Hydraulic Response Testing in a Bedrock Setting – An Innovative Approach

2023-05-16

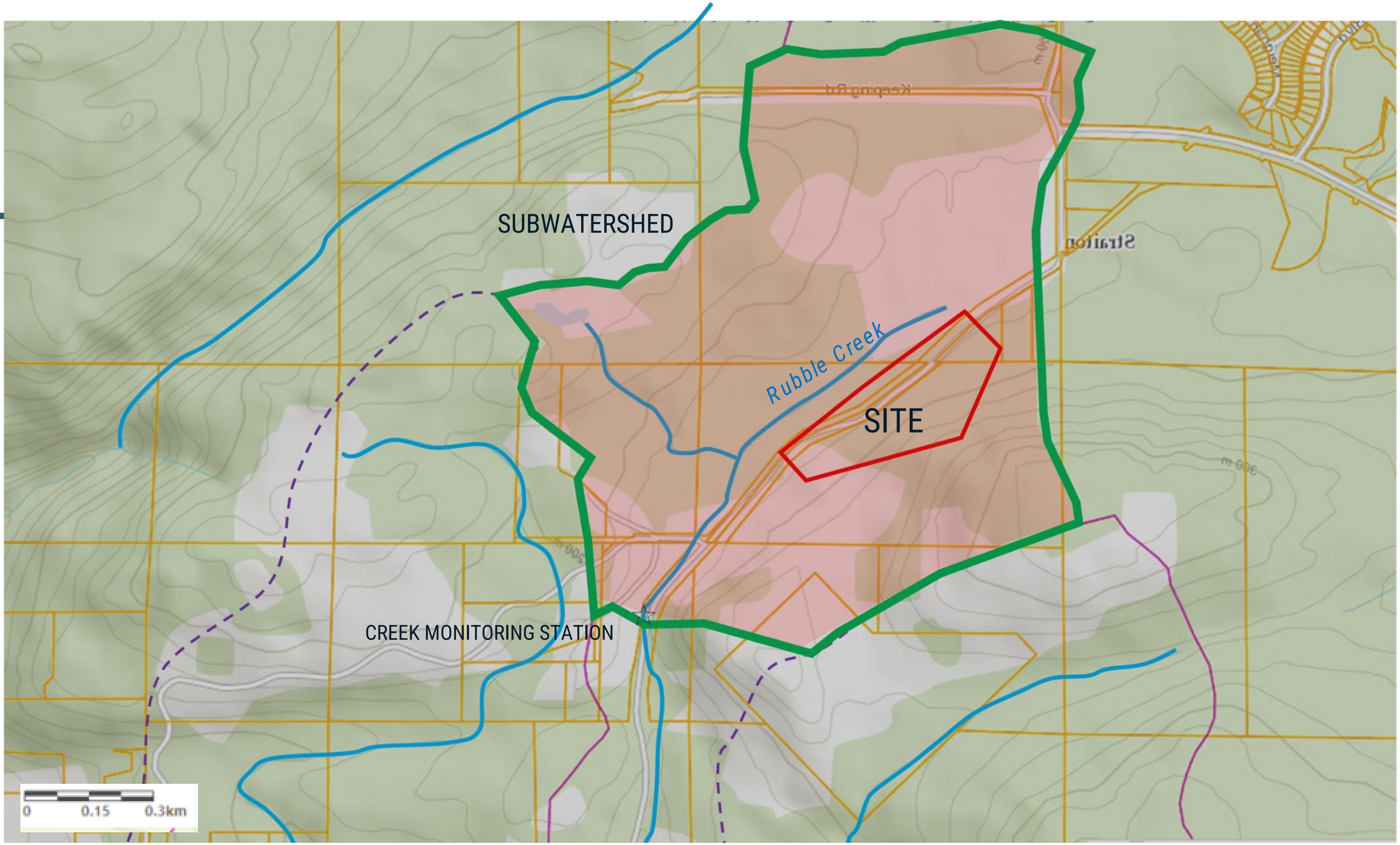
ACTIVE EARTH
ENGINEERING LTD

Setting

- Existing Quarry in southwestern BC
- Extracting rock since the early 2000s – blasting, crushing, sorting, hauling

Overburden

Creeks


SUBWATERSHED
Rubble Creek
SITE
CREEK MONITORING STATION
0
0.15
0.3km

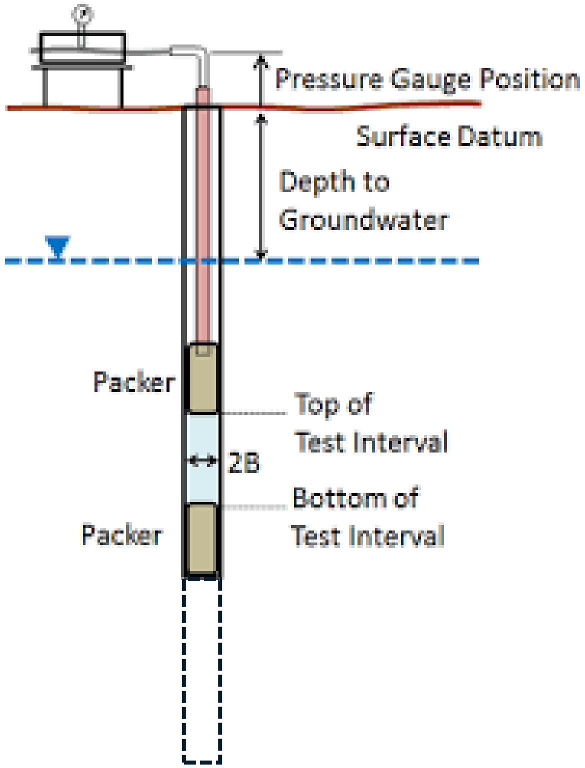
Question

- How might further quarrying impact the creek?
- What dewatering rates might we expect from the Quarry?

