

Aquifer Protection: Risk Management and Engineered Controls as an Alternative to Remediation

(Canmore Multiplex Site)



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Presentation Outline

- Site History
- Environmental Investigations
- Risk Management and Exposure Control Plan
- Plan Implementation
- Unexpected Findings
- Lessons Learned



Town of Canmore - History

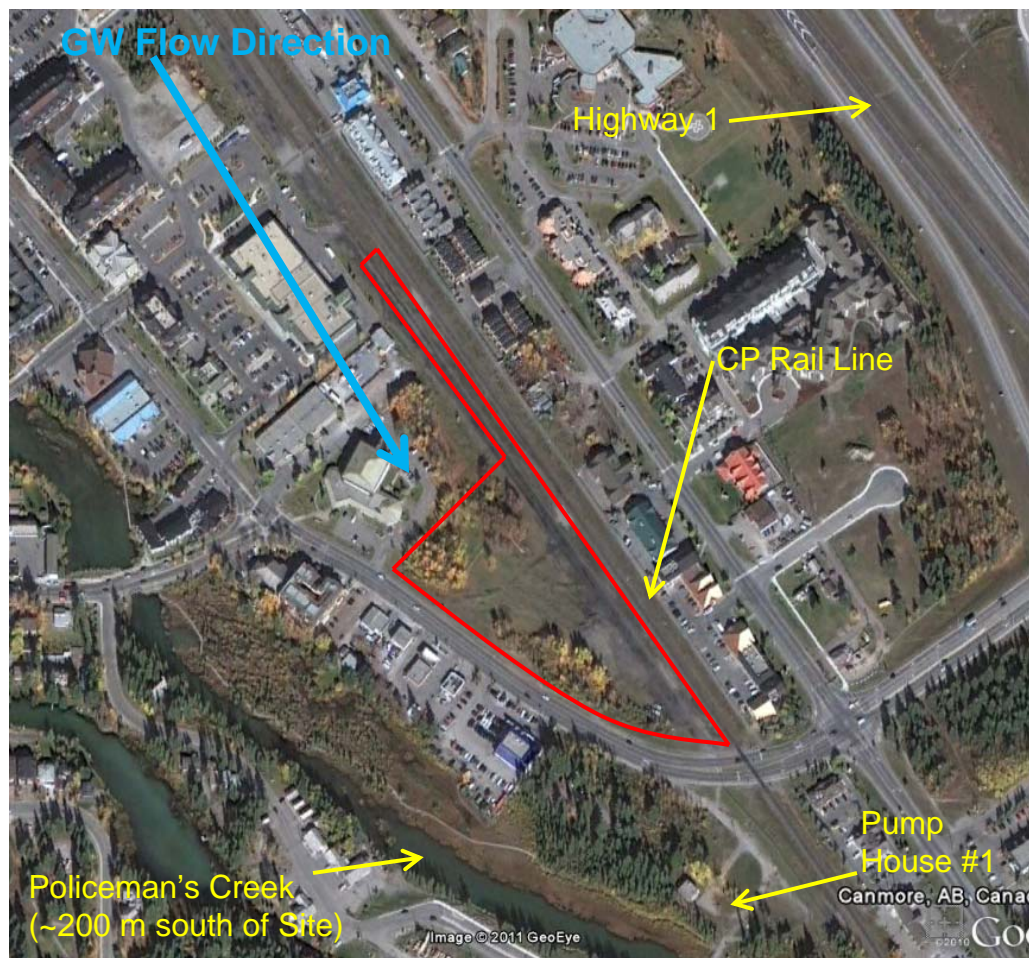


Okanagan Archive Trust Association

- Established by the Canadian Pacific Railway in 1883
- Was an important coal mining centre from late 1800's to 1979 when last mine closed
- Coal/clinker was commonly used as fill in Canmore to bring area up to grade
- Multiplex Site was location of a 12-bay roundhouse with turntable



Canmore Multiplex Site



Google Earth, 2011

- Phase II by Golder for CP Rail in 1992
 - Monitoring wells and test pits across Site
- Phase I and Data Gap Analysis for Town in 2010
- Supplementary Site Characterization for Town in 2010



