

*A Tier 2 Guideline Development Tool
Incorporating Vapour and Groundwater
Pathways, Vertical Offsets, Literature Values
for Half Life and Pathway Elimination*

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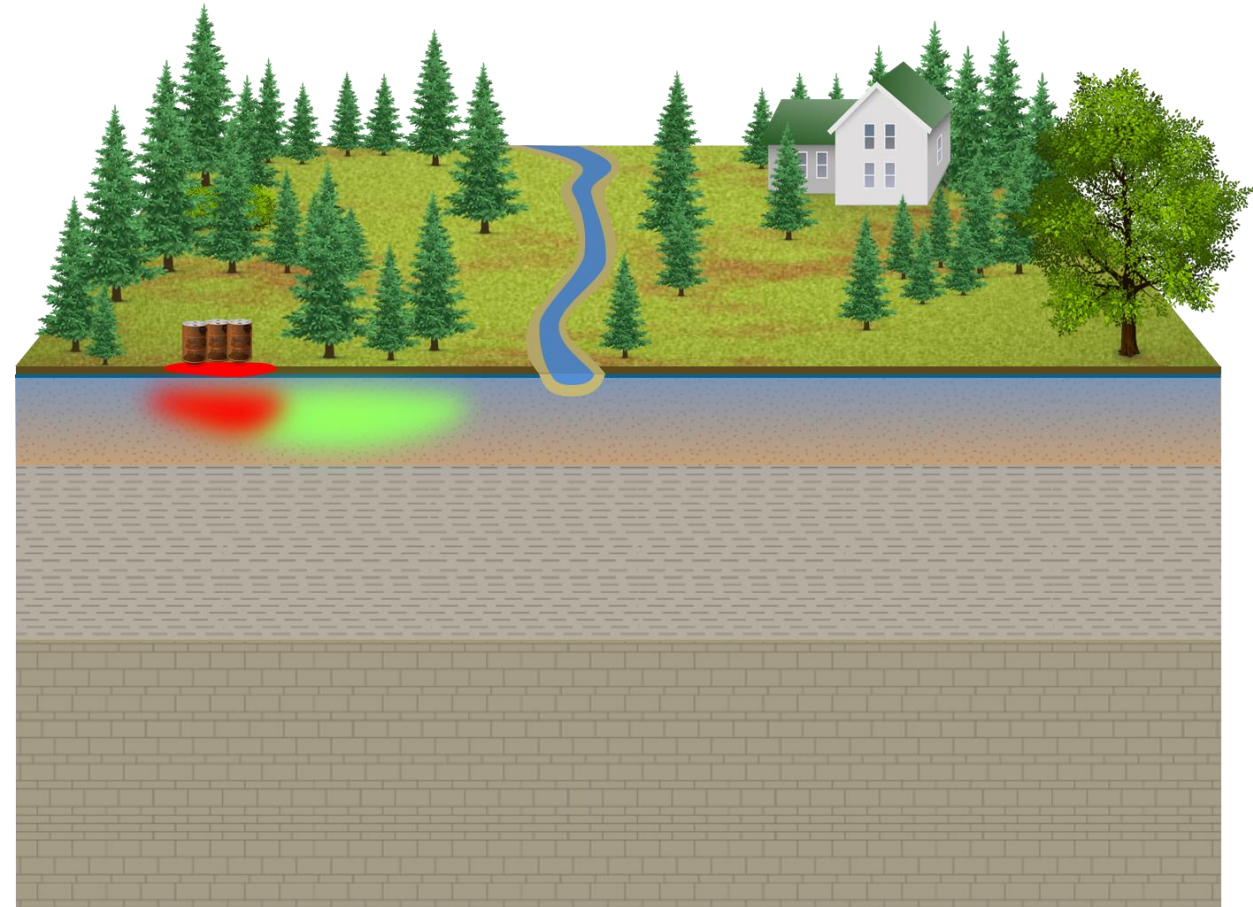
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Topics Covered

- Contaminated Sites Policy Framework
- Tier 2 guideline development tool
- Pathway elimination
- Guideline calculations
- Literature values for biodegradation rates
- Calculated guideline for an underlying domestic use aquifer (DUA)

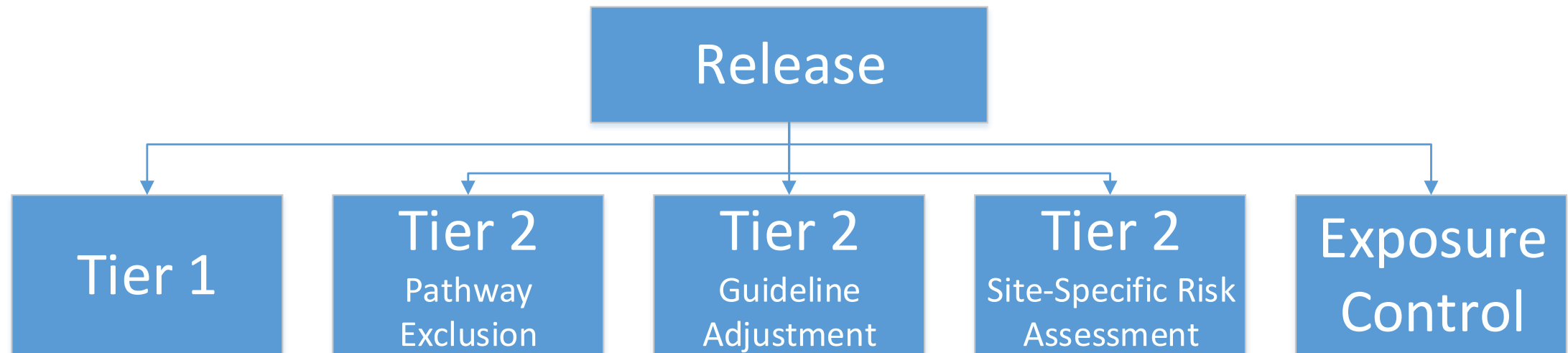
Rationale for Development

- Soil and groundwater are limited resources
- Tier 1 guidelines sometimes not appropriate
- Need for a standardized guideline development tool
- Functionality beyond what is permitted in current policy



Contaminated Sites Policy Framework

- Framework for the management of contaminated sites in Alberta
- EPEA states remedial measures must be implemented with potential to cause an adverse effect



Contaminated Sites Policy Framework

- Three options exist to manage contaminated sites



**Alberta Tier 1 Soil and Groundwater
Remediation Guidelines**

January 10, 2019



**Alberta Tier 2 Soil and Groundwater
Remediation Guidelines**

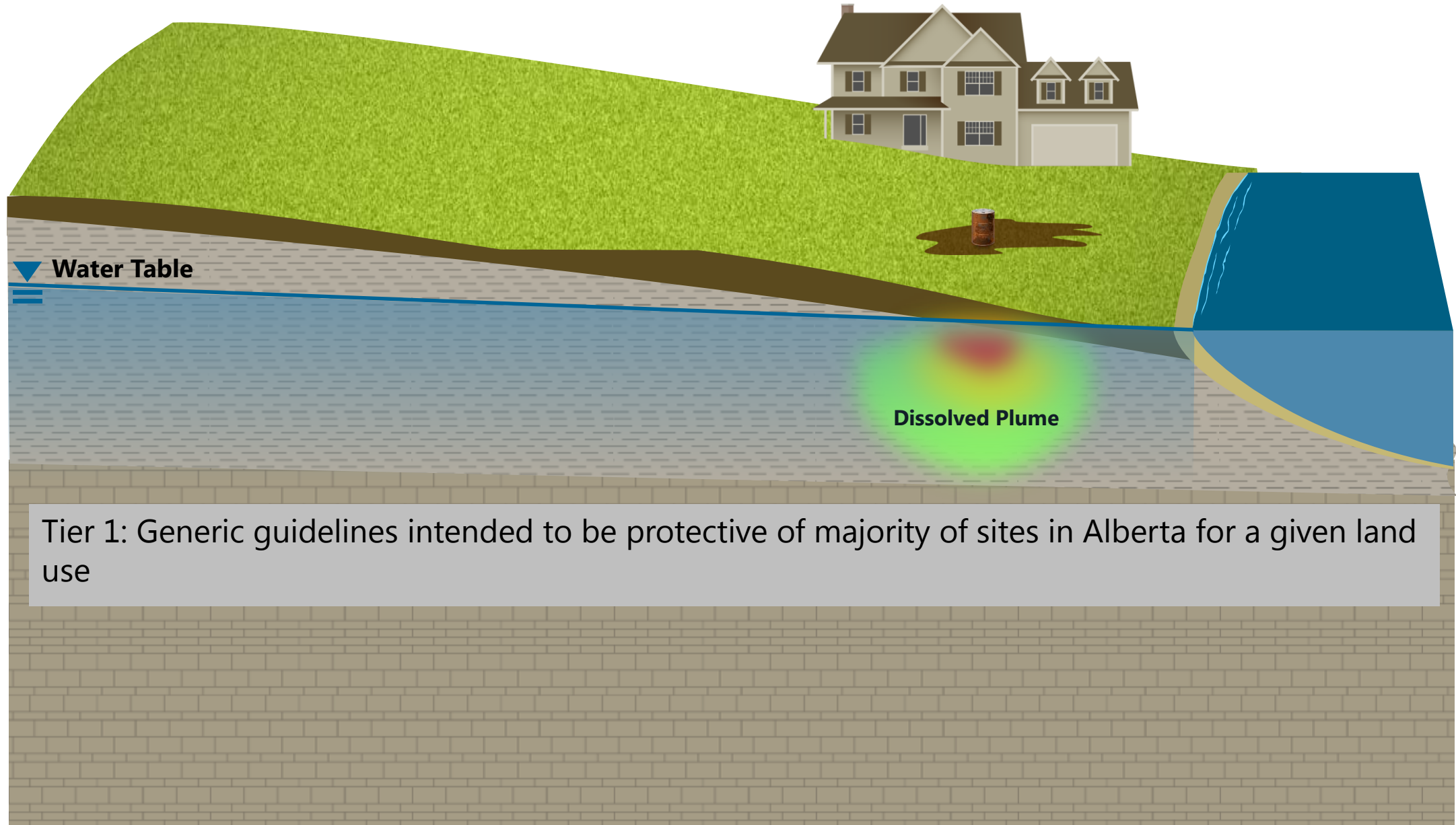
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Alberta Exposure Control Guide