- What is the contribution of groundwater to creek flow?
- What is the hydraulic conductivity of the bedrock mass and overburden materials?

Approach

- Packer testing



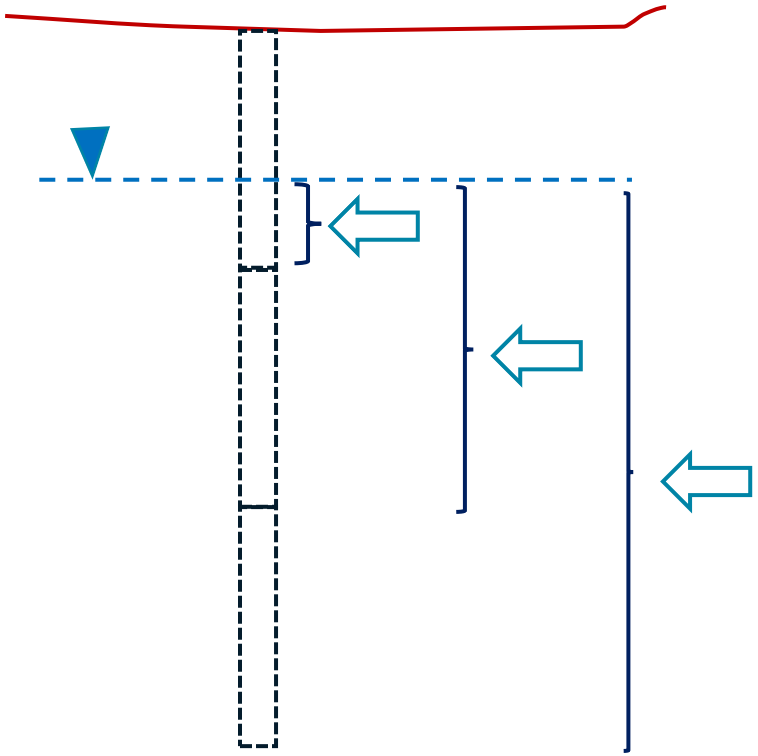
$$$
$50K/hole

Limited Packer Supply

Time consuming

Discreet intervals

- Our approach: open hole testing



$
$7K/hole

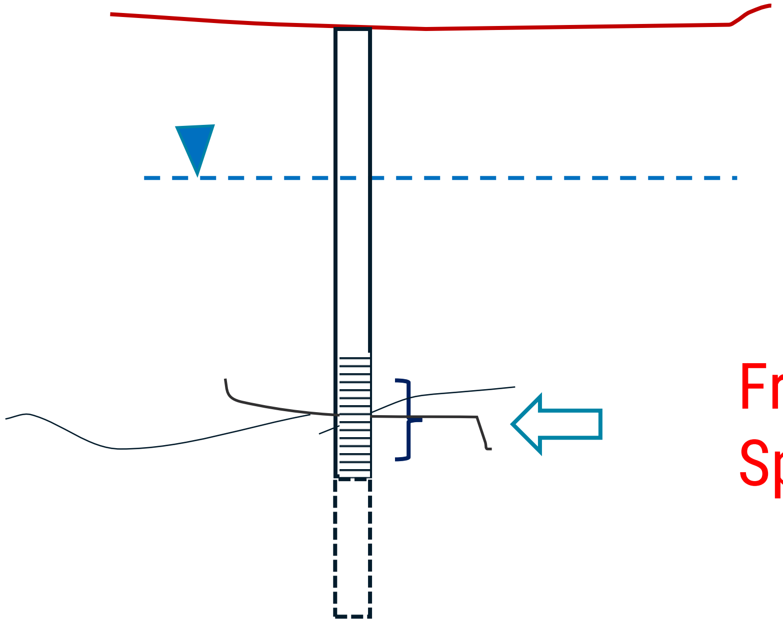
No special equipment

Less time

Wholistic

Approach

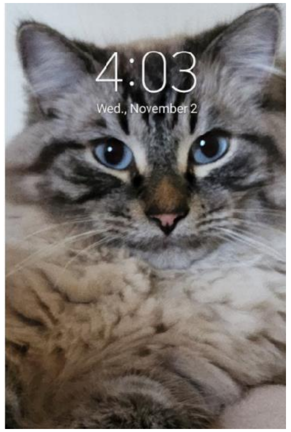
- Our approach: monitoring well testing



Fracture Specific

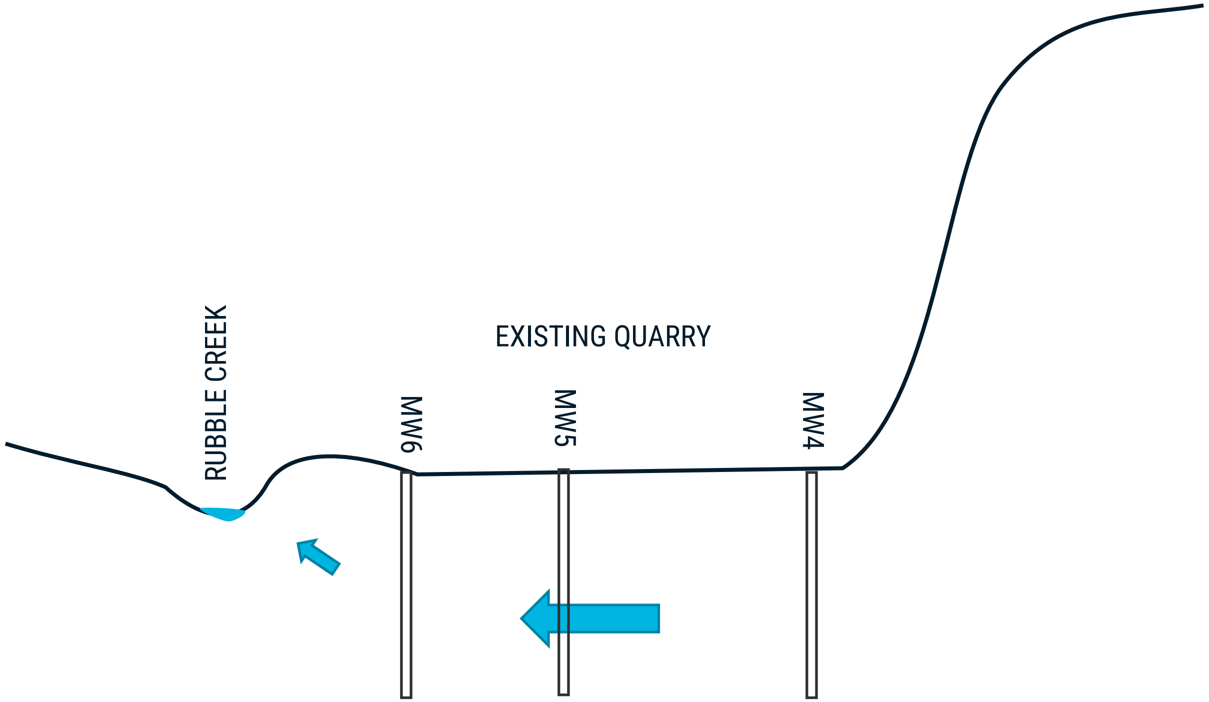
Team

- Active Earth Engineering (Summerland, Abbotsford, Burnaby, Victoria)



- Ground Source Drilling (Kelowna)

