WaterTech 2011

Technical Guidance on Site Specific Investigation for Elimination of Domestic Use Aquifer Pathway

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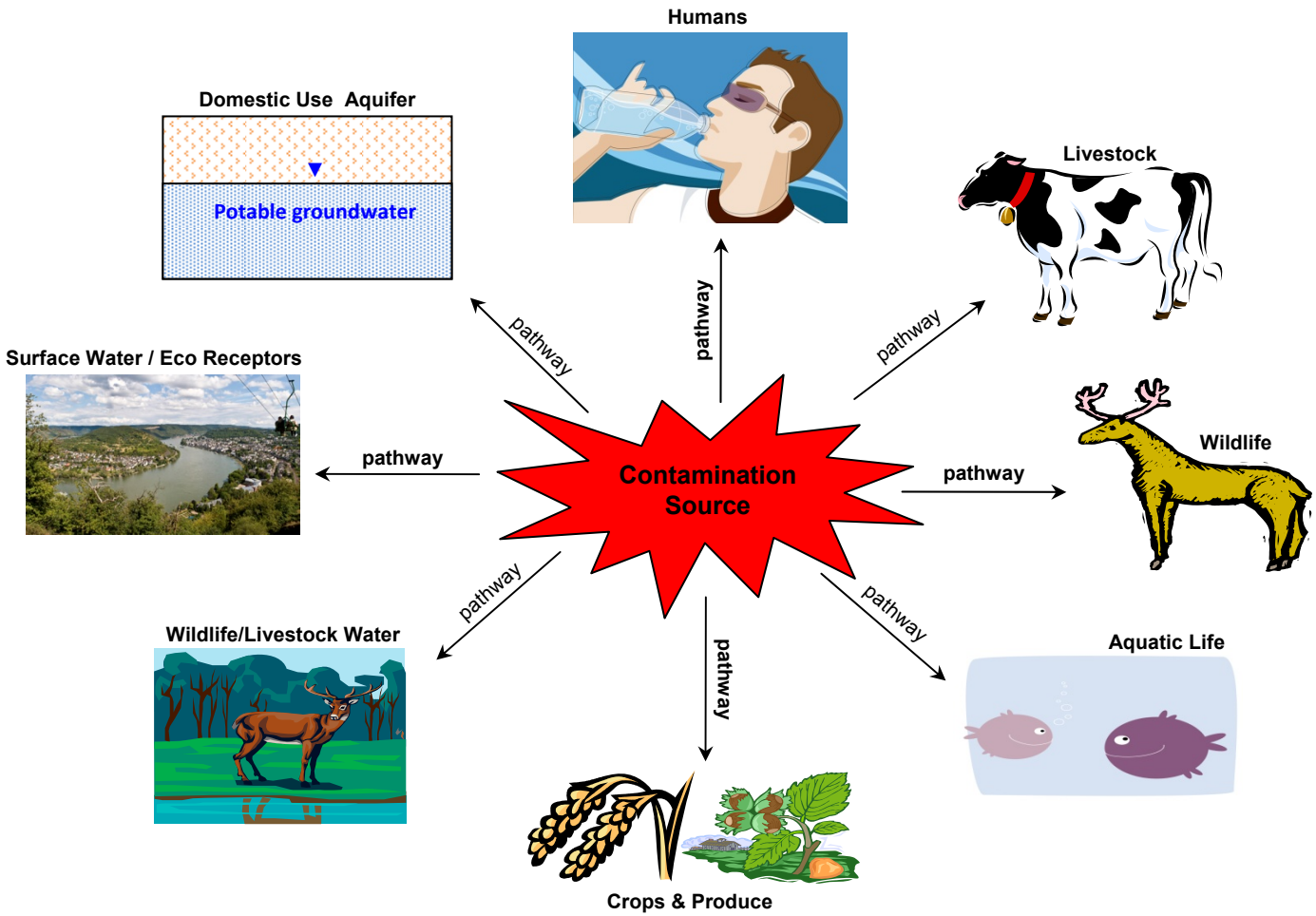
PHH ARC ENVIRONMENTAL

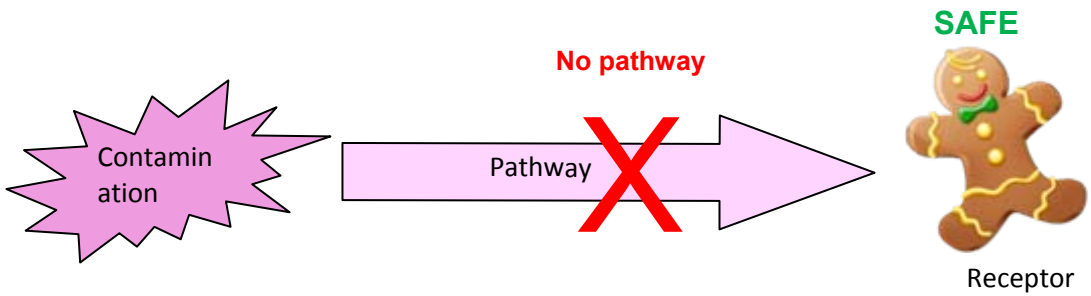
Risk Management

GENERIC SCENARIO



Risk Management

SITE SPECIFIC SCENARIO



What is a Domestic Use Aquifer (DUA)

An **AQUIFER** is a geologic formation that can store and transmit water.

Domestic Use Aquifer (DUA) is an aquifer containing good quality water for drinking and domestic use.

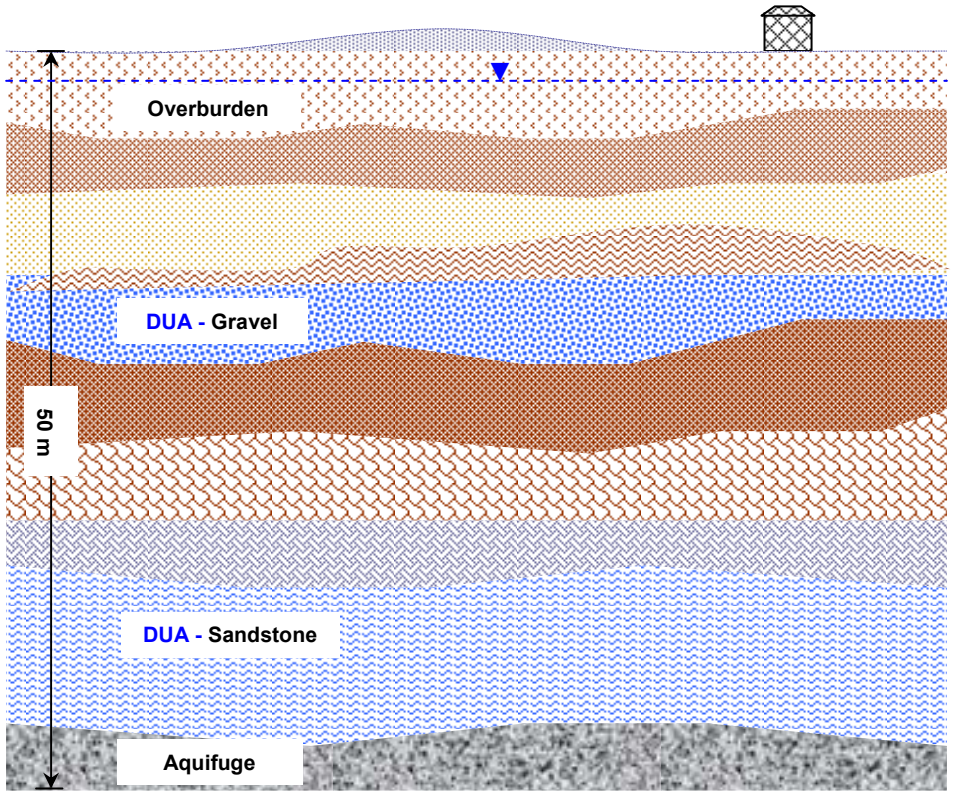
Alberta Environment[1] defines a **Domestic Use Aquifer (DUA)** as a geologic unit having one or more of the following properties:

- **bulk hydraulic conductivity is greater than $1x10^{-6}$ m/s and sufficient thickness to support a sustained yield of at least 0.76 L/min; or**
- **determined as DUA by Alberta Environment**
- **is currently being used for domestic purpose; or**

The following do not make it a DUA:

- ✓ if the shallow saline groundwater has suspended solid content > 4000 mg/L. However, the potential for presence of a DUA in a deeper stratigraphic unit must be investigated.
- ✓ when formation thickness is less than 0.5 m
- ✓ Formation containing water consists of peat deposit or muskeg