May 3, 2016

Tier 1 Guidelines



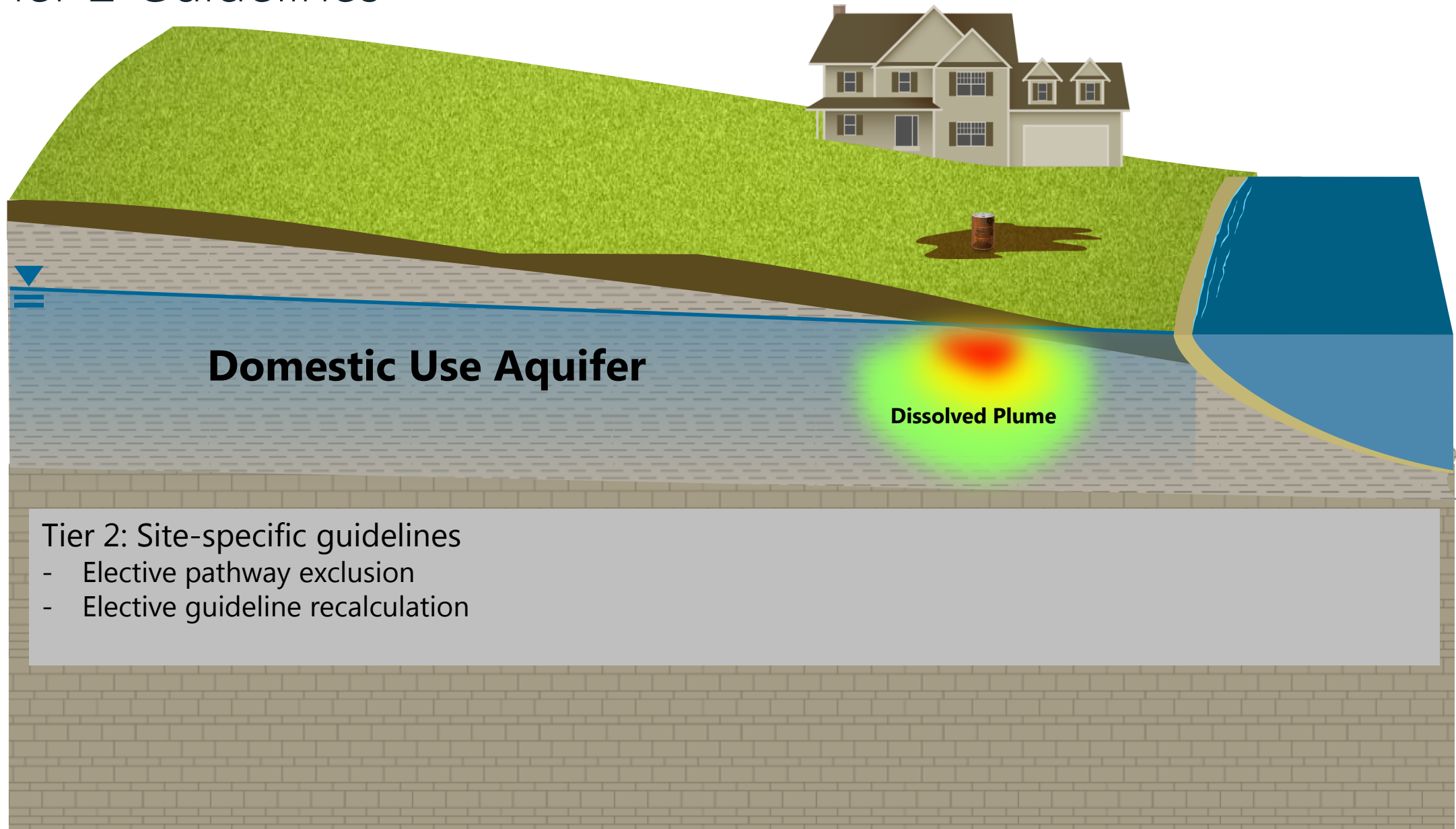
Tier 1: Generic guidelines intended to be protective of majority of sites in Alberta for a given land use

Tier 1 Guidelines

Table 1. Alberta Tier 1 Soil Remediation Guidelines

Soil Type			Fine		
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial
Unit (unless otherwise indicated)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
<i>Hydrocarbons</i>					
Benzene	0.046	0.046	0.046	0.046	0.046

Tier 2 Guidelines



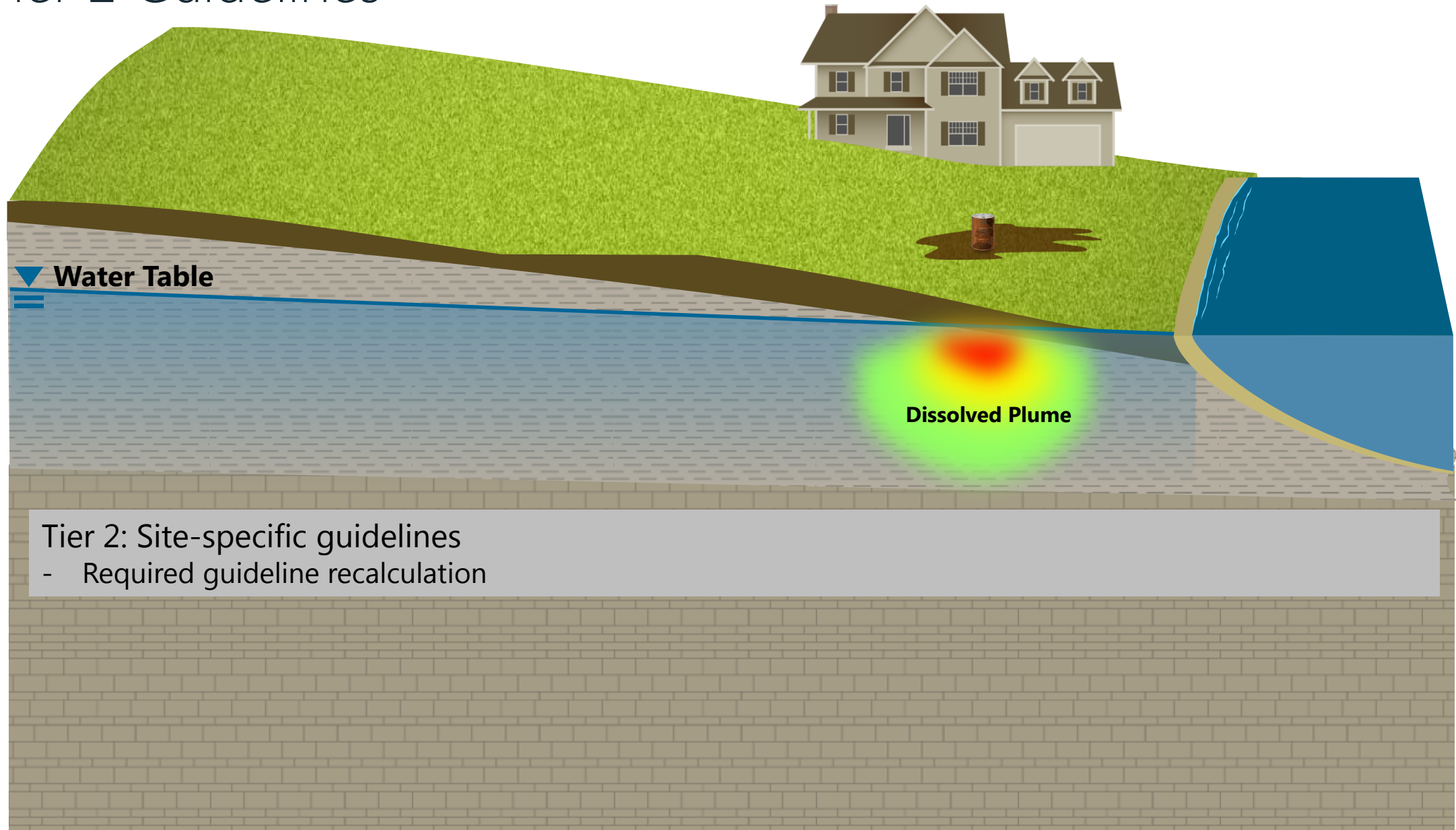
Tier 2 Guidelines: Pathway Exclusion

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 2.4.3 or 5.1.2. Tier 1 soil guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (ESRD 2007 as amended) .

