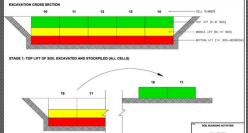


Remediation of 1,1,2 TCA via Soil Blending and Direct Injection at a Rail Car Cleaning Facility

Presented by Timothy Adams, PG Principal Hydrogeologist











El Dorado, KS



Remediation of 1,1,2 TCA via Soil Blending and Direct Injection at a Rail Car Cleaning Facility

Background

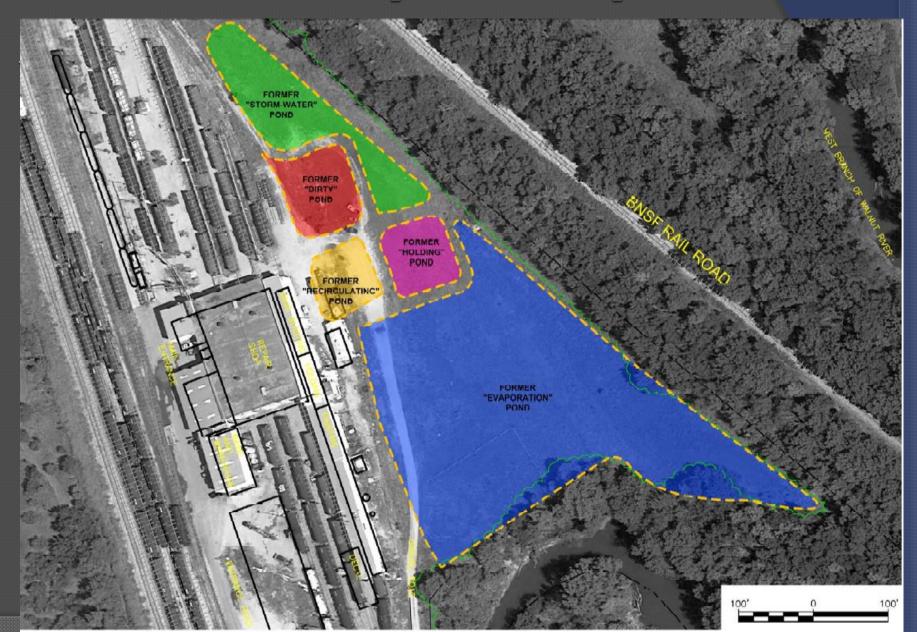
• Rail Car Cleaning Facility

- 38.6 Acres track, repair shops, offices, ponds
- Located in El Dorado, KS (30 mi. NE of Wichita)
- Site Operated from 1963 to 2005
- Company leases, manufactures and maintains rail cars - Inspection, cleaning, and servicing of pressurized and general purpose tank cars

Background

- Discharged water from tank car cleaning operations to a recirculating pond system
- Four ponds 7' deep and 1,000,000-gallon capacity
- Water was first discharged to "dirty pond" which was equipped with an oil recovery unit
- Dirty Pond + Holding Pond + Recirculating Pond
- Water was reused for cleaning and pressure testing
- The ponds were filled in and closed in 1987 and replaced with a pretreatment system with discharge to POTW

Former Pond System Layout



Regulatory Framework

● 1987 Pond Closure

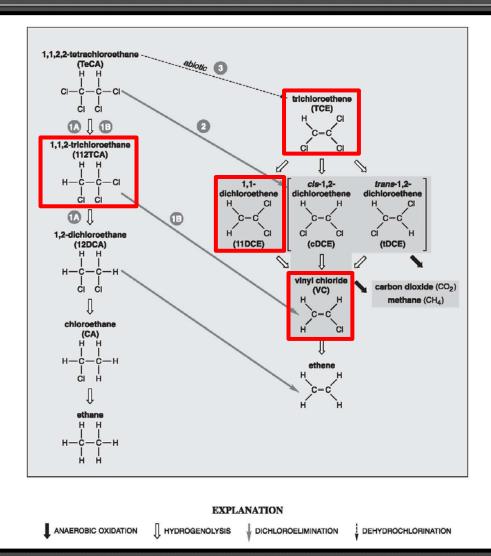
- March 1989 Geotechnical Investigation identified petroleum odors in 4 of 7 soil borings.
- January 1990 Groundwater Investigation (W-1 through W-4) identified BTEX and CVOCs
- June 2005 KDHE issued Site Reconnaissance and Evaluation Report requiring additional SI.
- August 2005 Site enrolled in the Voluntary Cleanup and Property Redevelopment Program (VCPRP) with the Kansas Department of Health and Environment (KDHE)

Site Investigation

 Investigation activities conducted from 1986 to the present have identified the following contaminants of concern (COC)

- 1,1-Dichloroethene (1,1-DCE) [parent]
- 1,1,2-Trichloroethane (1,1,2-TCA) [parent]
- 1,1-Dichloroethane (1,1-DCA)
- Trichloroethene (TCE)
- Vinyl Chloride (VC)
- Tot. Extractable Hydrocarbons (TEH) as Diesel No. 2
 BTEX