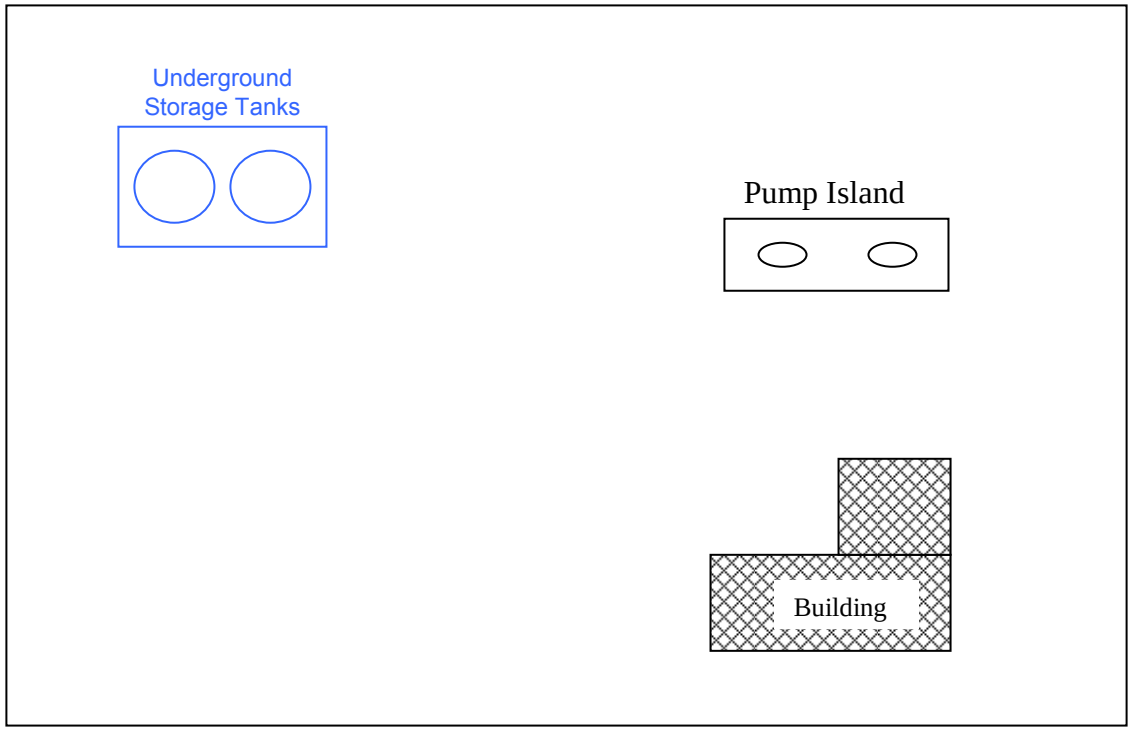
How can a DUA be associated with any site



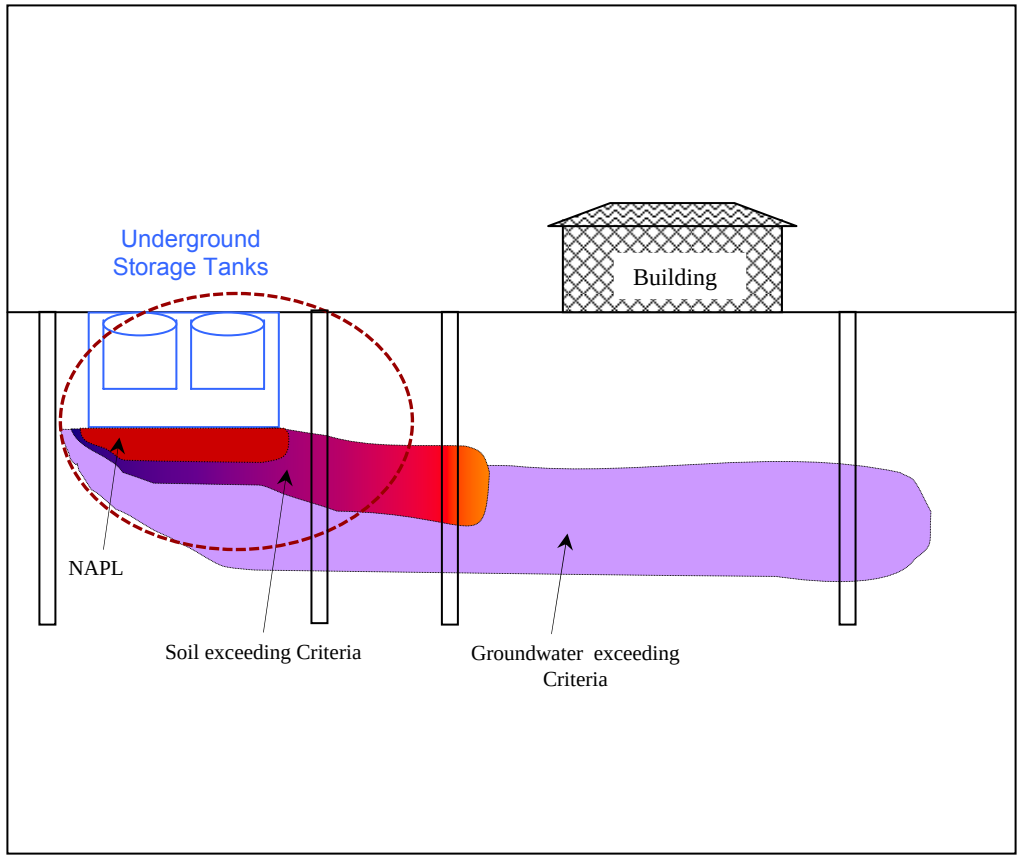
How can a DUA be eliminated for a site

Alberta Environment allows the exclusion of DUA pathway due to presence of naturally undisturbed geologic barrier between contamination and DUA. For petroleum hydrocarbon contaminants, this layer is required to be at least 5 meters of fine grained, unfractured massive material with hydraulic conductivity not exceeding $1x10^{-7}$ m/s.

Example of what triggers the need for DUA pathway elimination

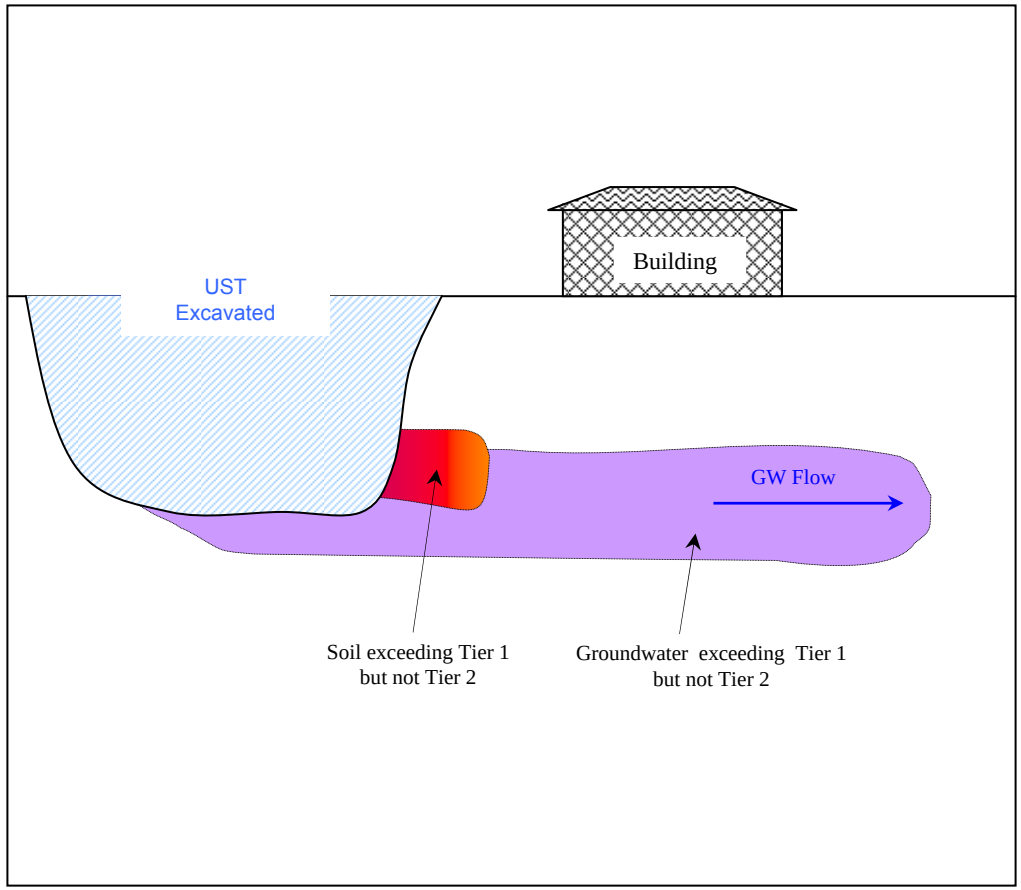


Contaminant concentrations at location of release are higher exceeding both the Tier 1 and Tier 2 guidelines, while concentrations at a distance from the source may exceed Tier 1 but not the Tier 2 criteria



a - The next most stringent criteria after DUA elimination

Remedial excavation may be performed to remove the source, and soil/groundwater not exceeding Tier 2 criteria[b] may be left in place