Receptor	Overall Guideline	Human			Ecological			Other	
		Direct Soil Contact	Vapour Inhalation	Protection of Domestic Use Aquifer	Direct Soil Contact	Nutrient/Energy Cycling Check	Protection of Freshwater Aquatic Life	Management Limit	
Tier 2 Pathway									
<i>Hydrocarbons</i>									
Benzene	1.646	78	1.7	1.6	Exclude	60	-	7.9	-

Tier 2 Guidelines



Tier 2: Site-specific guidelines
- Required guideline recalculation

Tier 2 Guidelines: Pathway Exclusion

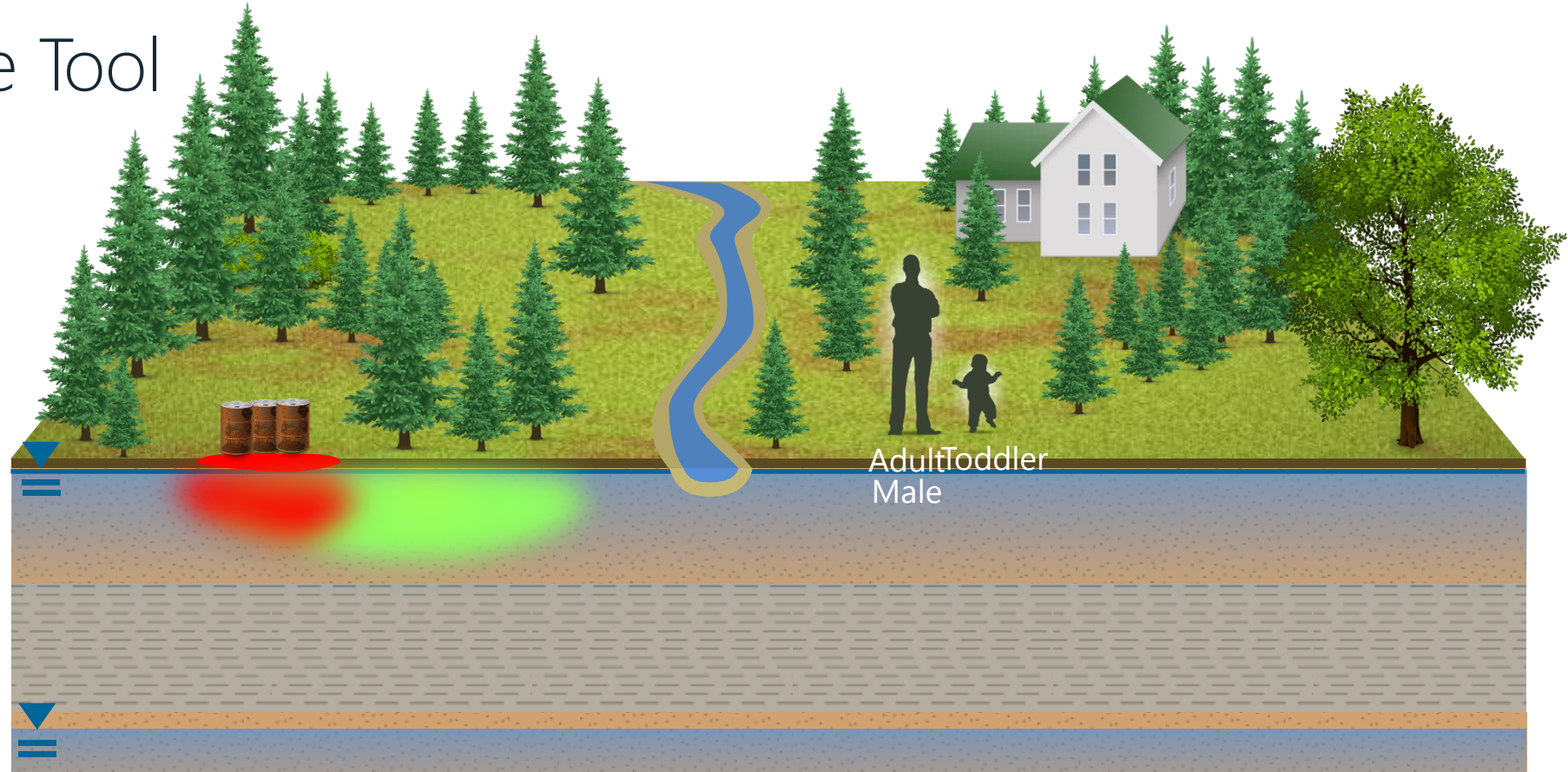
Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

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Tier 2 Pathway								
<i>Hydrocarbons</i>								
Benzene	0.09	78	1.7	1.6	Exclude	60	-	0.09

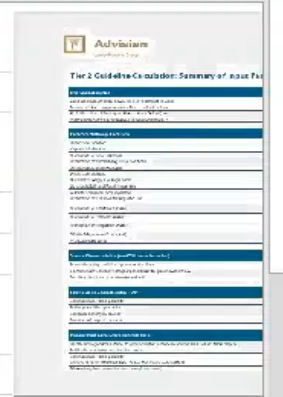
Tier 2 Guideline Tool

- Land use
- Grain size
- Input parameters by dilution factor
- Literature biodegradation rates
- Underlying domestic use aquifer
- Pathway exclusion
- Building characteristics
- Body type



Description	Source Zone (DF1)	Unsaturated Zone (DF2)	Soil/GW Interface (DF3)	Aquifer (DF4)
Water filled porosity	θ_w	θ_w		
Bulk density	ρ_b	ρ_b		ρ_b
Fraction of organic carbon	foc			foc
Hydraulic gradient			i	i
Hydraulic conductivity			K	K
Darcy velocity			V	V

	A	B	C	D	E	F
1	Tier 2 Guideline Calculation: Summary of Input Parameters				Date Modelled:	
2					Project No.:	
3	Site Characteristics					
4	Land Use (Select drop down for Tier 1 default values)					
5	Texture (Select drop down for Tier 1 default values)					
6	Half Life - Use default guideline values (Default) or most conservative of literature values (Literature)?					
7				Notes:		
8	Receptor/Pathway Exclusion	Excluded	Inactive	*If pathways are deemed as "inactive", the site moves to Exposure Control and is not modelled.		
9	Direct Soil Contact					
10	Vapour Inhalation					
11	Protection of DUA					
12	Protection of Underlying DUA (vertical)					
13	Offsite Migration (Human)					
14	Direct Soil Contact					
15	Nutrient/ Energy Cycling Check					
16	Livestock Soil and Food Ingestion					
17	Wildlife Soil and Food Ingestion					
18	Protection of Freshwater Aquatic Life					
19	Protection of Livestock Water			* Protection of Livestock Water can not be excluded for agricultural land use or natural aquifer and contamination is below the depth of a typical dugout.		
20	Protection of Wildlife Water					
21	Protection of Irrigation Water			* Protection of Irrigation Water can not be excluded for agricultural land use, unless the depth of a typical dugout.		
22	Offsite Migration (Ecological)					
23	Management Limit					



	A	B	C	D	E	F
1	Tier 2 Guideline Calculation: Summary of Input Parameters				Date Modelled:	
2					Project No.:	
3	Site Characteristics					
4	Land Use (Select drop down for Tier 1 default values)	Residential/Parkland				
5	Texture (Select drop down for Tier 1 default values)	Fine				
6	Half Life - Use default guideline values (Default) or most conservative of literature values (Literature)?	Default				
7				Notes:		
8	Receptor/Pathway Exclusion	Excluded	Inactive	*If pathways are deemed as "inactive", the site moves to Exposure Control and is not modelled.		
9	Direct Soil Contact					
10	Vapour Inhalation					
11	Protection of DUA					
12	Protection of Underlying DUA (vertical)					
13	Offsite Migration (Human)					
14	Direct Soil Contact					
15	Nutrient/ Energy Cycling Check					
16	Livestock Soil and Food Ingestion					
17	Wildlife Soil and Food Ingestion					
18	Protection of Freshwater Aquatic Life					
19	Protection of Livestock Water			* Protection of Livestock Water can not be excluded for agricultural land use or non-agricultural aquifer and contamination is below the depth of a typical dugout.		
20	Protection of Wildlife Water					
21	Protection of Irrigation Water			* Protection of Irrigation Water can not be excluded for agricultural land use, unless the depth of a typical dugout.		
22	Offsite Migration (Ecological)					
23	Management Limit					