1,1,2-Trichoroethane



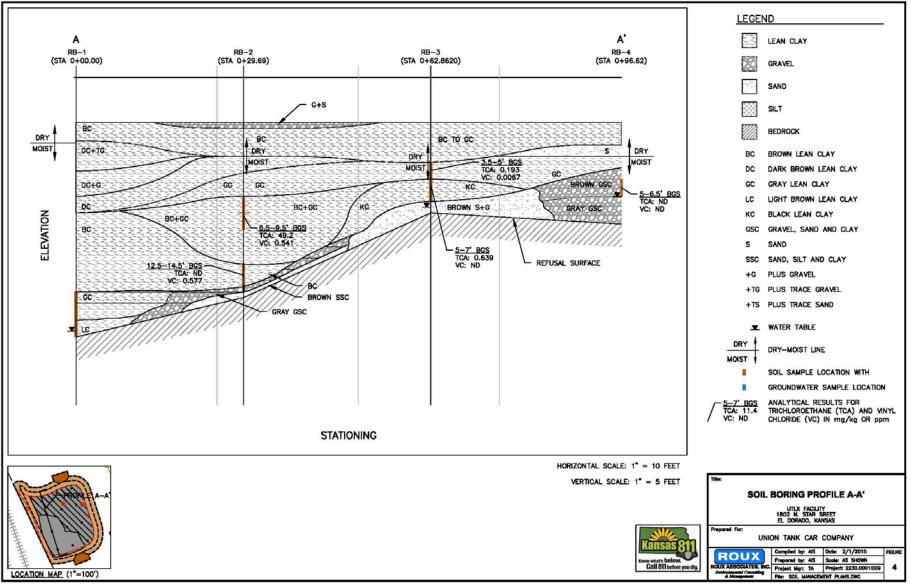


Site Geology

- Surficial soils consist of silt loam which is underlain by a highly plastic clay (8 to 21 feet thick) and underlying limestone bedrock
- Groundwater (8-10' bgs) occurs in the clay overburden and weathered bedrock zone which are in hydraulic communication
 Depth to the top of bedrock ranges (Fort Riley Limestone-Permian Age) from 8 ft bgs to 21' bgs in the dirty pond area.
 Site is located in 100-yr floodplain of the West Branch of the Walnut River

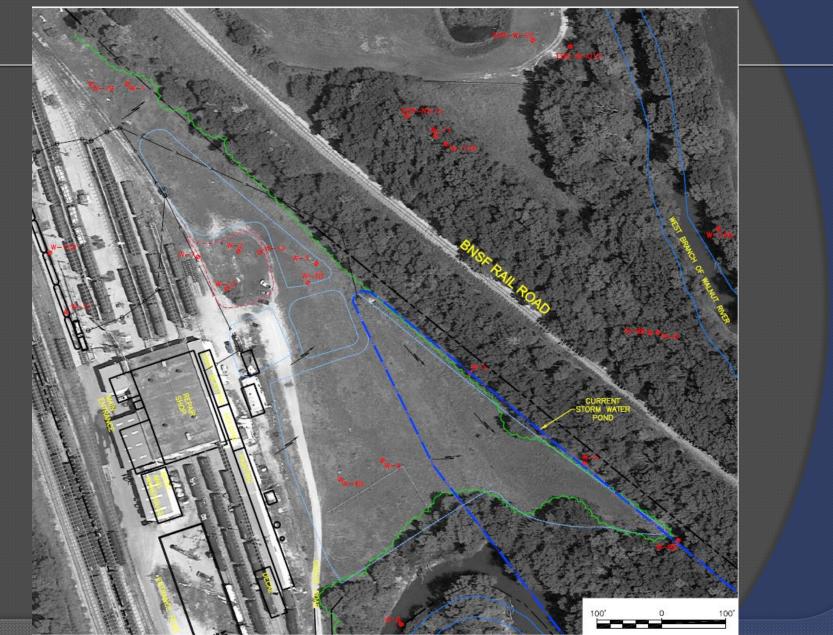
Blend Area-Cross Section

ROUX

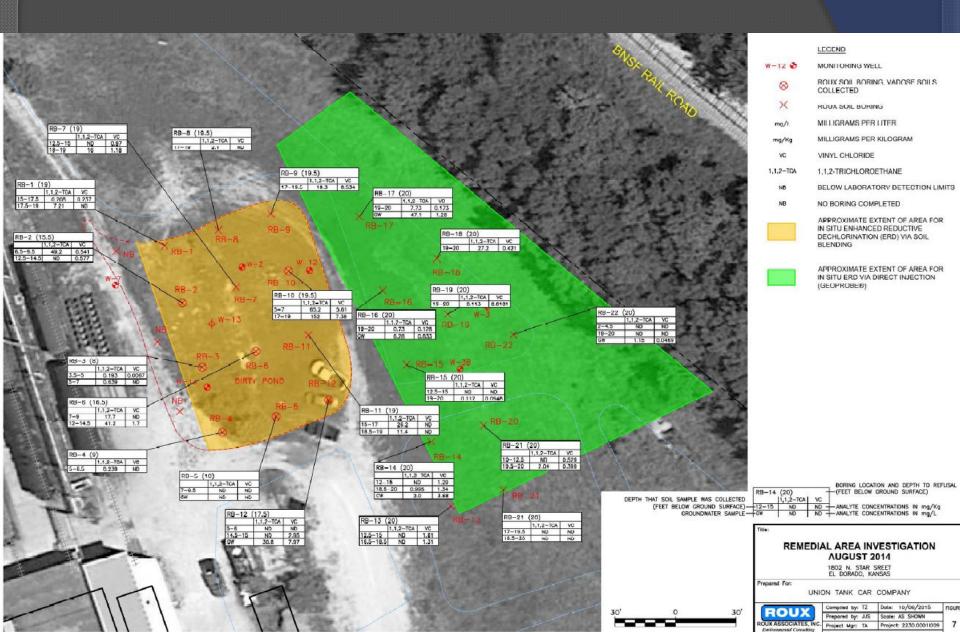


. (utility) el dorado, ks/roux or montoring/gps/soil mavagement plans.