b - The next most stringent criteria after DUA pathway elimination

How to proceed to a Tier 2 approach of DUA pathway elimination

Table 1 - Analytical results of petroleum hydrocarbons in soil

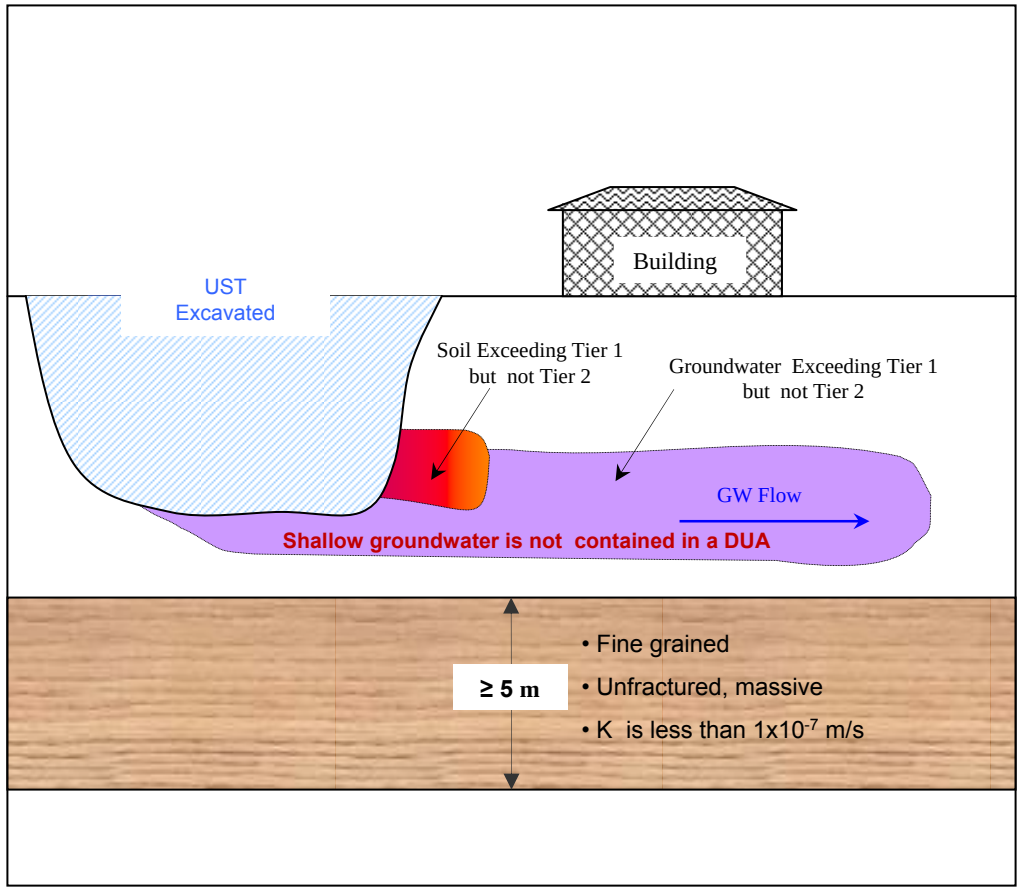
Sample ID	Sample Depth	Soil HHV	Benzene	Toluene	Ethylbenzene	Xylene	PHC F1	PHC F2	PHC F3	PHC F4
	m	ppm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
MW1		10	<0.005	<0.05	<0.01	<0.05	<10	<10	<10	<10
MW2		495	**1.05**	**41.2**	**6.13**	**37.56**	302	232	723	788
MW3		375	**0.37**	**14.42**	**9.15**	**18.15**	106	254	536	276
MW4		580	**0.95**	**37.08**	**23.52**	**33.8**	272	209	651	709
MW5		360	**0.33**	**12.98**	**8.23**	**21.83**	95	229	482	803
MW6		0	<0.005	<0.05	<0.01	<0.05	<10	11	40	36
Tier 1 Criteria[a] (lowest of all pathways)			**0.046**	**0.52**	**0.11**	**15**	**320**	**260**	**2500**	**6600**
Tier 2 Criteria[b] (excluding DUA pathway)			**11**	**330**	**430**	**230**	**320**	**260**	**2500**	**6600**

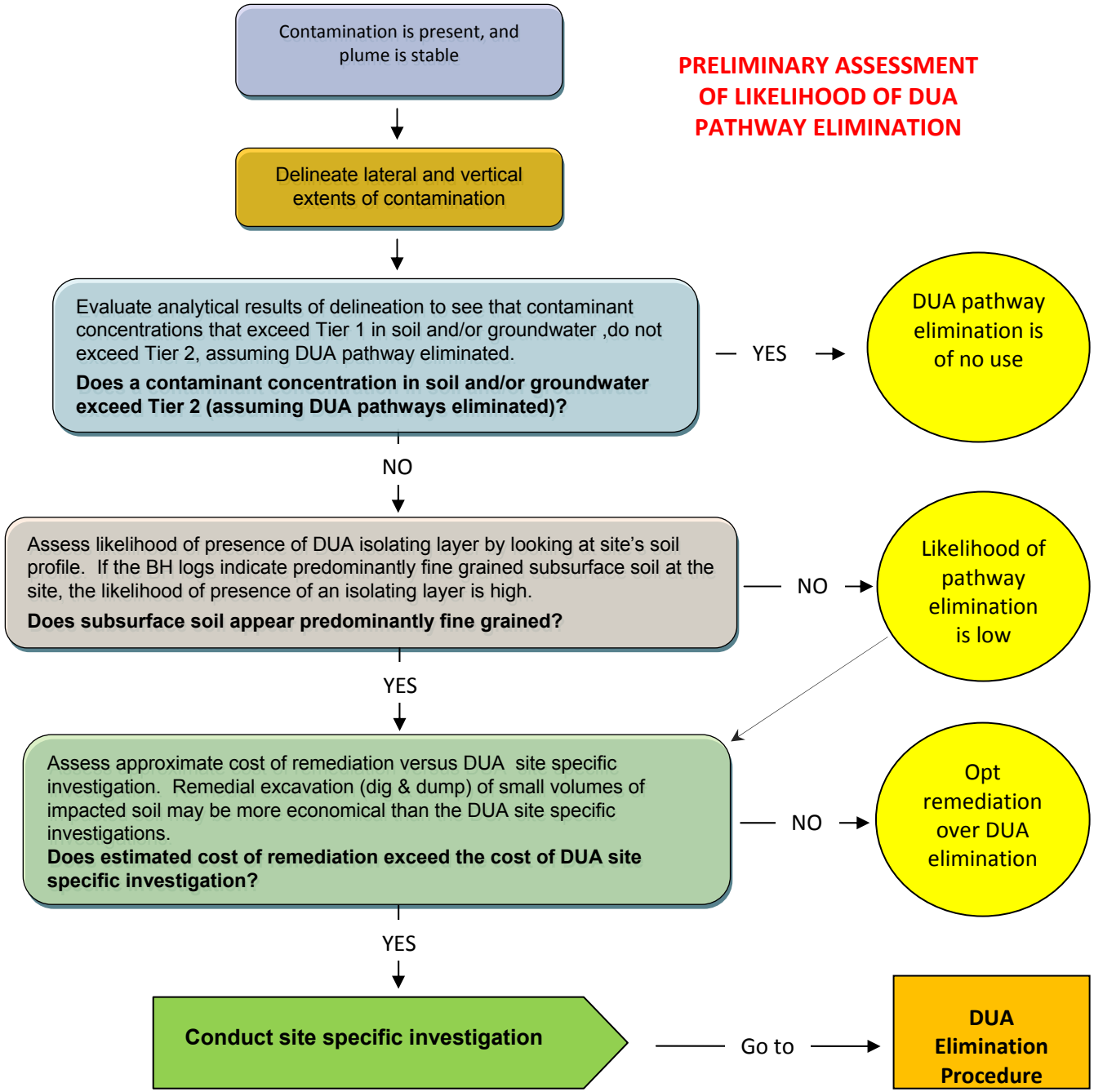
Table 2 - Alberta Soil and Groundwater Remediation Guidelines (2010) for commercial land use and fine grained soil

	Benzene	Toluene	Ethylbenzene	Xylene	PHC F1	PHC F2	PHC F3	PHC F4
Commercial Land Use (lowest criteria)	0.046	0.52	0.11	15	320	260	2500	6600
Vapour Inhalation	**11**	13000	6500	1700	4500	23000	NS	NS
Protection of Domestic Use Aquifer	**0.046**	**0.52**	**0.11**	**15**	1100	1500	NS	NS
Direct Soil Contact - Eco Receptors	310	**330**	**430**	**230**	**320**	**260**	**2500**	**6600**
Protection of Freshwater Aquatic Life	73	250000	NGR	NGR	20000	30000	NS	NS
Management Limit	NS	NS	NS	NS	800	1000	3500	10000
Direct Soil Contact - Human Receptors	120	31000	13000	210000	19000	10000	23000	30000
Off-Site Migration - Human Receptors	1100	290000	120000	NGR	30000	30000	30000	30000
Nutrient/Energy Cycling Check - Eco	NS	NS	NS	NS	NS	NS	NS	NS
Off-Site Migration - Eco Receptors	440	1100	790	930	3000	2100	4300	30000

Bold and **underlined** values in Table 1 exceed the Tier 1 criteria but not the Tier 2 after eliminating the DUA pathway criteria

DUA pathway can be eliminated, if soil containing shallow groundwater in not a DUA itself, and a massive fine grained lithologic layer of ≥ 5 m thick exist below the zone of contamination



