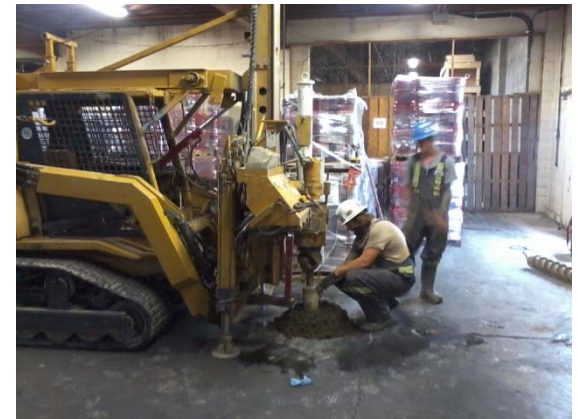
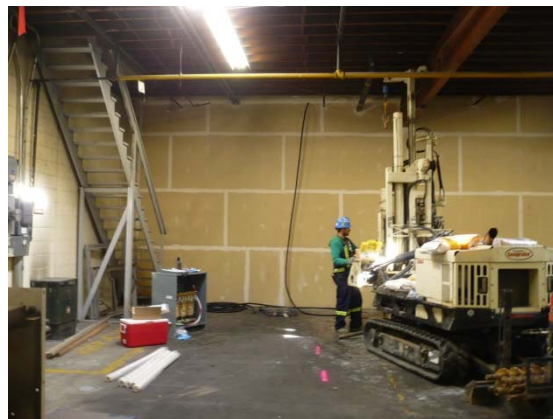
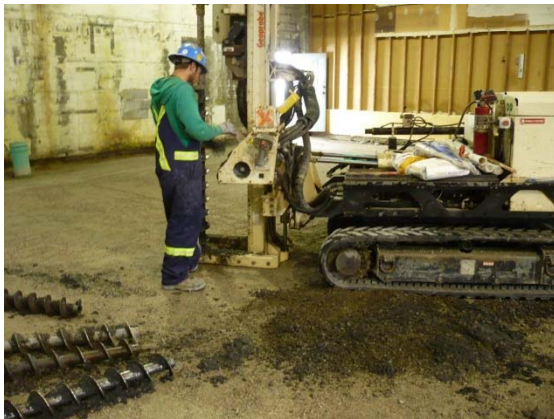


# Difficult Access & Difficult Drilling Conditions

Stage 2 Preliminary Site Investigation  
and Detailed Site Investigation



October 15, 2015

# About the Presenter.....

Tyler Joyce, C.Tech

Project Manager – Stantec Consulting

12 years experience in Contaminated Site Investigations.

- British Columbia Institute of Technology, Environmental Engineering 2009 – 2010, Bachelor of Technology
- British Columbia Institute of Technology, Chemical Sciences, 1999 – 2000, Certified Technician.



October 15, 2015

# Agenda

- 1 Introduction to Case Study
- 2 Contaminants Investigated
- 3 Problems Encountered during Site Investigation
- 4 Drilling Options Available
- 5 Unique Solutions
- 6 Results

# 1 Introduction to Case Study

Site Investigation that took 10 years to complete and resulted in the installation of 75 monitoring wells.



# 1. Introduction

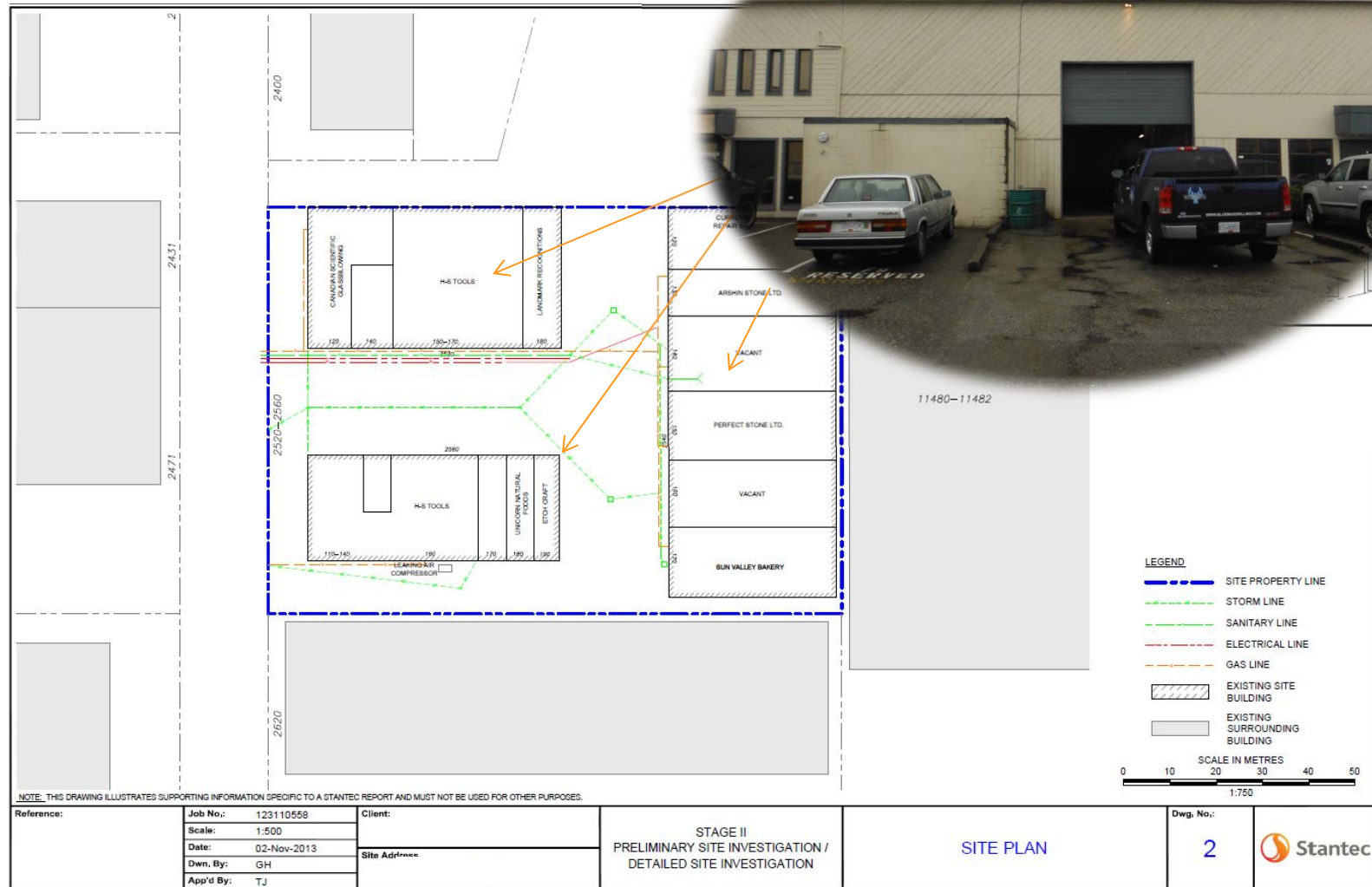
## Stage 2 PSI

- Light commercial multi-tenanted facility located in the lower mainland region of British Columbia
- Multiple areas of environmental concern to be investigated
- Potential for contamination in soil, groundwater and soil vapour to be present