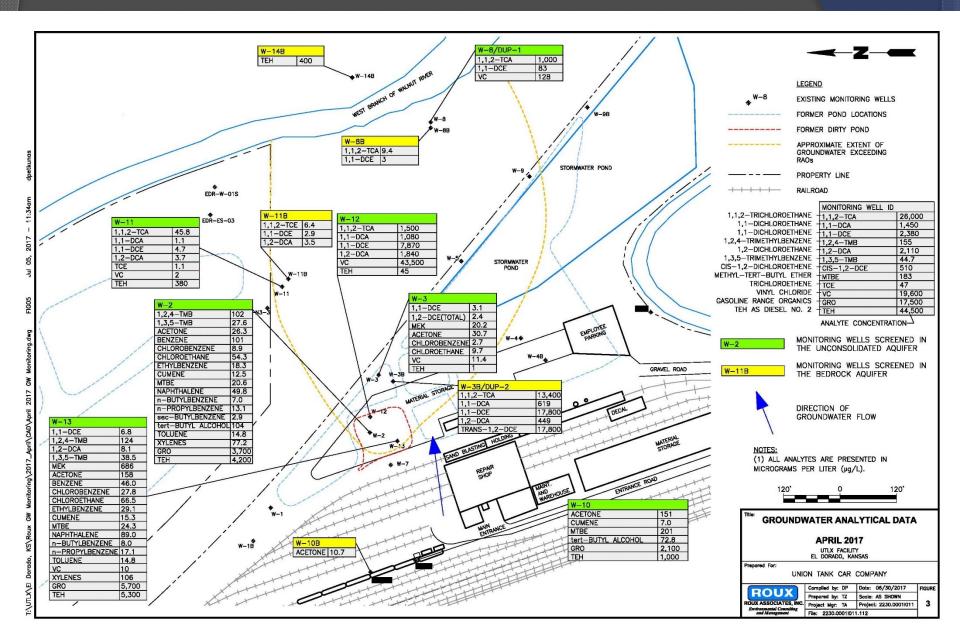
Site Plan



Source Area – Baseline Soil SI **ROUX**



Groundwater Data-May 2017 **ROUX**

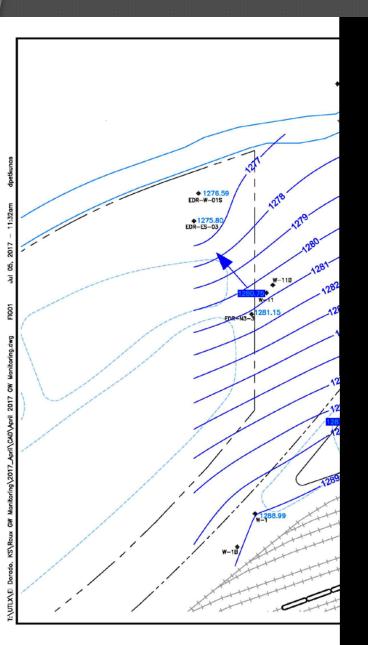


Key Aquifer Parameters

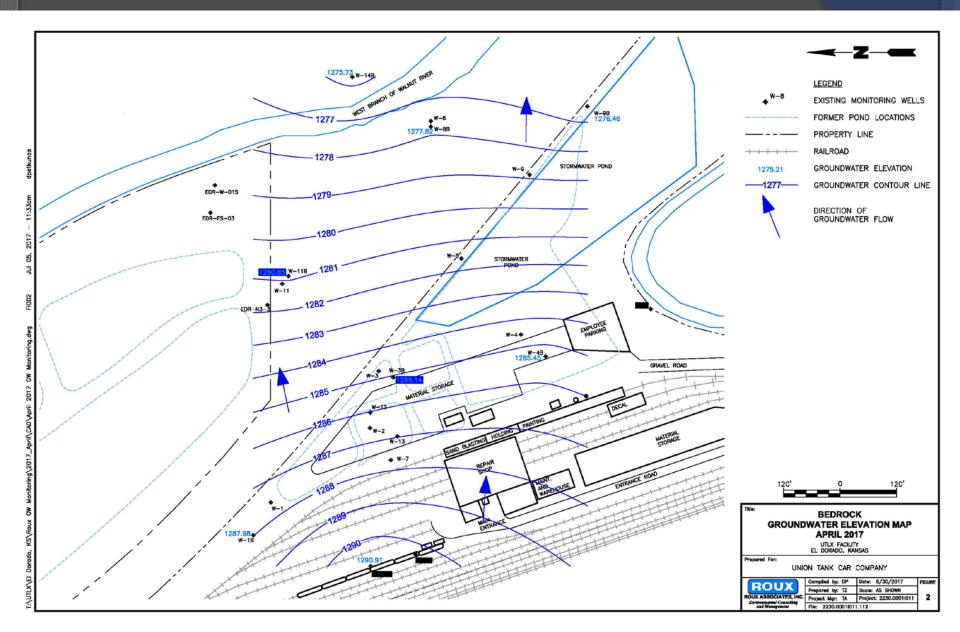
Key aquifer parameters are listed below:

In much De menne et en	TT '/	Aqui	fer	Defense Commo			
Input Parameter	Units	Unconsolidated	Bedrock	Reference Source			
Hydraulic Conductivity (K)	cm/sec	2.90E-04	2.50E-06	Foth, Bedrock Well Investigation Report, November. 27, 2012			
Gradient (i)	ft/ft	0.012	0.012	Roux, Groundwater Monitoring & Pilot Test Update Report, June 2012			
Porosity (n)	unitless	0.2	0.05	Foth, Bedrock Well Investigation Report, November. 27, 2012			
Velocity (V)	ft/year	20.4	0.8	Foth, Bedrock Well Investigation Report, November. 27, 2012			

Groundwater Elevations



Groundwater Elevations



Remedial Action Objectives¹

COC	Groundwater Tier 2 Cleanup Level (µg/L)	COC	Soil Tier 2 Cleanup Level (µg/kg)			
1,1,2-TCA	5	1,1,2-TCA	81			
1,1-DCA	25	1,1-DCA	496			
1,1-DCE	7	1,1-DCE	85.9			
1,2-DCA	5	1,2-DCA	60			
TCE	5	TCE	84.2			
VC	2	VC	20.5			

¹Kansas Administrative Regulations (K.A.R.) 28-71-11(l) and K.A.R. 28-71-11(b) including long-term care and maintenance of the property as defined in Environmental Use Control (EUC) Agreement.