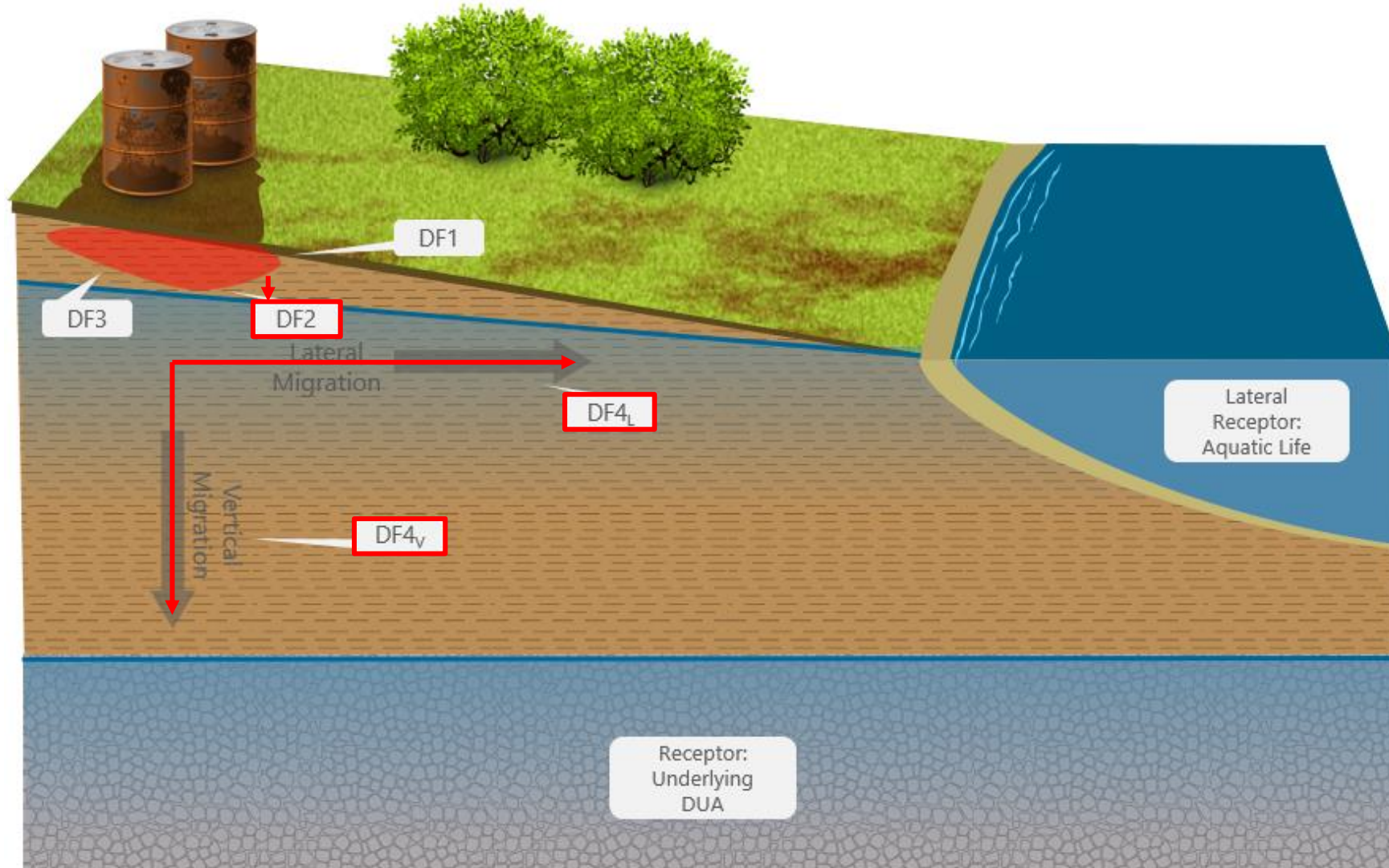


Tier 2 Guideline Tool

Calculated Tier 2 Soil Guidelines – Tier 1 to Tier 2

Receptor	Maximum On-Site Concentration	Overall Tier 2 Guideline	Human								Ecological		Other
			Direct Soil Contact	Vapour Inhalation		DUA	Underlying DUA	Direct Soil Contact	Nutrient/Energy Cycling Check	FWAL	Management Limit		
Pathway				Basement	Slab								
Building Type													
Hydrocarbons													
Benzene	1	0.00	78	1.8	1.6	-	-	60	-	NGR	-		
Toluene	2	0.50	645	2119	1928	-	-	110	-	NGR	-		
Ethylbenzene	10	0.073	1680	1036	930	-	-	120	-	NGR	-		
Xylenes	100	0.59	477	276	248	-	-	65	-	NGR	-		
Styrene	60	0.68	10496	248	221	-	-	-	-	1.5	-		
F1	200	210	12458	708	605	-	-	210	-	30000	800		
F2	150	150	6769	3650	3121	-	-	150	-	30000	1000		
F3	400	1300	14941	-	-	-	-	1300	-	-	3500		
F4	1000	5600	20990	-	-	-	-	5600	-	-	10000		
Acenaphthene	10	5380	5279	118283	98650	-	-	-	-	NGR	-		
Anthracene	30	2.5	24346	NGR	NGR	-	-	2.5	-	NGR	-		
Fluoranthene	50	50	3519	NGR	NGR	-	-	50	-	NGR	-		
Fluorene	0.02	2740	2726	268051	218330	-	-	-	-	NGR	-		
Naphthalene	11	0.047	1848	58	50	-	-	-	-	0.047	-		
Phenanthrene	37	NGR/-	-	-	-	-	-	-	-	NGR	-		
Pyrene	0.001	2100	2094	NGR	NGR	-	-	-	-	NGR	-		
Carcinogenic PAHs (as B(a)P TPE)	TPE: 3.5; IACR: 0.2	TPE <5.3; IACR <1	TPE <5.3	NGR	NGR	IACR <1	IACR <1	-	-	-	-		
Benz[a]anthracene	5	NGR/-	-	-	-	-	-	-	-	NGR	-		
Benzo[b+j]fluoranthene	0.02	NGR/-	-	-	-	-	-	-	-	-	-		
Benzo[k]fluoranthene	0.4	NGR/-	-	-	-	-	-	-	-	-	-		
Benzo[g,h,i]perylene	40	NGR/-	-	-	-	-	-	-	-	-	-		
Benzo[a]pyrene	1	20	-	-	-	-	-	20	-	NGR	-		
Chrysene	0.8	NGR/-	-	-	-	-	-	-	-	-	-		
Dibenz[a,h]anthracene	1.4	NGR/-	-	-	-	-	-	-	-	-	-		
Indeno[1,2,3-c,d]pyrene	1.1	NGR/-	-	-	-	-	-	-	-	-	-		