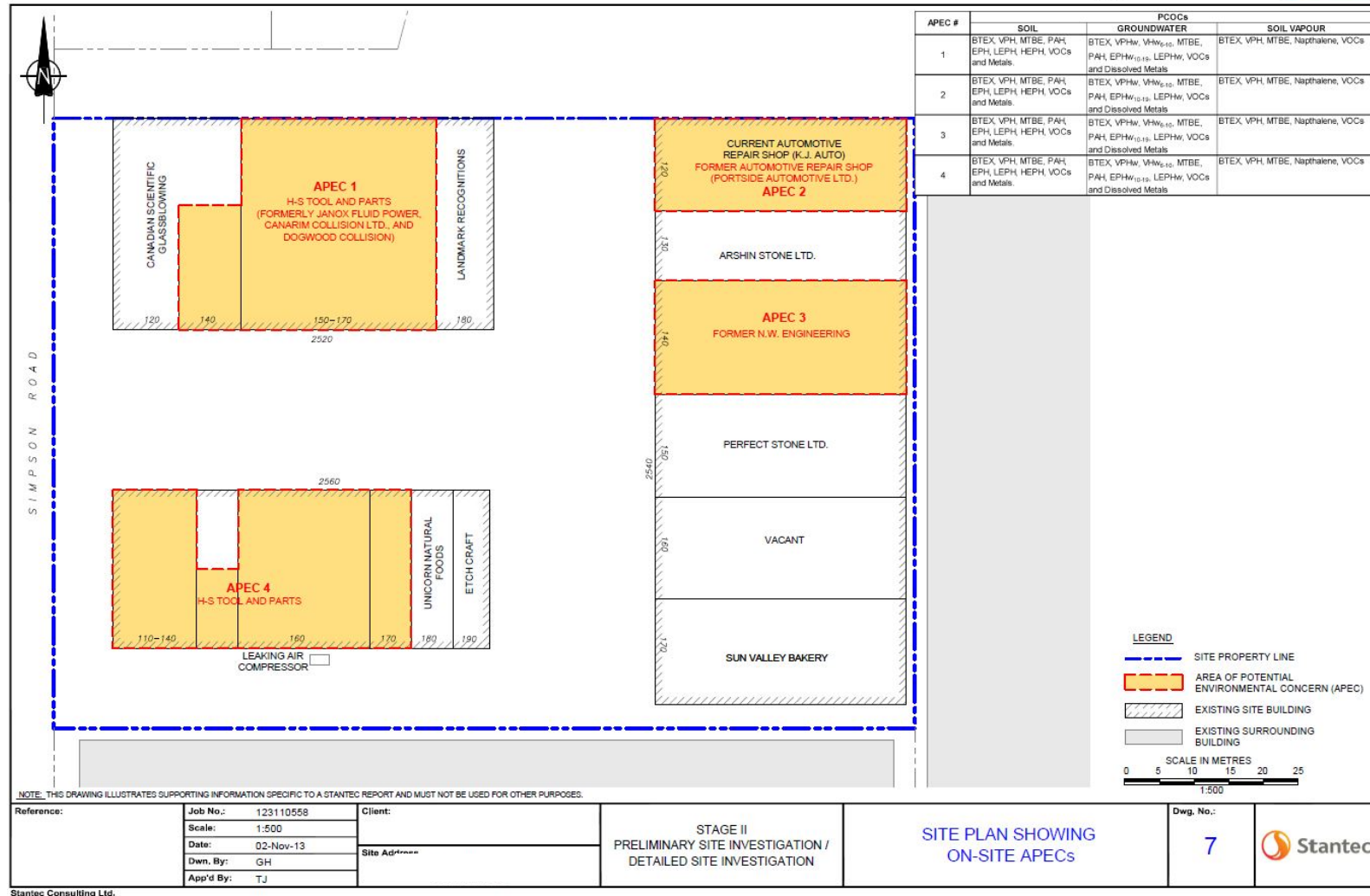




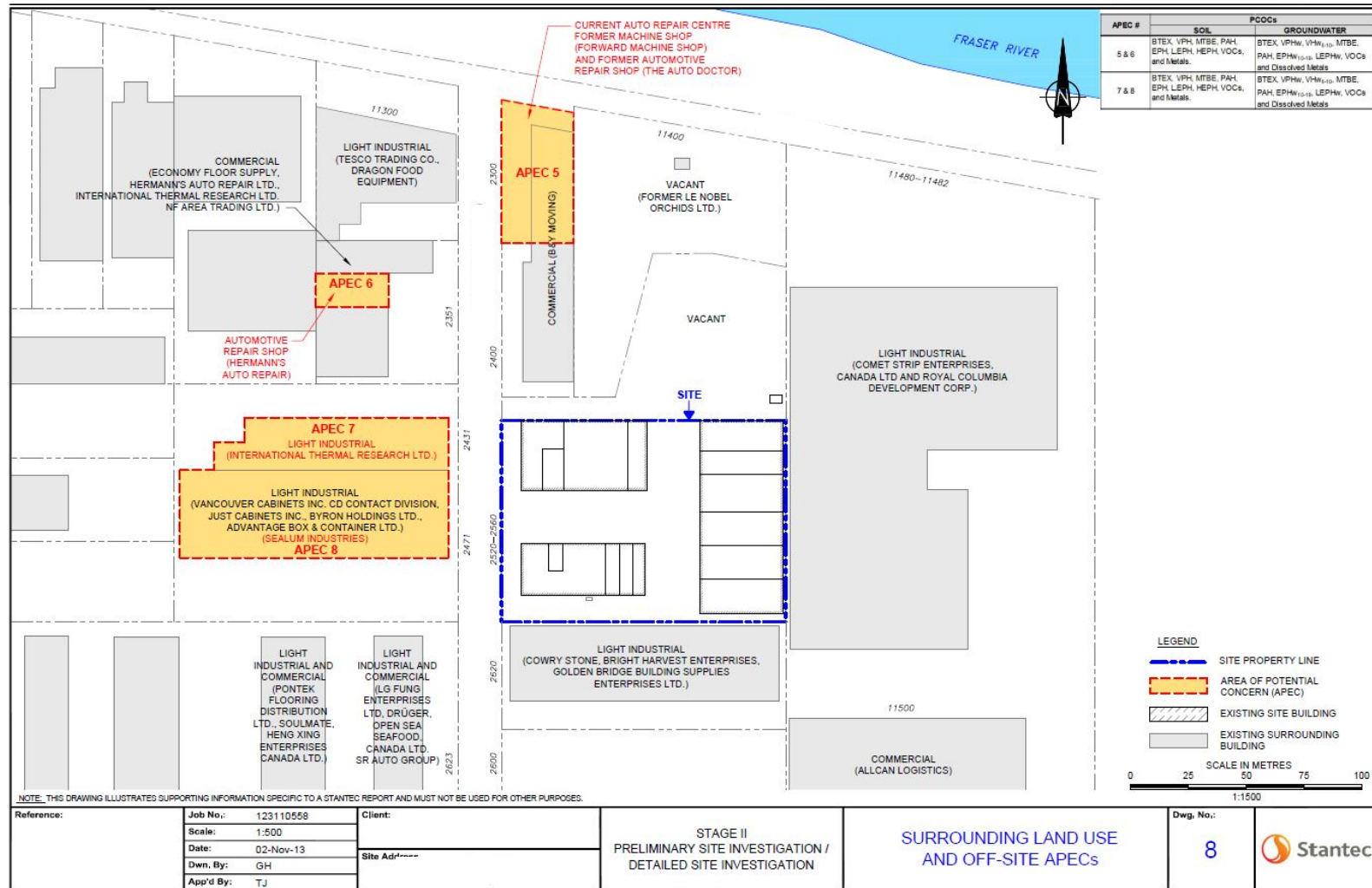
# Site Location Plan



# On-Site APECs and PCOCs



# Off-Site APECs and PCOCs





# 1. Introduction

## Stage 2 PSI and Detailed Site Investigation Findings...

- Geology encountered included Fraser River Delta sands overlain by silt with trace amounts of peat
- Two distinct hydrogeologic zones
- Complex groundwater flow regime encountered during investigation

## Slide 9

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**BB6**

Possibly expand to discuss different flows in two different strata? Makes site more interesting (and gives an even better idea of the complexities you had to deal with)

Beck, Bob, 30/09/2015

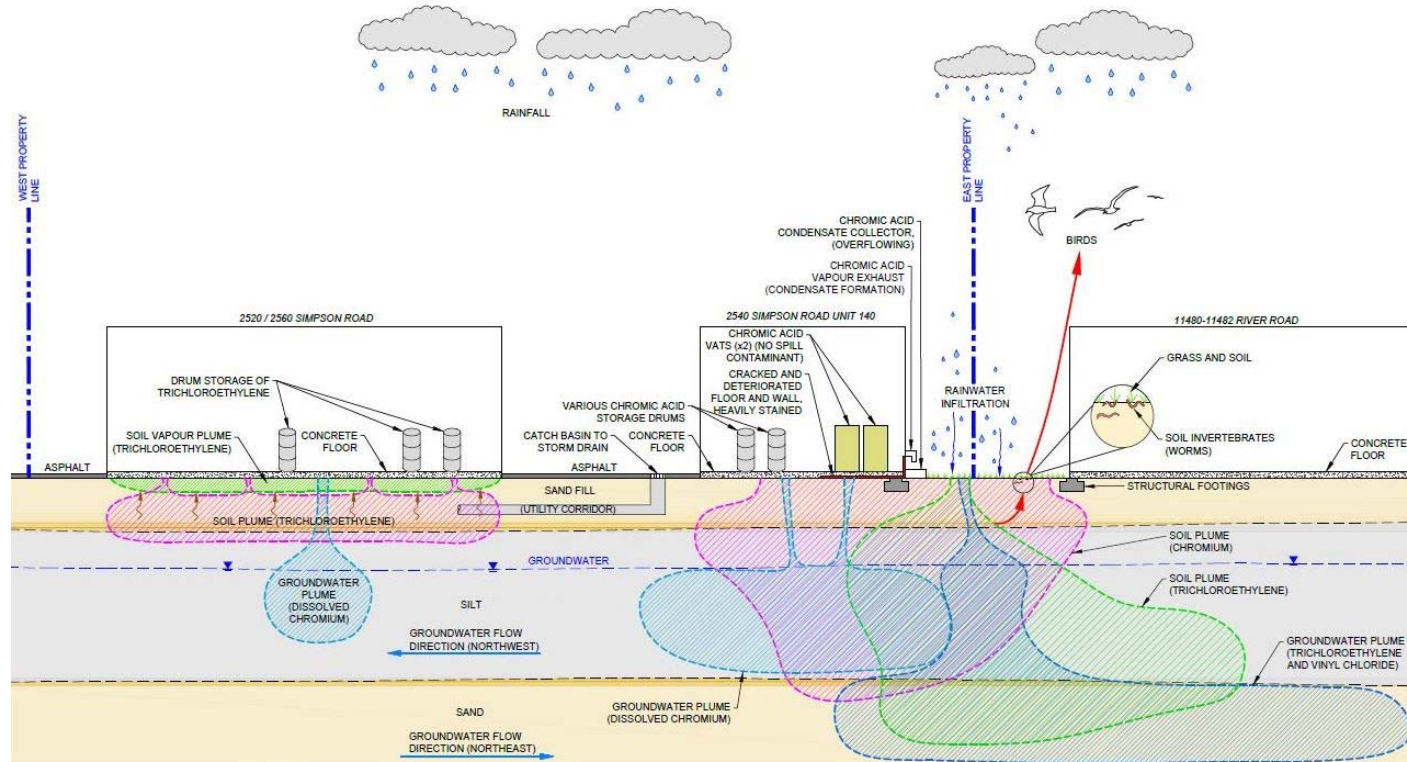
# 1. Introduction

## Hydrogeology

- Tidally influenced groundwater system
- Completed a complex hydrogeology monitoring program
- Groundwater flow direction determined to be northwest towards Fraser River in silt
- Groundwater flow direction determined to be northeast towards Fraser River in sand

# 1. Introduction

## Stage 2 PSI and Detailed Site Investigation Conceptual Site Model



[illegible]



# Site Geology



SAND FILL LAYER BB8  
SAND LAYER

CLIENT: <b>Brum Enterprises Ltd.</b> PROJECT: <b>Stage 2 PSI / DSI</b> <b>2540 - 2560 Simpson Rd.</b> <b>Richmond, BC</b>				WELL RECORD				WELL NO: <b>MW14-111</b>		
