Triad Best Management Practices Part 2 – Dynamic Work Strategies Case Studies

ConSoil 2008 – Milan

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Technical Session Objectives

- Provide case study examples of dynamic work strategies (DWS) used under a Triad approach
- Expose participants to the benefits of DWS
  - » Highlight how adaptive DWS are used to compress field efforts, make decisions, and target uncertainties in real-time
  - » Limit mobilizations, work plans, reports
- Demonstrate how sequencing of activities and integrated use of mid-level/senior staff and vendors/contractors can optimize performance

Dynamic Work Strategies

- Pre-defined field-based decisions, adaptive sampling
  - » Provide decision framework, logic diagrams, rules
  - » Real-time, near real-time, recent time data
- Requires regular and reliable communication
  - » Data management, CSM presentation and updates
  - » Stakeholder participation, QA/QC defined
- Eliminate multiple work plans, mobilizations, reports, continued data gaps
  - » In and out of field is OK if you lessen interim document requirements

Experience Has Demonstrated that Cleanup Work is Filled with Uncertainty

- Hog-and-haul for contaminated sediments and soils
  - » Removed volumes always greater (e.g., 2-3 times) than those estimated during the design phase
- Complicates:
  - » Program planning
  - » Cost estimation
  - » Remedial design and implementation

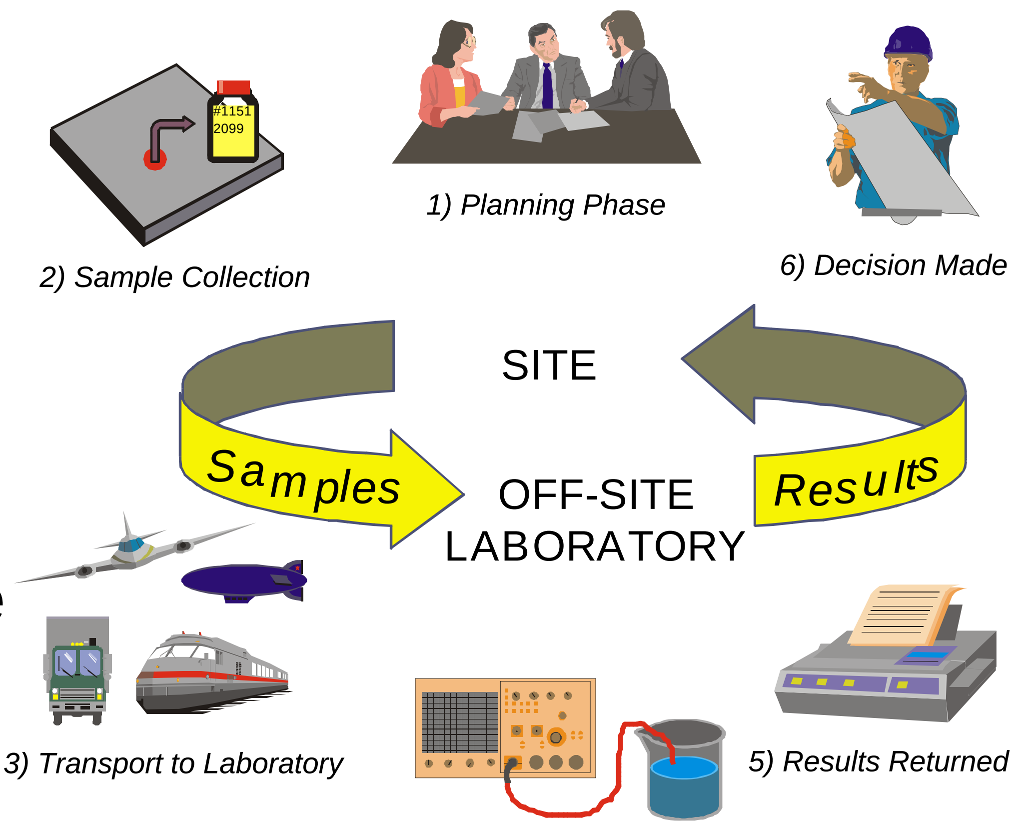
Standard Sampling and Analysis Programs are Expensive & Problematic

Characteristics:

- ◆ Preplanned Sampling
- ◆ Off-Site Lab Analyses

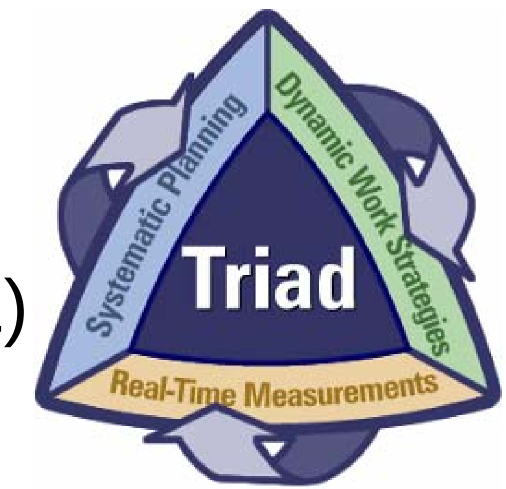
Problems:

- ◆ High cost per sample
- ◆ Surprise results
- ◆ Pressure to over-sample
- ◆ Multiple trips to the field



The Alternatives Go by Many Names…

- Observational Approach (geotechnical engineering)
- Adaptive Sampling and Analysis Programs (ANL)
- Expedited Site Characterization (ANL)
- Sequential sampling programs
- Directed sampling programs
- EPA Technology Innovation Program's Triad Approach



...But All Share Common Themes

- **Systematic Planning** (pulling together all information for a site to influence sampling program design, including specification of exactly what decision needs to be made)
- **Dynamic Work Strategies** (emphasis not on dictating sample numbers and locations, but on how these decisions will be supported in the field)
- **"Real-Time" Measurements** (providing data quickly enough to influence the outcome of the program)

Adaptive Sampling and Analysis Programs Can Cut Costs Significantly

Characteristics:

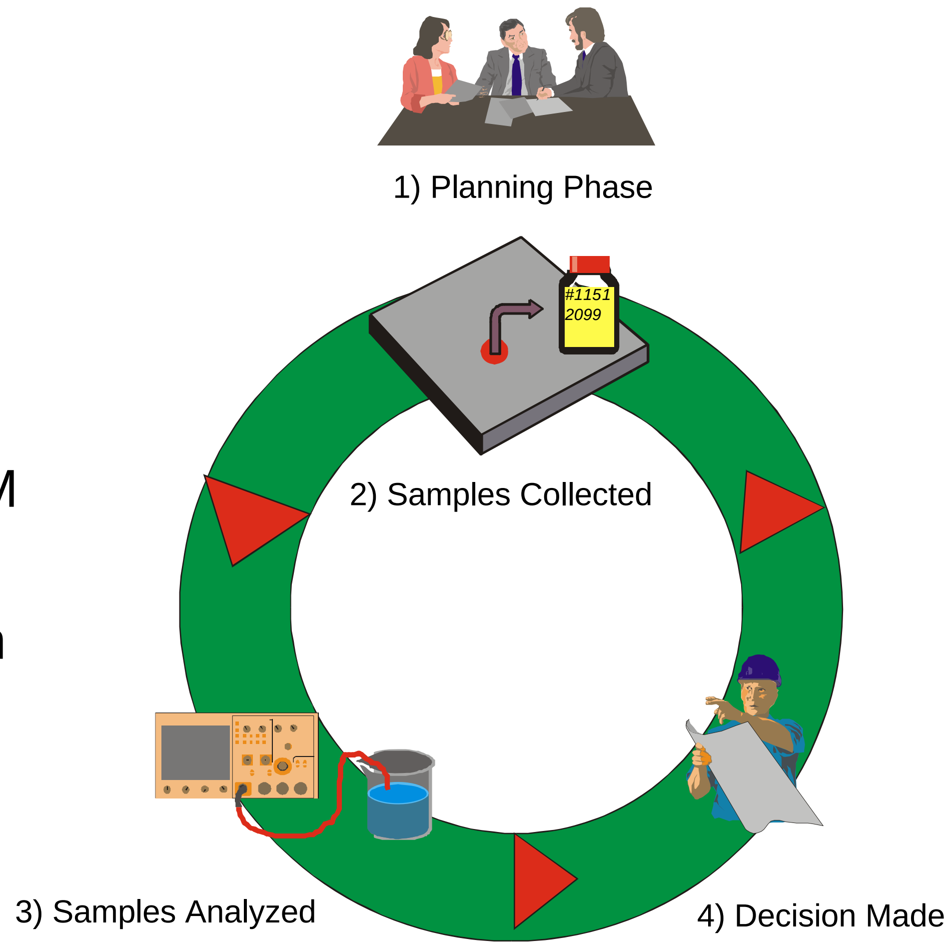
- Real-time sample analysis
- Rapid field decision-making

Advantages:

- Reduce cost per sample
- High density of information
- Targeted sampling- better CSM
- Reduce # of programs
- Achieve better characterization

Requirements:

- Real-time method
- Decision support in the field



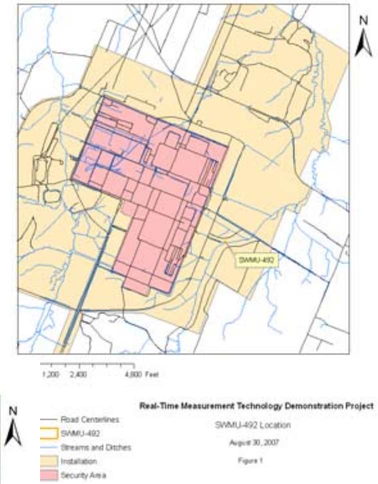
Dynamic Work Strategies

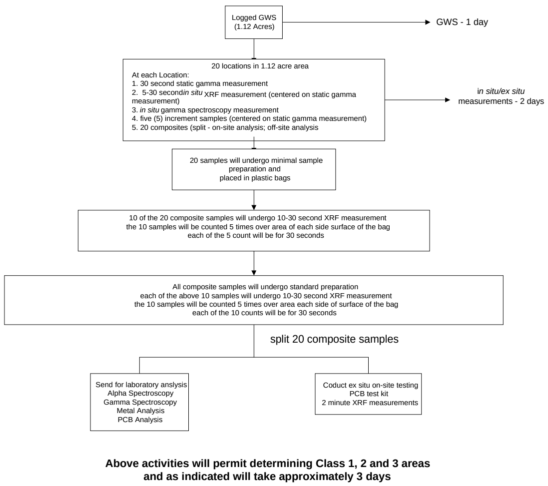
Real-Time Measurement Technology

Demonstration Project
Department of Energy Site

Dynamic Work Strategy Project

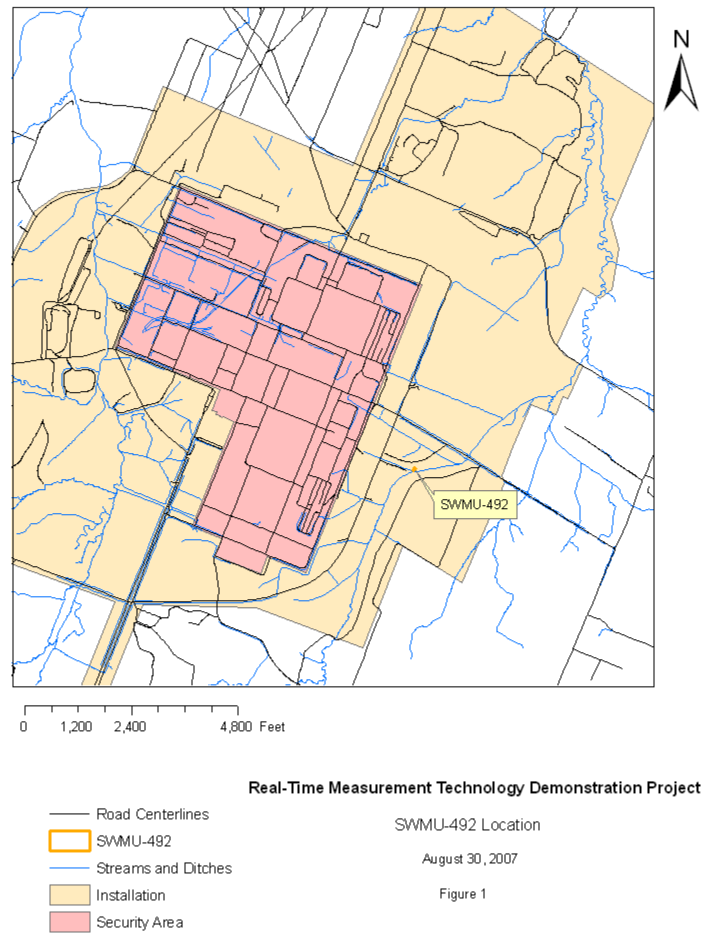
- ◆ Background
- ◆ Conceptual Site Model
- ◆ Decision & DWS Rules and Measurements
- ◆ Conclusions





