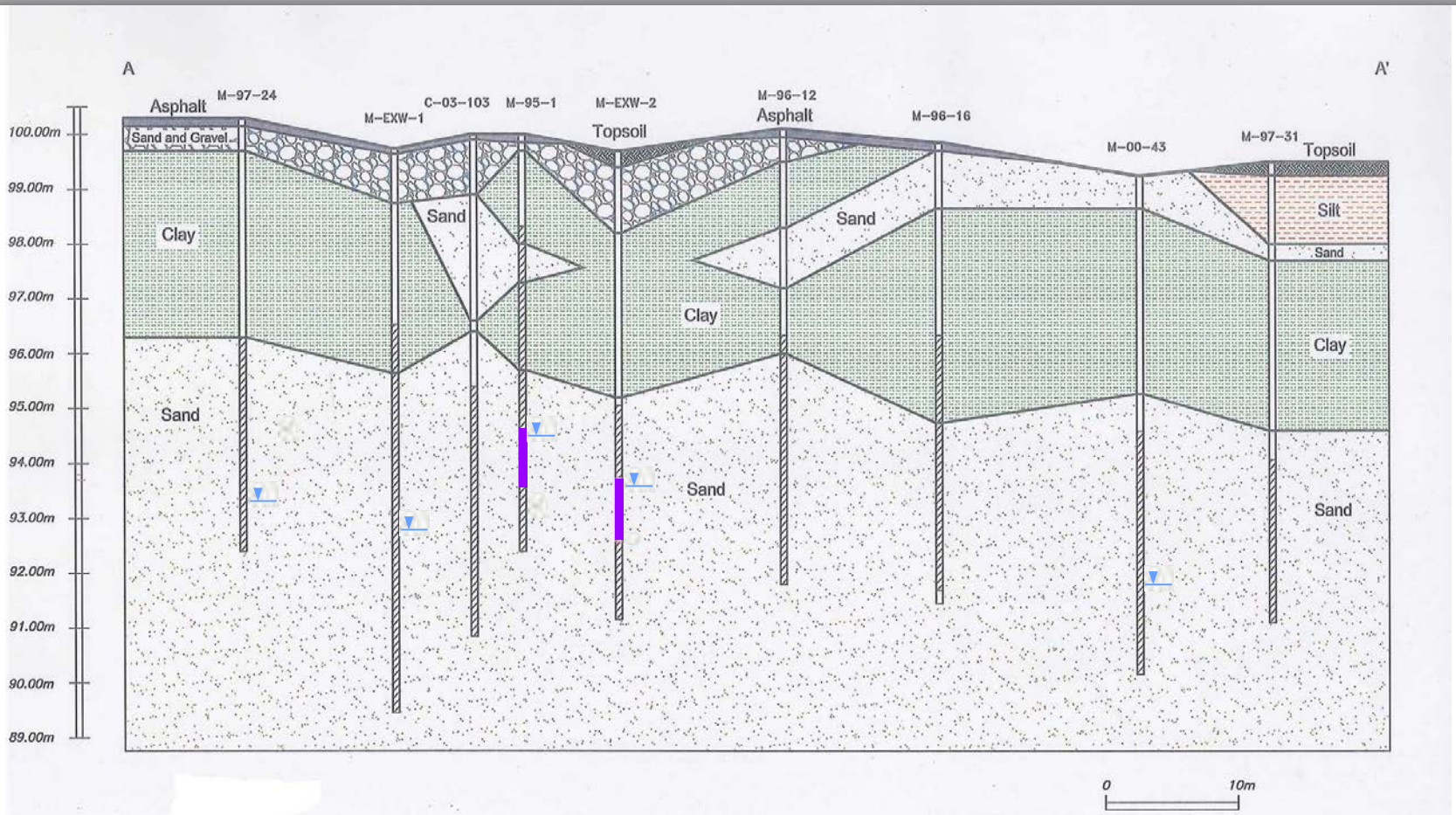
- AENV 2010. Alberta Tier 2 Soil and Water Remediation Guidelines.
- Kurc et al. 2008. To be or not to be a DUA? Available from Remtech webpage: http://www.esaa-events.com/remtech/2008/pdf/Paper-46.pdf (accessed May 14, 2012)

Example 1: Available Data - Site Plan

- Location: Calgary
- Data Source: Other consultants' reports, 1996-2007 (as available in 2008)