Literature Biodegradation Rates

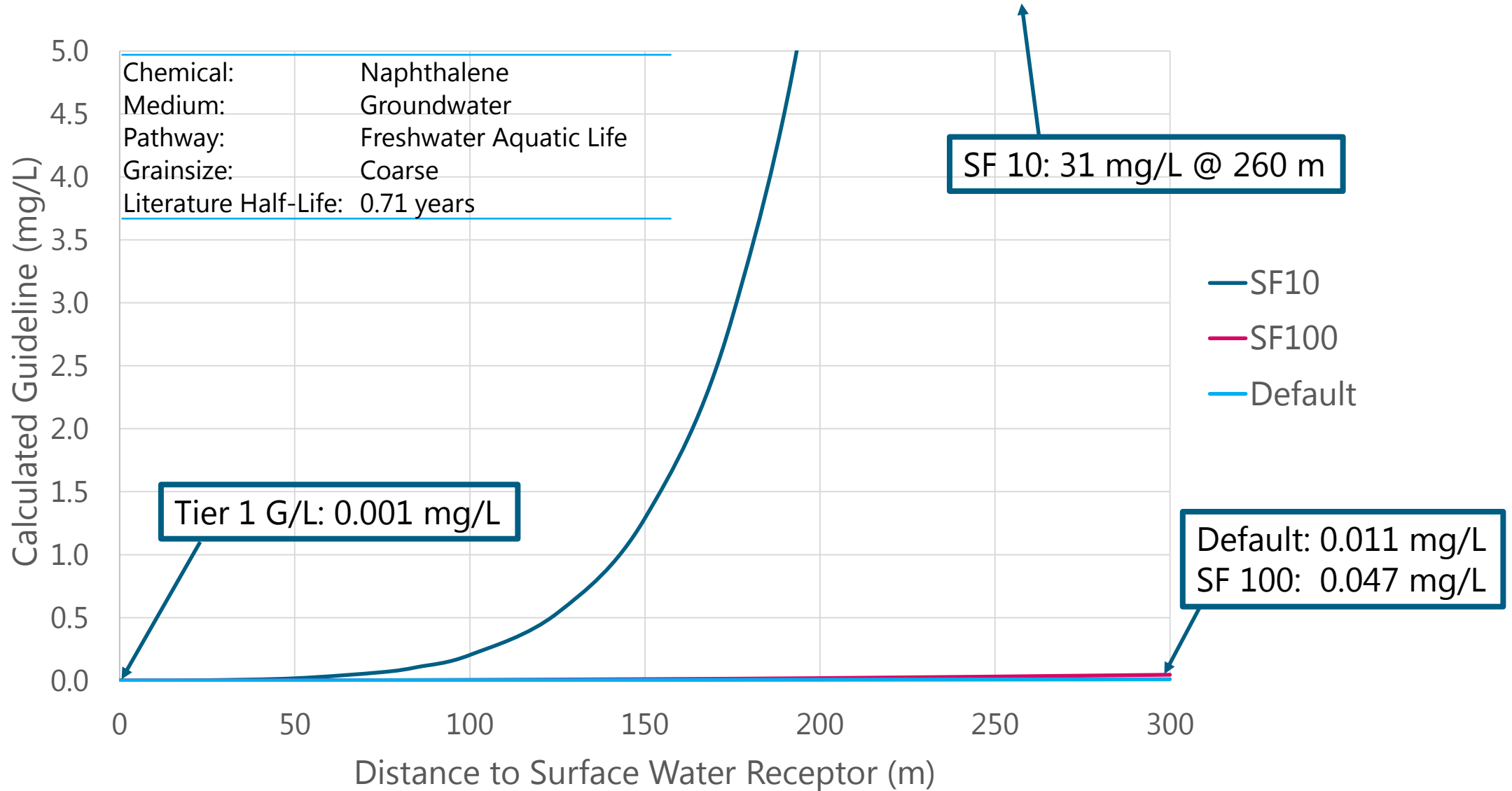


Biodegradation Rates

Safety Factor

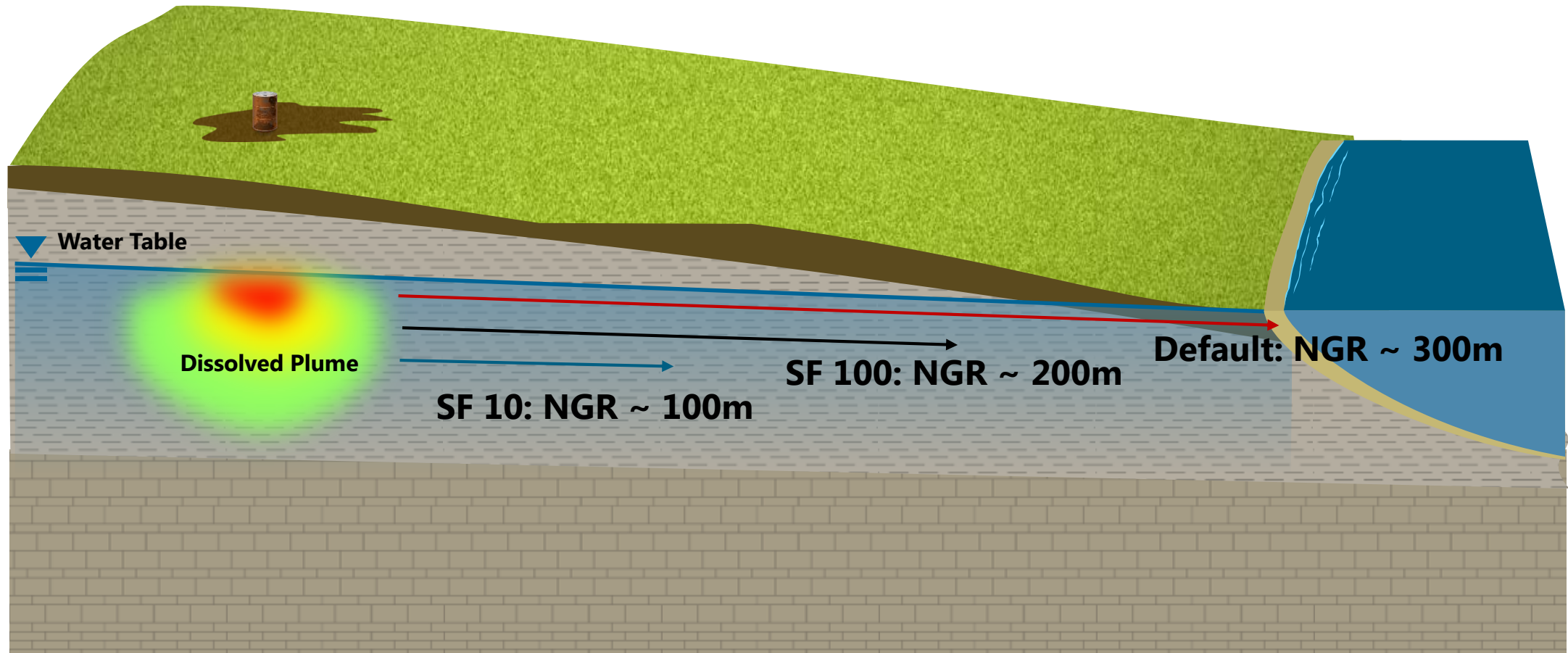
- Use the maximum value when ranges were found
- Example:
 - Literature value for naphthalene 0.7 yrs
 - Naphthalene 0.7 yrs x Safety Factor (SF) 10 = 7 yrs
 - Naphthalene 0.7 yrs x Safety Factor 100 = 70 yrs

Calculated Guidelines: Naphthalene



Distance to Exceed PAH Solubility Limit

Phenanthrene: Half Life 1.1 years



Notes:

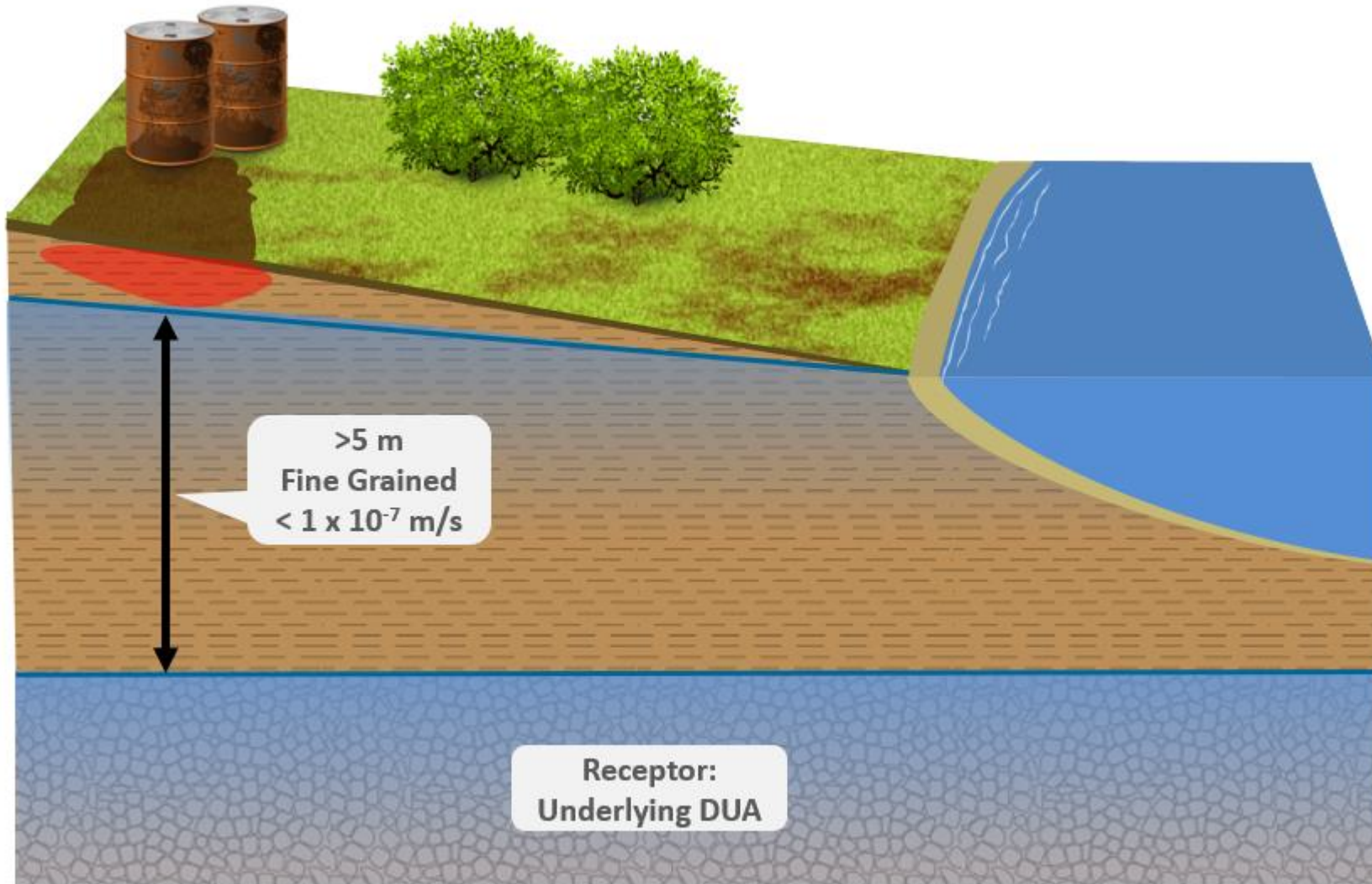
- SF 10: Half life used in guideline calculations = Maximum Literature Half Life * Safety Factor of 10
- SF 100: Half life used in guideline calculation = Maximum Literature Half Life * Safety Factor of 100