				PROJECT NO: <b>123110558</b> SURFACE ELEVATION: <b>1.65 m</b> SITE DATUM: <b>Richmond Monument #194</b>						
DEPTH [m]	SOIL TYPE	SOIL DESCRIPTION	SAMPLE TYPE	BLOW COUNT	COMBUSTIBLE VAPOUR LEVEL [ppmv]	SAMPLE ID Analysis [If Requested]	WELL COMPLETION	WATER LEVEL	COMPLETION NOTES	ELEVATION [m]
0.2	CONCRETE	SAND (FILL) medium grained, brown, moist			1 10 100 1000				roadbox, slag, cement 10/20 silica sand	-1.0
0.4										
0.6	SILT	some clay and organics, brown, moist							GW = 1.82 mbg (8/25/2014) bentonite seal	0.0
0.8										
1.0		- grey, no organics below 1.5 m - wet below 1.8 m								-1.0
1.2										
1.4										
1.6										
1.8										
2.0										
2.2										
2.4										
2.6										
2.8										
3.0										
3.2										
3.4	SAND	fine to medium grained, trace silt, grey, wet								
3.6										
3.8										
4.0										
4.2										
4.4										
4.6										
4.8										
5.0									10/20 silica sand 50 mm 010 slot PVC pipe	-3.0
5.2										
5.4										
		End of borehole at 5.5 m								
		Completion Information: Screened interval from 4.0 m to 5.5 m below surface								
		Top of Pipe (TOP) Elevation = <b>1.570 m</b>								
		Groundwater Information: Depth to groundwater from TOP = <b>1.74 m</b> (8/25/2014)								
INVESTIG. METHOD: Hollow Stem Auger INVESTIG. DATE: August 20, 2014 LOGGED BY: RA				Sample Notes:				Stantec Sheet 1 of 1		