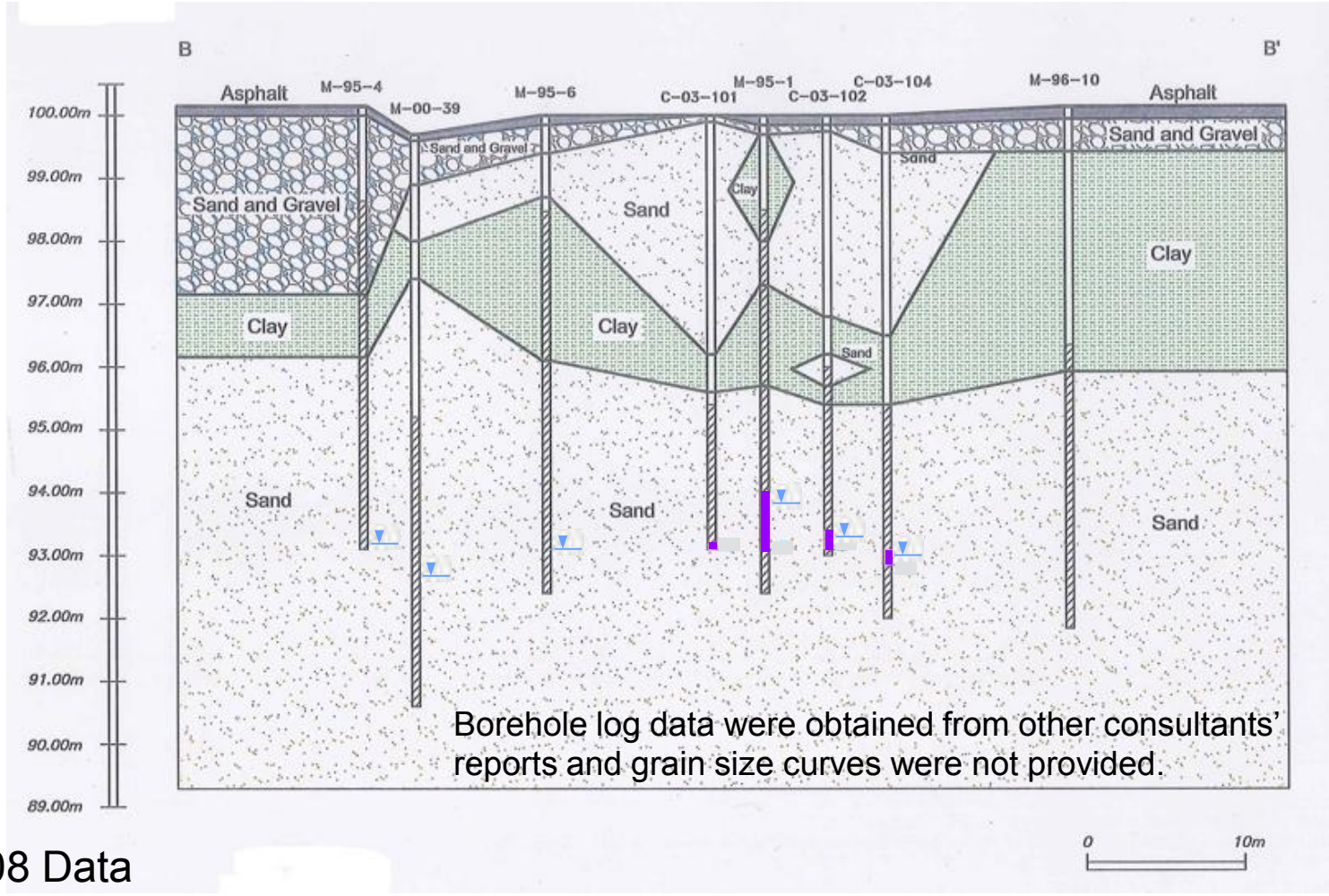


Example 1: Hydrogeologic Cross-Section A-A'



2008 Data

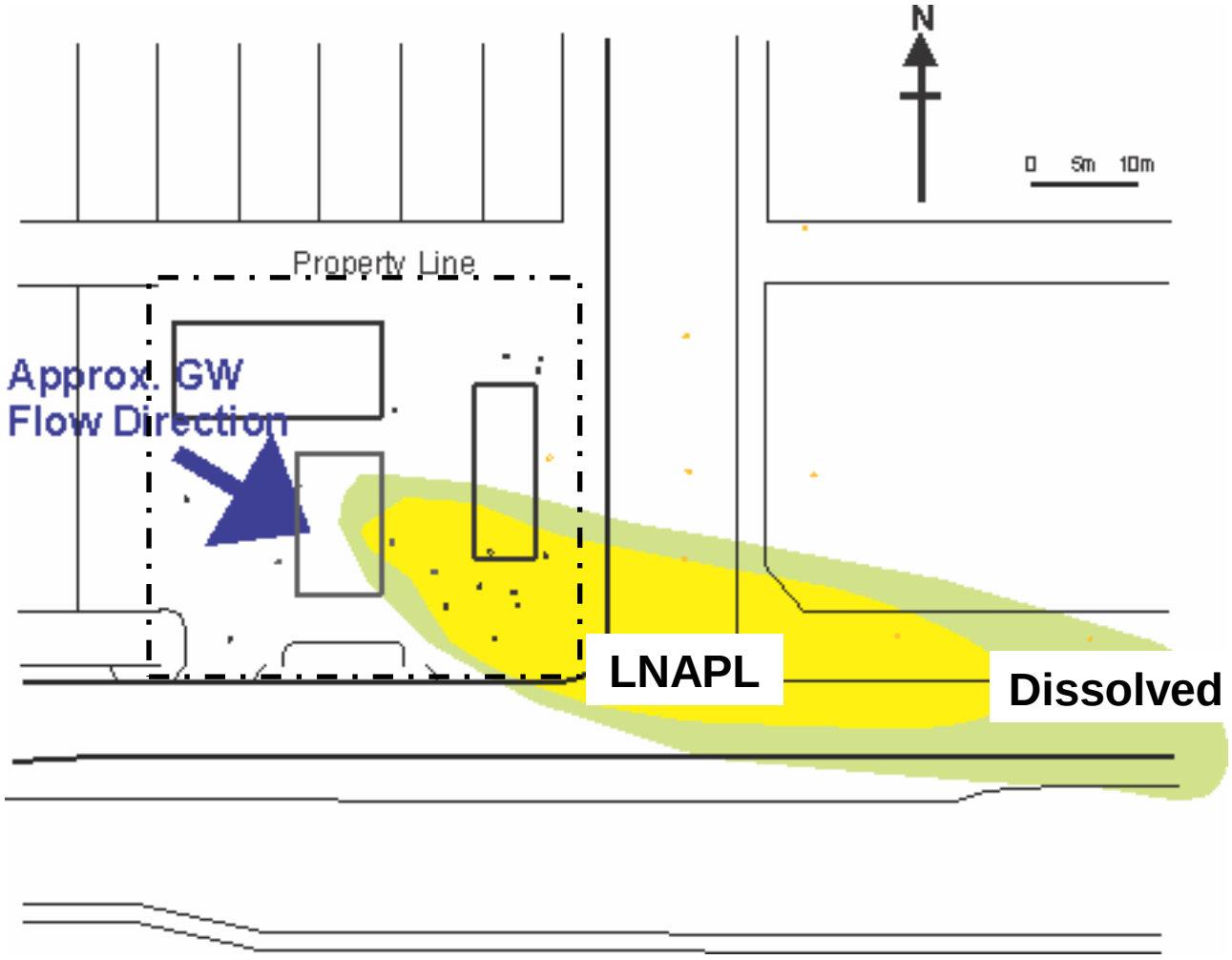
Example 1: Hydrogeologic Cross-Section B-B’



2008 Data

Example 1: Groundwater, LNAPL & Dissolved Plumes

LNAPL is gasoline



Example 1: Based on Available Information…

- Do we have sufficient data to carry out a DUA determination?

If Not

What additional work needs to be done?
Can it be done together with DUA determination?

If So

Where would you put your DUA wells?
How would they be screened?