ISCR Pilot – July 2013

 Aquifer Geochemistry and presence of 1,1-DCA; cis-1,2-DCE; and VC

Pilot Test

- Assess ERD amendment injections to promote the reduction of chlorinated solvents in groundwater at the site
- ERD with Anaerobic BioChem® (ABC) plus zero-valent iron (ZVI) (i.e.ABC+) successfully reduced parent COC and its breakdown products

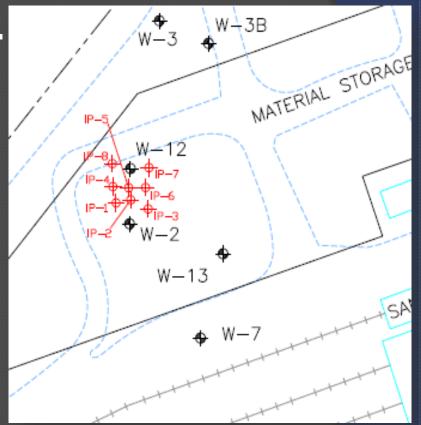




ISCR Pilot – July 2013

 \odot 2,000 lbs of ABC+ (i.e. 720 gal of ABC+ solution) ● 15% by weight ratio
 ■ • ZVI was added at a 50% by weight ratio (with respect to the ABC)

 ● (8) IPs - 13 lbs of both ABC and ZVI (i.e. ~26 lbs of ABC+).



ISCR Pilot Results – 2013

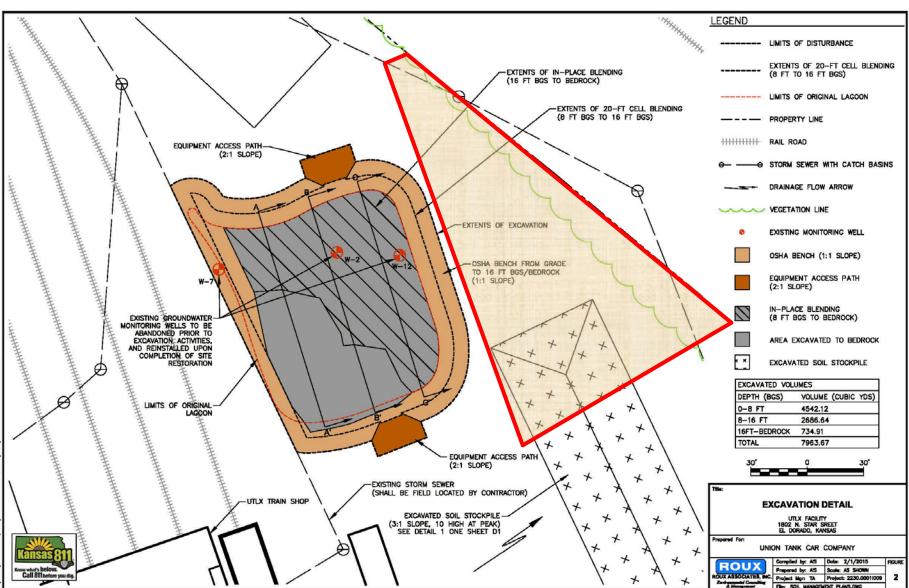
	KDHE Tier 2 RBSL	Well Location / Well ID / Sample Date											
Analyte		Source Area											
	KUTE HEI Z KUSE	W-12	W-12	Percent	W-3B	W-3B	Percent	W-2	W-2	Percent			
		6/1/2013 ⁽¹⁾	12/12/2013	Change	2/5/2013	12/12/2013	Change	6/1/2013 ⁽¹⁾	12/12/2013	Change			
Volatile Organic Compounds (V	VOCs)												
1,1,2-Trichloroethane	5	1380000	795000	-42.39%	669	9460	1314.05%	16500	< 200	-100.00%			
1,1-Dichloroethane	25	< 10000	< 10000	0.00%	85.1	539	533.37%	421	418	-0.71%			
1,1-Dichloroethene	7	53500	18500	-65.42%	2650	16700	530.19%	1660	1030	-37.95%			
1,2-Dichloroethane	5	< 10000	< 10000	0.00%	< 1.0	15	1500.00%	102	< 200	?			
cis-1,2-Dichloroethene	70	< 10000	< 10000	0.00%	10.8	108	900.00%	133	< 200	?			
trans-1,2-Dichloroethene	100	< 10000	< 10000	0.00%	47.4	269	467.51%	< 100	< 200	?			
Trichloroethene	5	16800	< 10000	0.00%	20	87.8	339.00%	137	< 200	?			
Vinyl Chloride	2	15100	16400	8.61%	80.6	1230	1426.05%	7980	13600	70.43%			
Geochemical Analyses								_					
Ethene		18.1	207	1043.65%	< 6.2	< 6.2	0.00%						
Ethane		6.4	66.2	934.38%	< 6.2	< 6.2	0.00%						
Methane		4,000	571	-85.73%	< 6.2	38.8	3800.00%						
Total Alkalinity* (mg/L)		555	506	-8.83%	301	306	1.66%						
Chloride (mg/L)		317	318	0.32%	119	159	33.61%						
Sulfate (mg/L)		161	451	180.12%	193	199	3.11%						
Nitrogen, Nitrate		0.36	NS	NA	< 0.010	NS	NA						
Field Parameters													
Temperature (°C)		15.4	15.14	-1.69%	14.79	13.68	-7.51%						
pH (S.U.)		6.4	5.81	-9.22%	7.48	7.44	-0.53%						
ORP (mV)		163	-519	-418.40%	153	108	-29.41%						
Conductivity (mS/cm)		2.13	2.77	30.05%	1.24	1.39	12.10%						
DO (mg/L)		0.05	0.37	640.00%	3.04	0.51	-83.22%						