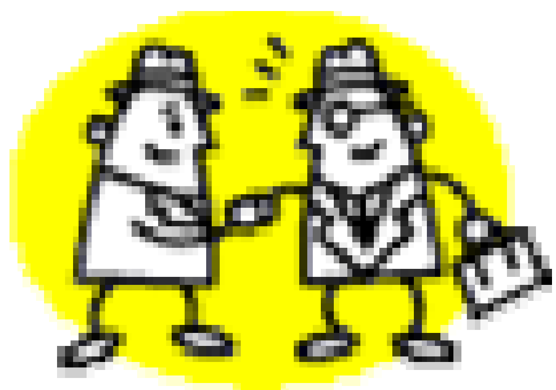
Site Background

- Site involved with uranium enrichment
- Primary target is Uranium and PCBs in soils (in historical samples)
- Four different real-time technologies:
  - » XRF for metals (including uranium)
  - » Test kits for PCBs
  - » GPS-logged gamma walkover surveys, and
  - » In situ gamma spectroscopy
- Multiple phases
  - » Characterization/Classification
  - » Remediation/Excavation
  - » Verifying compliance of site & waste



Background – Participants

- ◆U.S. Department of Energy
- ◆U.S. Environmental Protection Agency



Background – Project

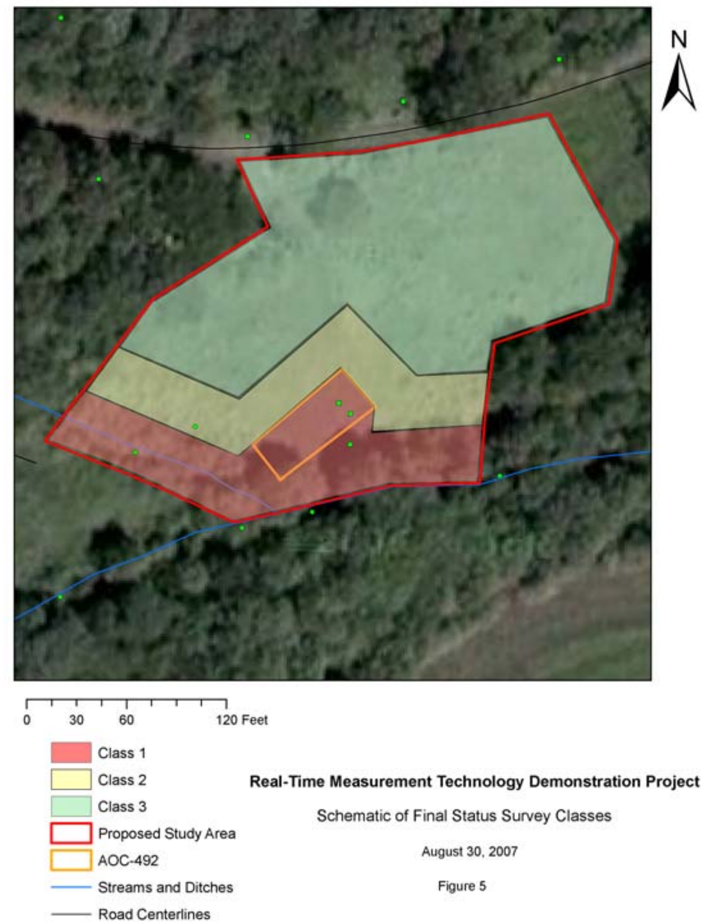
- Plan: Do within 10 day timeframe
- With:
  - » Gamma Walkover Survey (NaI Fiddler; 2 sec)
  - » High Purity Germanium detector
  - » X-Ray Fluorescent Detector (in-situ, bagged, cups)
  - » Assay kits (PCBs)
  - » Robotic position determination (LARADS total station)
- Demonstrate integrated DWS and Evaluate






Closure Strategy Modeled After MARSSIM Guidance

- Class 1, 2, and 3 area concepts used
  - » Class 1 - 1,000 m^2
  - » Class 2 - 800 m^2
  - » Class 3 - 2,700 m^2
- Data collection graded by area classification
- Demonstrating compliance with both area-averaged cleanup goals and hot spot levels



Proposed Field Work Use a Variety of Dynamic Work Strategies

- Targeting specific locations for more intensive sampling
- Carving site into smaller areas where data collection can be customized based on degree of contamination concerns
- Deploying adaptive compositing strategies
- Supporting real-time decision-making during excavation
- Implementing targeted off-site laboratory QC and verification analyses
- Optimizing data collection performance (e.g., how many samples to composite during adaptive compositing, how many XRF measurements to take for bagged samples, best XRF measurement acquisition times, etc.)
- Consolidating characterization, excavation, and closure data collection into one field effort

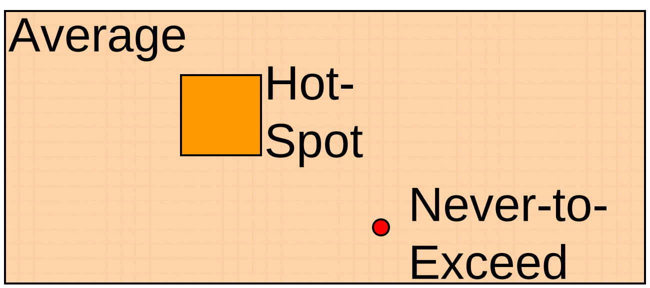
Conceptual Site Model

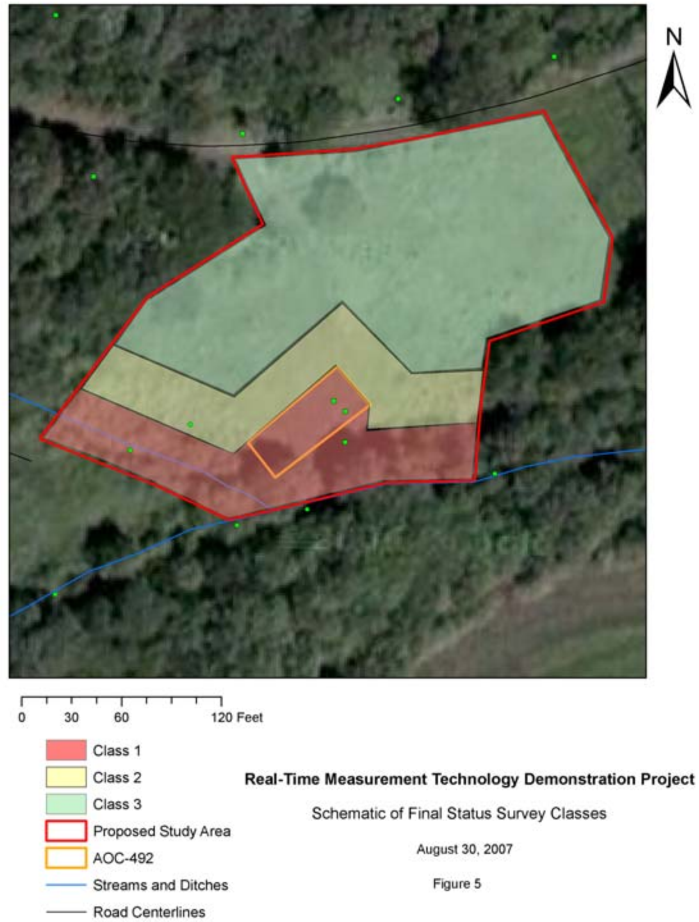
- COC's
  - » Uranium & PCB's
  - » Collocated in historical samples
- Sedimentation
  - » Class 1, 2 & 3 Areas from Creek
  - » Areas:
- Teenager Recreational Use

	Demonstration Project Level	Demonstration Project Hot Spot Level	Detection Limits[6]				
			GWS	*in situ* HPGe	XRF[7]	Test Kit[4]	Standard Laboratory[3]
PCB (low risk)	3.64 ppm	33 ppm	NA[2]	NA	NA	0.5 ppm	0.1 ppm
U-238	3.64 pCi/g	33 pCi/g	30 pCi/g	3 pCi/g	6 pCi/g	NA	2 pCi/g

Concentration Limits

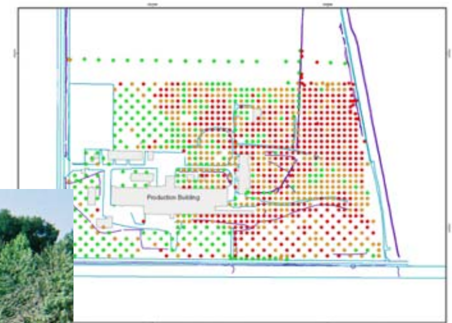
- Average over unit (L)
- Hot-Spot (9*L - over a 25 m^2 area)
- Never to Exceed (30*L - for discrete samples)

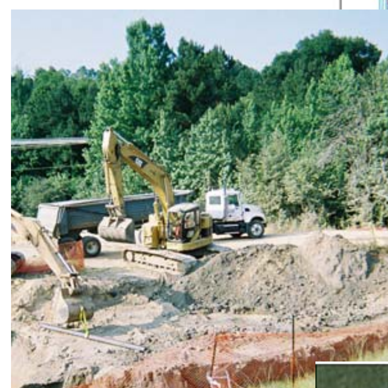




DWS for Decisions

- General Presence or Absence
- Guide Excavation
  - » Unit about 25 m^2
- Verify Release of Site and Waste
- Type I error rate (contaminated but declared clean) = 0.1
- Type II error rate (clean but declared contaminated) = 0.2





Significant Data Collection Will Take Place Within Small Window of Time

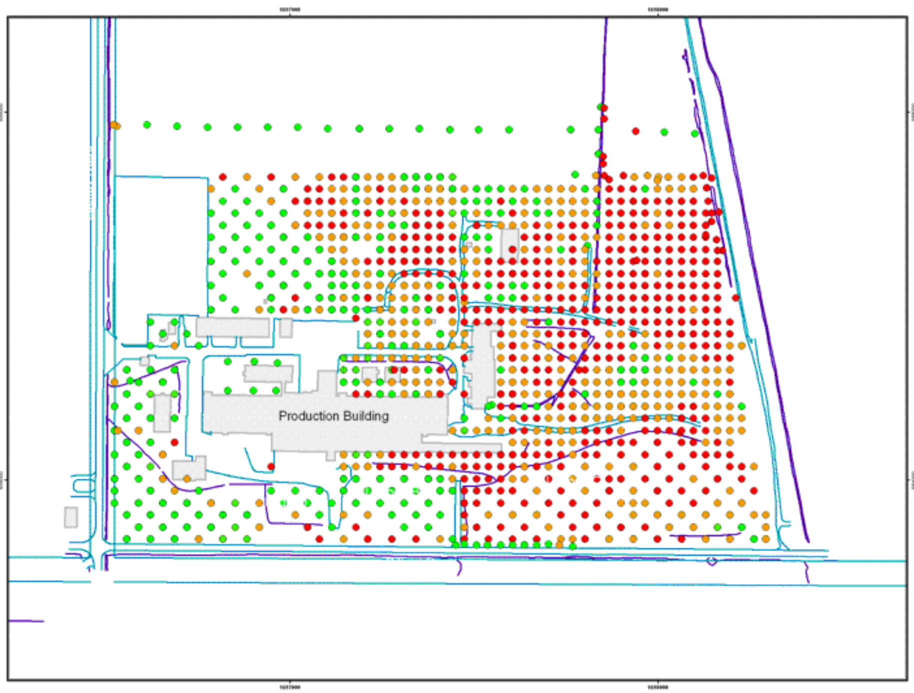
- Logged GWS of study area, data used to:
  - » break study area into three general areas for closure purposes
  - » Identify up to 20 locations for targeted sampling/measurement acquisition (XRF, in situ HPGe, test kits analyses)
- Data collected from 20 locations used to:
  - » interpret GWS results
  - » gain understanding about short-scale heterogeneity associated with contaminated soils
- Implement adaptive compositing strategies for Class 1 and Class 2 areas
  - » target PCB hot spot concerns (looking for 25 m2 areas)
  - » compositing more aggressive in Class 2 areas, less so in Class 1
  - » screening using real-time techniques, verification with lab analyses
- Support excavation work in areas known to exceed no action level
  - » support precise excavation through dig-face screening