## Slide 13

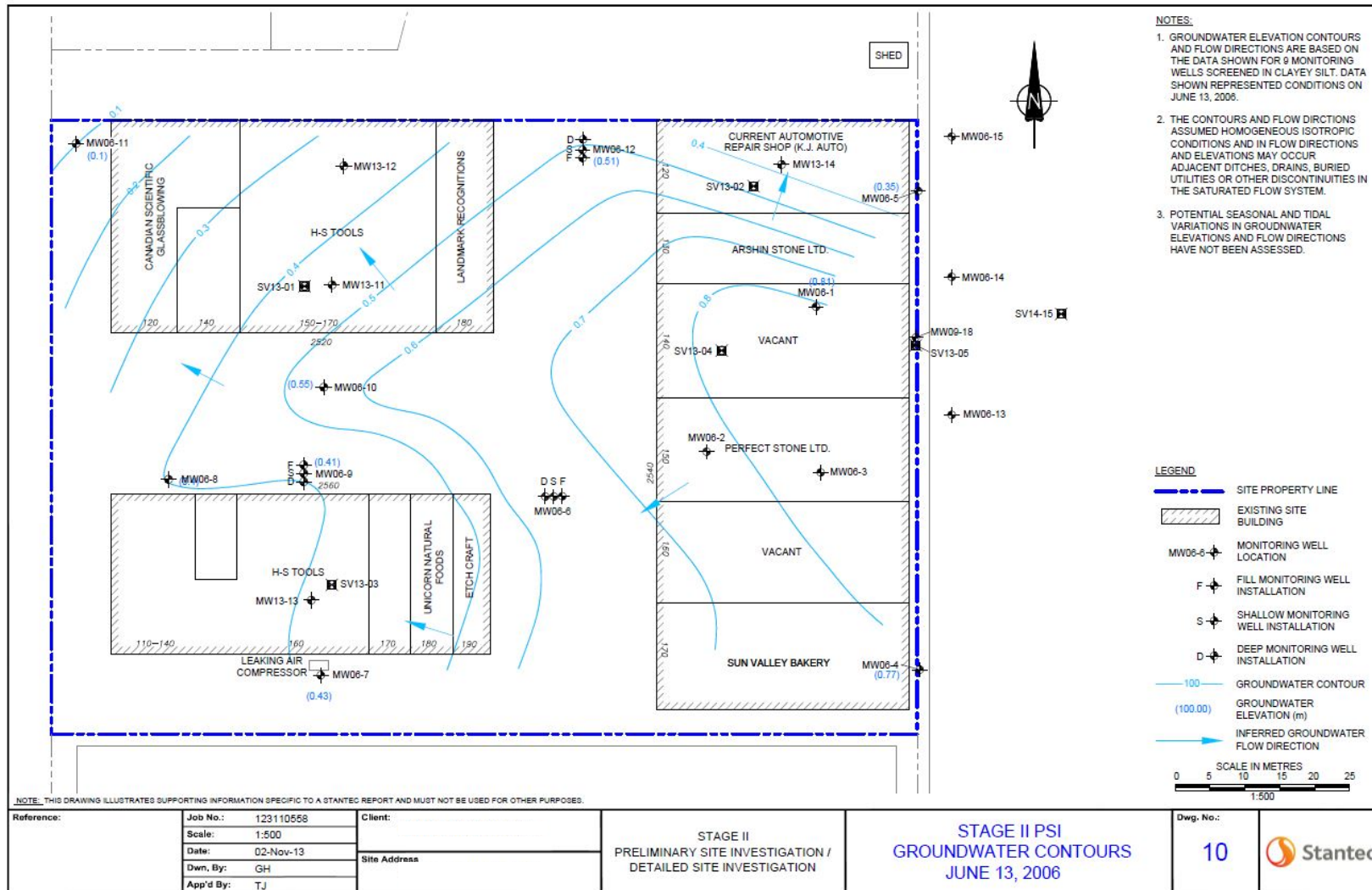
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**BB8**

Formatting issue -- overlapping type needs adjustment

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# Hydrogeology



## 2 Contaminants Investigated

- LNAPL & DNAPL
- Organics & Inorganics

## 2. Contaminants Investigated

- Contaminants of concern investigated during the Site investigation included:
  - Total chromium, speciated chromium (+3) and (+6), trichloroethylene, vinyl chloride, iron, manganese and arsenic
  - Investigated both organic and non-organic contaminants
  - Investigated both LNAPL and DNAPL contaminants (ie. PHCs versus chlorinated solvents).



# 3 Problems Encountered

*Every problem can be solved  
with an unique solution.....*



### 3. Problems Encountered

**Some of the Problems Encountered included the following:**

- Limited access back alley
- Adjacent property access issues
- Drilling inside with limited height clearance and limited space
- Drilling to depth in “heaving sand” environment

## Limited Access to Back Alley

- Access to back alley way blocked by fence
- Only option to access via building units
- Required to move through a door
- Difficult surface conditions in back alley
- Limited space between buildings



# Adjacent Property Access

- Investigation required on the adjacent property to assess possible migration of contaminants
- Adjacent property is a warehouse full of stock and inaccessible
- Unable to access certain locations of adjacent property



# Height Constraints and working inside buildings

- Investigation was required to be completed inside the buildings
- Roof height was 9'6" preventing us from using standard drill rigs



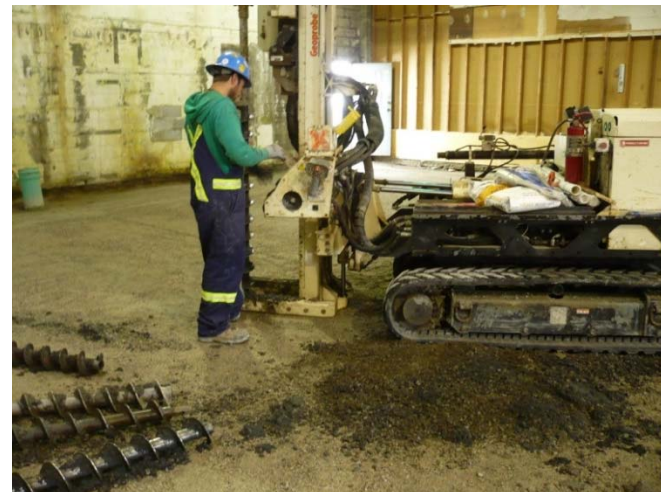
# Height Constraints and working inside buildings

- Considerations included:
  - Where to vent exhaust from drill rig
  - How to prevent marking the floor
  - Working after-hours to prevent disruption to tenants



# Fraser River Sands

- The investigation required delineation of contaminants into the Fraser River Sands
- Groundwater location at approximately 2.2 – 2.6 metres below ground in overburden silts
- Upward hydraulic gradient causing heaving sand phenomena



## 4. Drilling Options Available

- Investigate the various drilling options available
- Evaluate the drilling options available with the challenges faced at the Site
- Develop a matrix of options for challenges to select the most appropriate drilling technique for the Site constraints