Remedial Implementation Plan

In-Situ ERD via Soil Blending and Direct Injection



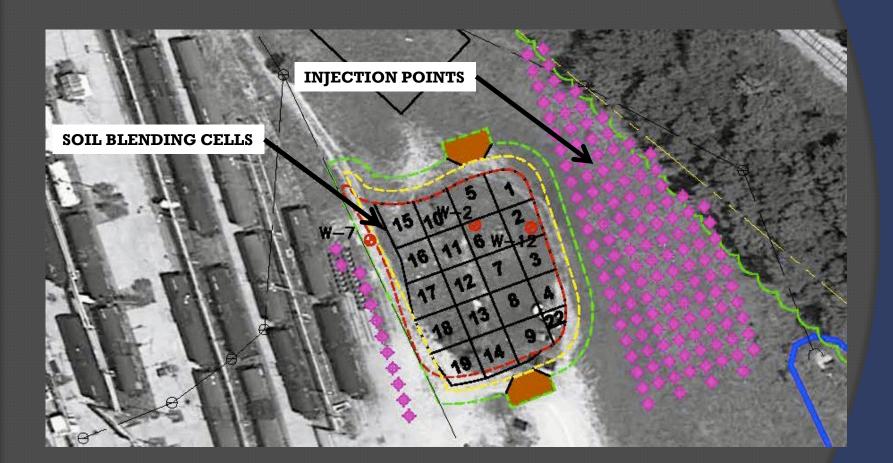
Engineering Design



ROUX

T:\UTLX\EL DORADO, KS\ROUX GW MONITORING\GPS\SOIL MANA

April-May 2015 Field Implementation





April-May 2015 Field Implementation

In-Situ Soil Blending

- 20'x20' treatment cells
- Each cell 6-foot lifts working from the top of bedrock upwards.
- Pilot Test Loading Rates
 - 3,246 gal ABC
 - 104,105 lbs ZVI
 - 66,169 gal water

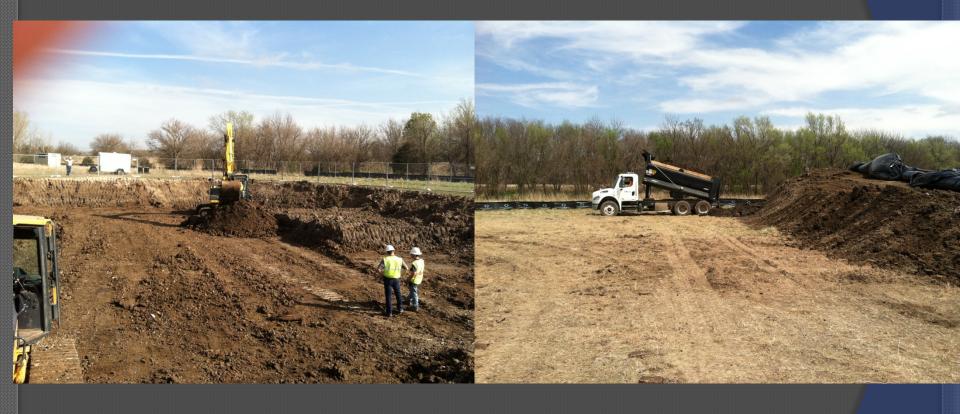


Blend Area Work Platform

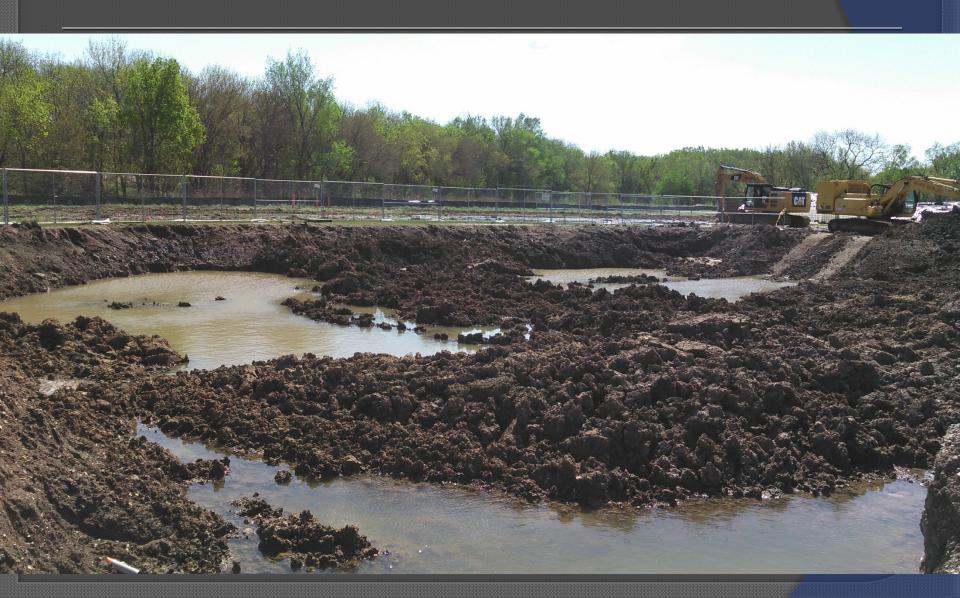
Vadose Zone Excavation and Stockpiling – 4,500 cy (600 cy T&D)



Work Platform Construction



Work Platform After Rain!