Estimated Number of Measurements

	GWS Data Points	XRF Measurements[1]	In Situ HPGe Measurement	Sample Increments	Test Kit PCB Analysis	Laboratory Analysis
Initial Walkover Biased Sampling	~5,000	320	20	100	20	20
Closure Data Collection	0	20/30	0	400	20/30	20/30
Soil Removal Support Data Collection	0/1,000	0/320	0/20	0/100	0/20	0/20
QA/QC[2] Requirements	20	120	0	0	20	0[3]
Total:	~6,000	460/790	20/40	500/600	60/90	40/70

General Presence or Absence

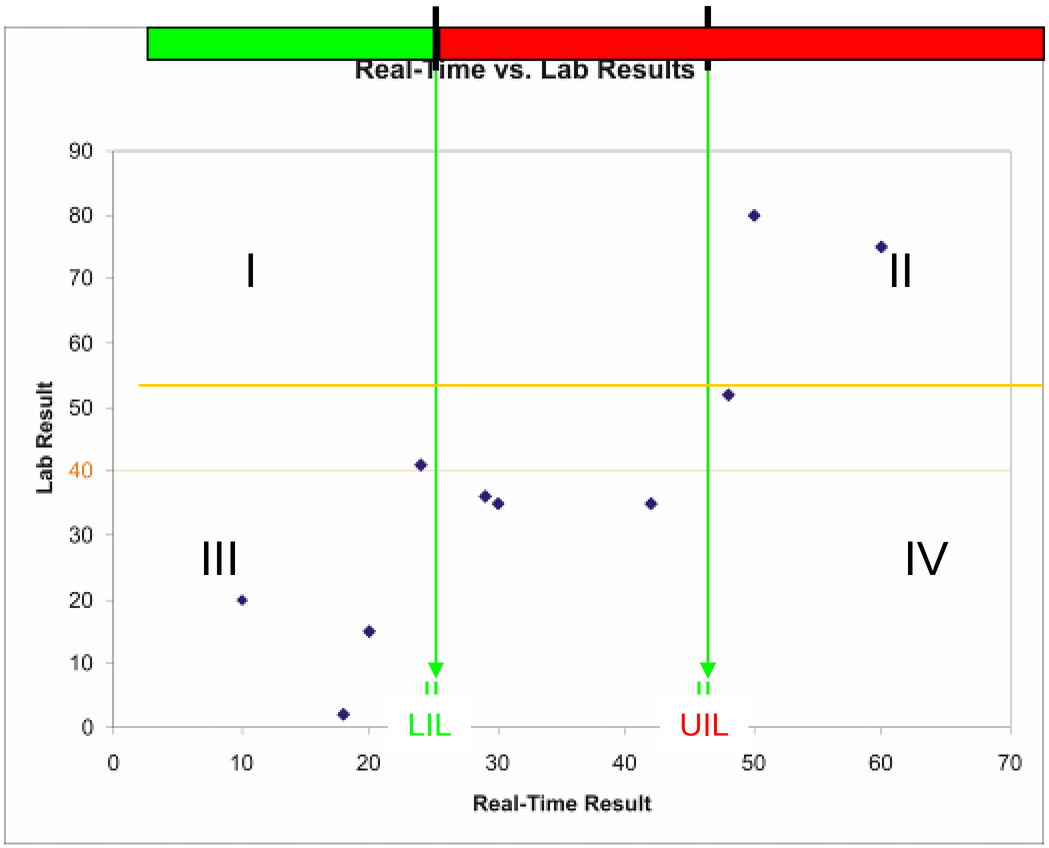
- GWS over Class 1, 2 & 3 areas
  - » Resolution about 1 m2
  - » Use raw and 25 m2 moving-window average
  - » Within 24 hours
    - — classify subunits in each for Class 1, 2 & 3 units
    - — Decide about need, number, and location of discrete samples
    - — Decide about need and location of excavation



General Presence or Absence

- Discrete Sample Analysis
  - » Decide within 24 hours of GWS
  - » 20 discrete measurements biased towards higher GWS measurements
    - — In situ XRF (5 – half minute readings within 1 m2)
      - – Spatial variability, Collocated metals
    - — In situ HPGe (<20 minute; uncollimated; 15 cm height)
      - – Determine other radionuclides (e.g., at background)
    - — 30 Second NaI Fiddler
    - — A composite Five-Increment Soil Sample (ICSS) from location
      - – 10 chosen for XRF bagged analysis after minimal prep (10 x 30s)
      - – All undergo standard prep and XRF; then split to:
        - Lab: beta, alpha, gamma spectrometry & metals analysis
        - Onsite: XRF cup analysis (120 s) & PCB test kits
    - — Assist in quantitative interpretation of GWS

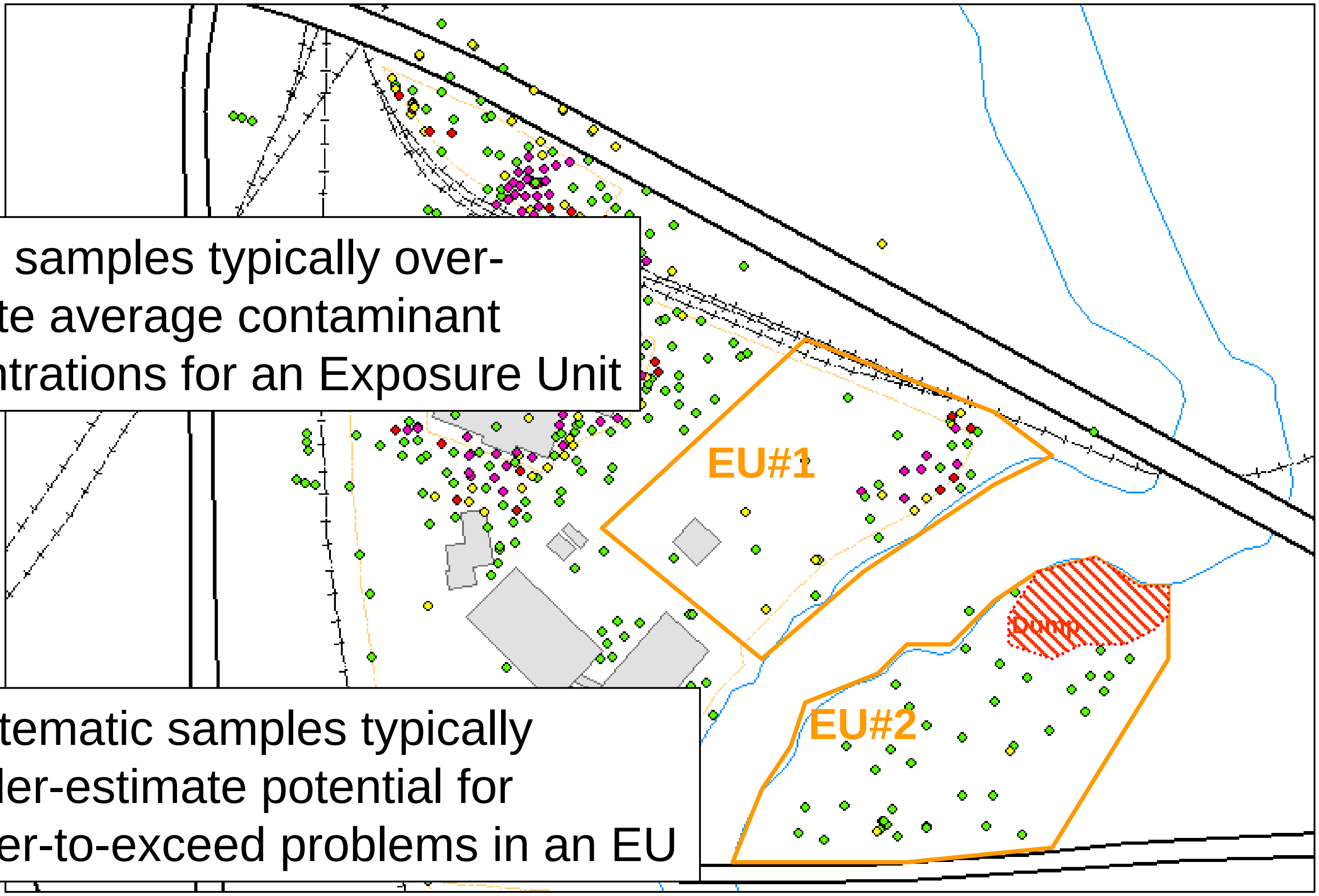
Develop DWS Upper and Lower Levels



- I: False Clean
- II: Correctly Identified Contaminated
- III: Correctly Identified Clean
- IV: False Contaminated
- I/(I+II)*100: % of contaminated samples missed by LIL (false clean rate)
- I/(I+III)*100: % of "clean" samples that are contaminated
- IV/(II+IV)*100: % of "contaminated" samples that are clean
- IV/(III+IV)*100: % of clean samples above the LIL (false contaminated rate)

False Clean Rate: 0% **False Contaminated Rate: 0%**

Bias Your Answer by Biasing Your Sampling Approach...

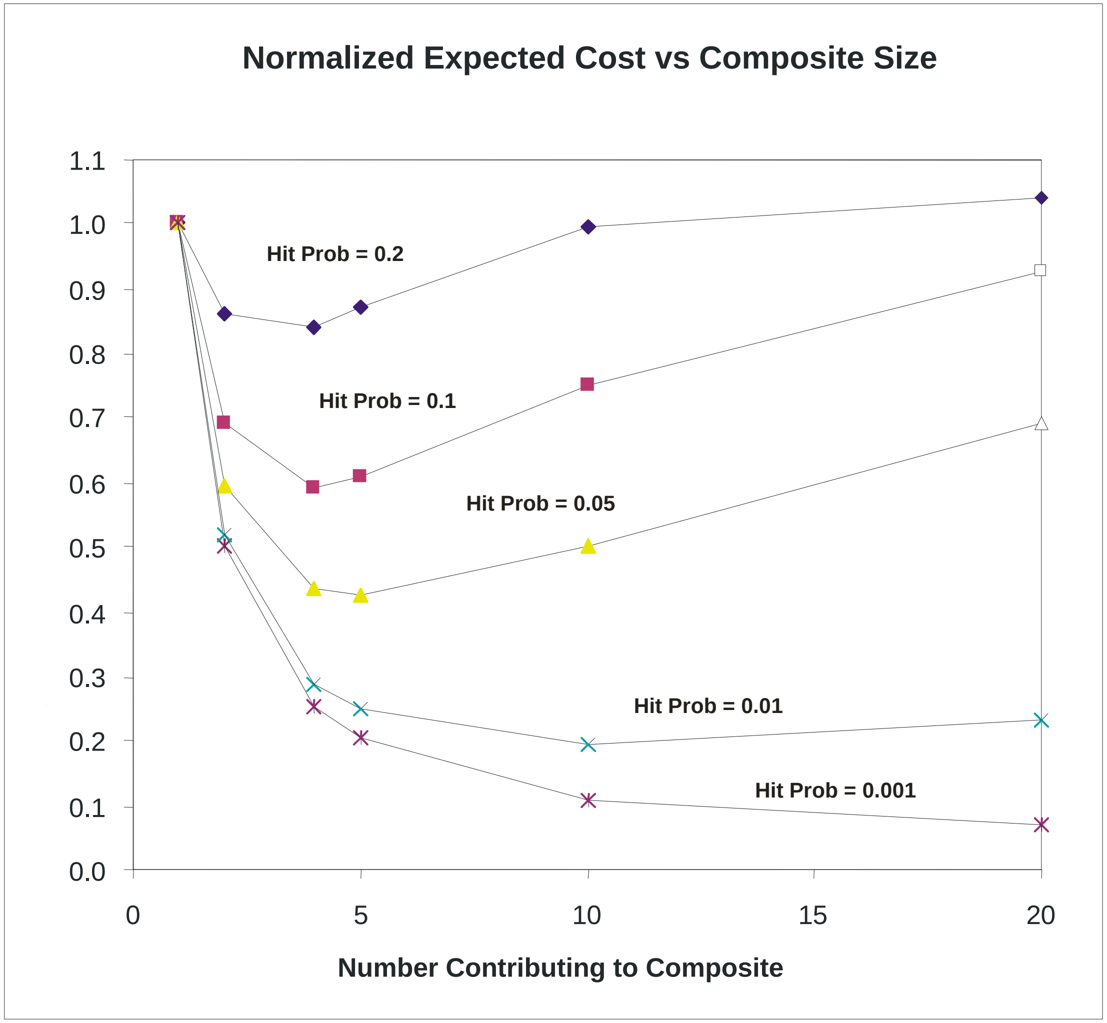


Biased samples typically over-estimate average contaminant concentrations for an Exposure Unit

Systematic samples typically Under-estimate potential for never-to-exceed problems in an EU

How Many Samples to Composite?