Hydrogeologic Setting

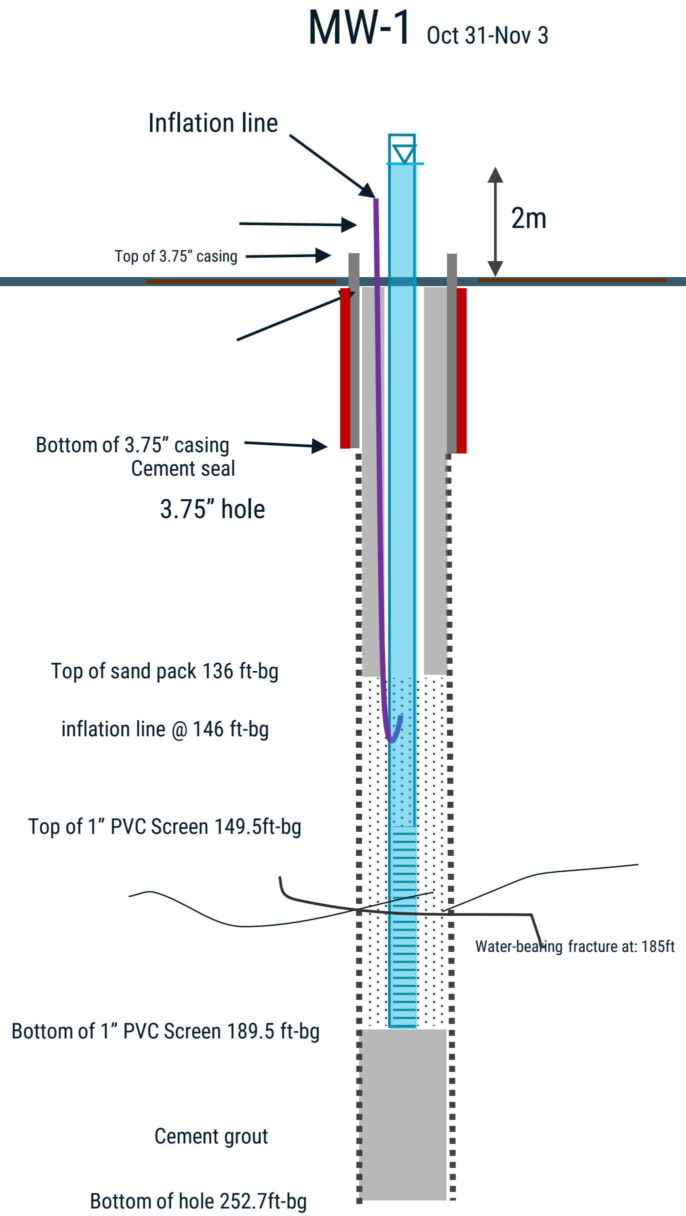


Lithology – MW1

Lithology – MW2

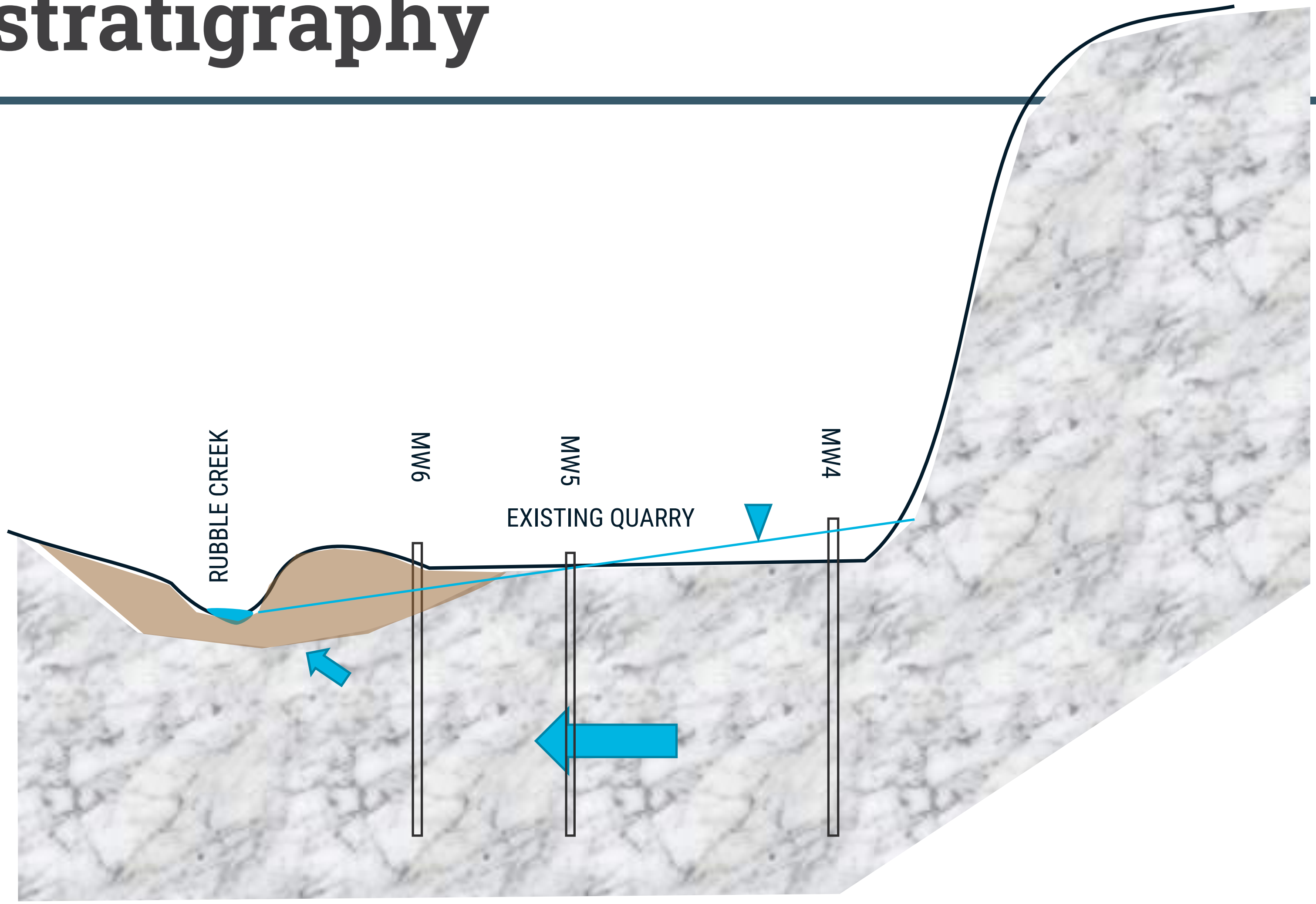
Monitoring Well Design

- 40ft long screen intercepting water-bearing fractures
- Inflation line placed above screen for response testing
- Sealed surface casing for control of artesian flow