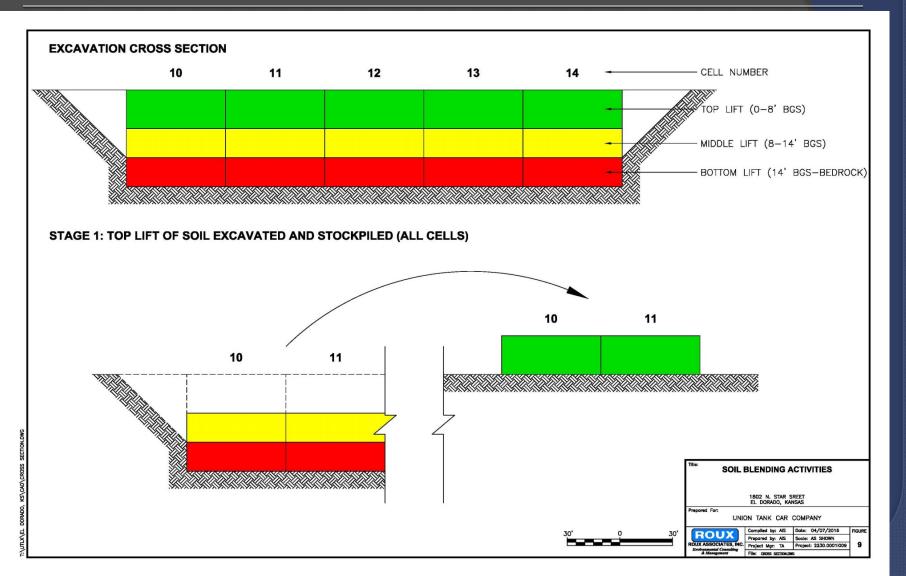
Soil Blending Implementation ROUX



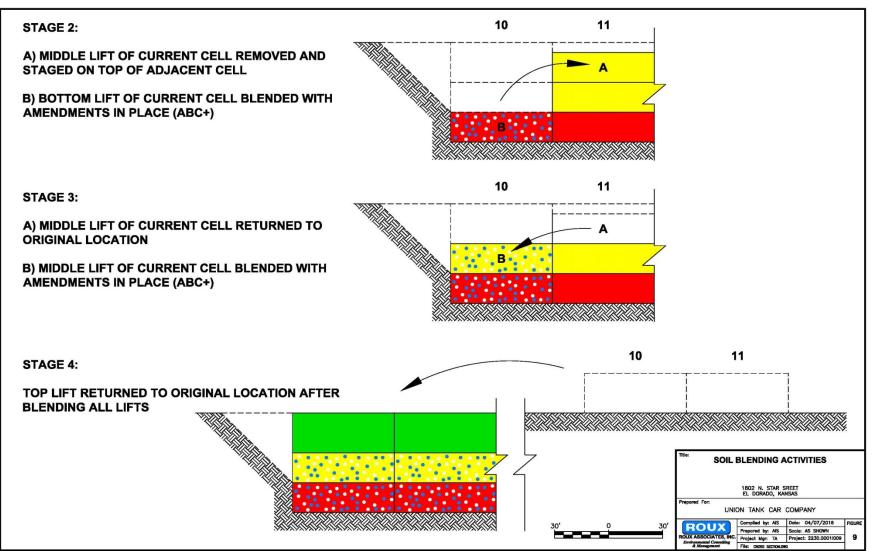
Video - Field Implementation ROUX Video I - ABC+/ZVI Placement

Video - Field Implementation ROUX Video 2 - Blending

April-May 2015 Soil Blend Implementation



April-May2015 Soil Blend Implementation



2015 Field Implementation

After soil blending, excavation was backfilled using stockpiled soils





Direct Injection

Roux advanced 146 direct injection locations

- 12 upgradient of the dirty pond area unable to be blended
- 134 downgradient of the dirty pond
- - 78.5 gal ABC+ per IP; 10,767 gal total ABC+
 - Targeted a 12 ft thick zone from 8 ft bgs to depth of bedrock.
 - Spaced approximately 10 ft apart;
 - 1 ft. vertical intervals via ChemGrout pump across the target depths to ensure proper vertical distribution of amendment.



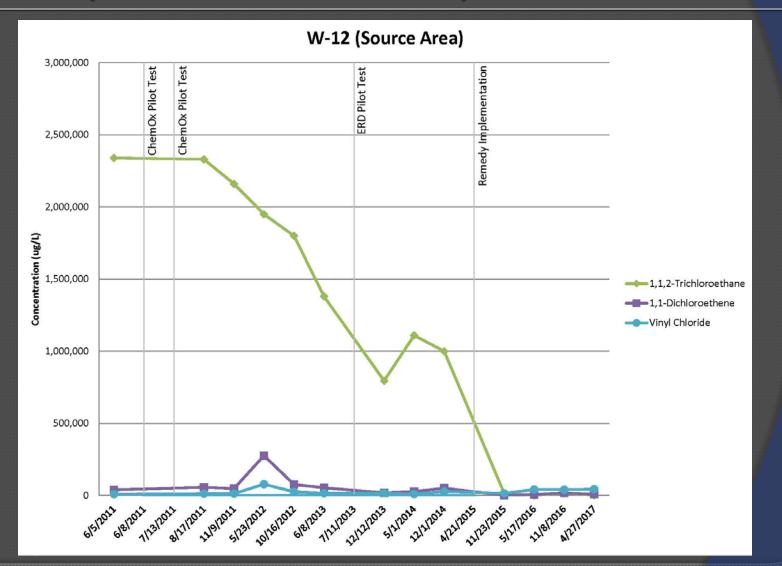
Post Remedy Monitoring Results

Post Remedy Performance Monitoring – Conclusions

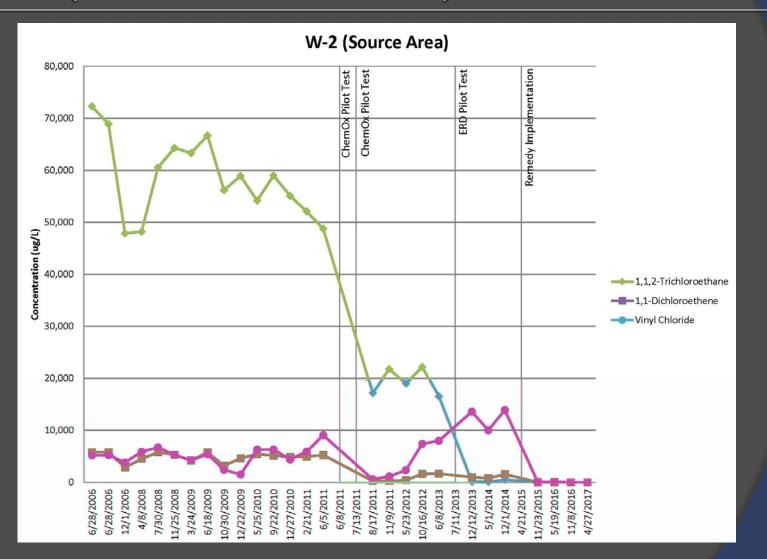
ROU

Concentrations of 1,1,2-TCA in source area wells W-2 and W-12 have decreased >99%, since February 2013. • Vinyl chloride at W-13 has increased nearly 3,000%, but is expected to decrease rapidly as VC is reductively dechlorinated to ethene. Modeled mass flux discharge to the West Branch of the Walnut River is below surface water quality standards