Addressing the Unknown



- A function of the probability of contamination being present
- The less likely contamination is present, the larger the number of samples to composite
- Graph at left shows the case when one has 20 sampled locations

Supporting Excavation

- Combine
  - »Initial GWS ($1m^2$) determines targeted areas
  - »From each 25 m^2 targeted area:
    - –5 x 30 s Fidler measurements
    - –5 x 30 s XRF measurements
    - –HPGe
    - –ICSS formed XRF cup; PCB test kit; lab

Supporting Final Status Unit Closure

- Some Measures Concurrent with Excavation
- Class 1: 40 x 25 m^2 areas
- ICSS-5 within each area
- Split into two:
  - » Archived
  - » Combined with ICSS from 4 others areas (CSS)
    - — Split for traditional off-site analysis and on-site XRF and PCB test kits
    - — Tested for levels of 20% of hot spot criteria
      - – If greater: each ICSS tested; identify area; clean later
    - — Average tested (over the 200 sample locations; 8 measurements)

Class 2 & 3

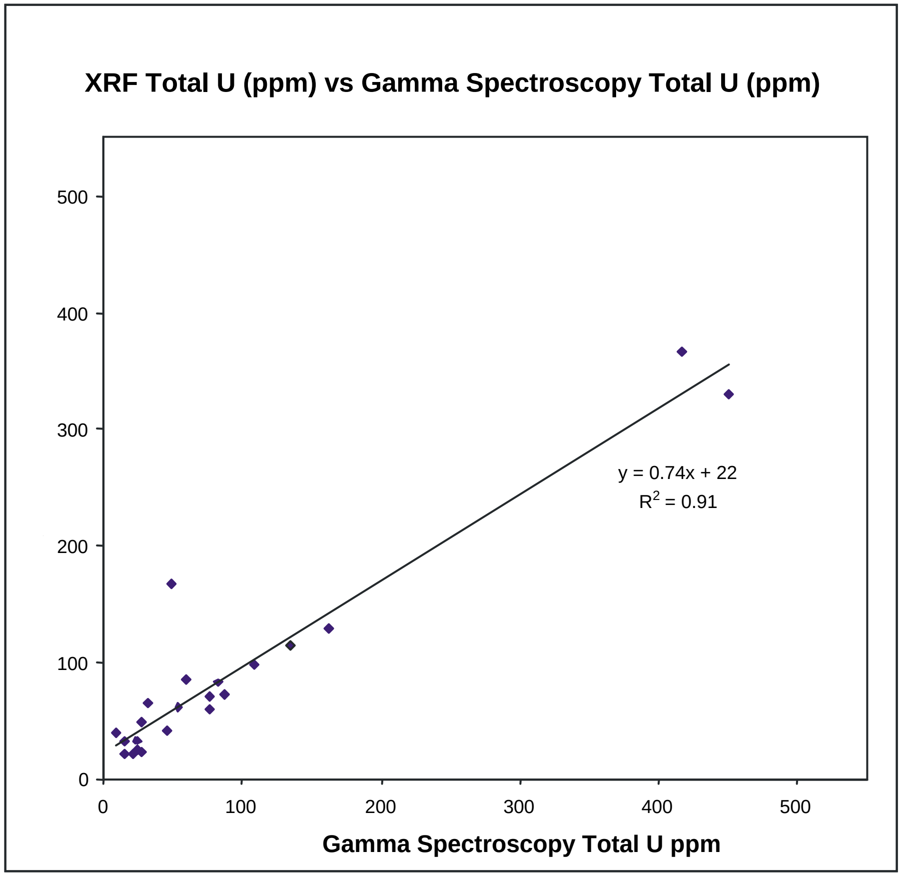
- Similar strategy
  - » Class 2:
    - 8 ICSS samples in each CCS
    - 4 measures; 160 sampling locations
  - » Class 3:
    - 8 random sampling areas of 25 m^2 selected
    - ICSS formed along with HPGe measurement

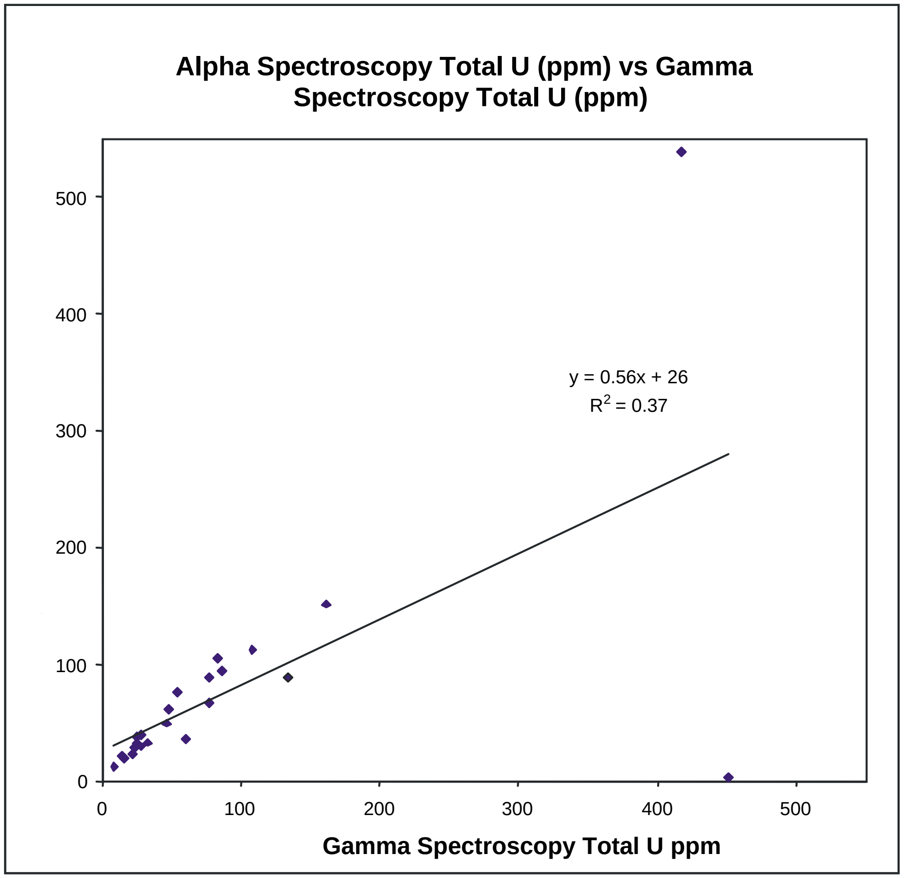
Conclusions

- An integrated DWS over activities (classification, excavation, & verification) and measures (gamma, XRF, test kits) was planned and executed.
- What actually happened?
- What is the path forward?

Definitive Data, Please Stand Up!

Set of samples analyzed with three different methods for uranium, via XRF (bagged samples), gamma spectroscopy (sample prep, but no extraction), and alpha spectroscopy (sample prep with extraction required)





Logged GWS
(1.12 Acres)

GWS - 1 day

20 locations in 1.12 acre area

At each Location:
1. 30 second static gamma measurement
2. 5-30 second *in situ* XRF measurement (centered on static gamma measurement)
3. *in situ* gamma spectroscopy measurement
4. five (5) increment samples (centered on static gamma measurement)
5. 20 composites (split - on-site analysis; off-site analysis

in situ/ex situ measurements - 2 days

20 samples will undergo minimal sample preparation and
placed in plastic bags

10 of the 20 composite samples will undergo 10-30 second XRF measurement
the 10 samples will be counted 5 times over area of each side surface of the bag
each of the 5 count will be for 30 seconds

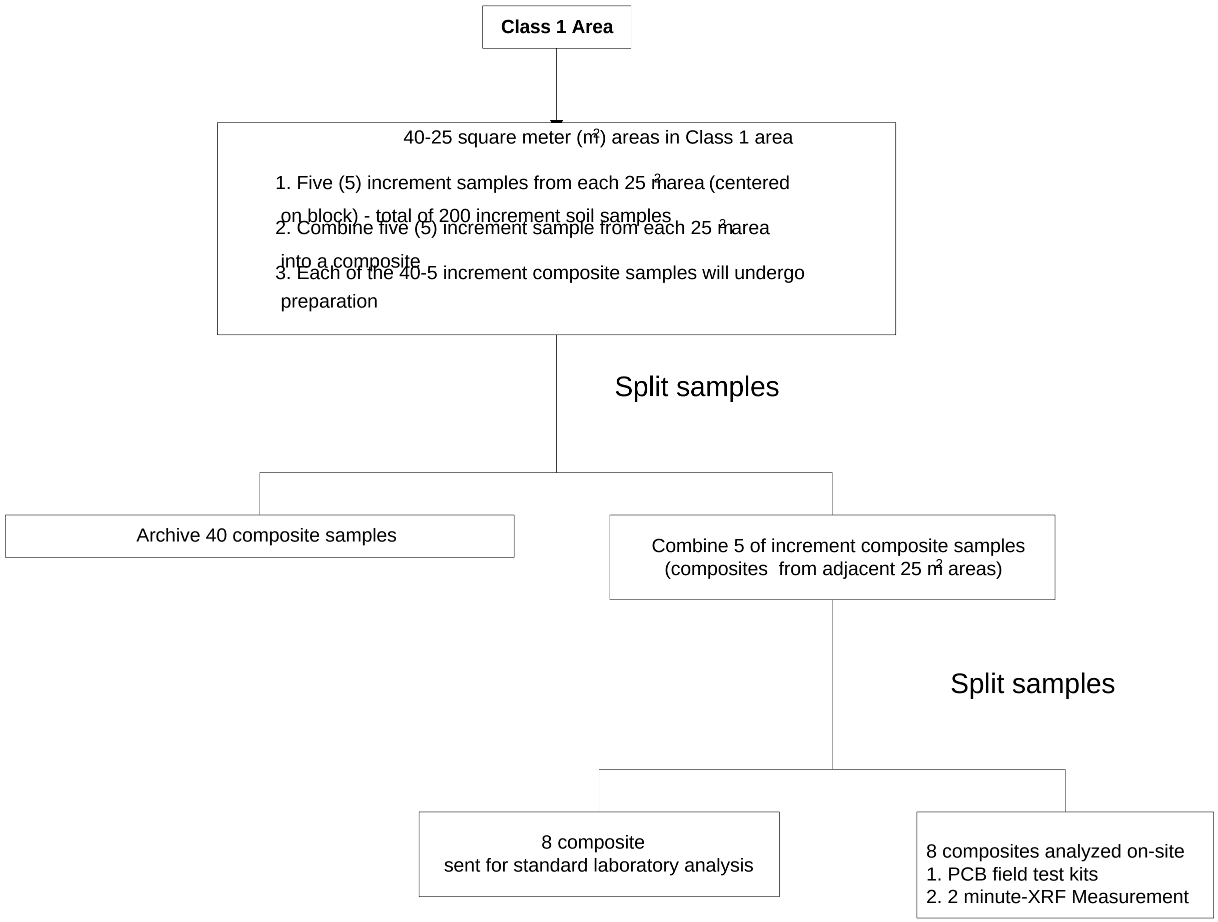
All composite samples will undergo standard preparation
each of the above 10 samples will undergo 10-30 second XRF measurement
the 10 samples will be counted 5 times over area each side of surface of the bag
each of the 10 counts will be for 30 seconds