Phase I ESA – Site Visit Photographs





Investigation Findings - Site Geology



- 2 -3 m of alluvial sediments and fill cover the Site
 - Fill consists of coal, clinker and ash material
- Alluvial sediments and fill underlain by high yield non-glacial fluvial sand and gravel
 - Up to 55 meters thick in some areas
- GW depth ~1.5 – 3 m bgs
- Estimated K of 4×10^{-3} m/s
- Estimated GW velocity of 2-3 m/day



Phase II Investigation Findings – Contaminant Characteristics

**Most significant issue identified in
Phase I ESA was on-Site fill**

- Boron above AB Tier 1 Guideline at two locations – not widespread
- PAHs above AB Tier 1 Guidelines in all samples submitted from fill
- Phenols (non-speciated) above AB Tier 1 Guidelines in fill
- No PAHs or phenols detected in groundwater in 2010
- No hydrocarbons detected in groundwater in 1992 or 2010

**General lack of correlation between
soil and groundwater results**





Soil Analytical Data

Sample ID	Units	AB Tier 1	AB Tier 2	10-1	10-2	10-2	10-3	10-4	10-5	10-6	10-7	10-8	10-8	10-9	10-10	G10-1	G10-1
B[a]P Eq.	mg/kg	IACR <1	8.0	7.5	7.5	<0.1	8.1	<0.1	0.8	0.6	6.6	0.6	0.2	0.8	<0.1	2	<0.1
IACR	-		NG	20.3	20.3	0.04	21.3	0.20	2.2	1.8	18.4	1.55	0.46	2.23	0.25	4.92	0.04
Boron	mg/kg	2	2	1.4	-	11	0.7	<0.2	1.7	0.8	0.4	0.9	0.9	1.3	4.8	0.4	0.6
Arsenic	mg/kg	26	26	2	-	2	5	2	2	1	3	2	-	2	4	5	2
Phenols	mg/kg	0.0024	130	<0.02	<0.02	3.9	0.07	<0.02	0.15	0.02	0.03	<0.02	<0.02	<0.02	0.33	<0.02	0.02
TOC	%	NG	NG	19	53	-	51	0.2	40	39	48	22	13	36	37	33	2.7

Notes:

Alberta Tier 1, Commercial Land Use - Coarse Grained Soil

Alberta Tier 2 , Commercial Land Use - Coarse Grained Soil, DUA and FWAL Pathways Eliminated



Groundwater Analytical Data

Sample ID	AB	AB	MW04-6	9A	9B	9A	9C		9D		MW04-1
Sample Date	Tier 1	Tier 2	May-10	May-10	May-10	May-10	May-10	Oct-10	May-10	Oct-10	May-10
Acenaphthene	0.0058	NG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	0.046	NG									
Acridine	NG	NG									
Anthracene	0.000012	0.32									
Benzo[a]anthracene	0.000018	NG									
Benzo[b+j]fluoranthene	0.00048	NG									
Benzo[a]pyrene	0.000015	0.0066									
Chrysene	0.0014	NG									
Fluoranthene	0.00004	0.86									
Fluorene	0.003	NG									
Naphthalene	0.0011	7									
Phenanthrene	0.0004	NG									
Pyrene	0.000025	NG									
Quinoline	NG	NG									
Phenol	0.004	1,000									
Dissolved Boron	5	NG	0.04	0.02	0.02	0.02	0.03	-	0.02	-	0.02

Notes:

Alberta Tier 1, Commercial Land Use - Coarse Grained Soil

Alberta Tier 2 , Commercial Land Use - Coarse Grained Soil, DUA and FWAL Pathways Eliminated

ND – Non-Detect



Investigation Findings – Contaminant Characteristics (continued)



- COCs are PAHs and phenols in fill
- AB Tier 1 Guidelines based on FWAL (DUA for IACR)
- If FWAL pathway eliminated, only PAH soil exceedance is B(a)P Equivalent
- **Conclusion:**
PAHs and phenols in fill were not a concern to receptors as they were not present in groundwater pathway



Possible Explanations

1. Over the past ~100 years, most of the compounds that would be readily leachable have already been leached out
2. Horizontal groundwater is so large relative to the downward flux of contaminants out of the soil, that compounds would be nearly instantly diluted to below detection
3. Compounds are strongly adsorbed within the coal matrix and are not readily leachable
 - PAHs which have a high adsorption coefficient and a very high K_{oc}
 - Coal has a high carbon content
 - Phenols are likely strongly adsorbed to iron oxides present and inorganic mineral surfaces (Dragun, 2007)