Tier 2 Guideline Tool

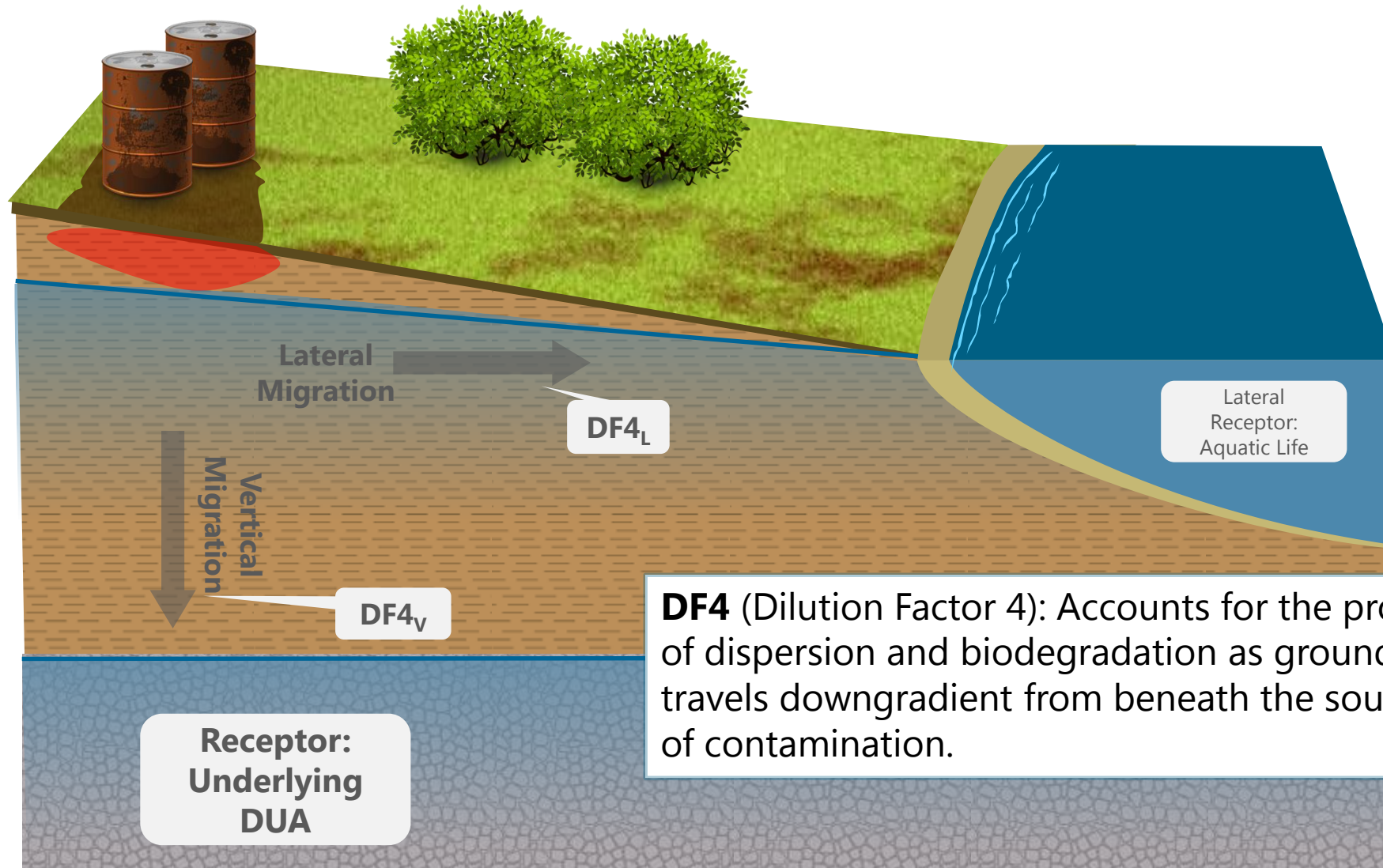
Literature Values for Half Life

Site Characteristics	
Land Use (Select drop down for Tier 1 default values)	Agricultural
Texture (Select drop down for Tier 1 default values)	Coarse
Half Life - Use default guideline values (Default) or most conservative of literature values (Literature)?	Default
	Default Literature

Innovative Application: Protection of Underlying DUA



Modifying the Model for Protection of Underlying DUA



Calculating Protection of Underlying DUA Guidelines for Water

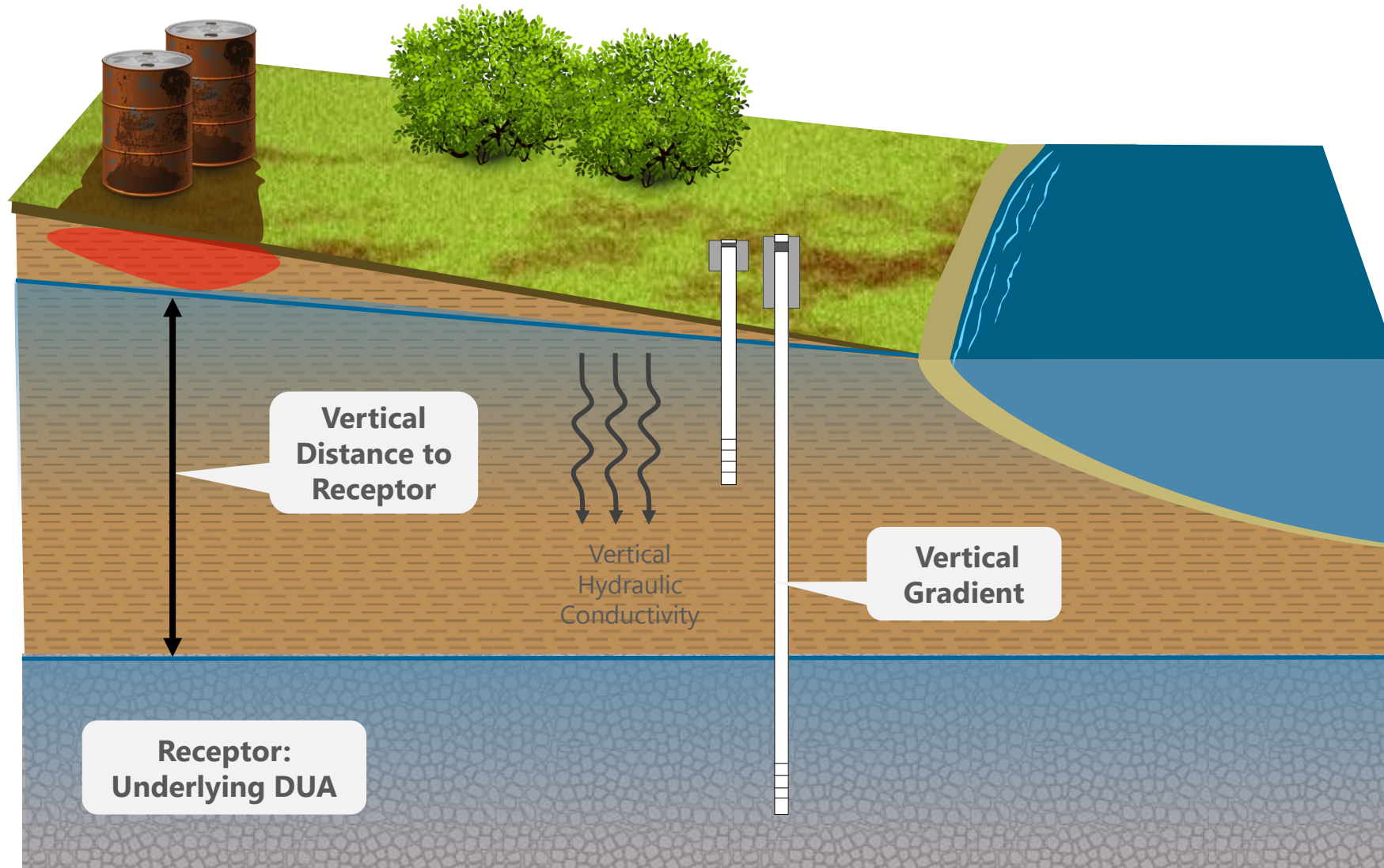
Lateral Calculation:

Surface Water Quality Guideline \times $DF4_L$ = Protection of Freshwater Aquatic Life Guideline