split 20 composite samples

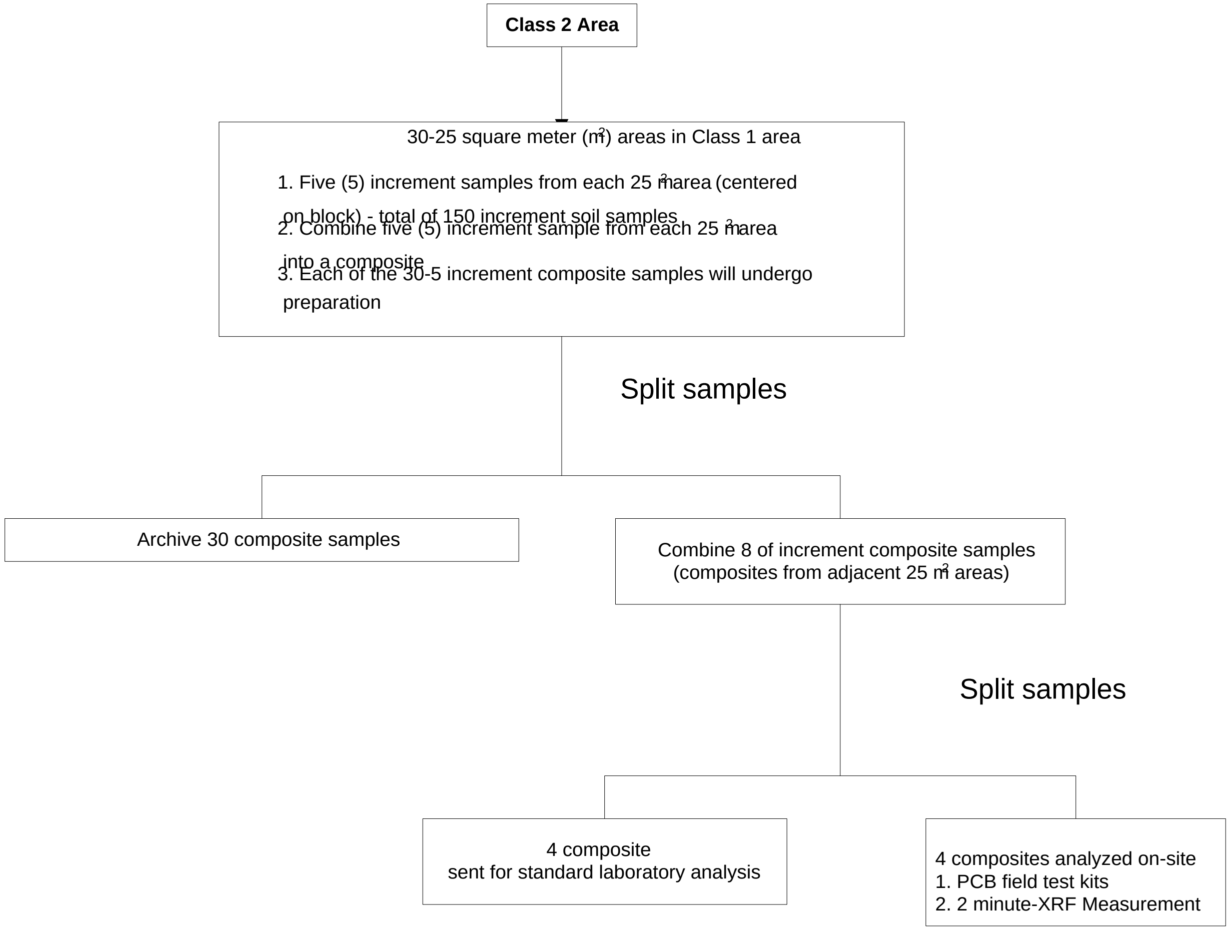
Send for laboratory anslysis
Alpha Spectroscopy
Gamma Spectroscopy
Metal Analysis
PCB Analysis

Coduct ex situ on-site testing
PCB test kit
2 minute XRF measurements

Above activities will permit determining Class 1, 2 and 3 areas and as indicated will take approximately 3 days



1. Will need to collect 60-65 samples per day (3 days)
2. Sample preparation will occur simultaneoulsy with sample collection



1. Will need to collect 60-65 samples per day (2.5 days)
2. Sample preparation will occur simultaneoulsy with sample collection

Class 3 Area

8-25 square meter (m^2) areas in Class 3 area

1. in situ gamma spectroscopy in each of the 8 areas
2. Five (5) increment samples from each 25 m^2 area (centered on block) - total of 40 increment soil samples
2. Combine five (5) increment sample from each 25 m^2 area into a composite
3. Each of the 8-5 increment composite samples will undergo preparation

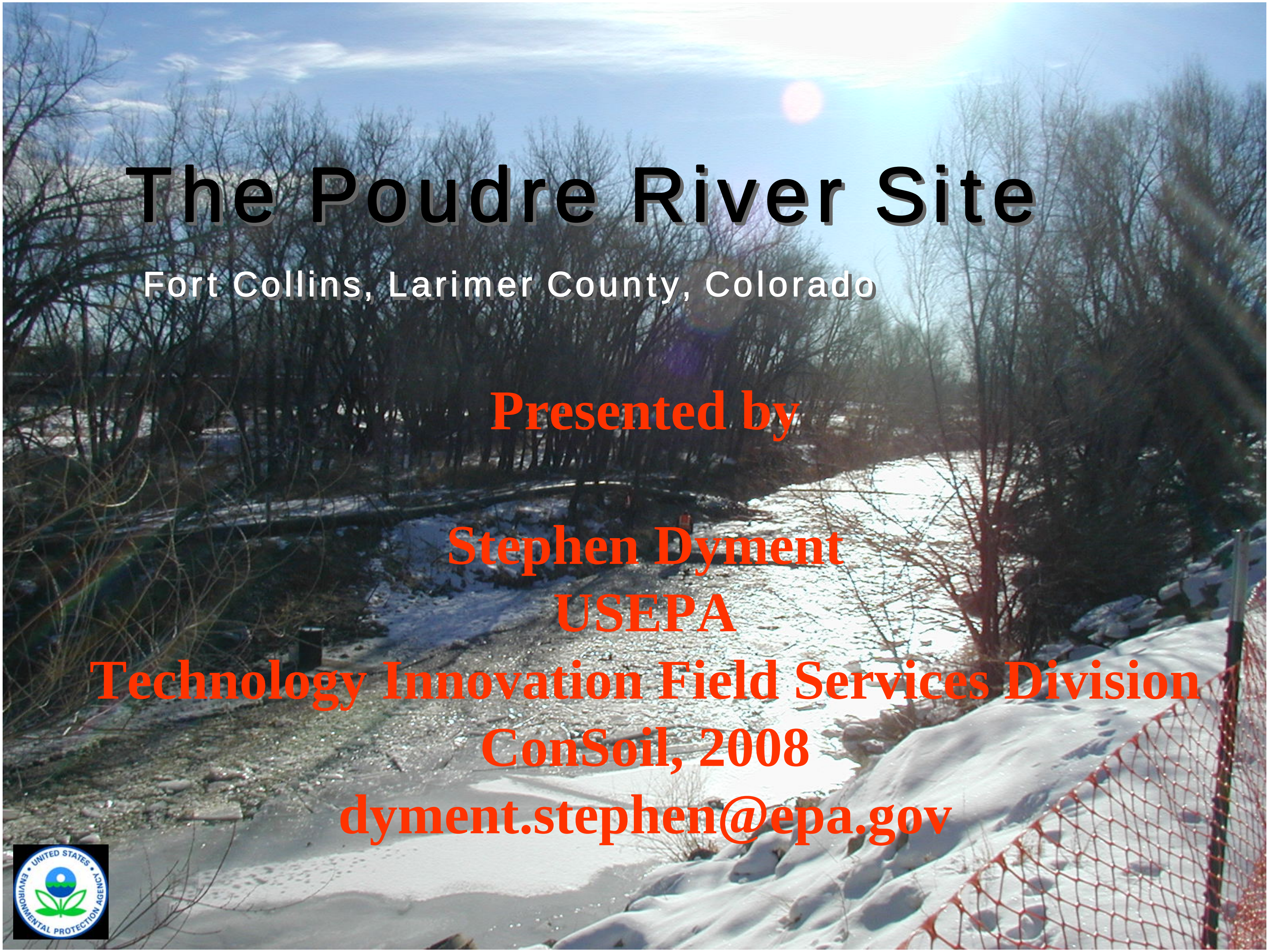
Split samples

Archive 8 composite samples

8 increment composites sample analyzed on-site
1. PCB field test kits
2. 2 minute-XRF Measurement

Send for laboratory analysis, if necessary

1. Will need to collect 1 days
2. Sample preparation will occur simultaneoulsy with sample collection



The Poudre River Site

Fort Collins, Larimer County, Colorado

Presented by

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ConSoil, 2008

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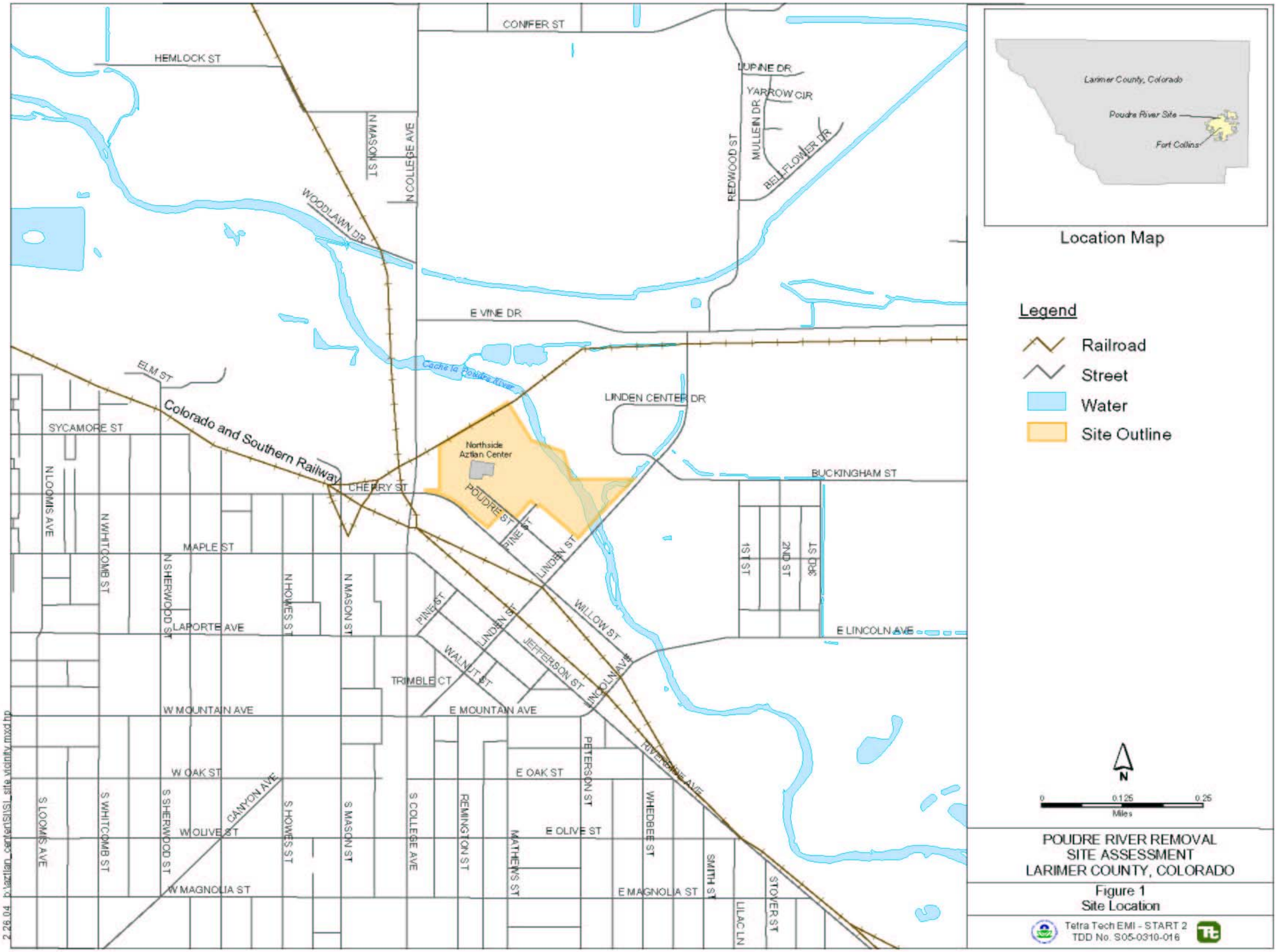
Cache La Poudre River
Investigation to
Remedy Implementation
in 2 Years

Poudre River Site – History

- 19 Acre Site - 12 acre former municipal burn landfill down gradient from MGP and USTs, next to city center
- 1995 NFRAP (No Further Remedial Action Planned) by EPA. Some dissolved TPH contaminants but lack of detections in surface water and sediment, no source areas identified.
- 2000 City of Fort Collins obtains $250K Brownfields grant
- City wants to relocate 20,000 sq ft community center on the old landfill, before it settled into the landfill
- City wants to build a new 50,000 sq ft recreation center on the Site
- Day care center located on the Site



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September 2002: Contractor Notices "Oily" Material in the River (During Drought Conditions)

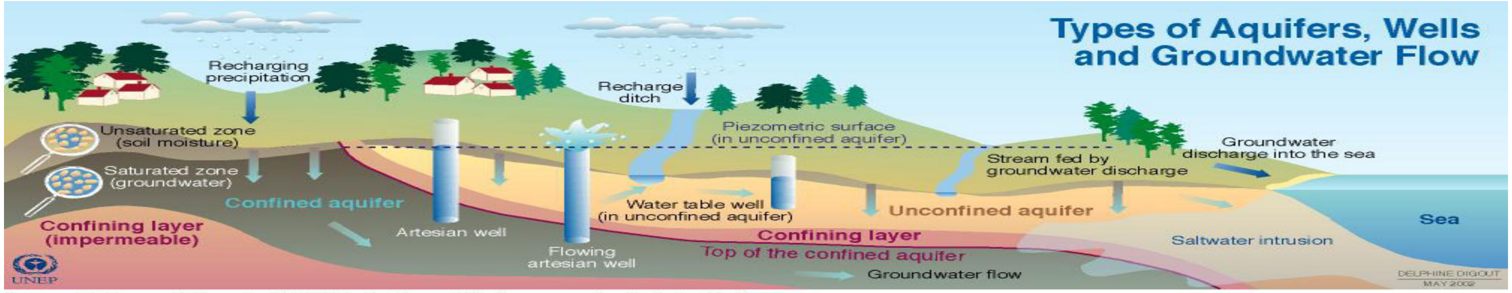
When Disturbed

Preliminary Conceptual Site Model

- Issues of potential concern
  - » Black coal tar discovered in the river
  - » UST/MGP related dissolved plume
  - » Landfill closure
- Previous study results
  - » No apparent link between dissolved plume and observed contamination in river
  - » Insufficient data for landfill closure
- Portions of the site studied by different PRPs for 5 years with differing goals.
  - » No comprehensive CSM had been developed!
  - » Dynamic work strategies never employed!