## 4. Drilling Options Available cont'd.

Problems Encountered	Auger (Solid and Hollow Stem)	Air Rotary (ODEX)	Sonic	Direct Push (including pionjar)
Limited Access	Yes	Yes	Yes	Yes
Adjacent Property Access (angle drilling)	Yes	Yes	No	Yes
Height Restrictions	Yes	Yes	Yes	Yes
Heaving Sands	No	No	No	No*

## 5. Unique Solutions

### Approached Drilling Companies for a Solution to our Problem:

- Blue Max Drilling out of Coquitlam, BC was able to provide solutions.
  - Track mounted Auger Drill Rig retrofitted to drill at angles
  - Geoprobe equipped with Macro Core Sampling Device
  - Geoprobe equipped with Direct Push Technology





# Overcoming Limited Access

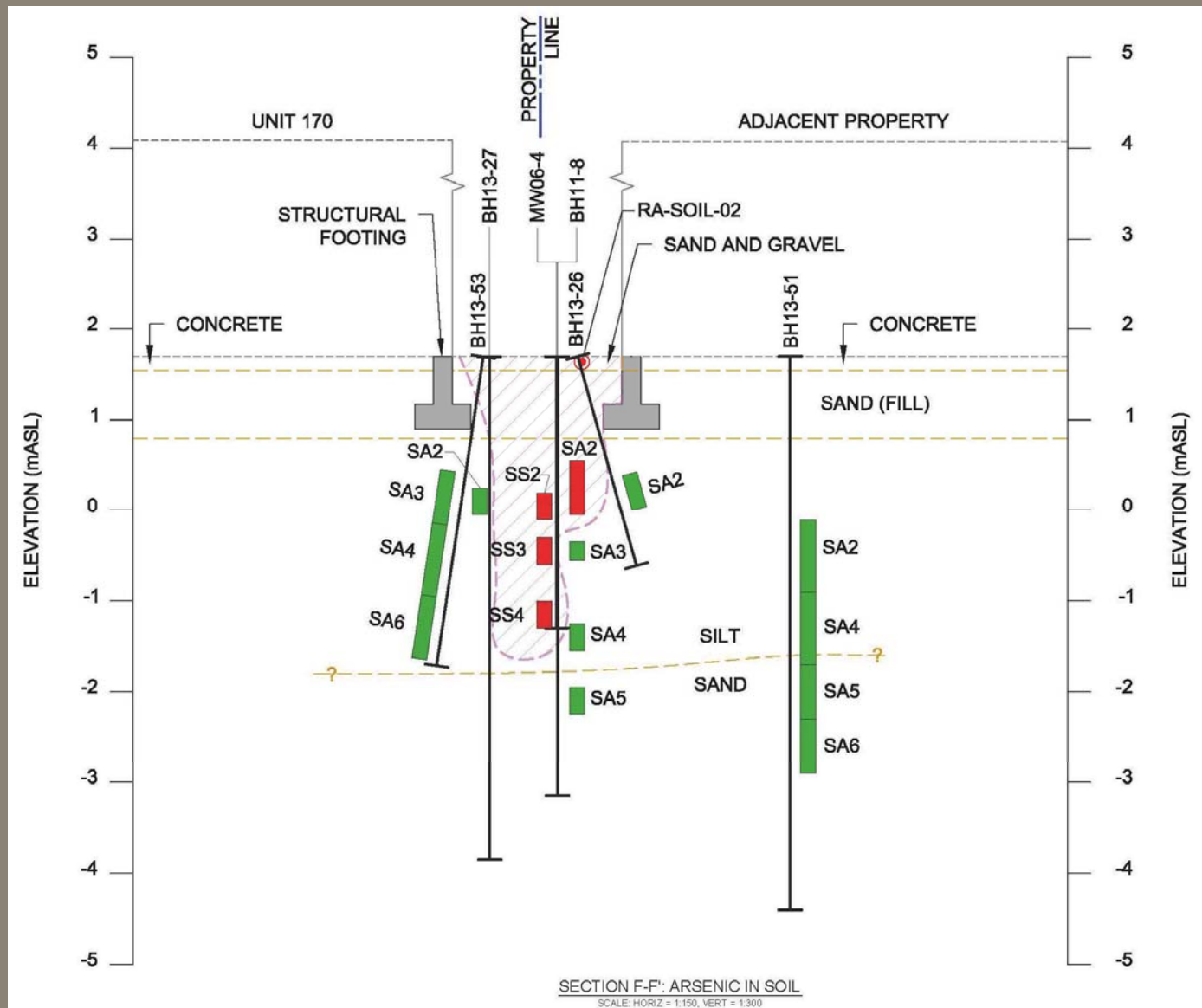
- Employed the use of the track mounted auger drill rig & Pionjar
- Installation of 1" monitoring wells



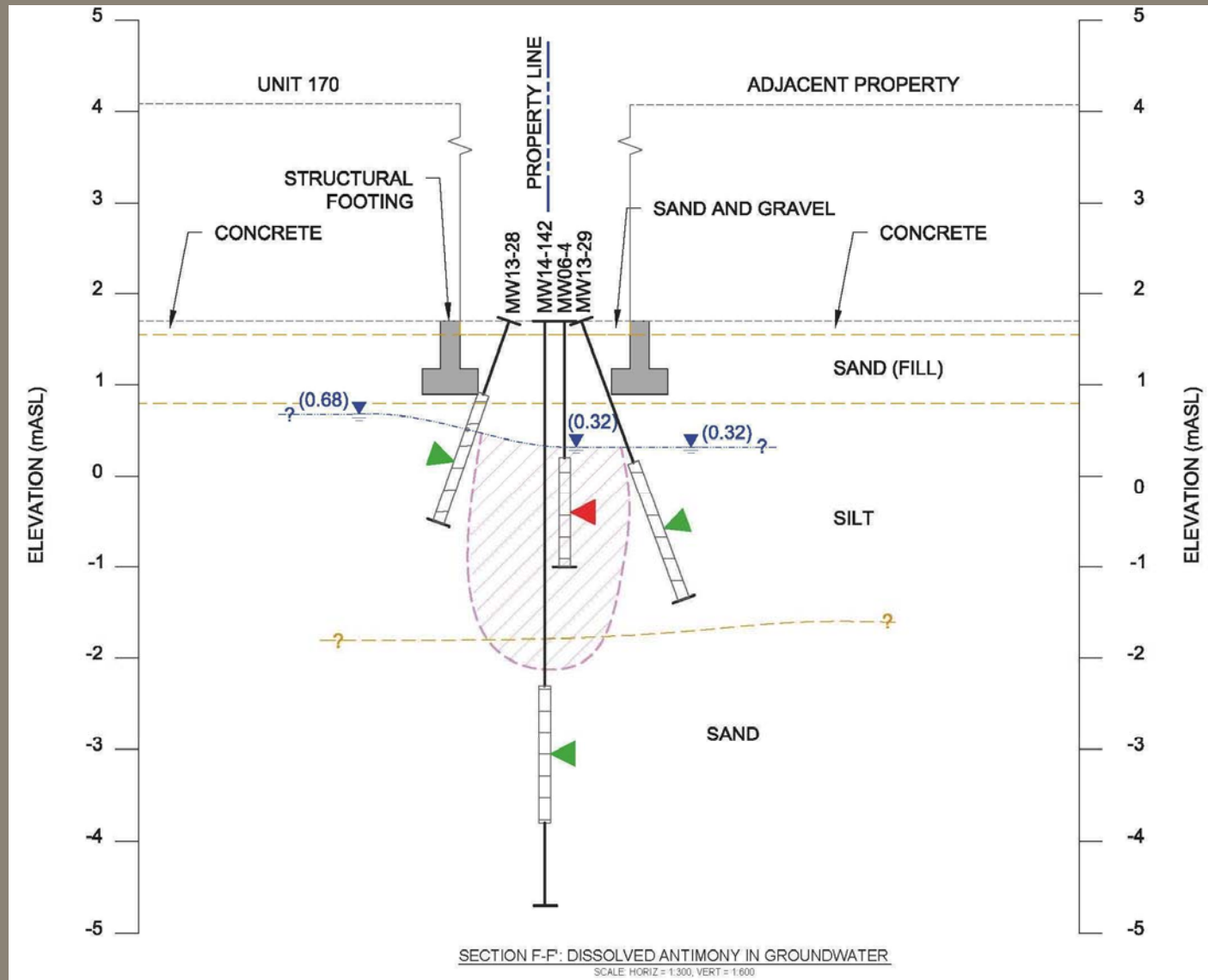
## Overcoming Access to Adjacent Property