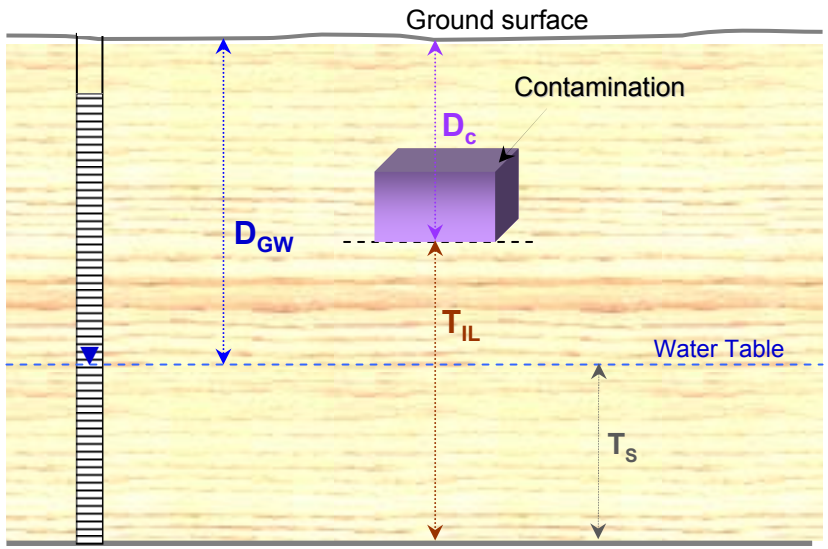

Contamination is present, and plume is stable
PRELIMINARY ASSESSMENT OF LIKELIHOOD OF DUA PATHWAY ELIMINATION
Delineate lateral and vertical extents of contamination
Evaluate analytical results of delineation to see that contaminant concentrations that exceed Tier 1 in soil and/or groundwater ,do not exceed Tier 2, assuming DUA pathway eliminated.
Does a contaminant concentration in soil and/or groundwater exceed Tier 2 (assuming DUA pathways eliminated)?
YES
DUA pathway elimination is of no use
NO
Assess likelihood of presence of DUA isolating layer by looking at site's soil profile. If the BH logs indicate predominantly fine grained subsurface soil at the site, the likelihood of presence of an isolating layer is high.
Does subsurface soil appear predominantly fine grained?
NO
Likelihood of pathway elimination is low
YES
Assess approximate cost of remediation versus DUA site specific investigation. Remedial excavation (dig & dump) of small volumes of impacted soil may be more economical than the DUA site specific investigations.
Does estimated cost of remediation exceed the cost of DUA site specific investigation?
NO
Opt remediation over DUA elimination
YES
Conduct site specific investigation
Go to
DUA Elimination Procedure

DUA Elimination Procedure

Step 1: Determine whether soil containing shallow groundwater is classified as a DUA. If it is a DUA, the DUA pathway cannot be eliminated.

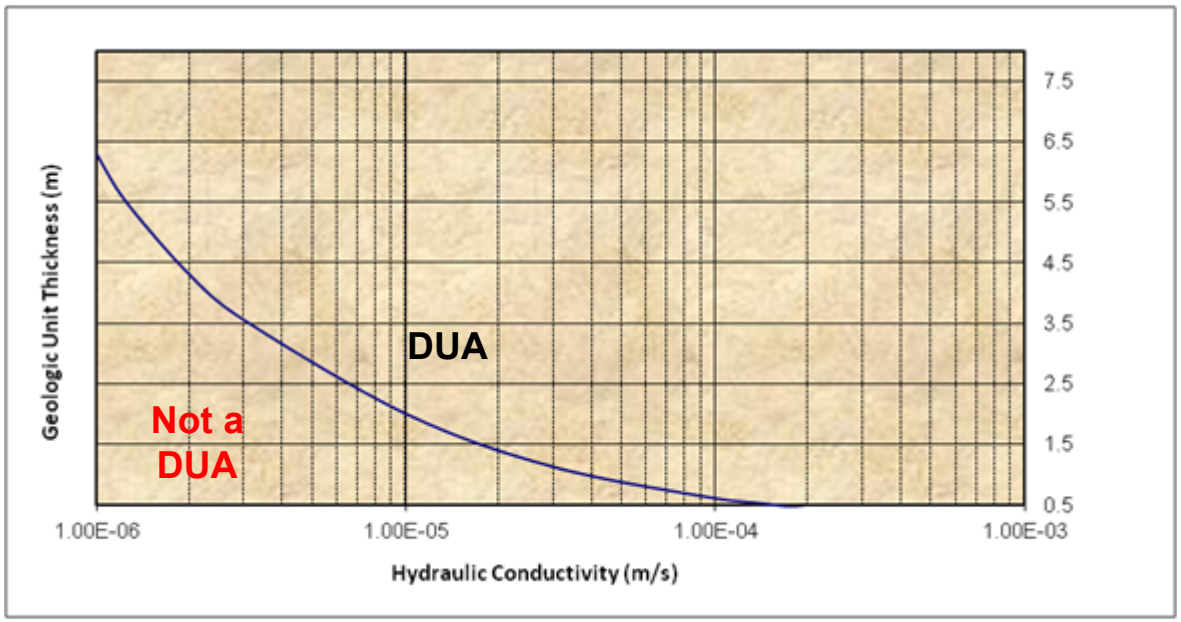
a) Determine depth to groundwater (D_W), saturated thickness of aquifer (T_S), maximum depth of contamination (D_C), and required thickness of isolating layer (T_{IL}), which is 5 m for petroleum hydrocarbons. If $\mathbf{D_{GW} \leq (D_C + T_{IL})}$, then follow step b; if not go to *Step 2.*

b) Determine the lateral hydraulic conductivity (K) of the shallow soil containing the groundwater through a slug test. If K ≥ $1x10^{-6}$ m/s), compare the K value and saturated thickness (Ts) to the chart provided in next slide (from 2010 Alberta Tier 2 SGRG, Appendix E, page E2). If the formation containing shallow groundwater is DUA, the DUA pathway cannot be excluded; If not go to *Step 2*.



Modified from IOL SOP[3]

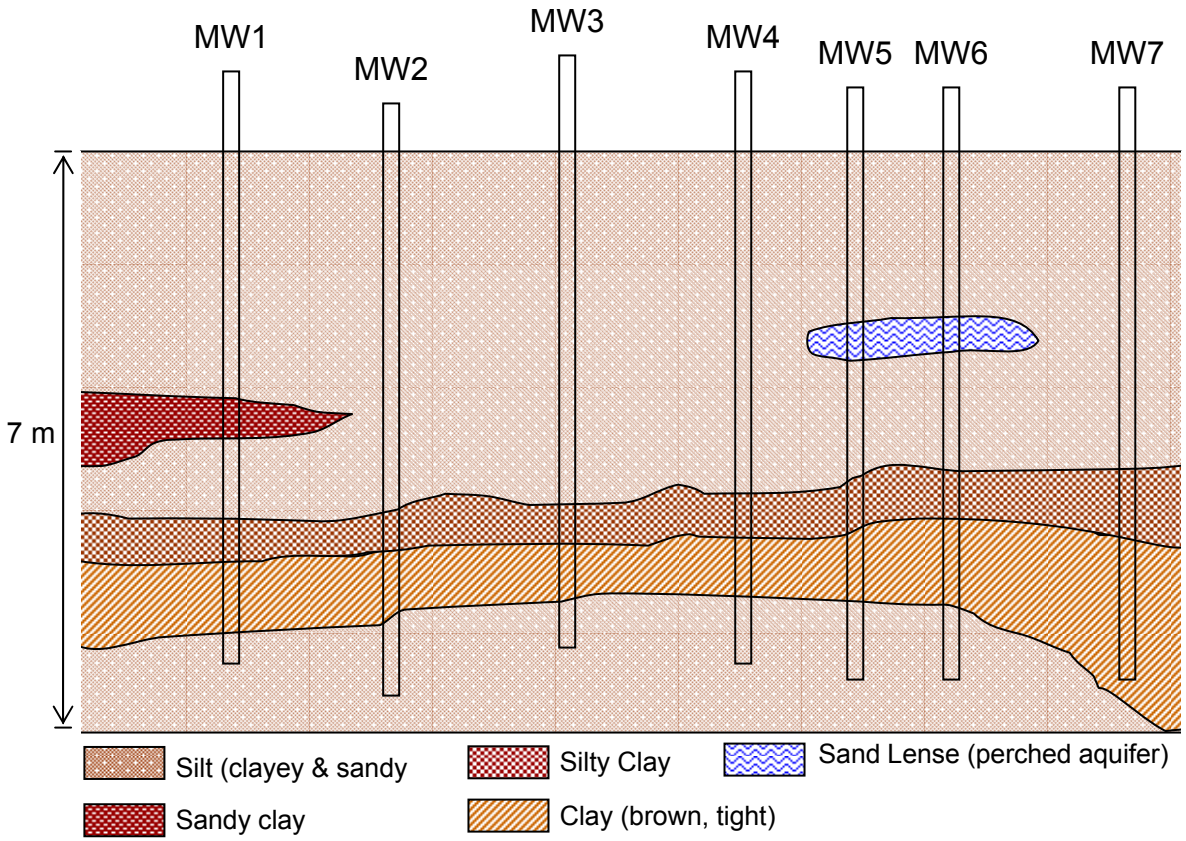
Hydraulic Conductivity* vs *Geologic Unit Thickness
to determine whether soil containing shallow groundwater is classified as a DUA



Minimum thickness required to meet DUA condition for an unconfined aquifer.
Source: Alberta Environment's *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* 2010, Appendix E, page E2

Conducting Slug Test

Selection of monitoring well/s



To conduct slug for confirming whether the shallow groundwater is contained in a DUA, select monitoring well that has lithology representative of the site

Step 2: **If the soil containing shallow groundwater is NOT classified as a DUA, the DUA pathway elimination is possible** and a site specific investigation is needed to confirm the presence of an isolation layer below zone of the contamination. This requires drilling of DUA test holes.