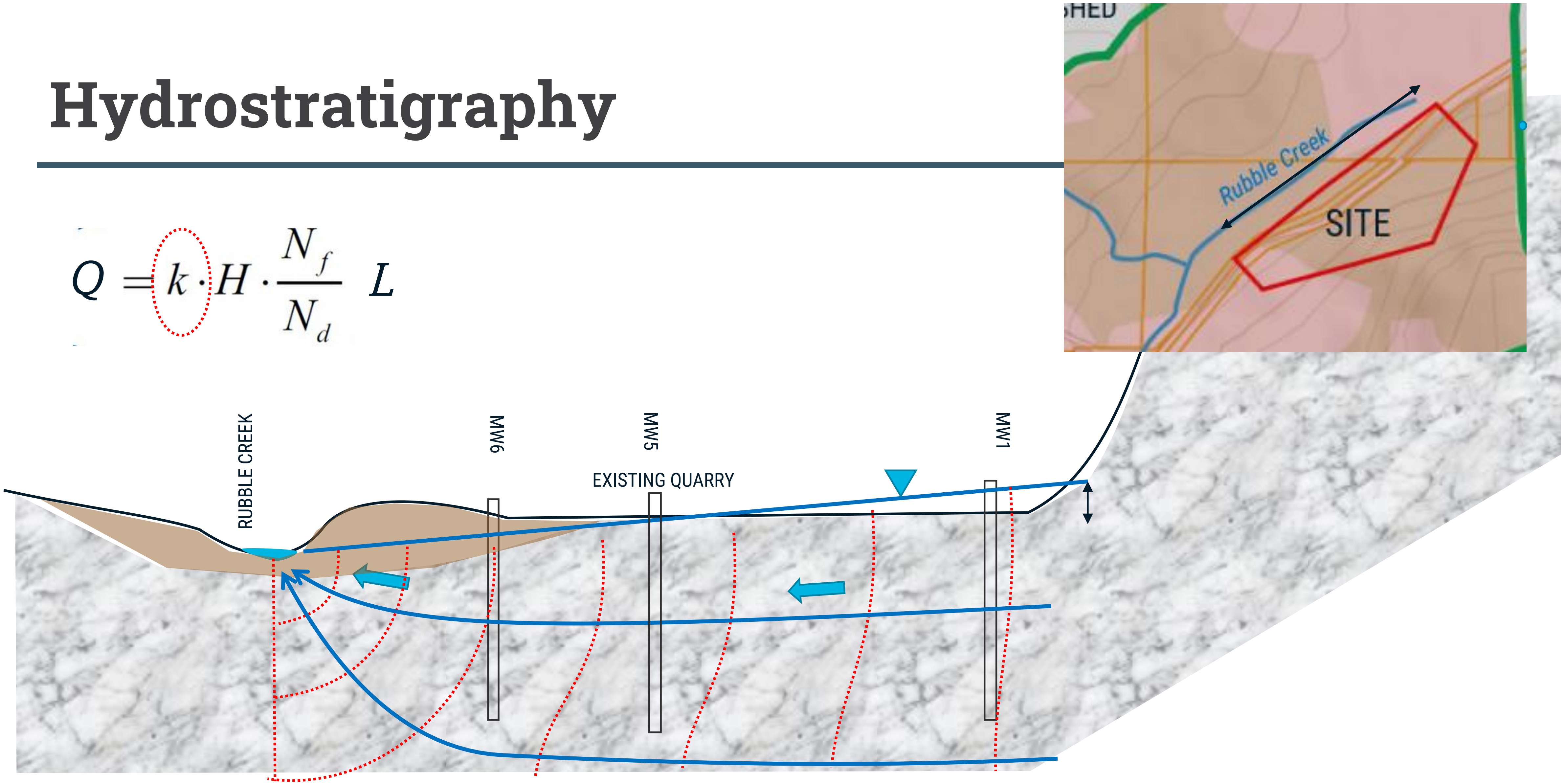
Monitoring Well Design

Hydrostratigraphy



Hydrostratigraphy

$$Q = k \cdot H \cdot \frac{N_f}{N_d} \; L$$

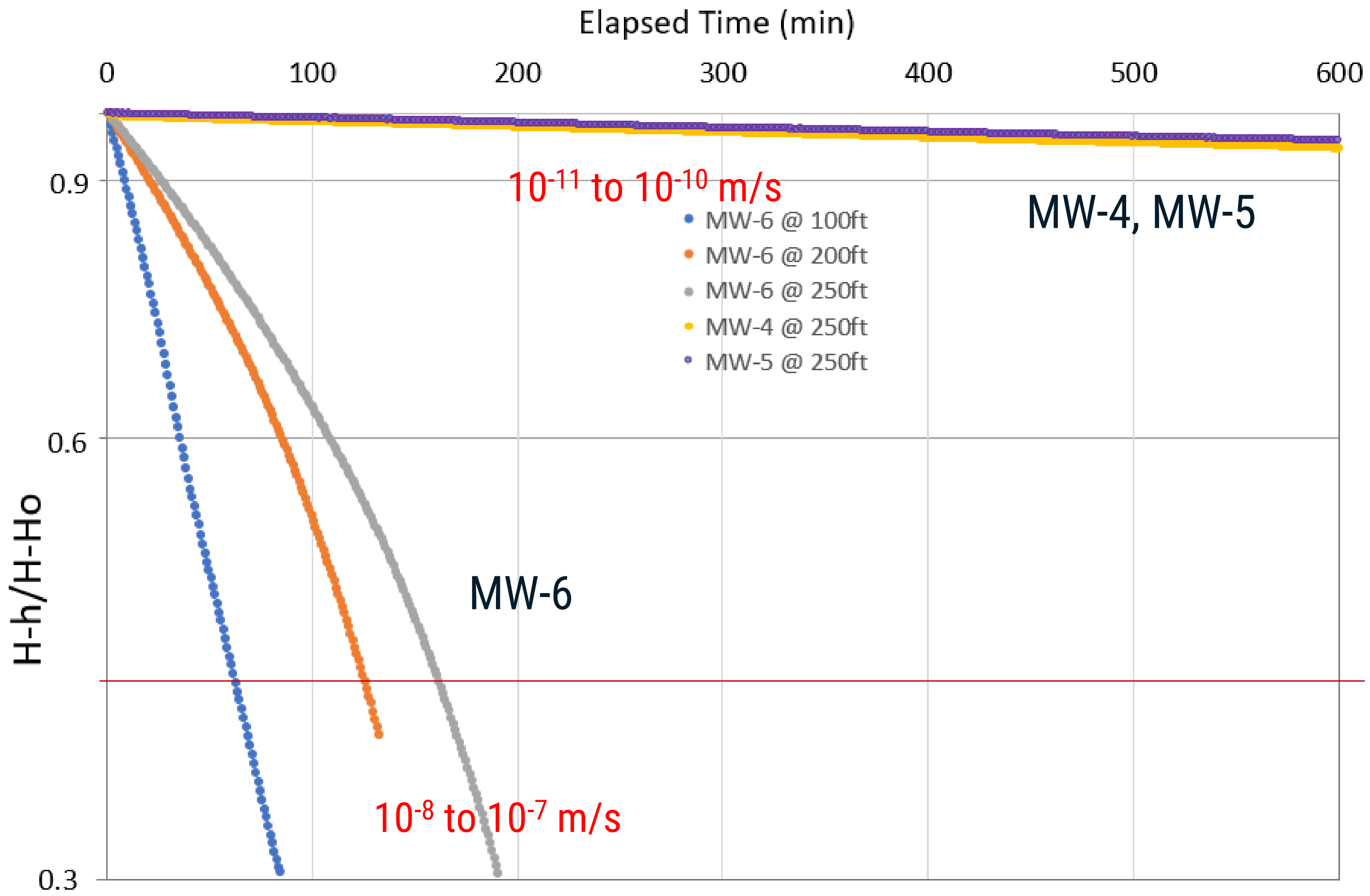