Example 1: Data Summary

- For this site, CSM data can be summarized using an Excel spreadsheet:
  - Usable for relatively simple sites
  - Spreadsheet available upon email request
- It forms only a part of a CSM, needs to be supplemented by additional data such as site plans, cross-sections, etc.

Minimum Data Required for the Development of a Conceptual Site Model

Reference Number: 471413 01001

Date: 2012-05-17

Data for Developing a Conceptual Site Model

☑ Attach scaled and dimensioned Site Plan

Soil Data

For each major soil stratum, enter:

soil type: Select either fine, coarse, bedrock, weather bedrock, or ?

hydraulic conductivity: K_h and K_v (m/s)

		Soil Type	K_h	K_v	ϕ_e
Stratum	1:	coarse	?	?	?
	2:	fine	?	?	?
	3:	coarse	?	?	?

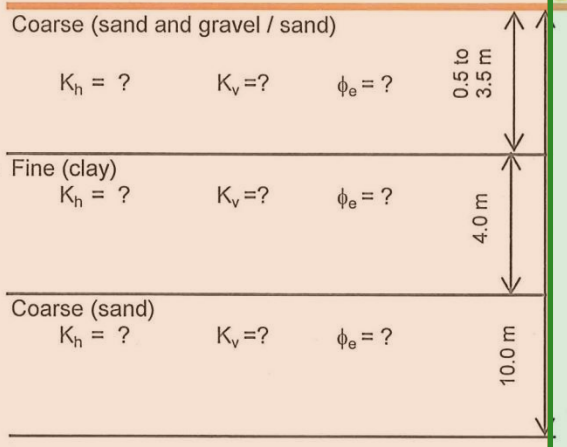
Maximum depth of intrusive investigations (m): 10.0

Estimated thickness of exclusion layer (for DUA evaluation), T_x (m): 5.0

Sketch (can be hand drawn) K in m/s

Sketch in: each major soil stratum, groundwater and contaminant depths.

Depths are not drawn to scale



Groundwater

Depth to GWT:

min. 6.4 m bgs

max. 7.2 m bgs

Hydraulic Gradient:

value: ?

direction: SE

Assumed effective porosity

ϕ_e = 0.25 to 0.30

D_w = 6.2 m

D_L = 7.4 m

Seasonal Variation = 0.5 m

Contaminant(s) of Potential Concern

☑ PHC ☐ DNAPL ☐ PAHs ☐ Salt

☐ Fertilizer ☐ Sulphate

☐ Others:

Delineated: ☑ Horizontal ☐ Vertical

Criteria Selection

Attach summary from:

☐ Pathway selection and receptor identification as described in IOL Staged Phase II ESA POP

☑ 2010 Alberta Tier I and Tier II (pathway elimination) generic criteria selection summary (DUA Excel spreadsheet)

☐ Site-specific criteria development

☐ Other criteria development procedure:

D_c = 8.0 m

D_i = 10.0 m

Soil Data

Groundwater Data

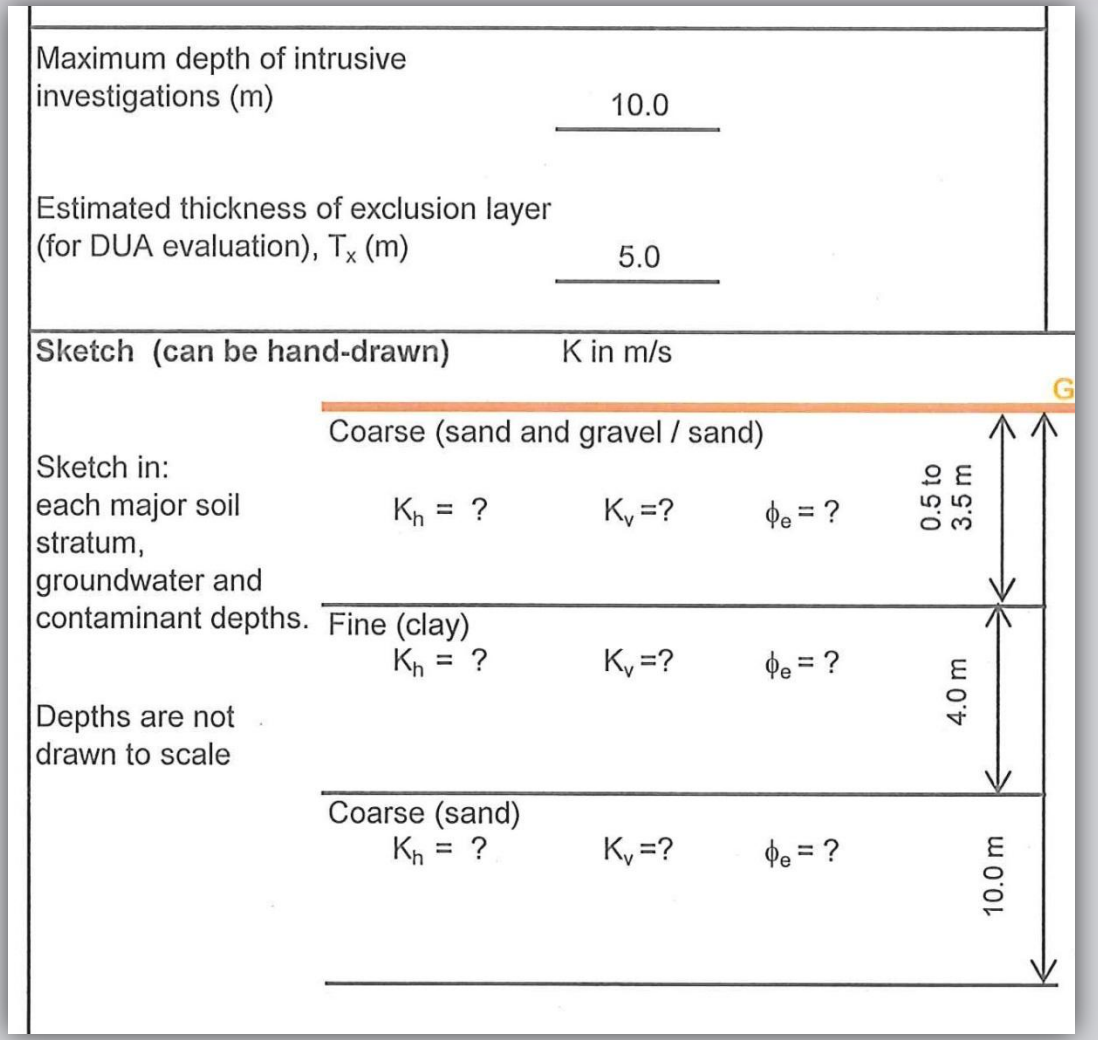
Contaminant Data

Notes: bgs denotes below ground surface.
GWT denotes groundwater table.
Data based on data available in 2008 (from other consultants)