- Employed the use of the track mounted drill rig
- Track rig was retrofitted to allow drilling on angles
- Completed hollow stem and solid stem drilling to allow for soil sampling and monitoring well installation

# Overcoming Access to Adjacent Property



# Overcoming Access to Adjacent Property



# Overcoming Heaving Sands

- Heaving sands present in Richmond, BC
- Site Geological Conditions:
  - Silt to 3.7 mbg
  - Sand below 3.7 mbg
  - Saturated below 2 mbg
- SSA, HSA, ODEX, Sonic, regular Direct Push not an option

# Overcoming Heaving Sands

- Required to obtain soil samples down to a depth of 18.3 mbgs
- Required to install monitoring wells with screen extending to 10 mbgs
- Unique solution of equipping Geoprobe with macro core sampling device



# Direct Push – Macro Coring

## Advantages

- Clay, silt, sand
- **Saturated, heaving sands**
- Undisturbed soil sample
- Target sample depths
- Excellent monitoring well installation



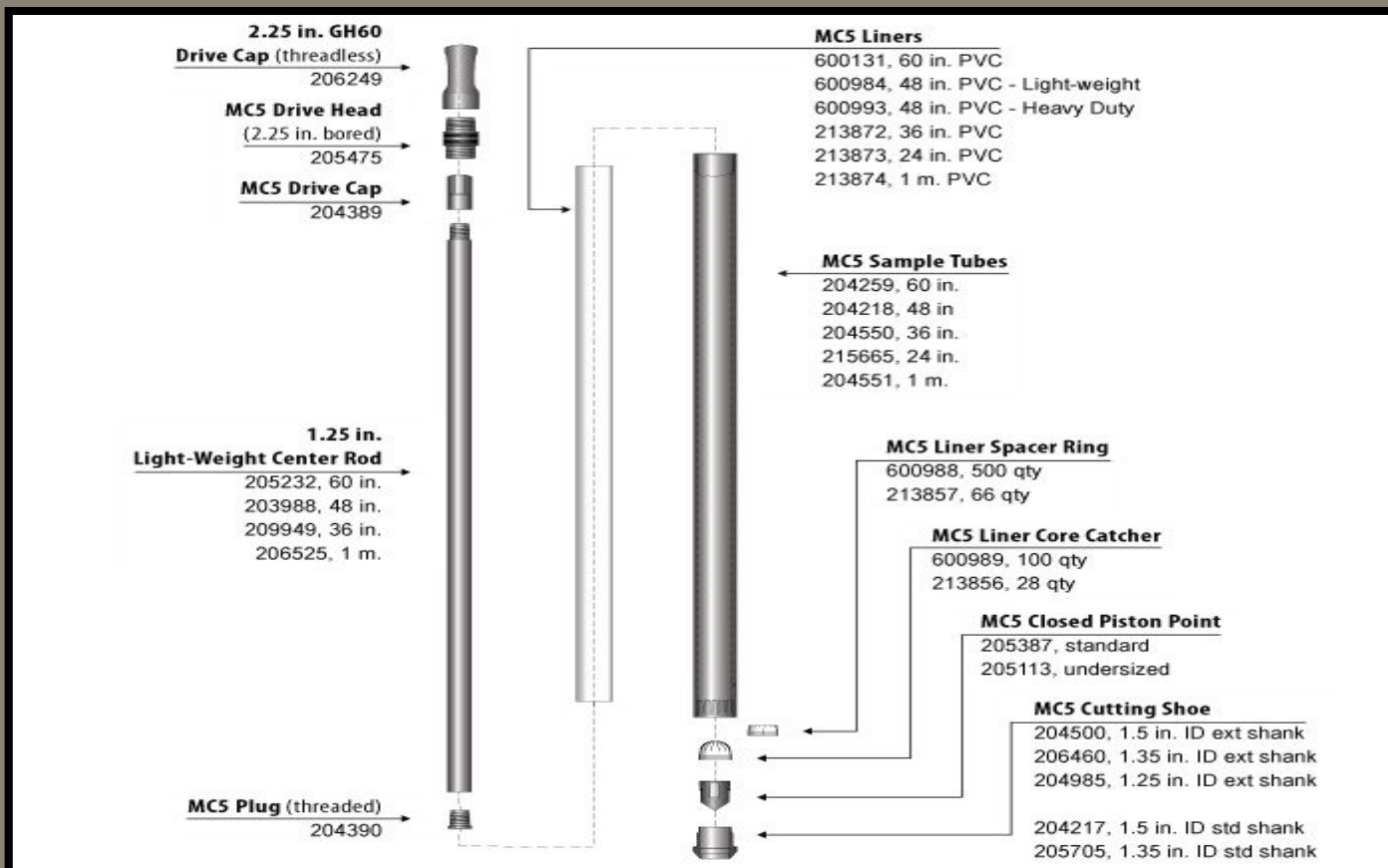
# Direct Push – Macro Coring

## Disadvantages

- Sample compression & low recovery
- Refusal
  - Dense, hard, and coarse soils
- More time intensive than direct push
- Difficulties with liner removal
- Noisy