Open Hole Hydraulic Response Tests

Idea #1

Hose reel protects logger from open hole movement

Recovery Curves - Hvorslev

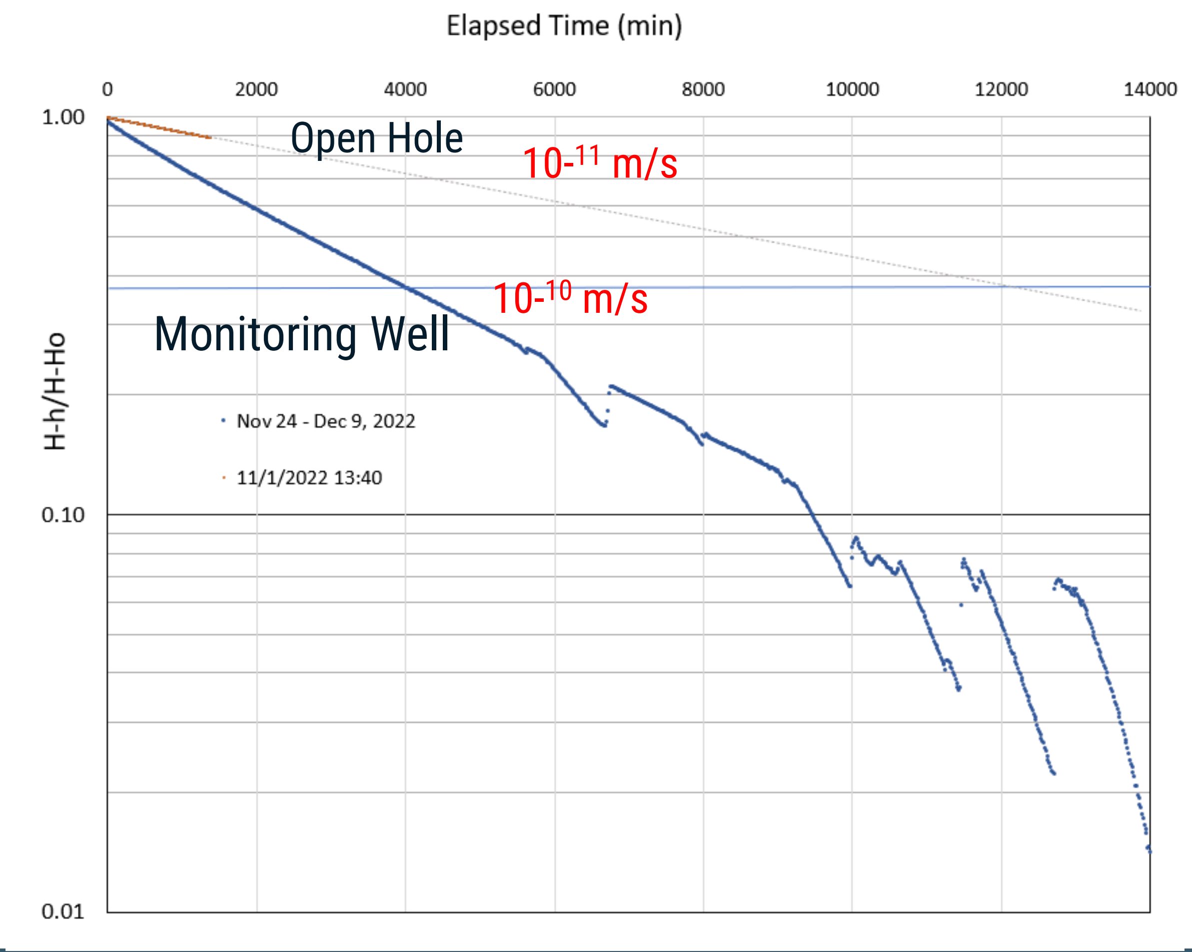


Open Hole tests

Monitoring Well Hydraulic Response Tests