Example 1 – Soil Data Summary

Data Gaps

- Suspicious soil classification during drilling –
  sand jumps to clay
- Maximum depth of drilling is 10 m, similar to maximum depth where impact is detected



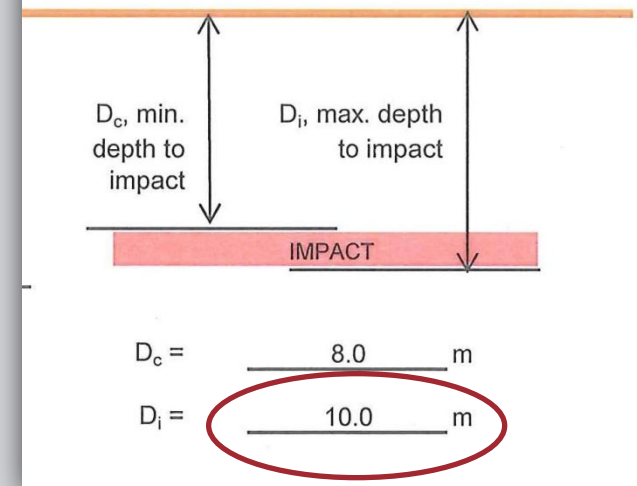
Example 1 – Contamination Data

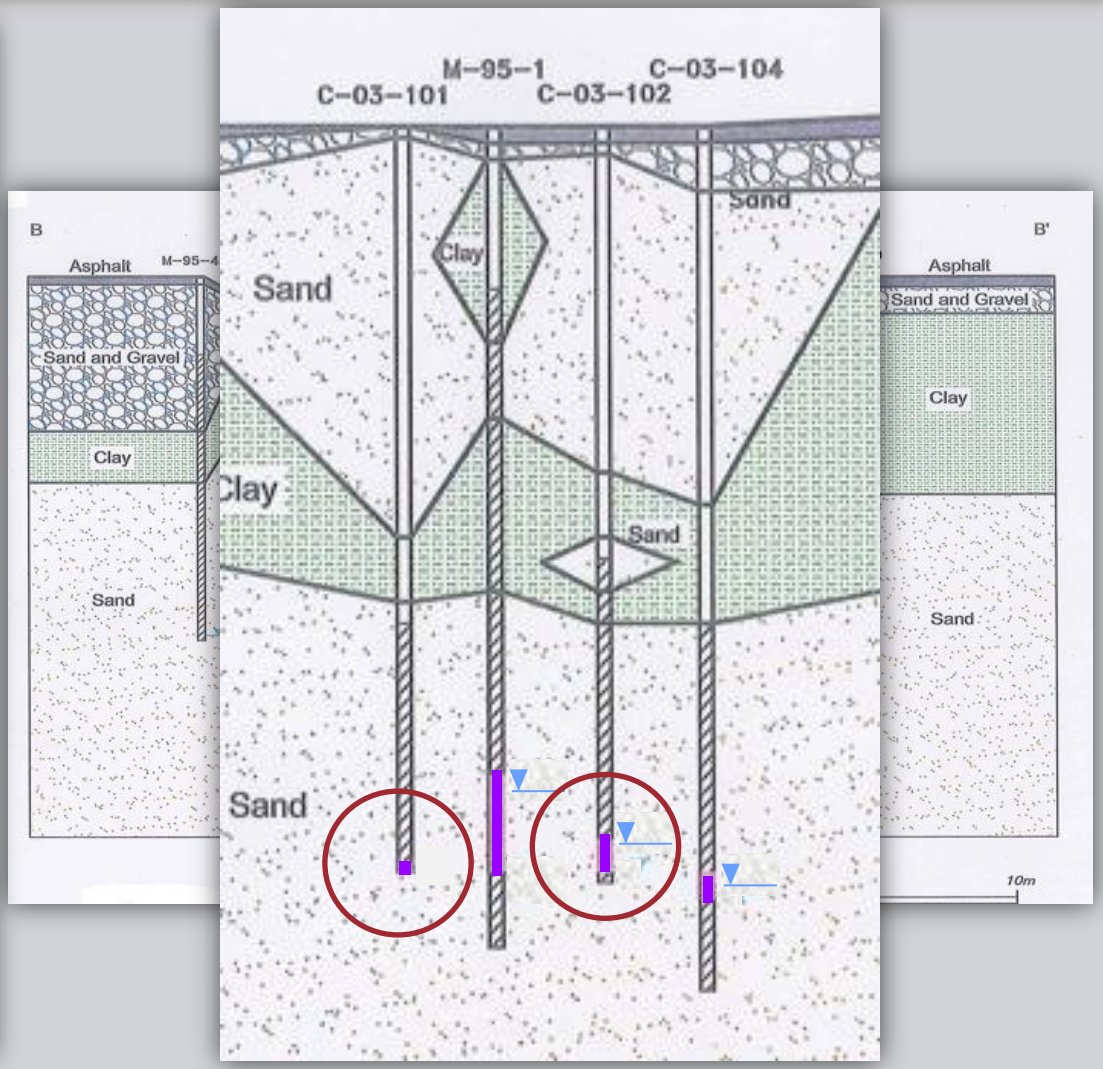
Delineated: ☑ Horizontal ☐ Vertical

Criteria Selection

Attach summary from:

- ☐ Pathway selection and receptor identification as d IOL Staged Phase II ESA POP
- ☑ 2010 Alberta Tier I and Tier II (pathway eliminatio criteria selection summary (OAEI spreadsheet)
- ☐ Site-specific criteria development
- ☐ Other criteria development procedure:



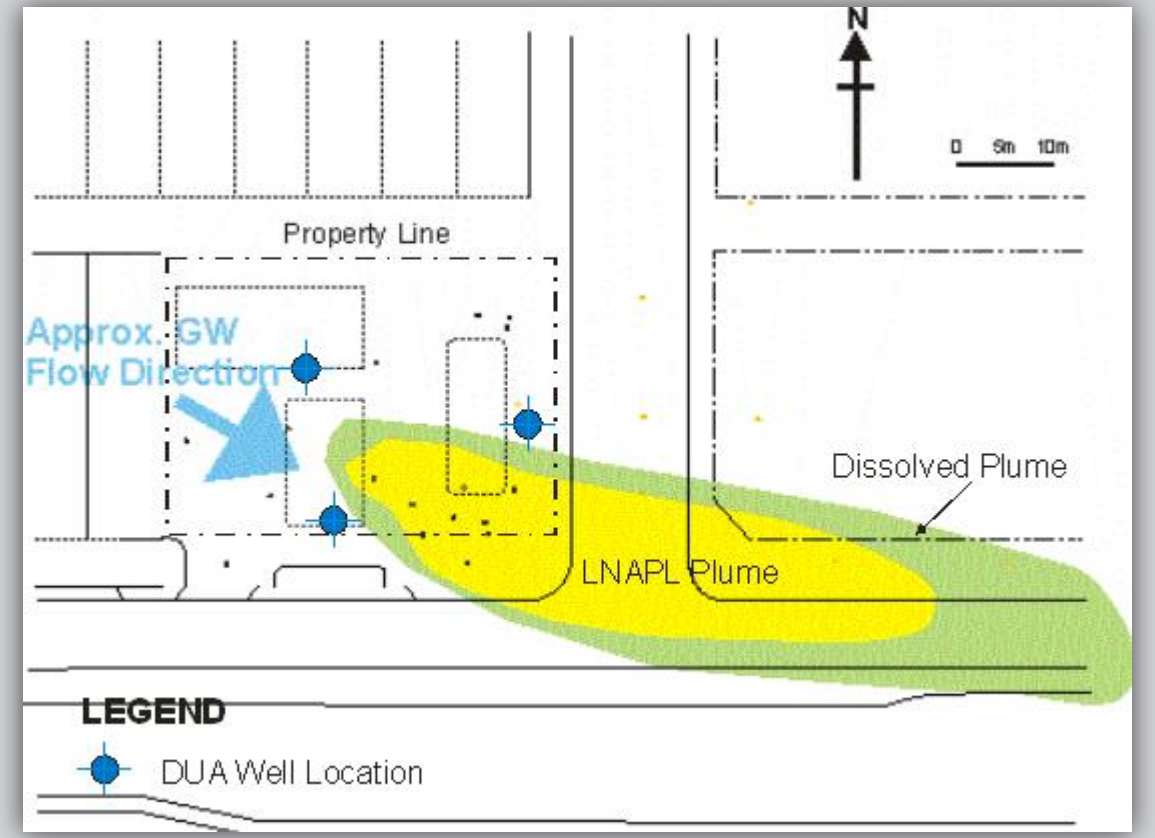


Example 1: Next Steps - 1

- Step 1:
  Additional drilling to vertically delineate LNAPL impact and ascertain soil types

Example 1: Next Steps - 2

- Step 2: Install at least 3 deep DUA wells as shown screened below the lowest impact with ~4 m screen length



Deep DUA wells should be located outside impacts to avoid potential cross-contamination!

Examples

- CSM Example 2:
  - Vapour intrusion assessment using soil gas monitoring wells

Example 2 – Vapour Intrusion Assessment

- Objective:
  To assess the potential of soil vapour intrusion due to dissolved gasoline impacts in groundwater for a residence using standard Parsons (OAEI) soil gas monitoring wells (SGMWs)

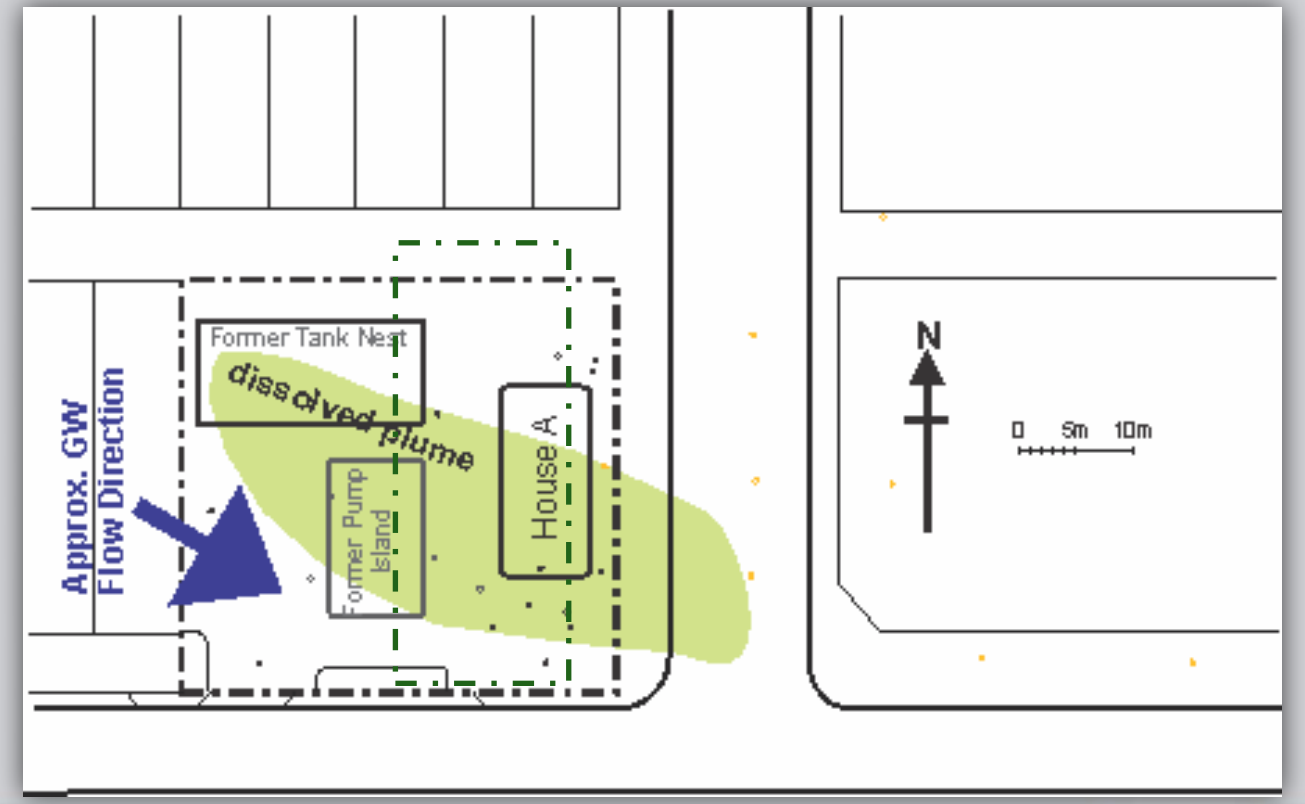
References:

Wong and Agar, 2009. Development of a technically defensible soil gas sampling strategy for vapour intrusion assessments. Canadian Geotechnical Journal, **46**(1): 102-113.

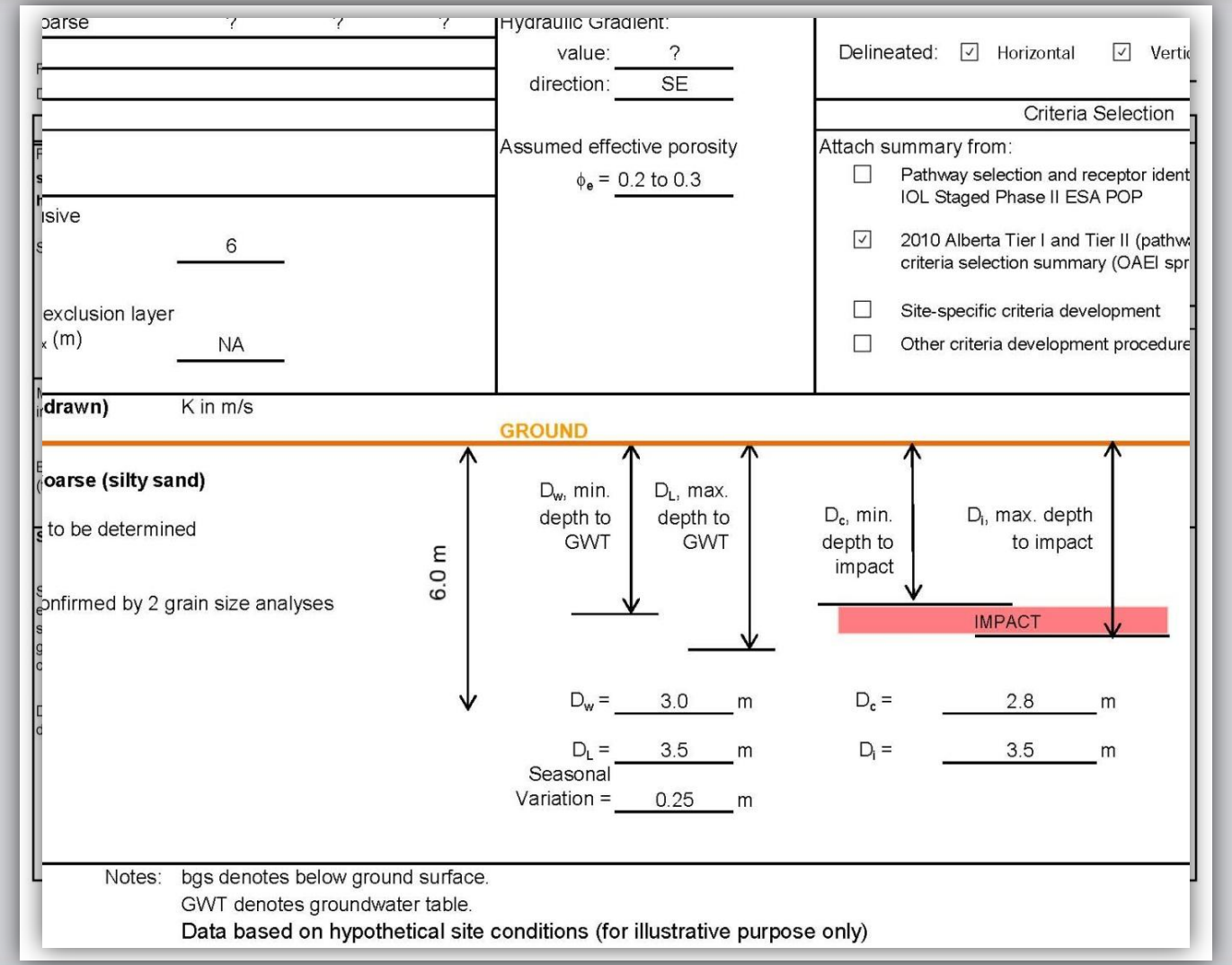
Example 2: Site Plan

- A hypothetical site located at the same location as in Example 1, site condition is shown in the following slide