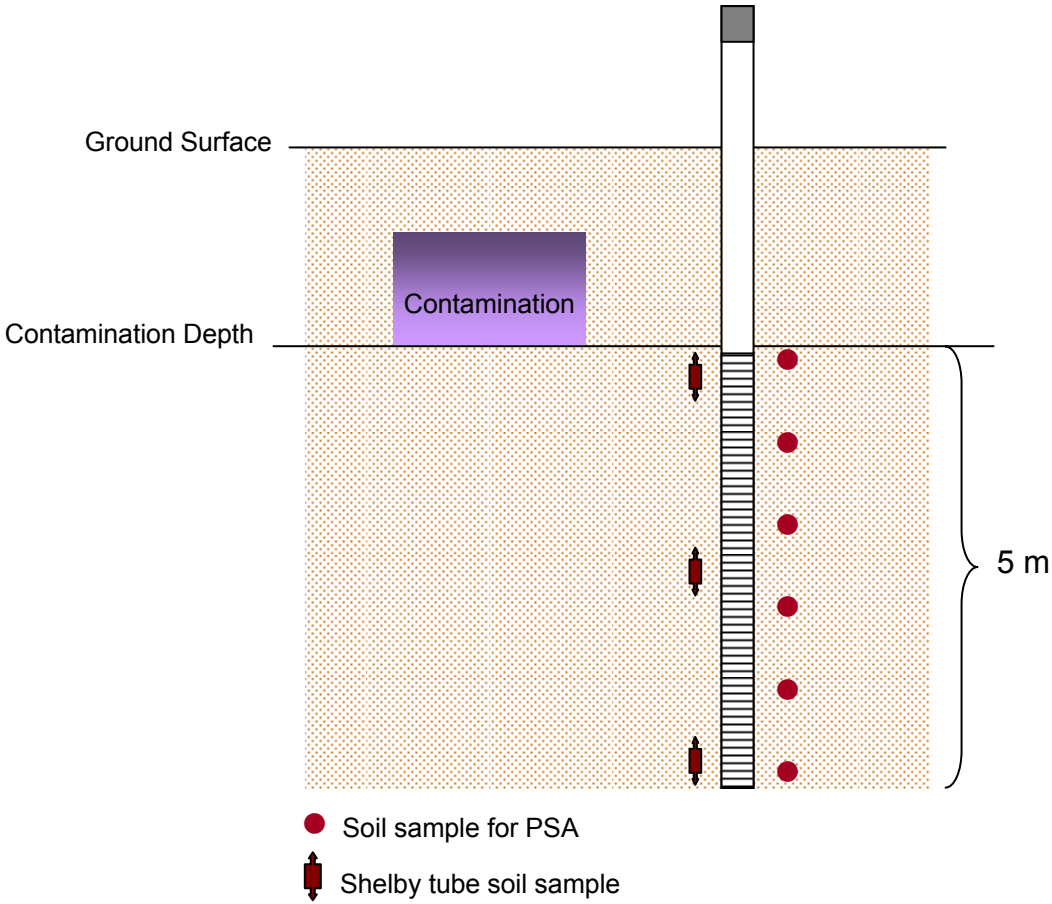
To account for the spatial heterogeneity of subsurface lithology, the number of DUA test wells required on typical facilities are as follow:

Typical site type	DUA test wells
• Retail fuel outlet	1 to 2
• Bulk plant / Well site	2 to 4
• Battery site	3 to 6

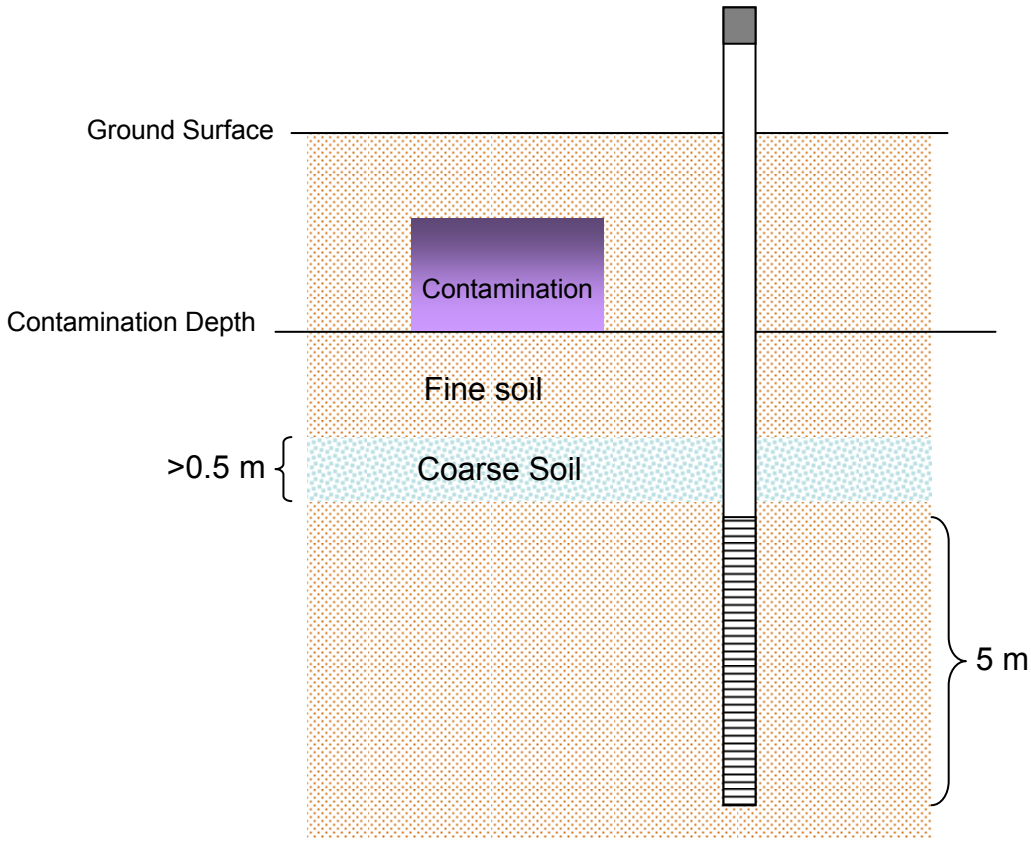
Drill DUA test holes away from the contamination plume, preferably at upstream side of the plume to avoid cross contamination.

DRILLING A DUA TEST WELL

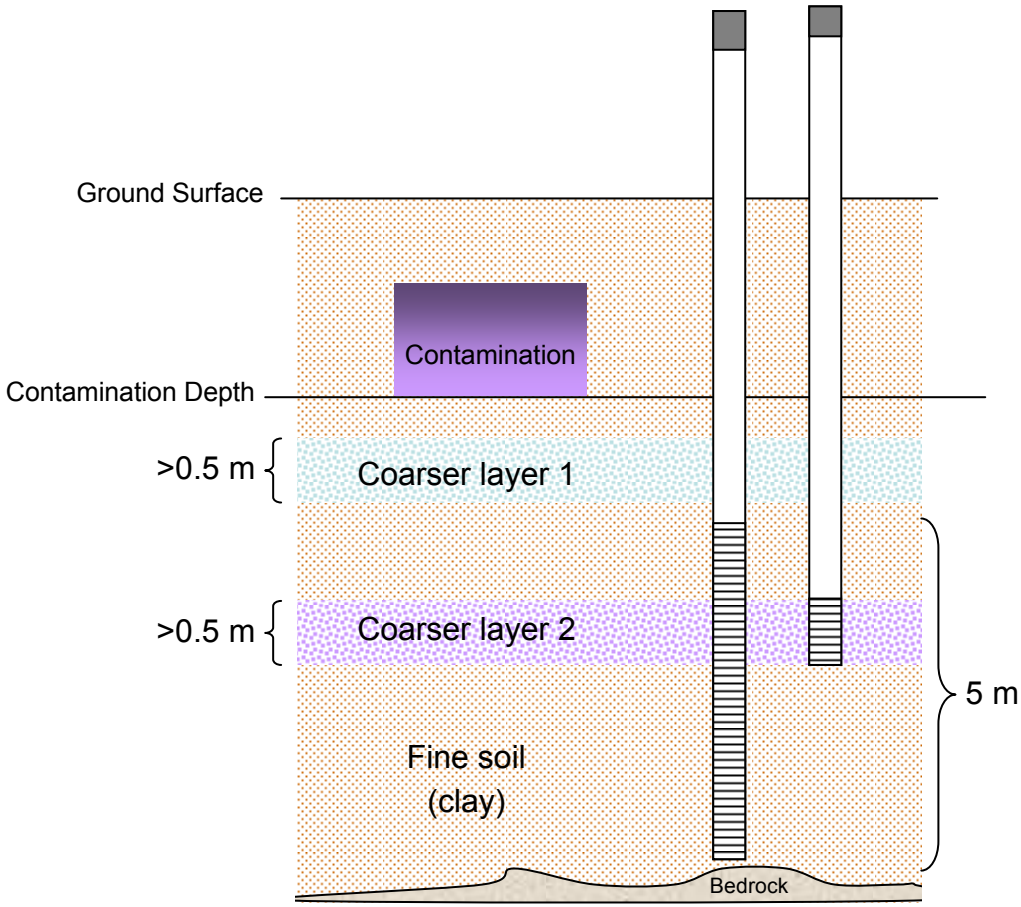
Soil sampling to demonstrate hydraulic properties of isolating layer