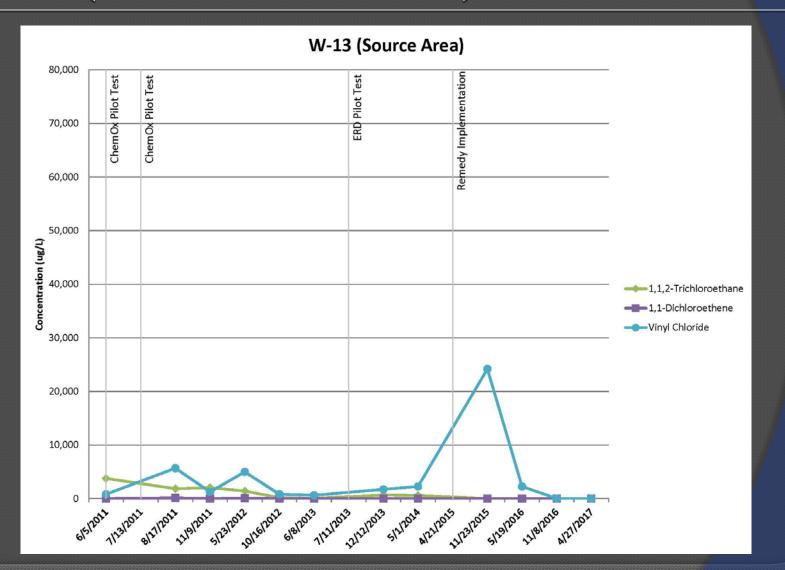
Post Remedy Performance Monitoring **ROUX** W-12 (Source-Blend Area)



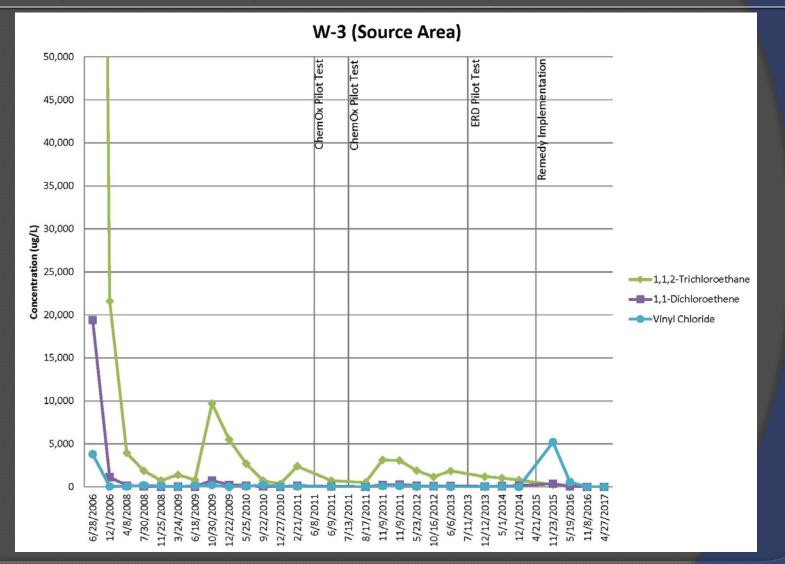
Post Remedy Performance Monitoring – W-2 (Source-Blend Area)



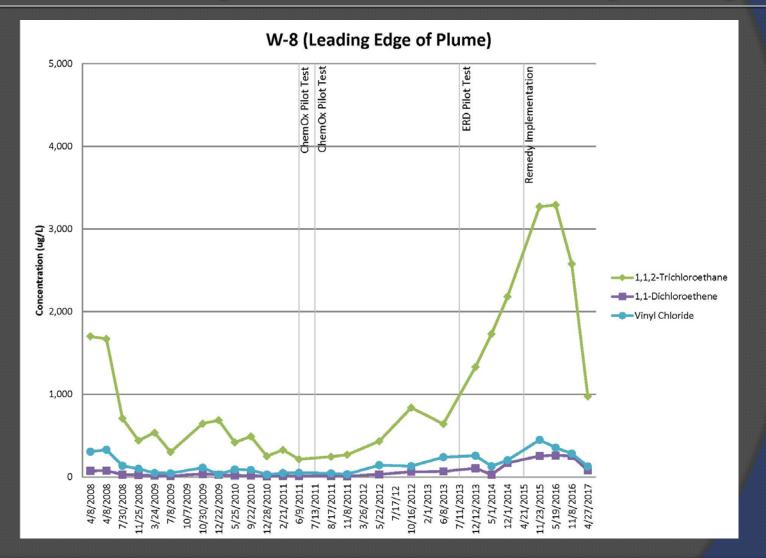
Post Remedy Performance Monitoring – W-13 (Source-Blend Area)



Post Remedy Performance Monitoring **ROUX** W-3 (Source-Injection Area)



Post Remedy Performance **ROUX** Monitoring – W-8 (Leading Edge)