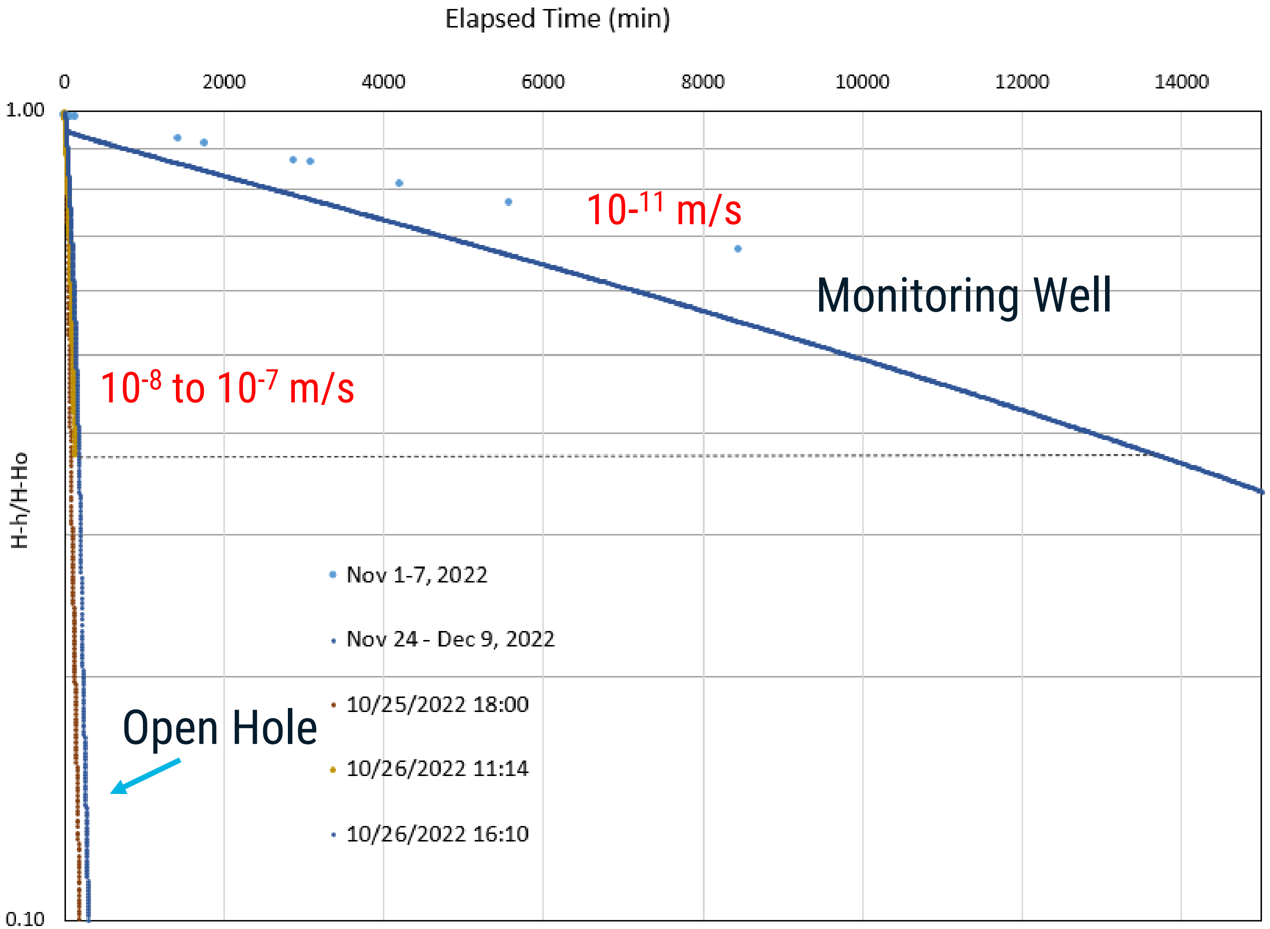
Idea #2

Hydraulic Response Test Results – MW-4



Location	Depth Range (ft)	K (m/s)	Representative of:
MW-4	22 to 250	1.3E-10	deep bedrock
	150 to 190	4.5E-11	deep bedrock