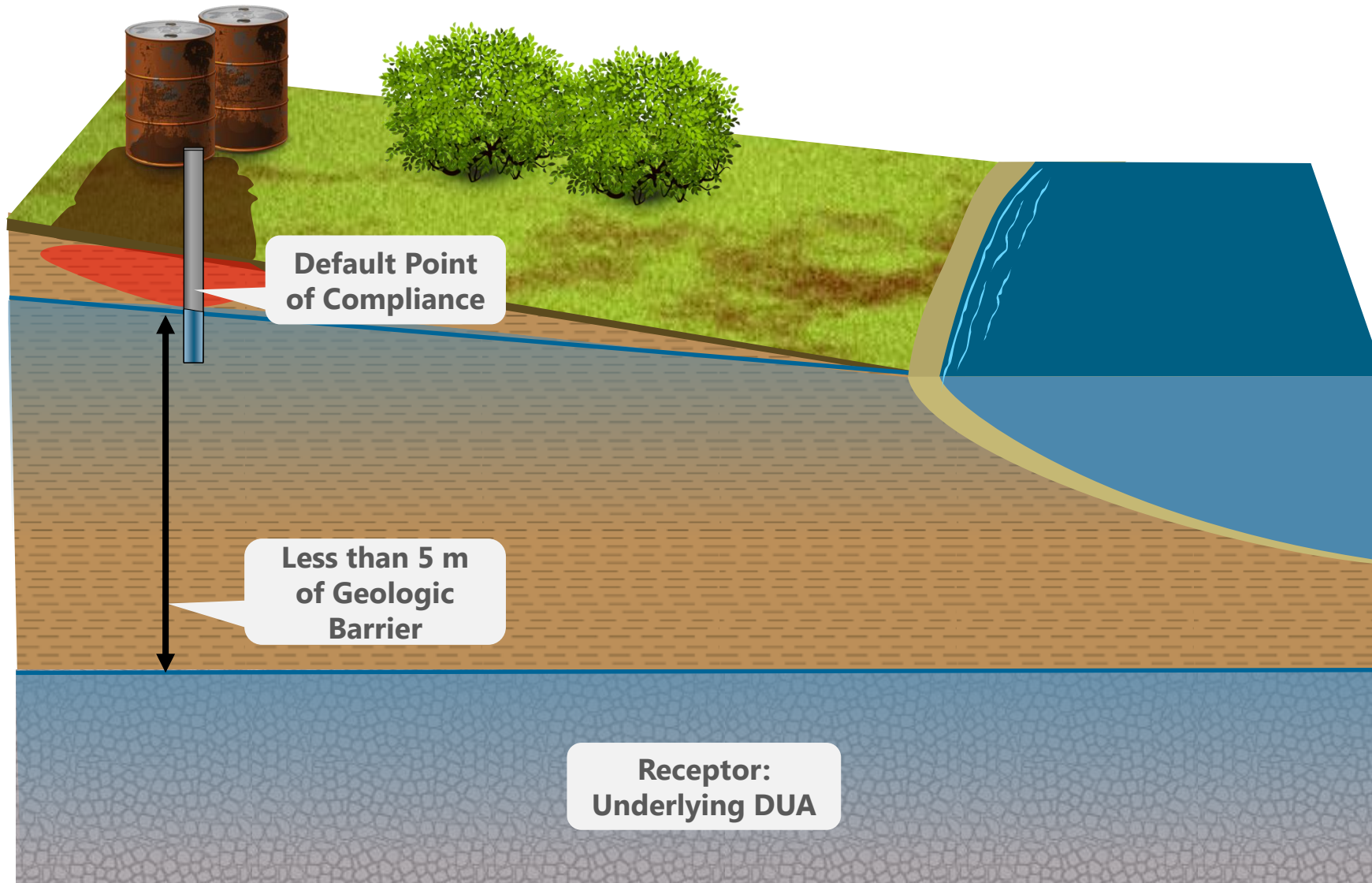
Vertical Calculation:

Drinking Water Guideline \times $DF4_V$ = Protection of Underlying DUA Guideline

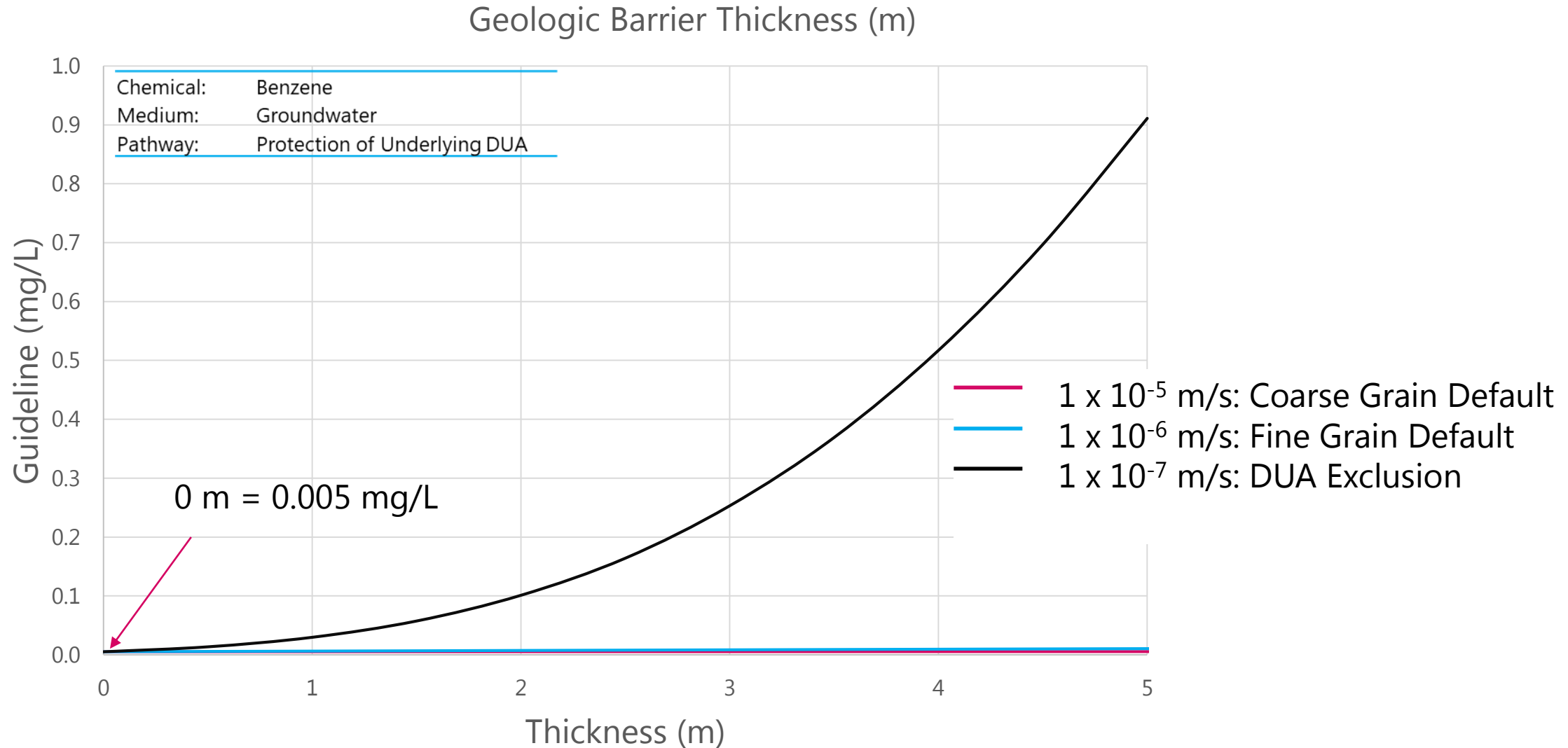
Parameters Required to Recalculate for Vertical Protection of DUA Guideline



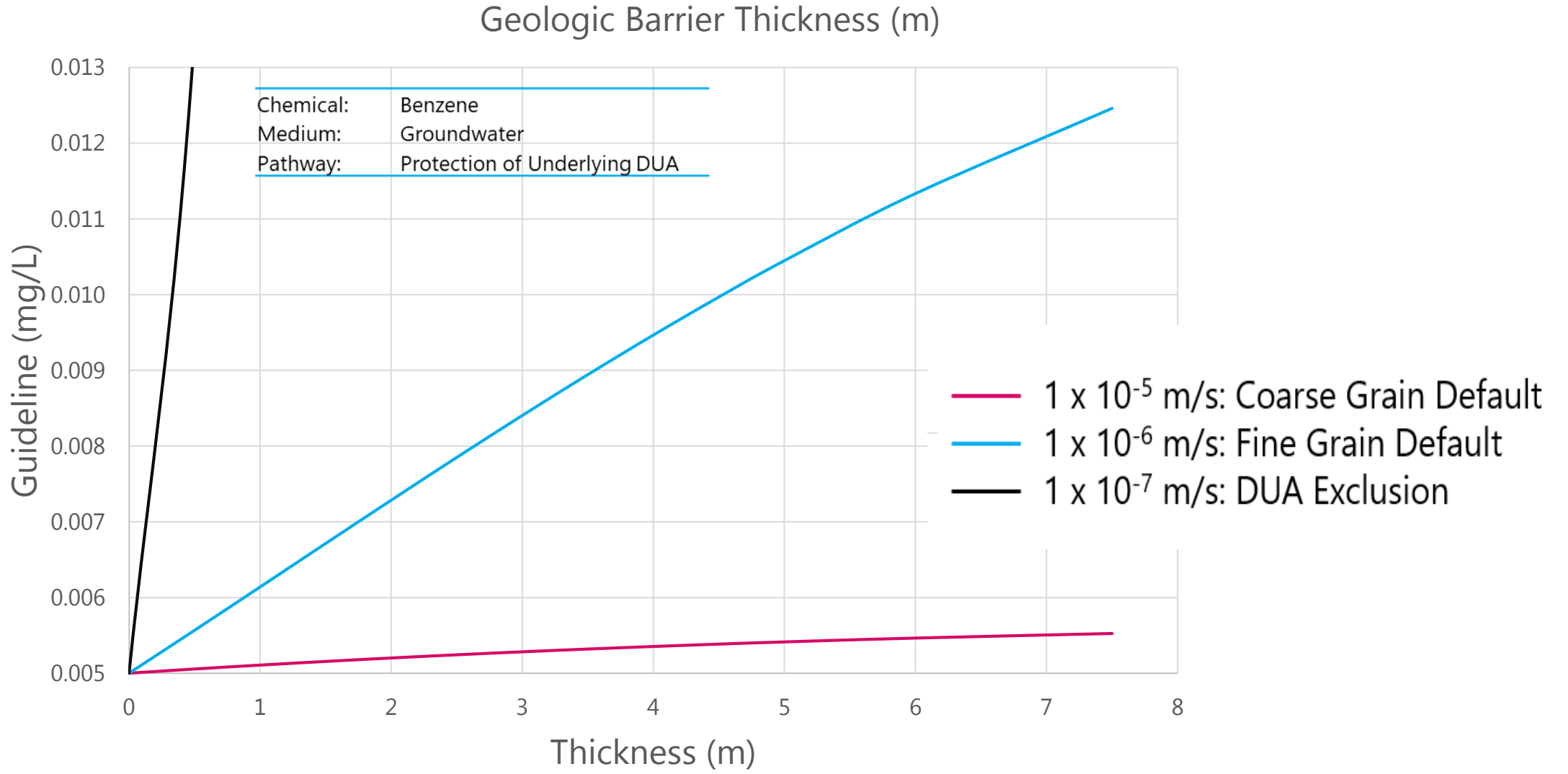
Protection of Underlying DUA: Less than 5 m of Geologic Barrier