Geology and Hydrogeology

- ◆Site adjacent to meandering river
- ◆Landfill covers the site to a depth of 7 to 18 ft bgs with ground water at 13 to 17 ft bgs
- ◆Landfill underlain by sandstone bedrock
- ◆Beneath the sandstone is the Pierre Shale
- ◆Topography of shale unknown
- ◆Ground water discharges to river (gaining)



Source: Environment Canada, 2001 (Adapted from: http://www.ec.ca/water/index.htm).

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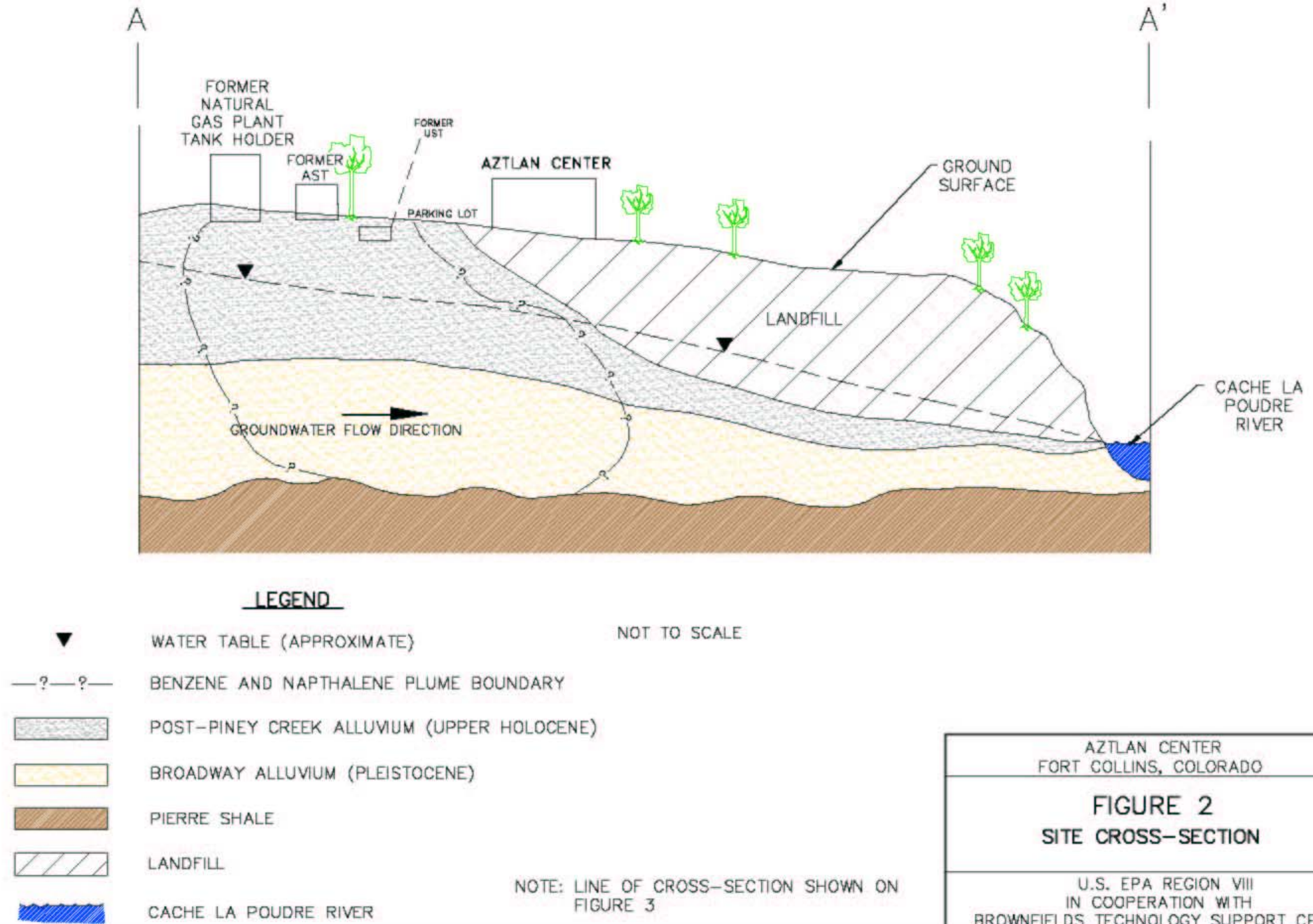
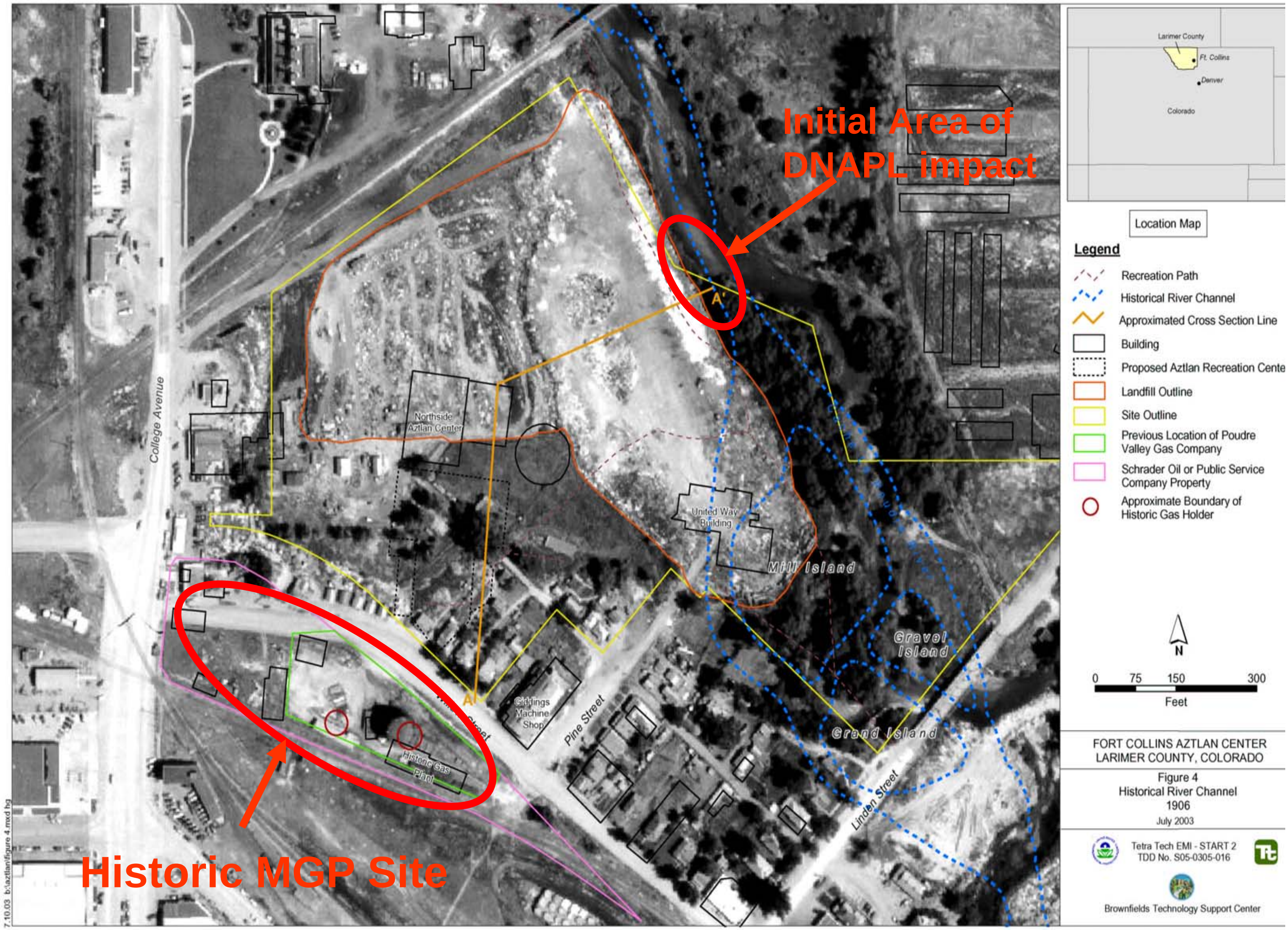


AZTLAN CENTER
FORT COLLINS, COLORADO

FIGURE 2

SITE CROSS-SECTION

U.S. EPA REGION VIII
IN COOPERATION WITH
BROWNFIELDS TECHNOLOGY SUPPORT CENTER



Initial Area of DNAPL impact
Historic MGP Site
College Avenue
Northside Aztlan Center
United Way Building
Mill Island
Gravel Island
Grand Island
Giddings Machine Shop
Historic Gas Plant
Pine Street
Linden Street
A
A'
Larimer County
Ft. Collins
Denver
Colorado
Location Map
Legend
Recreation Path
Historical River Channel
Approximated Cross Section Line
Building
Proposed Aztlan Recreation Cente
Landfill Outline
Site Outline
Previous Location of Poudre Valley Gas Company
Schrader Oil or Public Service Company Property
Approximate Boundary of Historic Gas Holder
N
0 75 150 300
Feet
FORT COLLINS AZTLAN CENTER
LARIMER COUNTY, COLORADO
Figure 4
Historical River Channel
1906
July 2003
Tetra Tech EMI - START 2
TDD No. S05-0305-016
Brownfields Technology Support Center
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Differing CSMs by PRPs

During systematic planning we hear comments like…

- "Stuff in the river is not the same as what was historically found at the up-gradient MGP"
- "DNAPL in the river is the result of a dumping scenario"
- "Paleo-channels effecting migration"
- "That DNAPL is not mobile"
- "The dissolved plume is result of USTs"

Lot's of finger pointing

Targeted Brownfields Assessment Dynamic and Appropriately Sequenced

- Geophysics (EM 34 and EM 31)
- Direct push soil and ground water grabs
  - » 15 initial locations, 15+ dynamic locations
    - – On-site modified GC/MS (8260) analysis
    - – Off-site laboratory analysis
- Sampling of temporary small gauge wells and existing site monitoring wells (some by PRP consultants)
    - – On-site modified GC/MS (8260) analysis
    - – Off-site laboratory analysis
- Product fingerprinting- PAH ratios
- The CSM is refined and responsibility of various PRPs becomes clearer
  - » Triggering action among various parties