Post Remedy Performance Monitoring – May 2017

	KDHE Tier 2	Well Location / We Source									
Analyte	RBSL		W-12								Percent
		2/5/2013	6/6/2013	12/12/2013	5/1/2014	12/1/2014	11/23/2015	5/19/2016	11/8/2016	4/27/2017	Change*
Volatile Organic Compounds (VOCs)											
1,1,2-Trichloroethane	5	NS	1,380,000	795,000	1,110,000	1,000,000	14,400	1,320	15,600	1,500	-100%
1,1-Dichloroethane	25	NS	< 10000	< 10000	<20,000	<20,000	1,210	1,380	2,790	1,080	NA
1,1-Dichloroethene	7	NS	53,500	18,500	27,500	50,800	1,420	6,300	17,000	7,870	-85%
1,2-Dichloroethane	5	NS	< 10000	< 10000	<20,000	<20,000	1,790	1,990	2,300	1,840	NA
cis-1,2-Dichloroethene	70	NS	< 10000	< 10000	<20,000	<20,000	<500	313	801	<1000.0	NA
trans-1,2-Dichloroethene	100	NS	< 10000	< 10000	<20,000	<20,000	<500	332	968	<1000.0	NA
Trichloroethene	5	NS	16,800	< 10000	<20,000	<20,000	<500	653	1,290	<1000.0	NA
Vinyl Chloride	2	NS	15,100	16,400	<20,000	27,600	14,800	41,400	40,200	43,500	188%
Geochemical Analyses	· ·			· · · · ·			· · · · · · ·				
Ethene		18.1	NS	207	98.4	NS	2,310	1,380	1,500	2,500	13712%
Ethane		6.4	NS	66.2	194	NS	1,020	755	818	1,000	15525%
Methane		4,000	NS	571	1,210	NS	243	716	1,070	1,440	-64%
Total Alkalinity* (mg/L)		555	NS	506	670	NS	1890	1660	1,880	1,560	181%
Chloride (mg/L)		317	NS	318	305	NS	590	820	717	888	180%
Sulfate (mg/L)		161	NS	451	305	NS	2.5	<1	<1	<1	NA
Nitrogen, Nitrate		0.36	NS	NS	<0.1	NS	0.89	0.91	<0.5	3.5	NA
Field Parameters											
Temperature (°C)		15.4	NS	15.14	16.34	NS	19.55	15.47	18.25	15.1	2%
pH (S.U.)		6.4	NS	5.81	6.13	NS	6.57	6.39	6.28	6.34	1%
ORP (mV)		163	NS	-519	-383	NS	-73	-68	-91	-449	375%
Conductivity (mS/cm)		2.13	NS	2.77	2.42	NS	5.39	5.34	6.04	5.71	-168%
DO (mg/L)		0.05	NS	0.37	0.00	NS	0.00	0.00	0.00	0.00	100.00%

ROUX

Notes:

Units in ug/L unless otherwise noted

NA: Not Available

NS: Not Sampled

*Percent change from June 2013 to April 2017 for VOCs

Post Remedy Performance Monitoring – May 2017

		I ID / Sample Date									
Analyte	KDHE Tier 2 RBSL	Area									
Analyte		W-3									Percent
		2/5/2013	6/6/2013	12/12/2013	5/1/2014	12/1/2014	11/23/2015	5/19/2016	11/8/2016	4/27/2017	Change*
Volatile Organic Compounds (VOCs)										
1,1,2-Trichloroethane	5	NS	1,860	1,180	1,040	811	257	<10	<2	<2	-99.9%
1,1-Dichloroethane	25	NS	<20.0	<20.0	<20.0	9.6	89.8	32.8	3.7	<2	NA
1,1-Dichloroethene	7	NS	118	76.2	82.5	150	381	56.3	<2	3.1	-99.2%
1,2-Dichloroethane	5	NS	<20.0	<20.0	<20.0	3.1	78.2	12.9	8.3	<2	NA
cis-1,2-Dichloroethene	70	NS	<20.0	<20.0	<20.0	1.9	31.6	<10	<2	<2	NA
trans-1,2-Dichloroethene	100	NS	<20.0	<20.0	<20.0	3.1	<20	<10	<2	<2	NA
Trichloroethene	5	NS	<20.0	<20.0	<20.0	10.5	42.6	<10	<2	<2	NA
Vinyl Chloride	2	NS	27.2	37.7	33.6	55.6	5200	569	6.7	<2	-75%
Geochemical Analyses		_		· ·						· · · · · ·	
Ethene		NS	NS	NS	NS	NS	NS	263	117	128	NA
Ethane		NS	NS	NS	NS	NS	NS	127	27.1	17	NA
Methane		NS	NS	NS	NS	NS	NS	6,380	9,630	12,800	NA
Total Alkalinity* (mg/L)		NS	NS	NS	NS	NS	NS	1,190	1,200	1,030	NA
Chloride (mg/L)		NS	NS	NS	NS	NS	NS	26.7	15.6	12	NA
Sulfate (mg/L)		NS	NS	NS	NS	NS	NS	<1	<1	<1	NA
Nitrogen, Nitrate		NS	NS	NS	NS	NS	NS	1.3	1.5	1.9	NA
Field Parameters		-		AL 53						A	
Temperature (°C)		NS	NS	NS	NS	NS	NS	13.81	17.03	14.76	NA
pH (S.U.)		NS	NS	NS	NS	NS	NS	6.34	6.52	6.67	NA
ORP (mV)		NS	NS	NS	NS	NS	NS	-73	-149	-159	NA
Conductivity (mS/cm)		NS	NS	NS	NS	NS	NS	2.55	2.37	1.97	NA
DO (mg/L)		NS	NS	NS	NS	NS	NS	0.00	0.00	0.62	NA

Next Steps

 Continue Performance GW Monitoring-Monitored Natural Attenuation

- Began 4th Quarter Nov-2015 Monitoring
- Semi-annual for 4 years Next Nov 2017
- Demonstrate plume stability and EUC

Record Environmental Use Controls
 Groundwater use restriction

Annual Reporting to KDHE

Conclusions and Lessons Learned

• Experience is the key

- ISCR delivery via Blending and direct injection delivery were successful
- Initial Post monitoring indicates >99% reduction 1,1,2-TCA in blend area
- Ethane/Ethene produced >1 to 2.3 mg/L
- Heavy spring rains coupled with the open excavation - Dewatered >42k gal from platform with permitted discharge to POTW

• Work Area in al00-yr floodplain

 Developed a contingency plan to relocate stockpiled soils for floodplain conditions



Thank You & Questions



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