Site-Specific Risk Evaluation

- Cost to excavate and dispose of fill was cost prohibitive to Multiplex Project

Potential Risks:

1. Ecological health risk due to direct contact with impacted soil (for boron exceedances)
 2. Human health risk due to ingestion of potable water (DUA pathway)
 3. Ecological (aquatic life) health risk associated with discharge of impacted groundwater to Policeman's Creek (aquatic life pathway)
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- DUA and aquatic life risks were determined to be low as groundwater did not appear to contain measurable concentrations of COCs
 - Possibility of contaminant remobilization as a result of disturbance during excavation
 - Risk Management/Exposure Control option chosen to mitigate risk and minimize soil disturbance



Risk Management and Exposure Control Plan



Purpose:

1. Ensure that the soil conditions do not pose an unacceptable risk to human and ecological health;
2. Assess if off-Site groundwater and surface water conditions are changing with time; and
3. Ensure groundwater consumers using the downgradient water wells (Pump House 1) are protected



Pump House #1

- Most significant receptor
- Shallow well screened from ~ 14 to 19 m bgs
- Deeper well screened from ~40 to 45 m bgs
- Capture zone extends through south portion of the Multiplex Site
- No interaction between the deep and shallow wells when simultaneously pumped
- Minimal vertical movement within the aquifer
- Pumping had no impact on Policeman's Creek
- Hydrogeological study suggested risk of contamination to shallow well would only occur if source of contamination was present deeper than 7 m bgs





The Plan

3 Components to Construction Management Plan:

1. Soil Management Plan
2. Surface Water Management Plan
3. Groundwater Monitoring Plan



Soil Management Plan

- Where possible, fill not to be disturbed
- Excavated fill kept separated from un-impacted soil
- Fill to be stored in lined and bermed containment cell
- Fill to only be reused under building footprint
 - kept away from building edges
 - Place at least 1 m above seasonally high water table





Surface Water/Groundwater Management Plan

Surface Water

- Runoff minimization
- Excavation halted and stockpile covered during precipitation events

Groundwater

- Two downgradient monitoring wells to be sampled every 2 days for PAHs and phenols (rush analysis)
 - If concentrations exceed baseline - daily sampling until levels decline
 - If concentrations above Tier 1 or increasing – daily sampling, excavation activities to be stopped, daily sampling of Pump House #1
 - If concentrations above Tier 1 in Pump House #1 – wells taken out of commission
- Sampling frequency to be incrementally decreased if concentrations of PAHs or phenol do not increase
- On-going sampling until subgrade work is completed