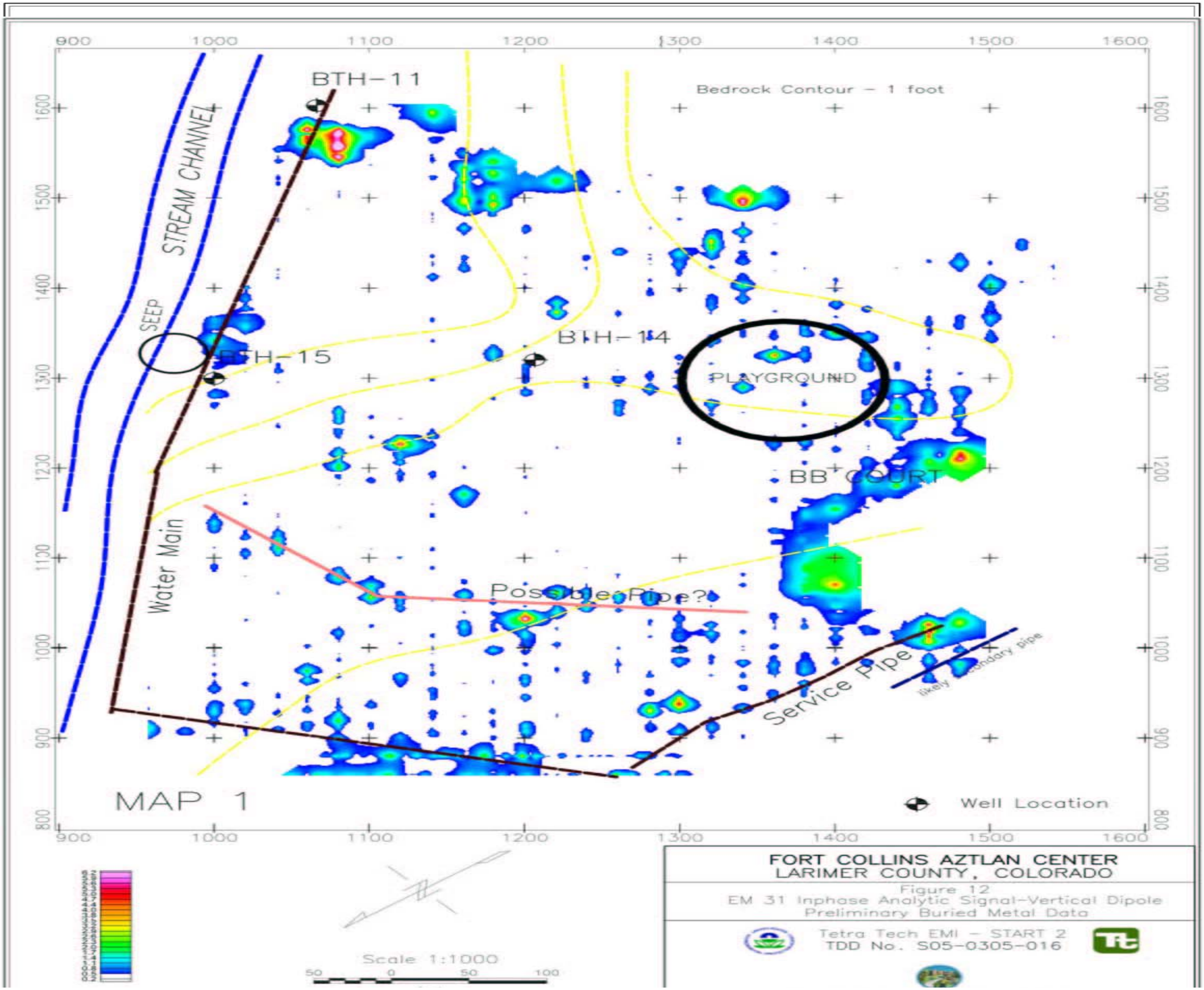
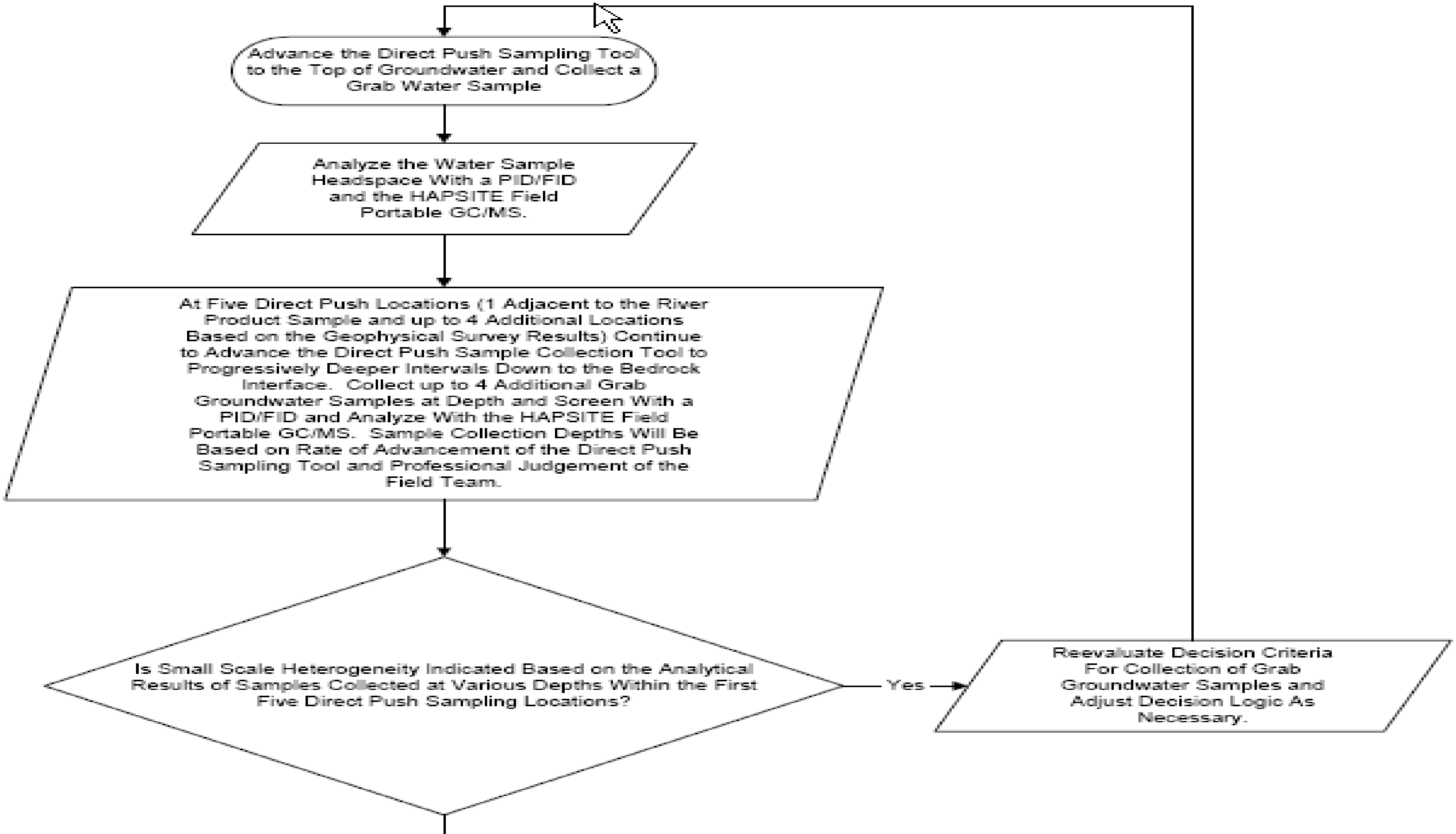

BTH-11
Bedrock Contour - 1 foot
STREAM CHANNEL
SEEP
BTH-15
BTH-14
PLAYGROUND
BB COURT
Water Main
Possible Pipe?
Service Pipe
likely secondary pipe
MAP 1
Well Location
Scale 1:1000
FORT COLLINS AZTLAN CENTER
LARIMER COUNTY, COLORADO
Figure 12
EM 31 Inphase Analytic Signal-Vertical Dipole
Preliminary Buried Metal Data
Tetra Tech EMI - START 2
TDD No. S05-0305-016

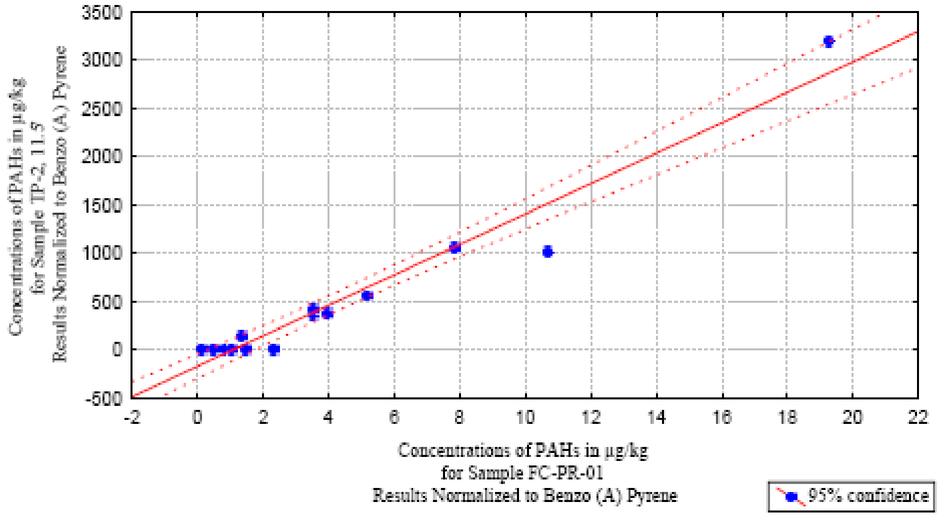
Figure 8
TBA - Sample Collection Decision Logic Diagram



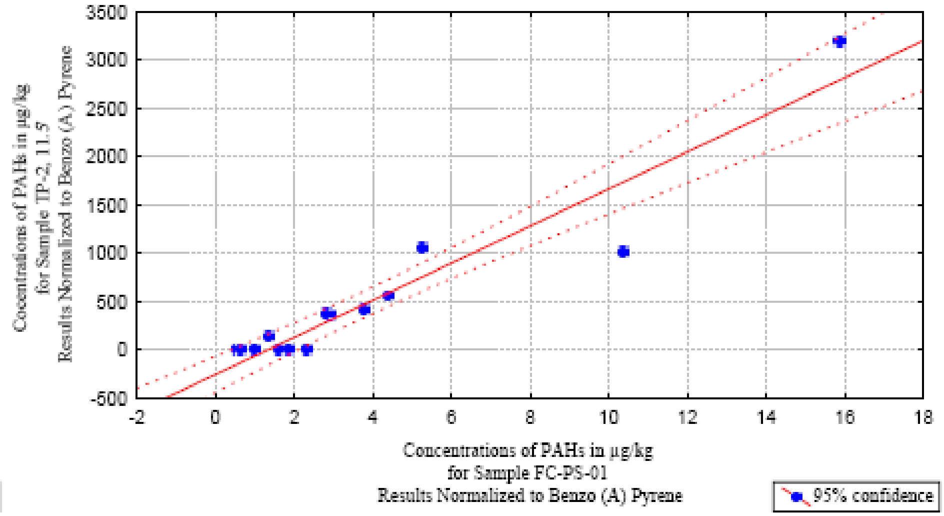
October 2003 Water Level Contours

Correlations of PAH Concentrations in µg/kg
Normalized to Benzo (A) Pyrene
Cache La Poudre River Samples vs. Sample TP-2 11.5'

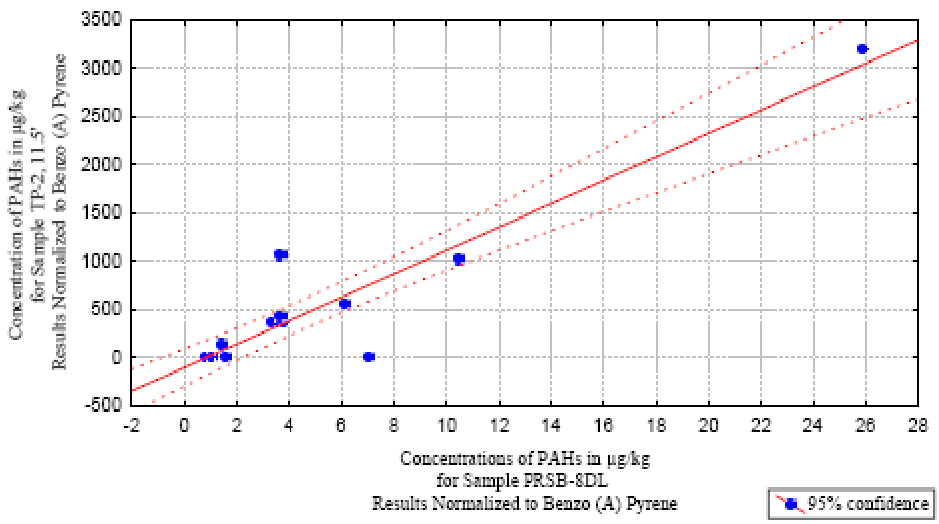
Scatterplot: FC-PR-01 vs. TP-2, 11.5'
Results Normalized to Benzo (A) Pyrene
TP-2, 11.5' = -168.4 + 157.56 * FC-PR-01
Correlation: r = .97603