…. drilling a DUA test well

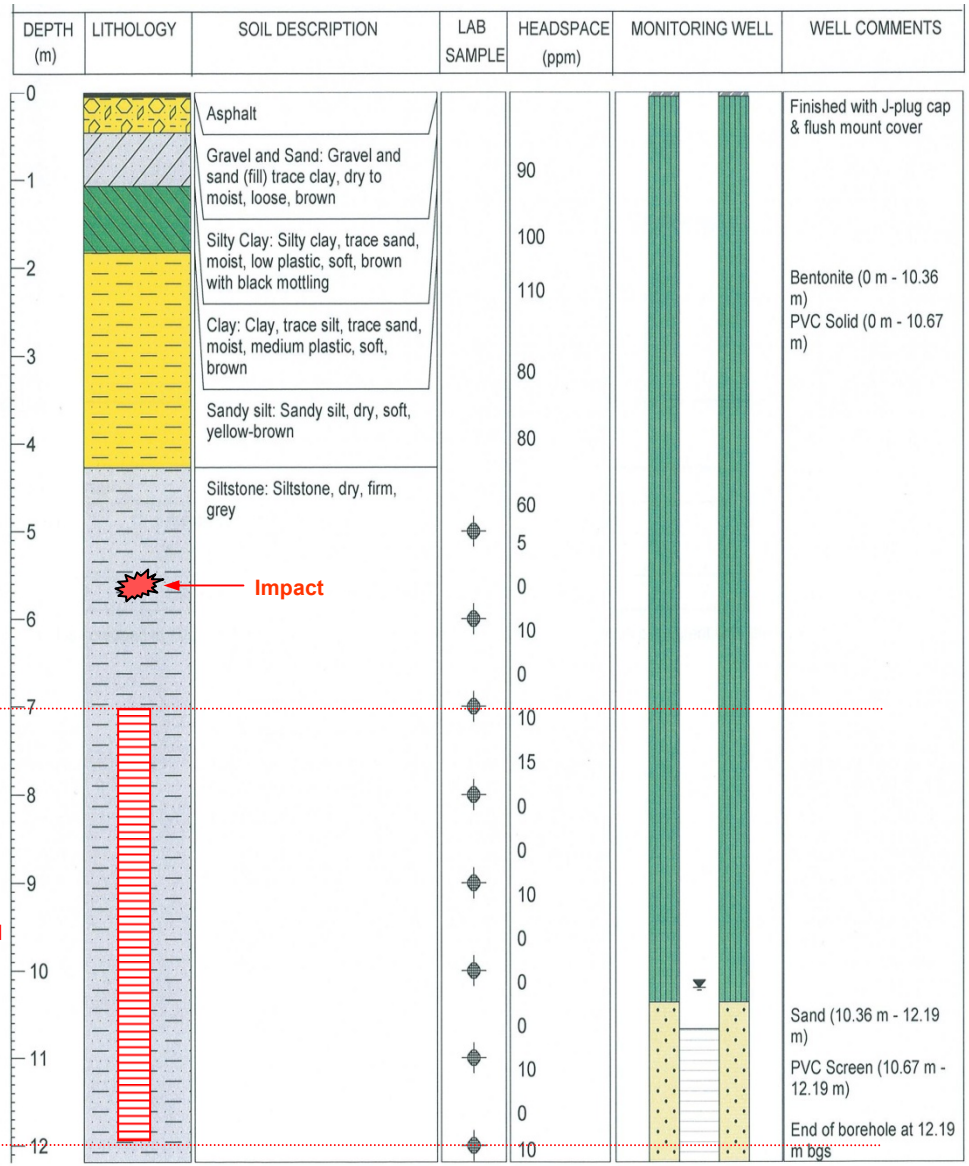


…. drilling a DUA test well



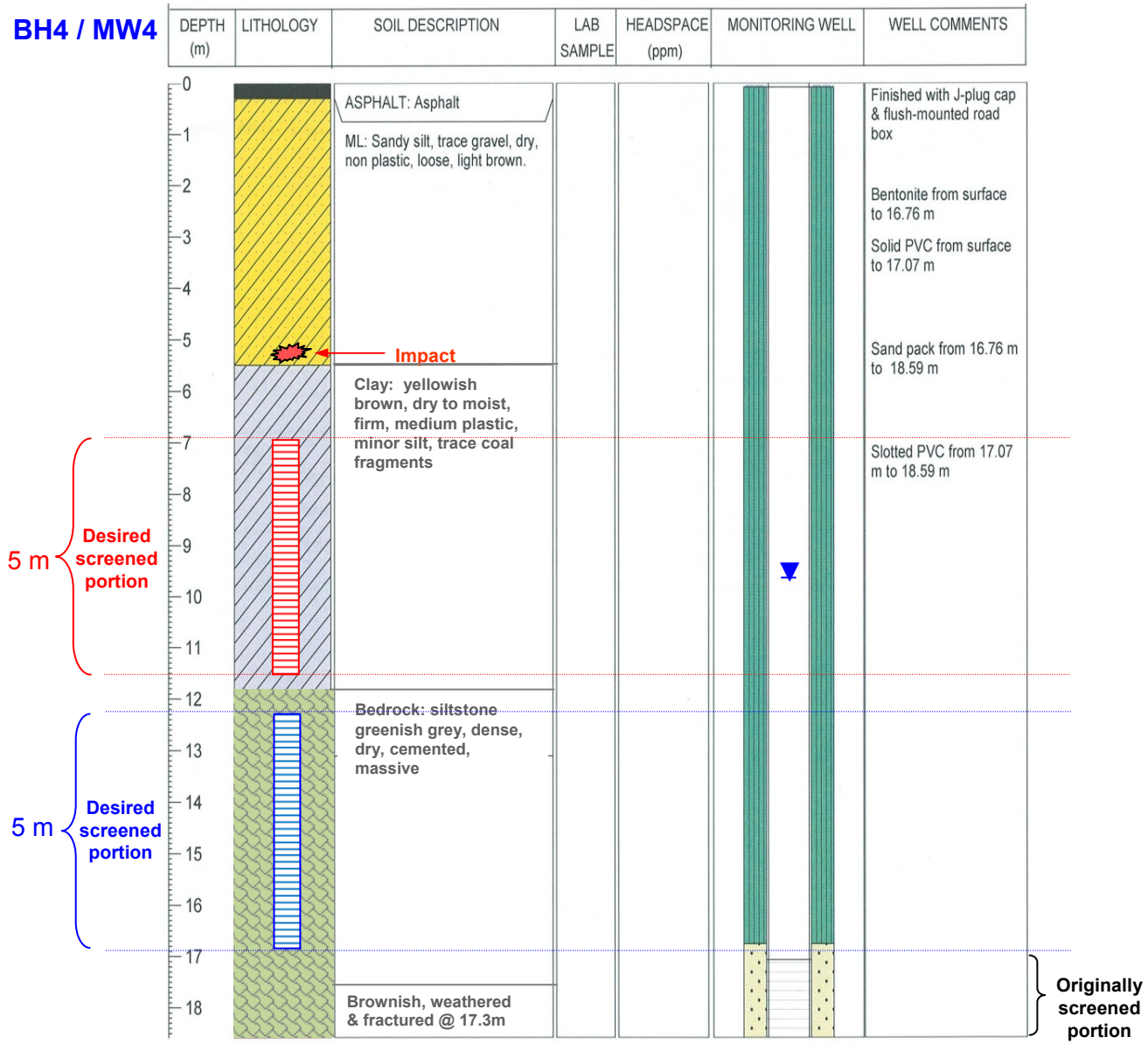
Lithology to screen for a DUA test well

BH3 / MW3

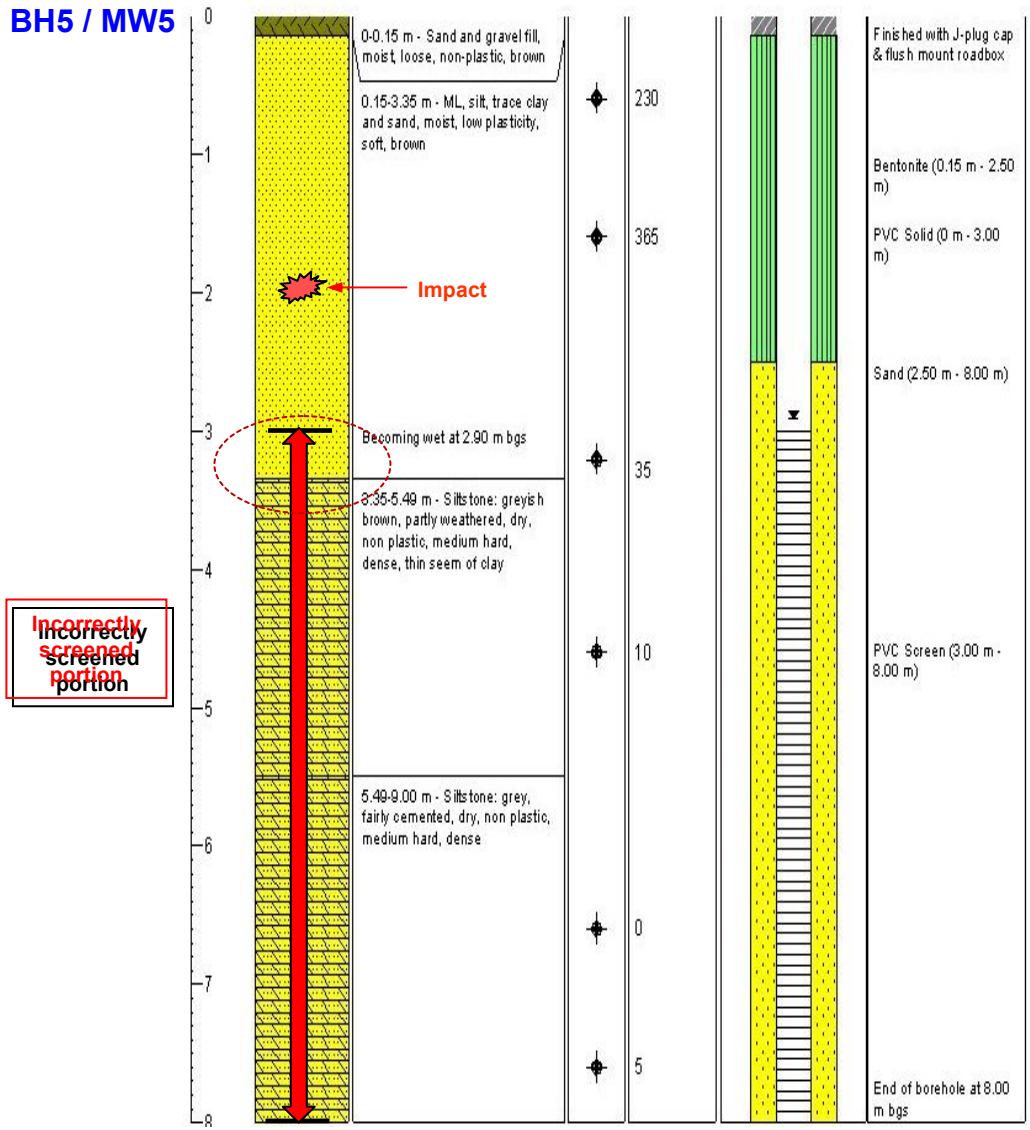


To capture hydraulic properties of entire isolating layer, the full thickness (5 m) of the layer is preferred to be screened.