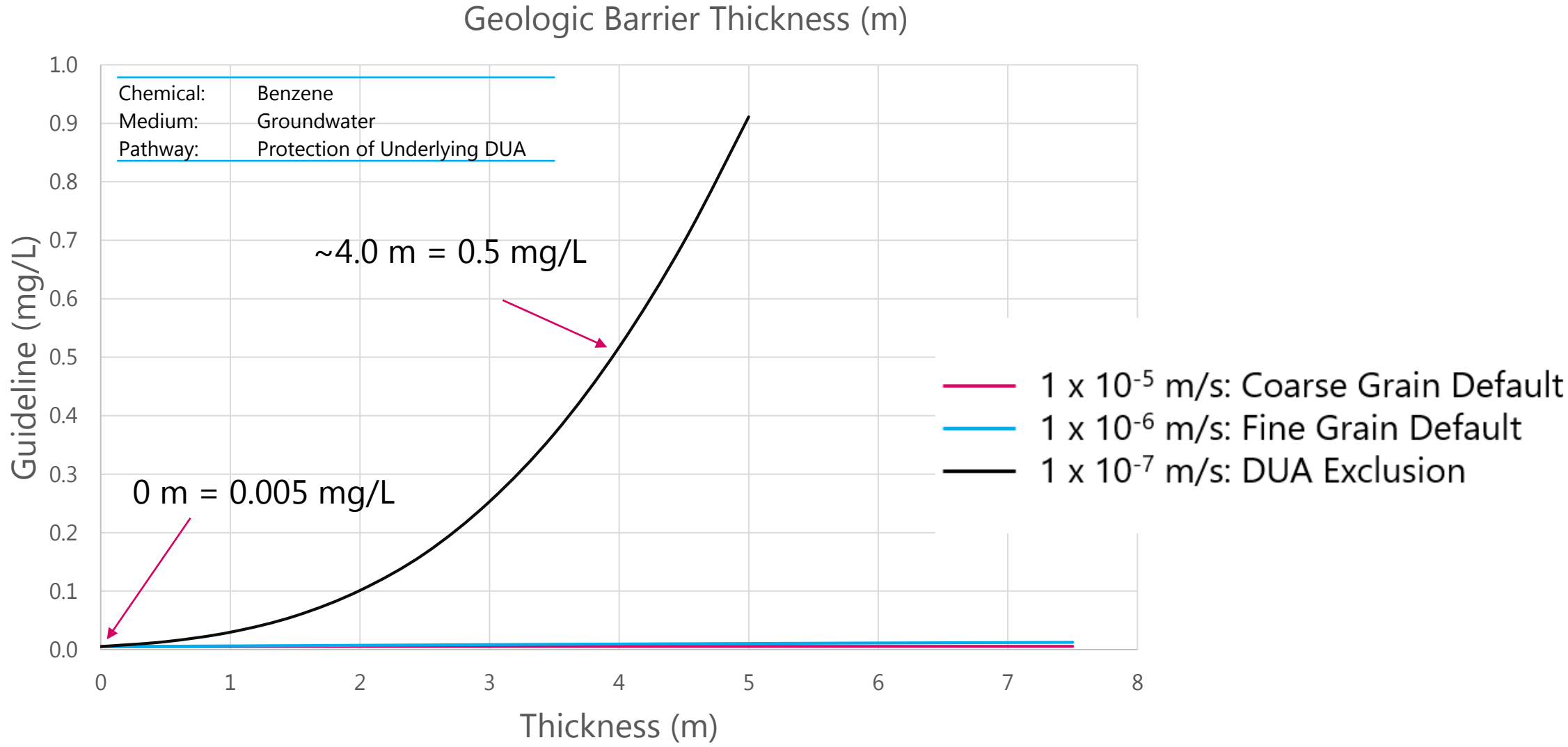
Protection of Underlying DUA: Less than 5 m of Geologic Barrier



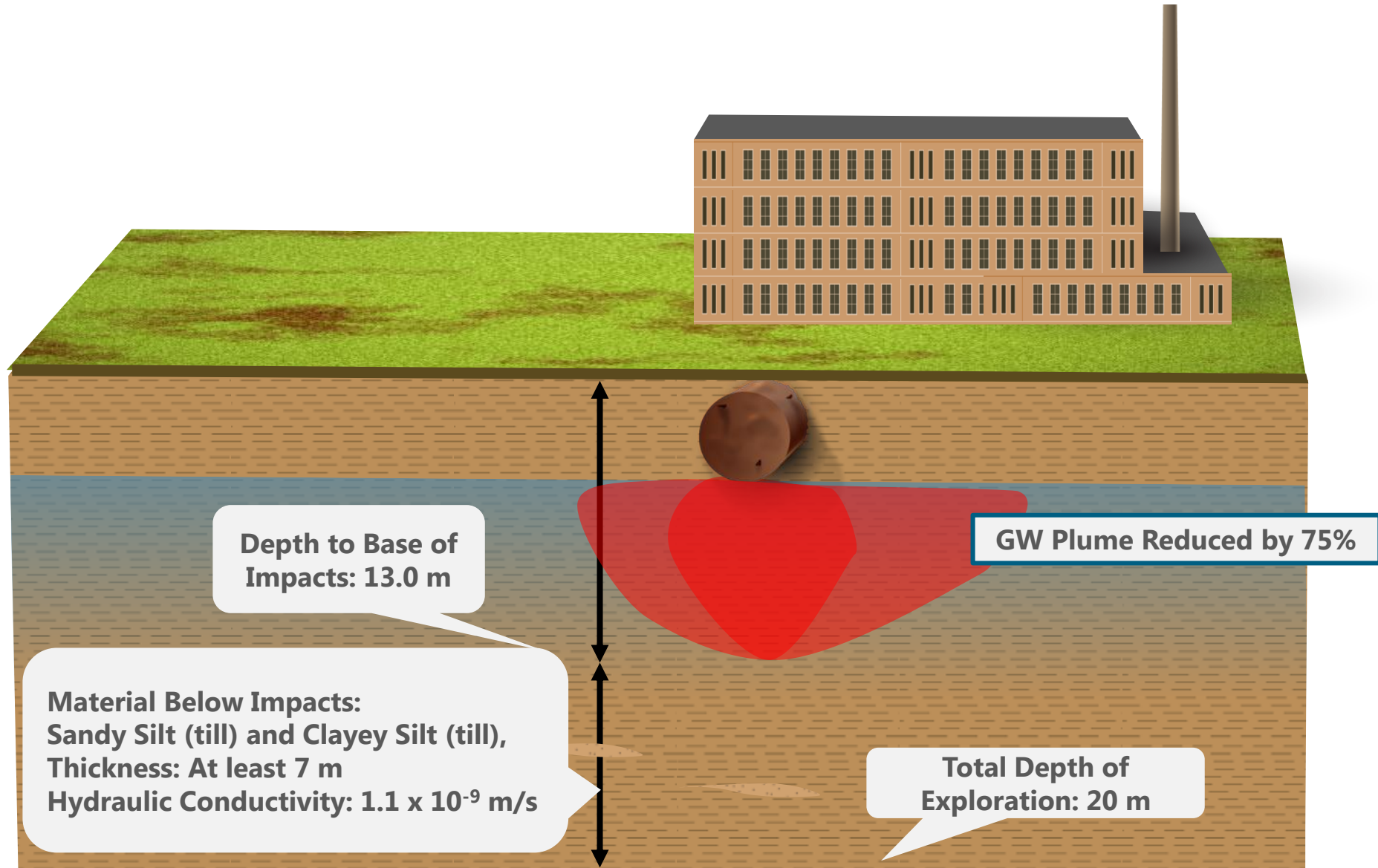
Protection of Underlying DUA: Less than 5 m of Geologic Barrier



Protection of Underlying DUA: Less than 5 m of Geologic Barrier



Case Study: Leaking Tank with PHC and PAH Impacts



Benefits of Advisian's Guideline Recalculation Tool

- All exposure pathways
- Cost savings
- Quickly generate Tier 2 guidelines
- Degradation rates
- Underlying DUA



Acknowledgements

- Louise Burden
- Brian Greflund
- Bryce Reiter

References

- AEP (Alberta Environment and Parks) 2019a. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Land Policy Branch, Policy and Planning Division. January 2019.
- AEP (Alberta Environment and Parks) 2019b. Alberta Tier 2 Soil and Groundwater Remediation Guidelines. Land Policy Branch, Policy and Planning Division. January 2019.
- Health Canada 2015. Conceptual Site Model Builder.

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