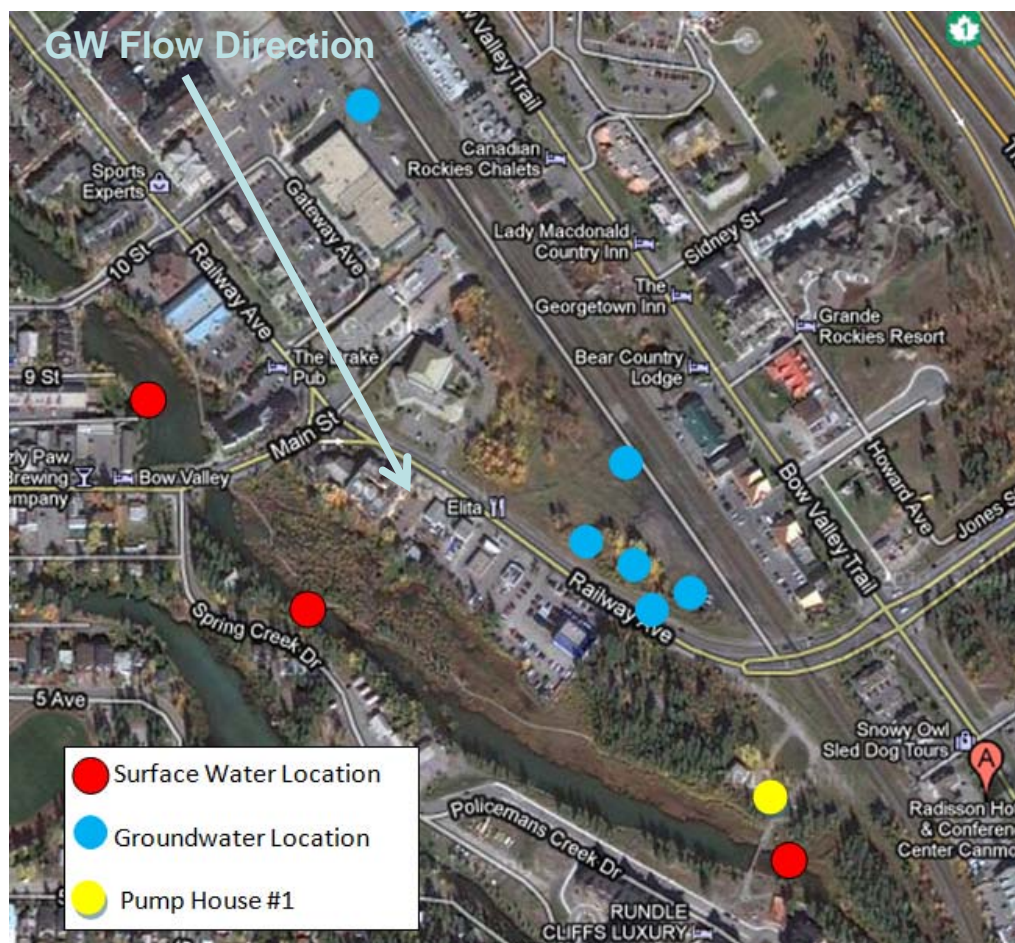


Plan Implementation

- Plan accepted by Alberta Environment on December 22, 2010
 - AENV required that exceedances of direct contact pathway be removed
 - Pump House #1 Shallow Well shut in as a precautionary measure
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- Groundwater monitoring initiated on April 13, 2011
 - PAH concentrations above Tier 1 noted in two downgradient wells on April 25th
 - Sampling frequency increased and Pump House #1 sampled
 - Detections in Pump House #1 - Construction Halted



PAHs in Pump House #1

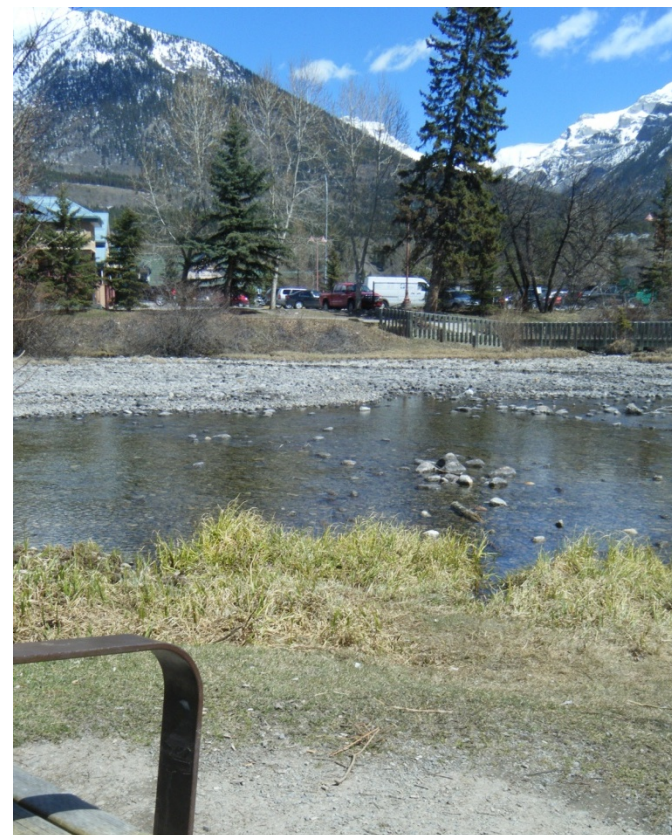


- PAHs including chrysene, phenanthrene and benzo(a)anthracene detected above Tier 1 in Pump House #1 shallow well
- No detections in deep well
- Pump House #1 not analyzed for PAHs before
- Comprehensive sampling program initiated including surface water sampling and upgradient groundwater sampling