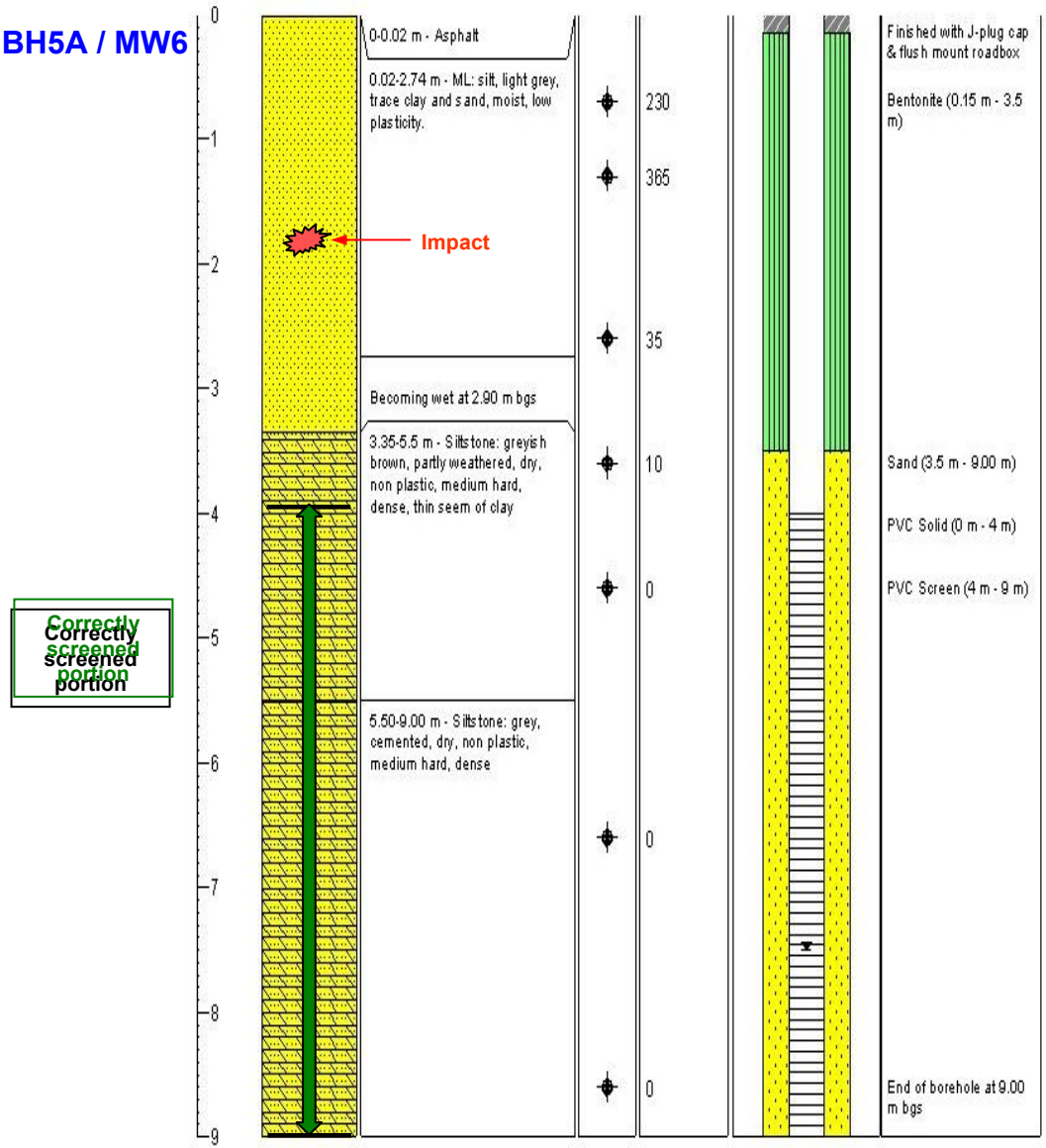
Lithology to screen for a DUA test well

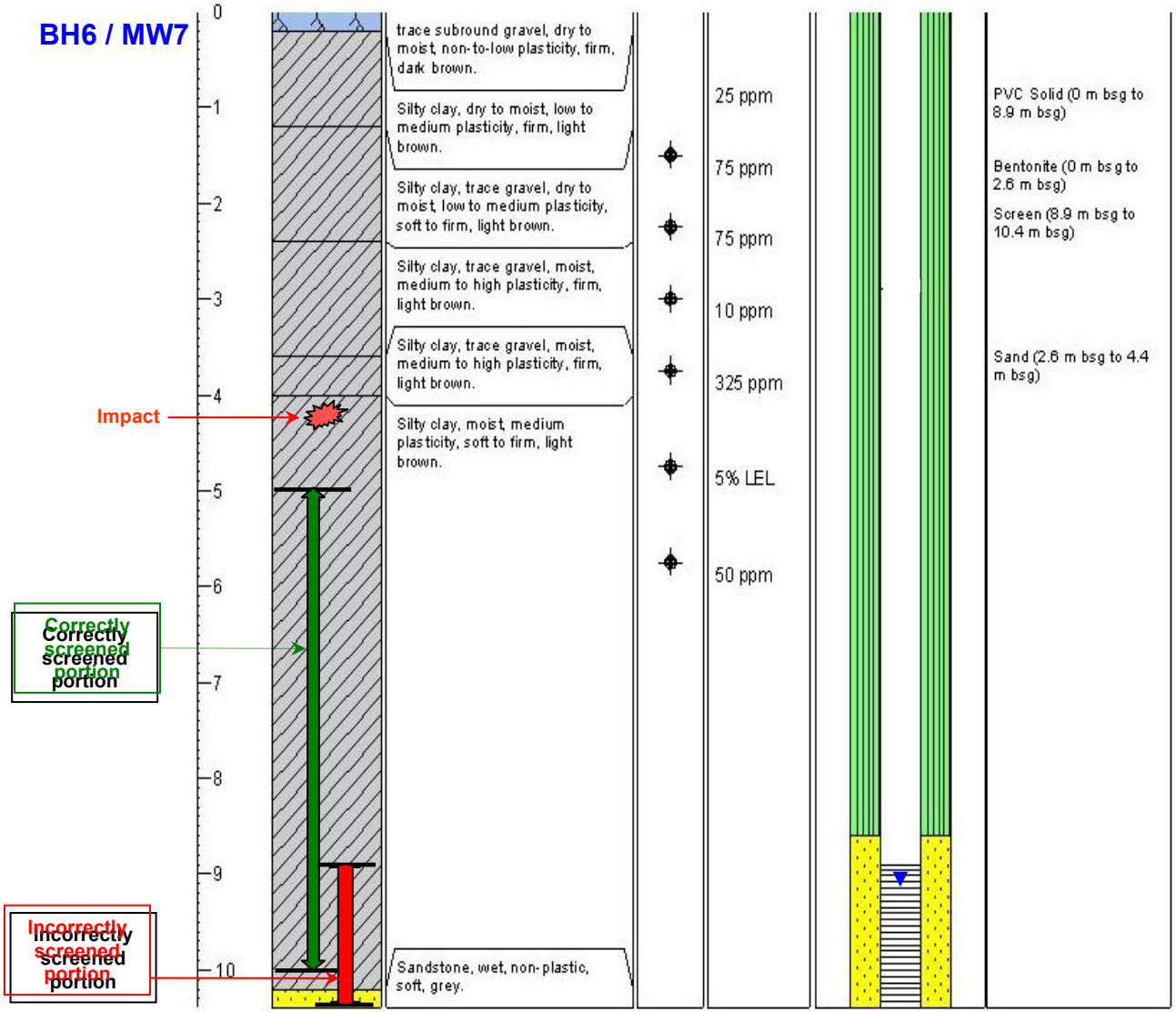


Lithology to screen for a DUA test well

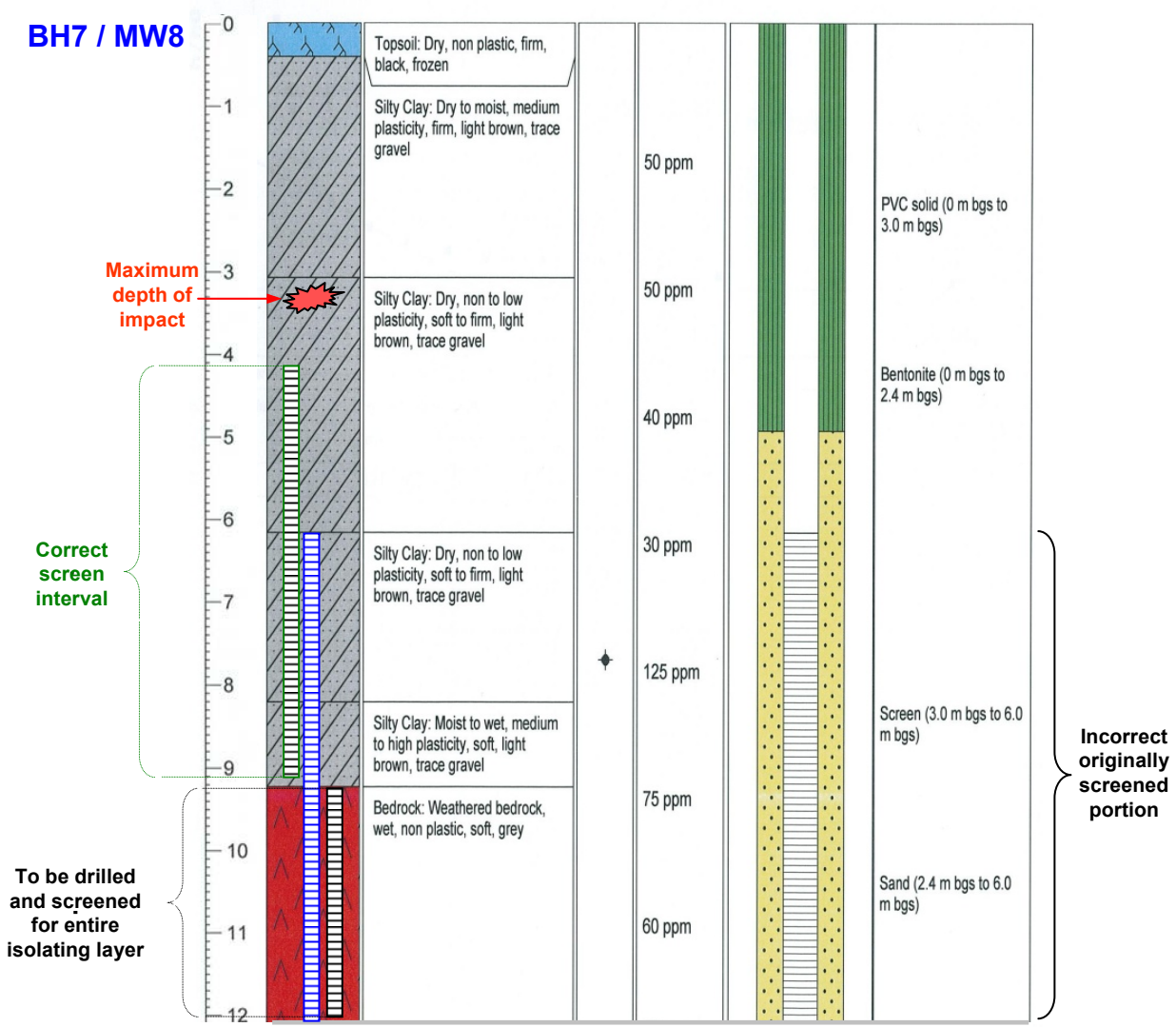


Lithology to screen for a DUA test well



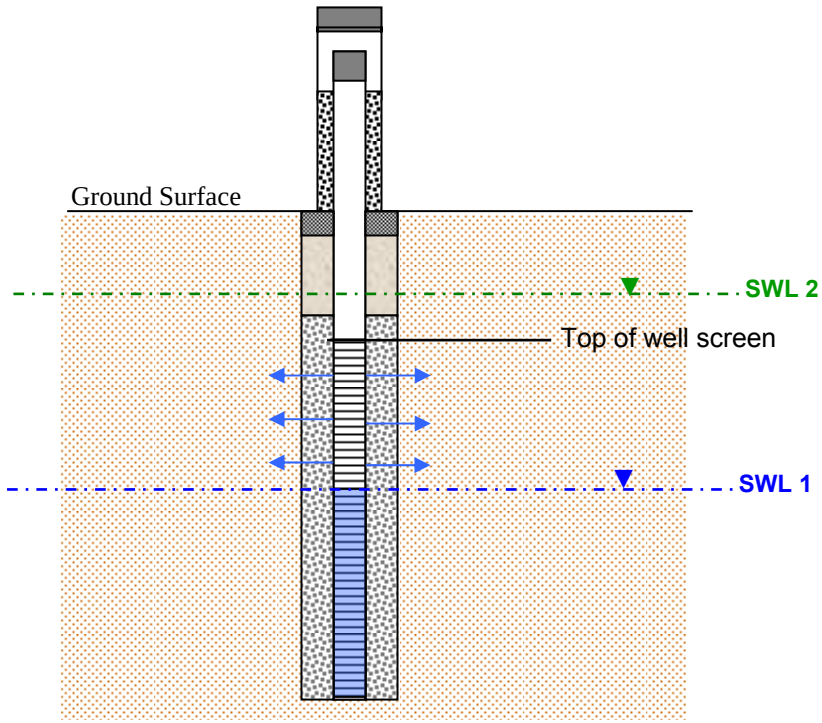

BH6 / MW7
0
1
2
3
4
5
6
7
8
9
10
trace subround gravel, dry to moist, non-to-low plasticity, firm, dark brown.
Silty clay, dry to moist, low to medium plasticity, firm, light brown.
Silty clay, trace gravel, dry to moist, low to medium plasticity, soft to firm, light brown.
Silty clay, trace gravel, moist, medium to high plasticity, firm, light brown.
Silty clay, trace gravel, moist, medium to high plasticity, firm, light brown.
Silty clay, moist, medium plasticity, soft to firm, light brown.
Sandstone, wet, non-plastic, soft, grey.
25 ppm
75 ppm
75 ppm
10 ppm
325 ppm
5% LEL
50 ppm
PVC Solid (0 m bsg to 8.9 m bsg)