# How it Works

- Internal rod holds a closed piston point in place while advancing through soil



# How it Works

Steel Centre Rod



Closed Piston Point  
Cutting Shoe

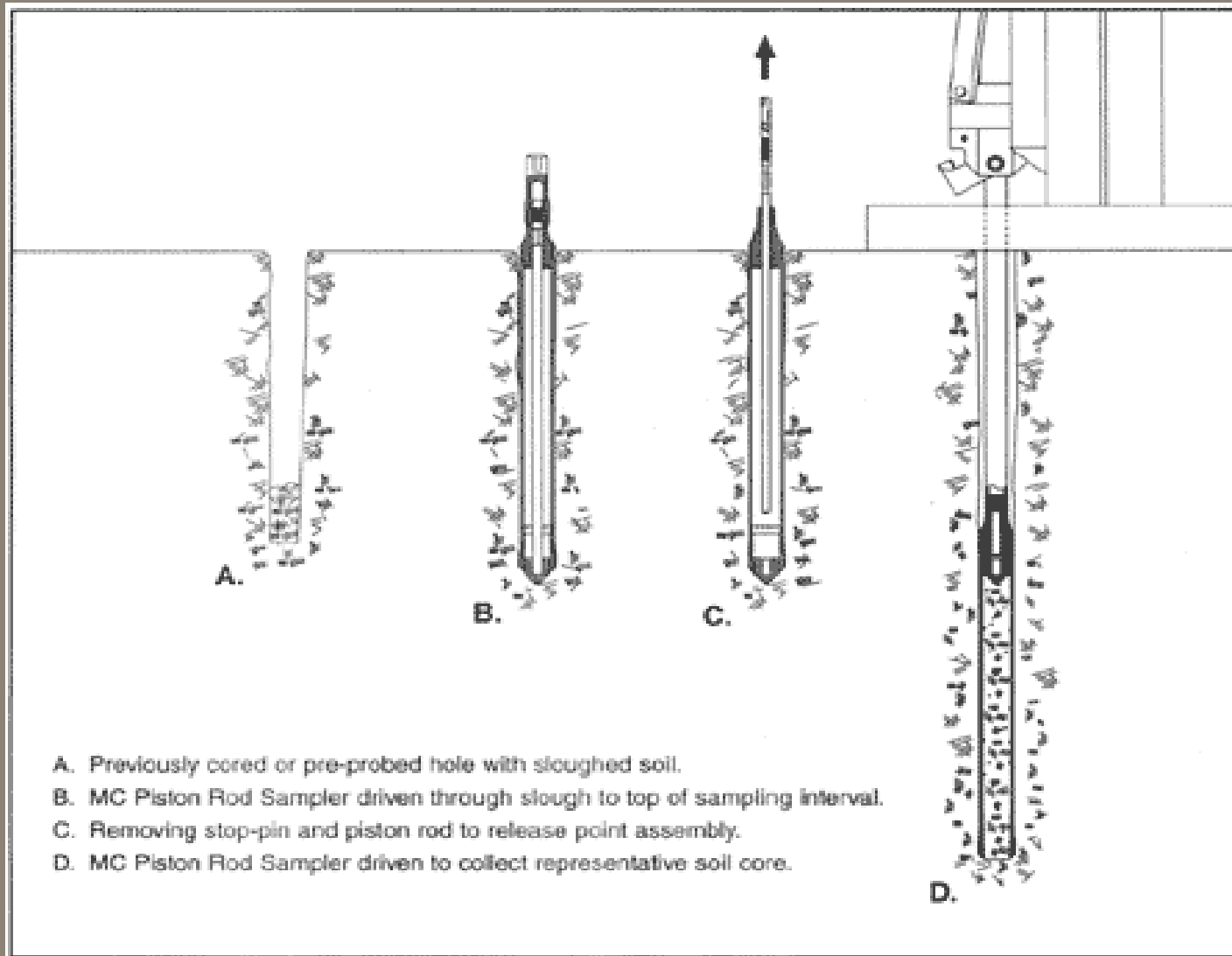


Add drive cap to top of steel  
Insert plastic sample tube liner  
Add drive cap to top of steel  
closed piston point in place  
sample tube  
while advancing borehole