House A is a house with a basement slab at 2.5 m bgs

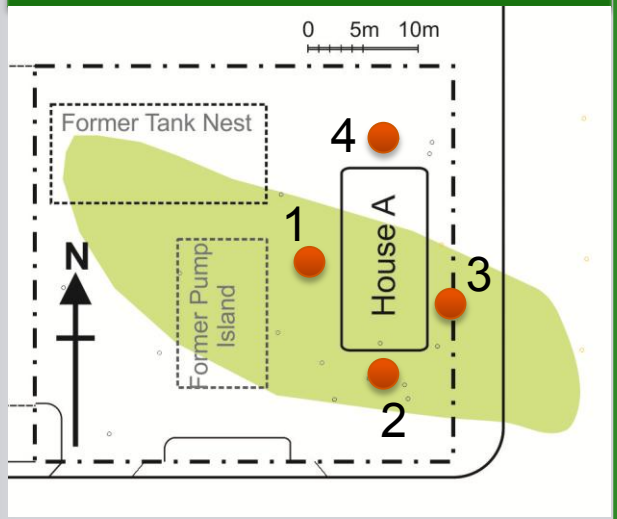


Example 2 – Data Summary

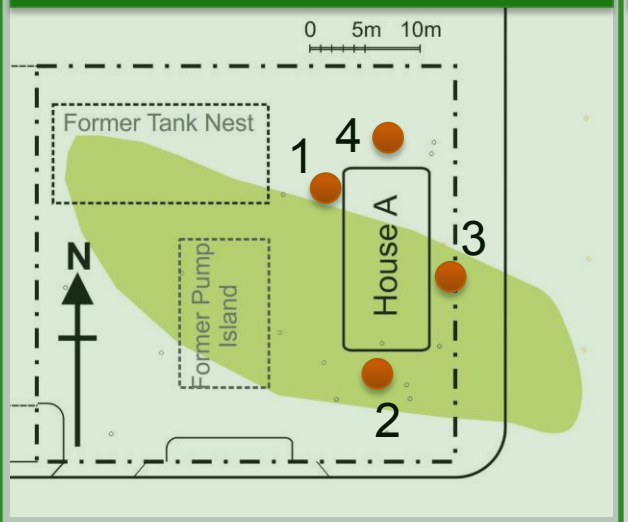


Example 2 – Proposed SGMW locations

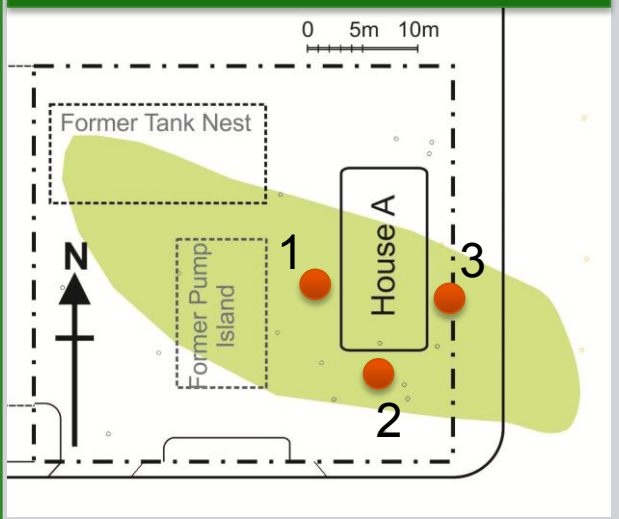
Option 1



Option 2



Option 3



● Proposed SGMW location

Which option is more appropriate – 1, 2 or 3?

Examples

- CSM Example 3:
  - Develop a CSM for an inactive industrial landfill

Example 3 – CSM for an Inactive Industrial Landfill

- Objectives:
  - To understand geological and hydrogeological conditions
  - To summarize soil, groundwater and soil gas chemical conditions onsite
  - To identify data gaps
  - To recommend additional measures for post-closure care

Example 3 – Data Source & Site Plan

Key Data Sources

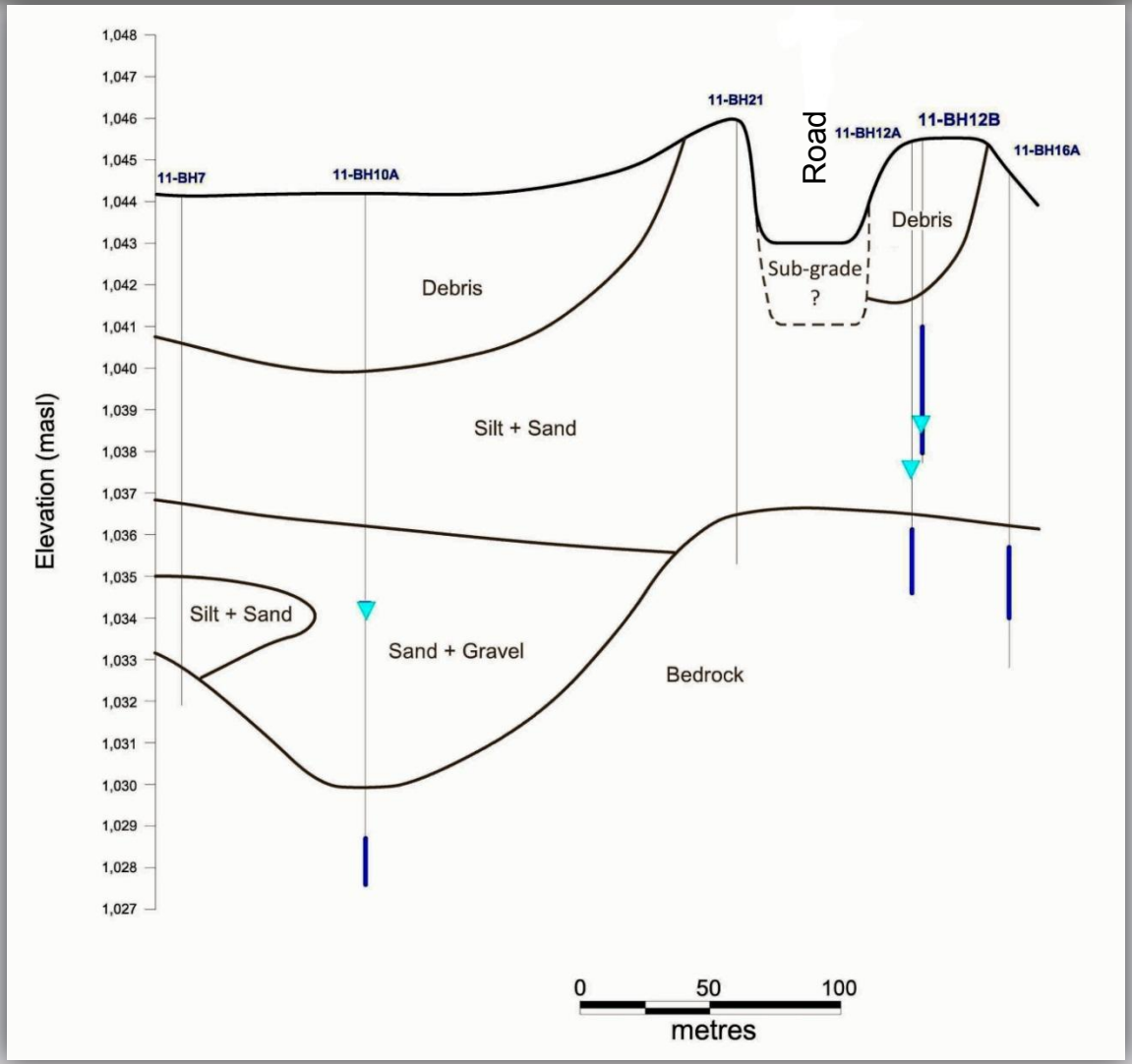
- Other consultants' reports, 1967-2010
- Parsons (OAEI) - intrusive site investigation reports (including geophysics) - 2011 and 2012
- Environment Canada - climatic data
- Land use data
- Air photos, e.g. National Air Photo Library
- Alberta Environmental Site Assessment Repository (ESAR)