Bentonite (0 m bsg to 2.6 m bsg)
Screen (8.9 m bsg to 10.4 m bsg)
Sand (2.6 m bsg to 4.4 m bsg)
Impact
Correctly screened portion
Incorrectly screened portion

Lithology to screen for a DUA test well



Conducting slug test

Do not use falling head method if water level in the test well is below top of well screen



Thank You

QUESTIONS

No question is a silly question

Hydraulic Conductivity vs *Geologic Unit Thickness* to determine whether soil containing shallow groundwater is classified as a DUA

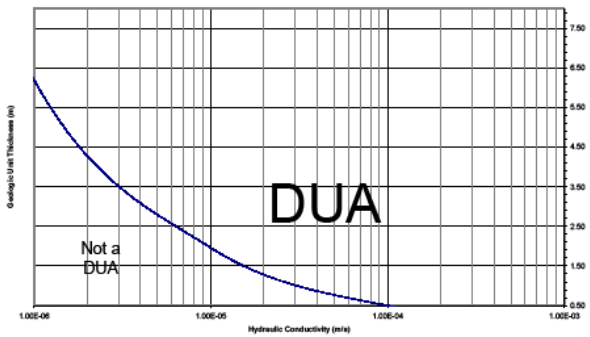


Figure 1. Minimum thickness required to meet DUA condition for a confined aquifer. Site-specific calculations can be made using the method in Section E.4

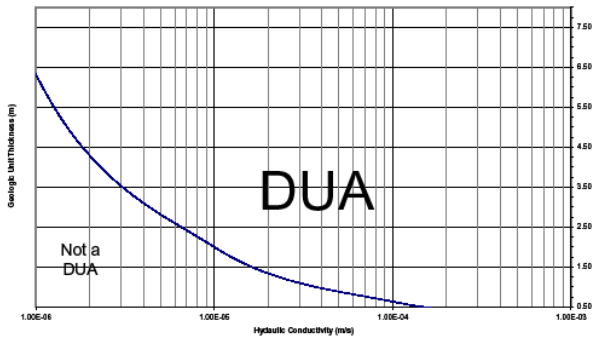


Figure 2. Minimum thickness required to meet DUA condition for an unconfined aquifer. Site-specific calculations can be made using the method in Section E.4

… conducting slug test