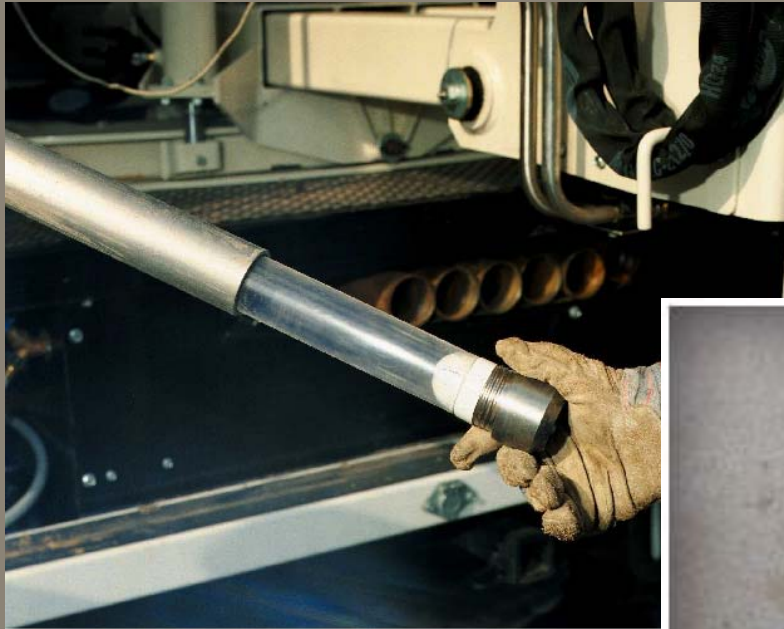
Steel Sample Tube

Insert plastic piston and cutting  
shoe into bottom of steel  
sample tube

# How it Works



# Direct Push – Macro Coring



## 6. Summary of Results

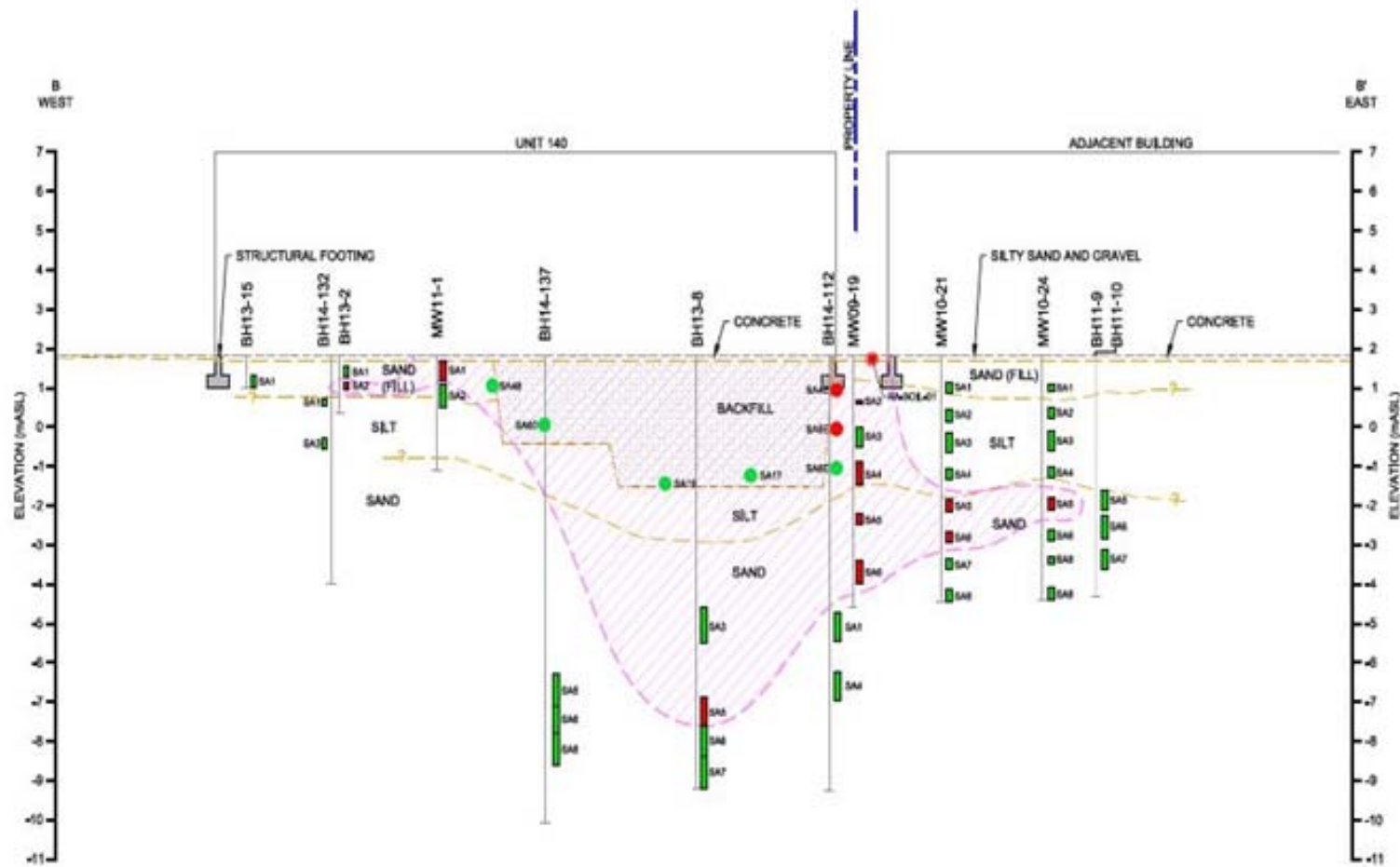
- Unique solutions that were employed offered the following:
  - Ability to obtain representative soil samples in all strata at discrete target locations.
  - Ability to install monitoring wells into heaving sands with excellent sand packs.



## 6. Summary of Results

- Unique Solutions that were employed offered the following:
  - Ability to fully characterize and delineate the soil and groundwater contamination for all identified contaminants.

# Soil Cross-Sectional View



SECTION B-B' - TOTAL CHROMIUM IN SOIL  
SCALE: HORIZ = 1:300, VERT = 1:500

## Slide 41

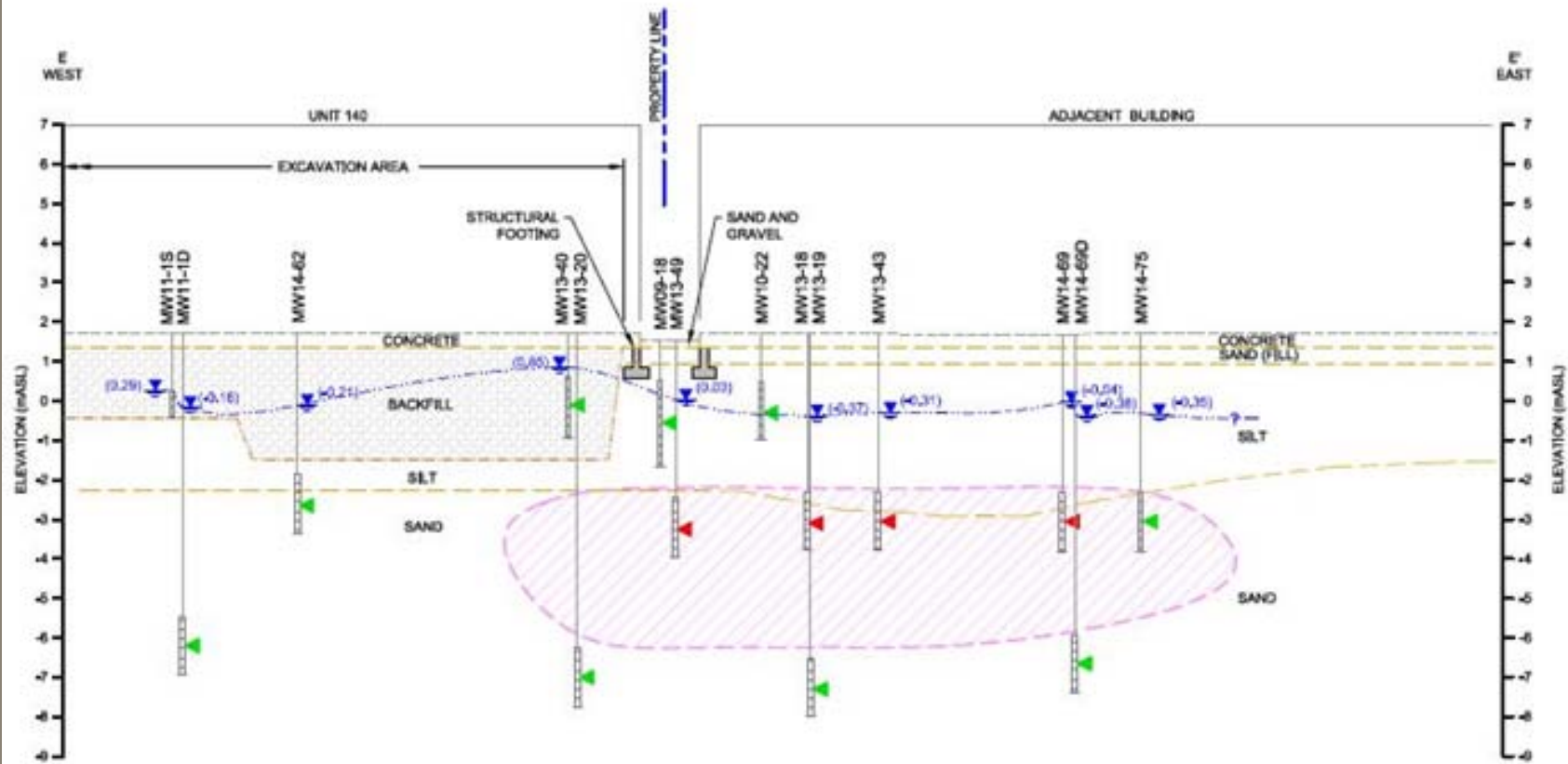
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**BB17**

Suggest cropping this and following graphic -- legend and figure box just add clutter -- cross-section is the thing -- that way you can also add an explanatory caption, e.g.

Beck, Bob, 30/09/2015

# Groundwater Cross-Sectional



**SECTION E-E: VINYL CHLORIDE IN GROUNDWATER  
SHALLOW, INTERMEDIATE, AND DEEP ZONE (0.9 - 9.8 mbqs)**  
SCALE: HORIZ = 1:300, VERT = 1:600

# Questions?

Tyler Joyce  
778-328-1041  
[Tyler.Joyce@Stantec.com](mailto:Tyler.Joyce@Stantec.com)