Site Plan

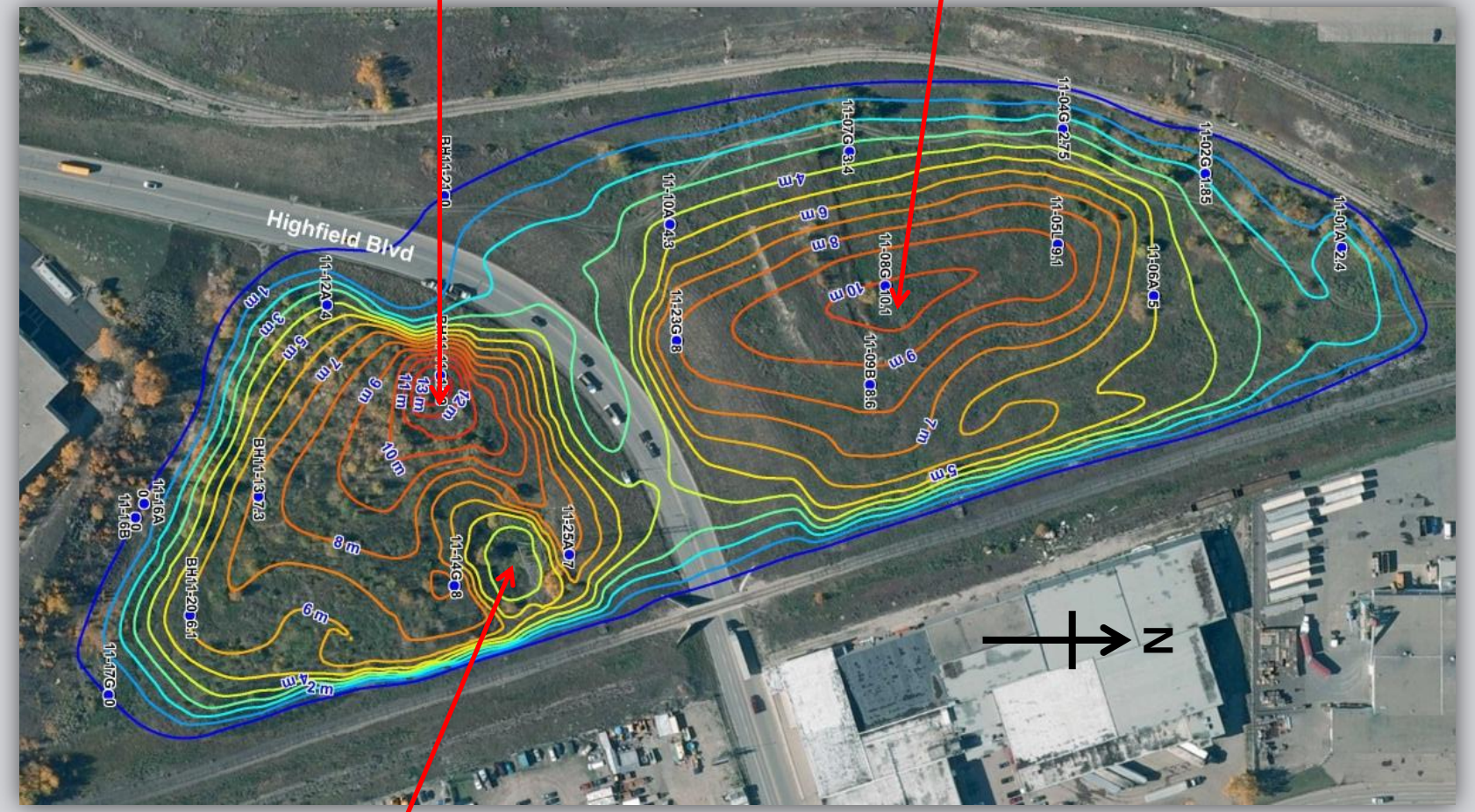
Example 3: Data Summary

- Topography
- Surface water drainage pattern
- Geology and Hydrogeology:
  - cross-sections
  - potentiometric contours
- Cross-section from site to a river
- Thickness of debris
- Chemical impacts identified:
  - soil, groundwater & soil gas

Example 3: Typical West-East Cross-Section



Example 3: Debris Thickness



Data Gaps Identified - 1

- Soil Gas:
  - Chloroform is the PCOC, source is uncertain, not delineated, potential exposure not assessed
- Debris:
  - Disposal methods of waste material unknown
  - Landfill cap is only intermittent
- Soil:
  - Background concentrations of PCOCs not determined
  - Leachable metals analyses not performed for soils > 6 m bgs
  - Possible asbestos impact

Data Gaps Identified - 2

- Groundwater (gw):
  - Background concentrations of PCOCs not determined
  - Vertical and lateral extents of gw impacts not delineated
  - Seasonal variation of potentiometric elevation not determined
- Surface Water:
  - Potential impact on surface runoff by exposed debris
  - Effect from surface runoff from upgradient locations
- Future Land Use:
  - Unknown

Recommendations on Post-Closure Care

- Engineered cover/cap over complete site
- Additional soil gas monitoring wells at site boundaries with adjacent buildings
- Regular monitoring and sampling of groundwater and soil gas for selected parameters to determine trends
- Develop site-specific risk management criteria
- Detailed geochemical modelling for contaminant transport

Take Home Messages

Take Home Messages

- To develop a CSM we need:
  - Objective(s) of the CSM
  - Site information
  - Geologic data
  - Groundwater and surface water hydrogeologic data
  - Contaminant data
  - Transport pathways and receptors
  - Applicable remediation technology (if required)
- A CSM is a living document and needs to be updated as new information becomes available
- A CSM provides a documented basis for rational decisions

Questions and Discussion

- Thank you for attending

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