Results of Sampling Program

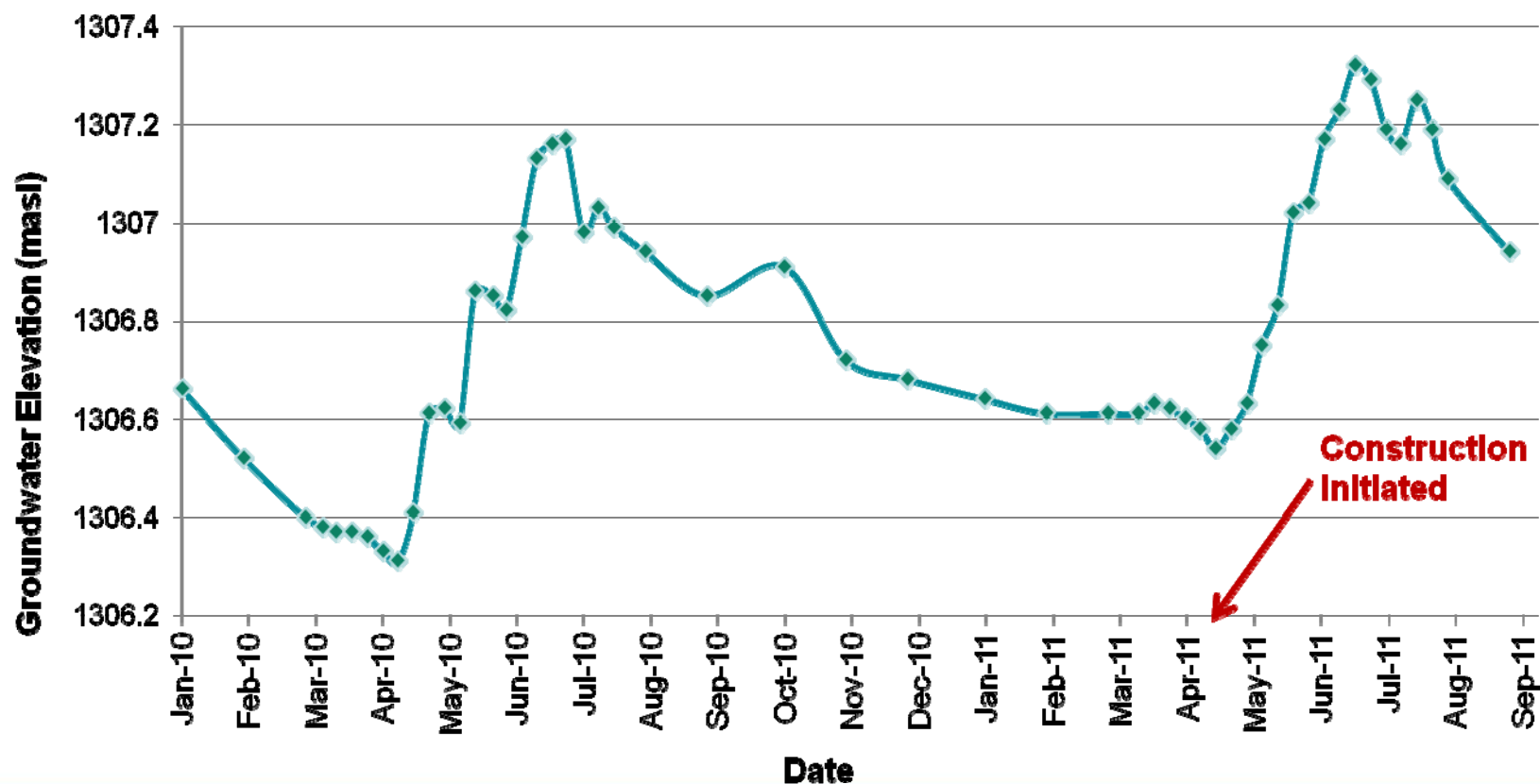
- Highest concentrations of PAHs in groundwater measured up-gradient at adjacent construction site
- PAH detections in surface water at all three sampling points
- Varying detections in most on-Site monitoring wells including up-gradient well
 - All non-detect since mid-May
 - Pump House #1 shallow well - last PAHs detected in early July





Results of Sampling Program (continued)

- PAHs detections not directly related to Multiplex construction
- May be related to seasonal rainfall events, high water table or spring freshet
- Majority of PAHs are adsorbed and not mobile as dissolved component





Buried Surprises



November 1, 2011

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More Buried Surprises





Lessons Learned

From Golder standard Phase II Limitations:

“...it is never possible, even with exhaustive sampling and testing, to dismiss the possibility that part of a site may be contaminated and remain undetected.”



Thank You!



Photo Provide Courtesy of Gibbs Gage Architects



Acknowledgements

- The Town of Canmore
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- Maxxam Analytics
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