Hydraulic Response Test Results – MW-6



Location	Depth Range (ft)	K (m/s)	Representative of:
MW-6	4 to 100	1.9E-07	overburden and shallow bedrock
	40 to 200	5.9E-08	shallow bedrock
	40 to 250	3.8E-08	shallow and deep bedrock
	220 to 250	3.2E-11	deep bedrock
		4.8E-11	deep bedrock

Estimated Baseflows

$$Q = k \cdot H \cdot \frac{N_f}{N_d} L$$

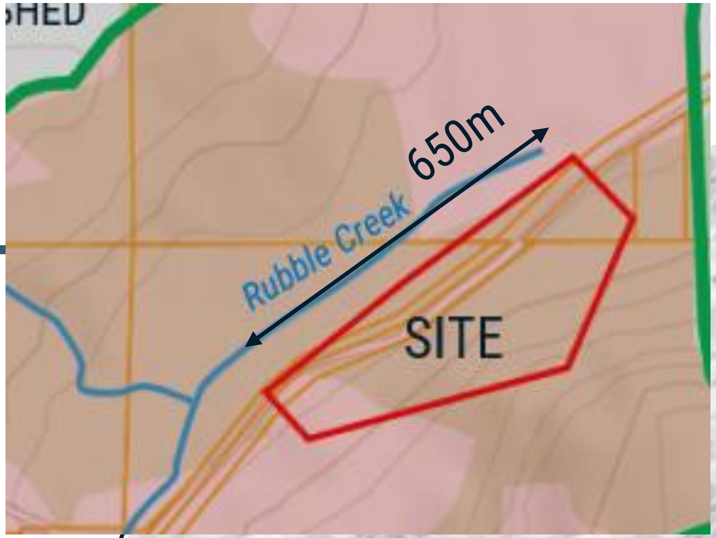
1e-7 m/s

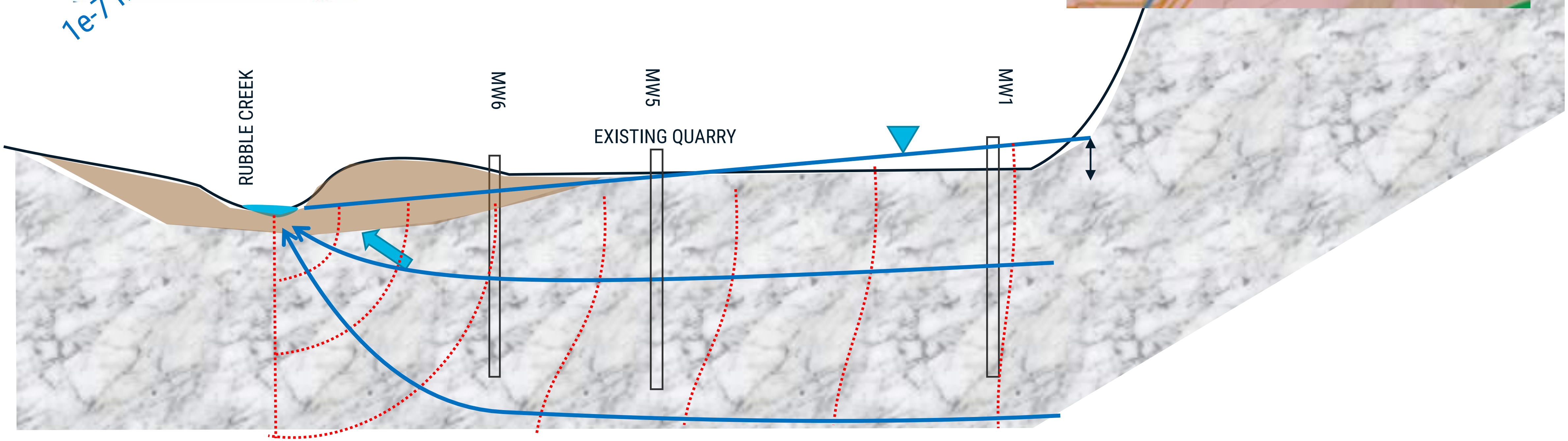
2m

0.8

650 m

6.7 L/min or 1.8 USgpm





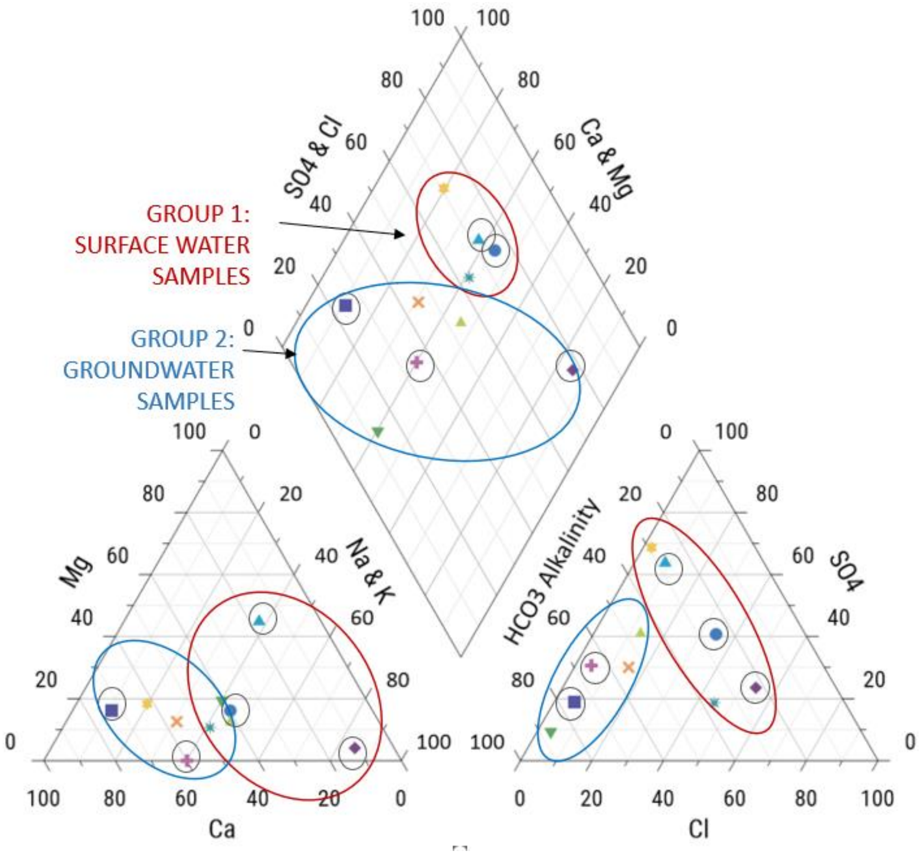
Take Away Points

- Rising head tests in open bedrock holes can give rough estimate of hydraulic conductivity over different depth intervals
- Evacuating water column using compressed gas creates a large and immediate head change

- Easy to do
- Relatively inexpensive

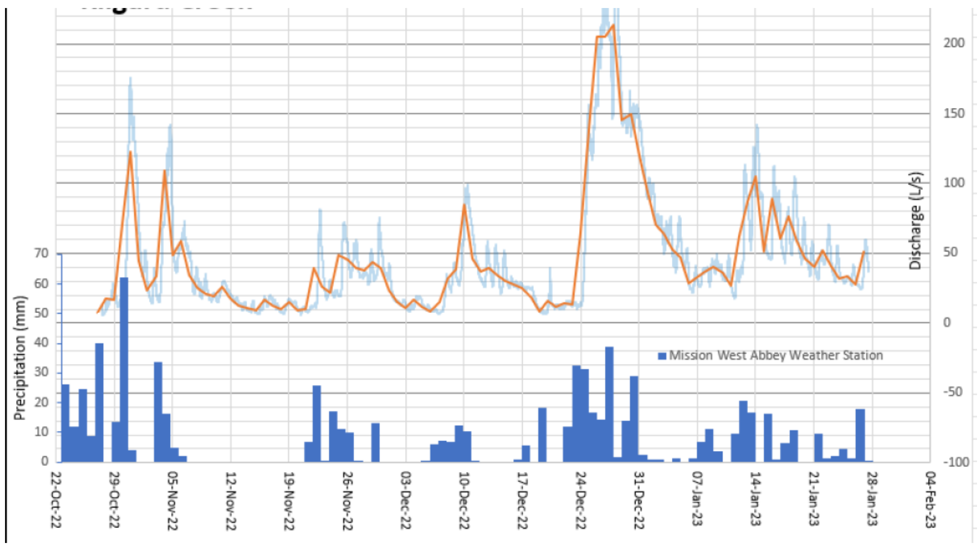
Other hydrogeological Tools

- Geochemistry



Other hydrogeological tools

- Water balance



	GROUPING	WATER BALANCE COMPONENT	UNITS	VALUES	NOV	DEC	JAN	QUARTERLY
		Number of days			30	31	31	
CLIMATE DATA	CALCULATION OF NET PRECIPITATION	Elevation correction		1	1.0	1.0	1.0	
		Total Precipitation (2022-2023)	mm		141.4	260.8	199.2	**601**
		Adjusted Total Precipitation	mm		141.4	260.8	199.2	**601**
		Thornthwaite - a		0.52				
		Potential Evapotranspiration	mm		87.6	13.4	93.7	**195**
		Actual Evapotranspiration coefficient		0.7	0.7	0.7	0.7	
		Actual Evapotranspiration			61.3	9.4	65.6	**136**
		Net Precipitation (Total P -ET)	**mm**		80.1	202.2	133.6	**416**
RUNOFF / INFILTRATION	RUBBLE CREEK CATCHMENT	Runoff coefficient		0.6	0.87	0.93	0.93	**0.91**
		Catchment area	km2	1.193				
		Runoff	mm		69.5	188.4	123.6	381
			m3		**82,907**	**224,743**	**147,456**	**455,106**
		Infiltration	mm		10.6	13.8	10.0	34
			m3		12,609	16,465	11,916	**40,990**
CREEK FLOW	RUBBLE CREEK	Drainage area	km2	1.193				
		Station average monthly flow rate	**m3/s**		**0.0303**	**0.0586**	**0.054**	
		Total discharge	mm		65.8	131.6	120.1	**318**
			m3		**78,538**	**156,954**	**143,294**	**378,786**
GROUNDWATER AND STORAGE OUTPUTS	BASEFLOW TO RUBBLE CREEK	**Measured Station minimum flow rate**	**m3/s**	**0.010**				
		Estimated average release from pond storage	**m3/s**	**0.006**				
		Estimated groundwater baseflow	**m3/s**	**0.004**				
			mm		8.7	9.0	9.0	**27**
			m3		10,368	10,714	10,714	**31,795**

Acknowledgements

- Special thanks to:
- Justin and Kieren of Ground Source Drilling
- David Kneale of Active Earth
- Our valued clients ☺