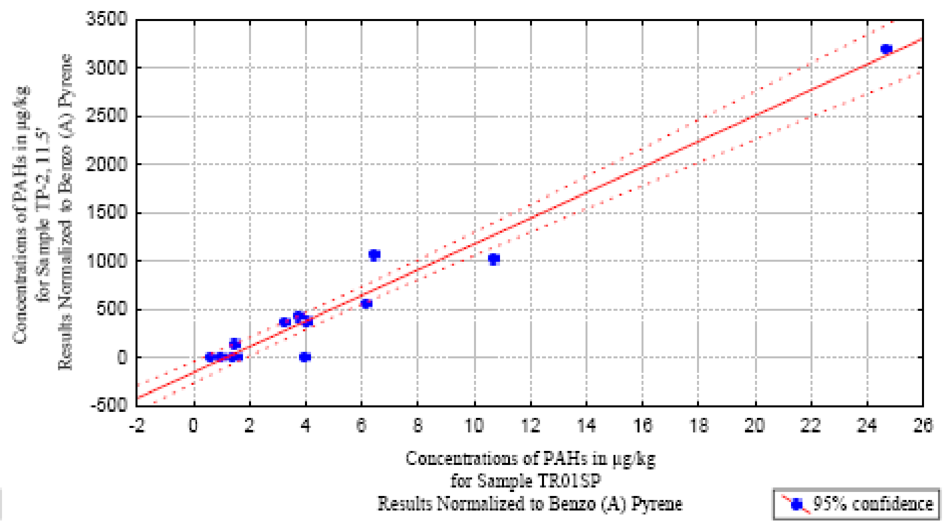
Scatterplot: FC-PS-01 vs. TP-2, 11.5'
Results Normalized to Benzo (A) Pyrene
TP-2, 11.5' = -253.1 + 192.05 * FC-PS-01
Correlation: r = .95265



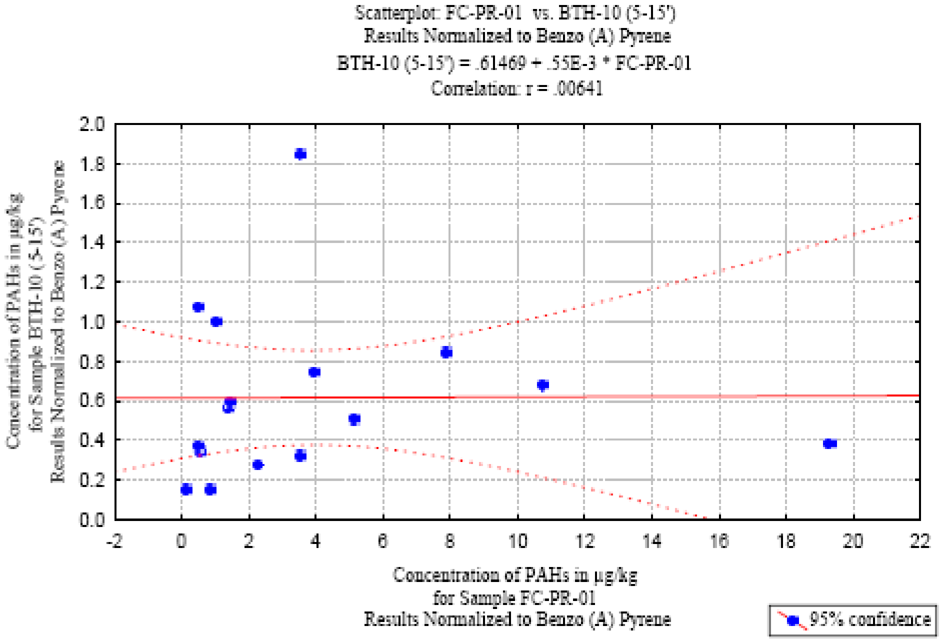
Scatterplot: PRSB-8DL vs. TP-2, 11.5'
Results Normalized to Benzo (A) Pyrene
TP-2, 11.5' = -104.1 + 121.29 * PRSB-8DL
Correlation: r = .93976

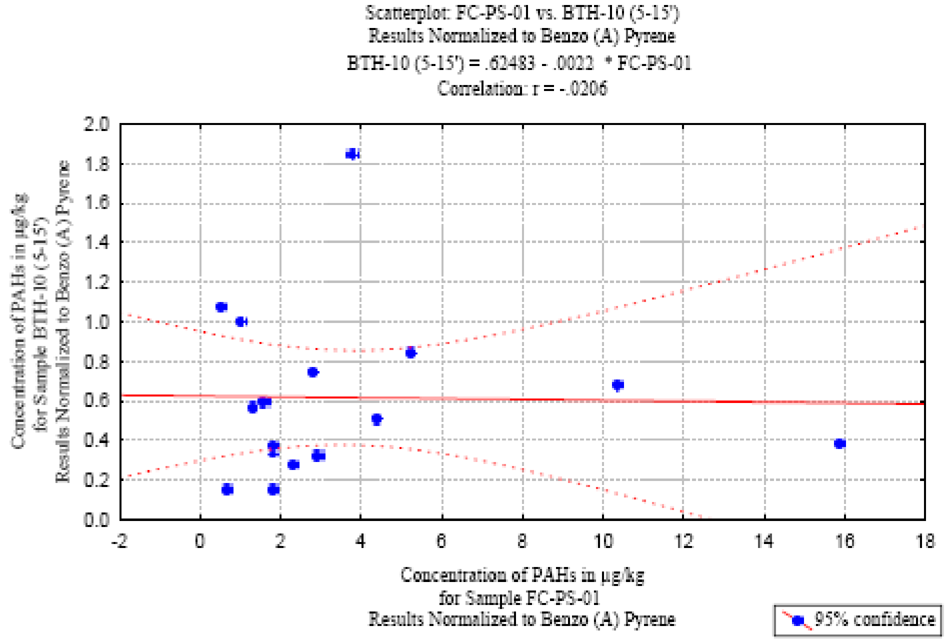


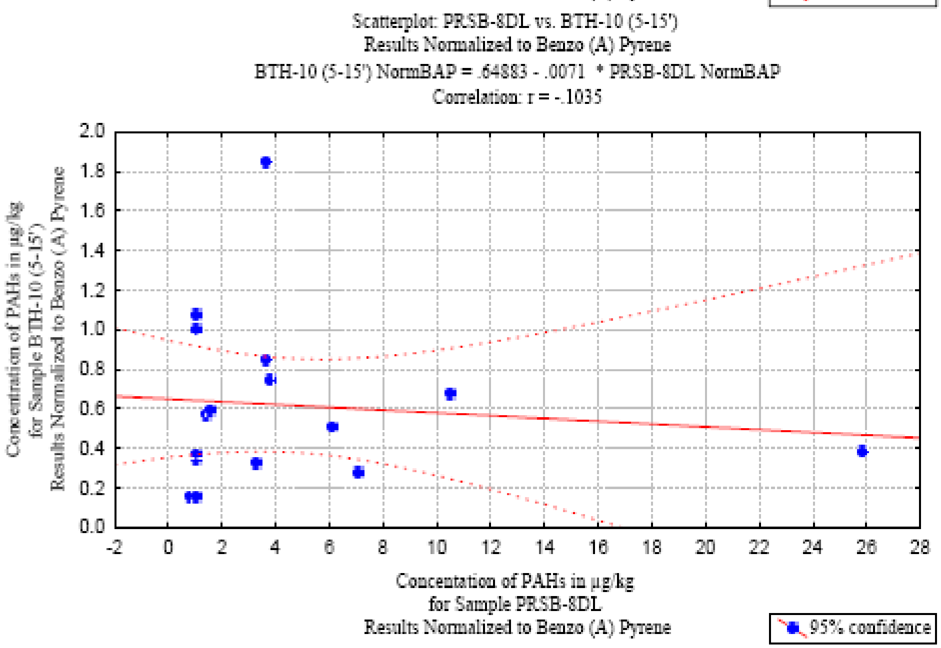
Scatterplot: TR01SP vs. TP-2, 11.5'
Results Normalized to Benzo (A) Pyrene
TP-2, 11.5' = -155.2 + 133.06 * TR01SP
Correlation: r = .98078

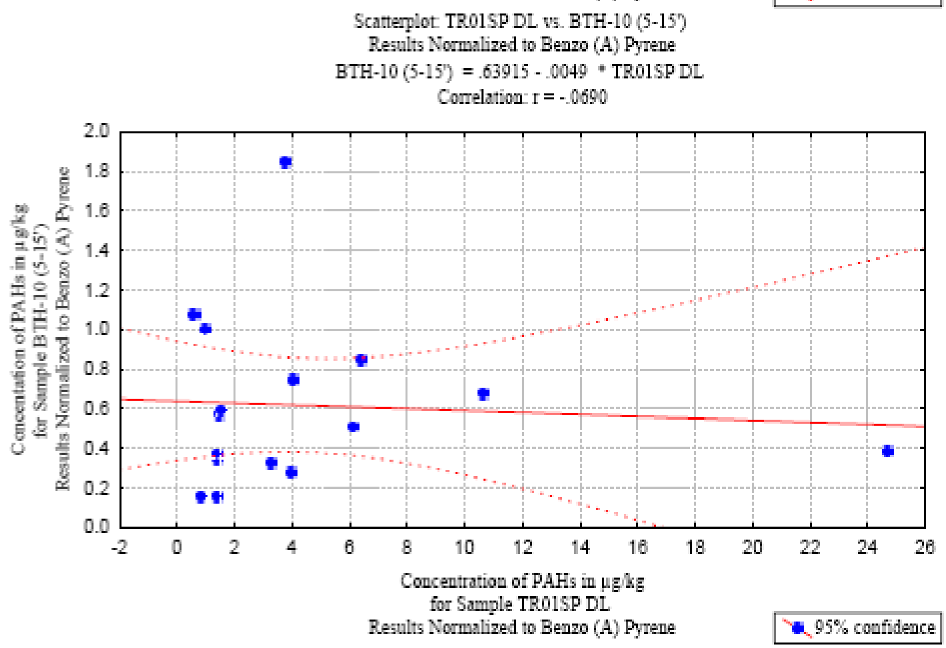


Correlations of PAH Concentrations in µg/kg
Normalized to Benzo (A) Pyrene
Cache La Poudre River Samples vs. Sample BTH-10 (5-15')

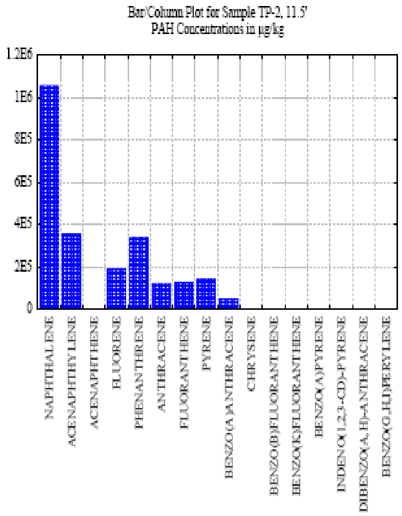


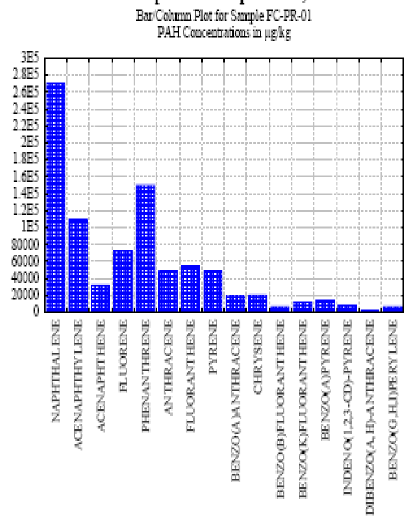


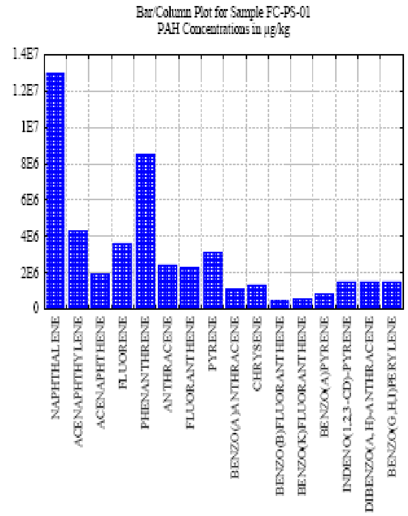


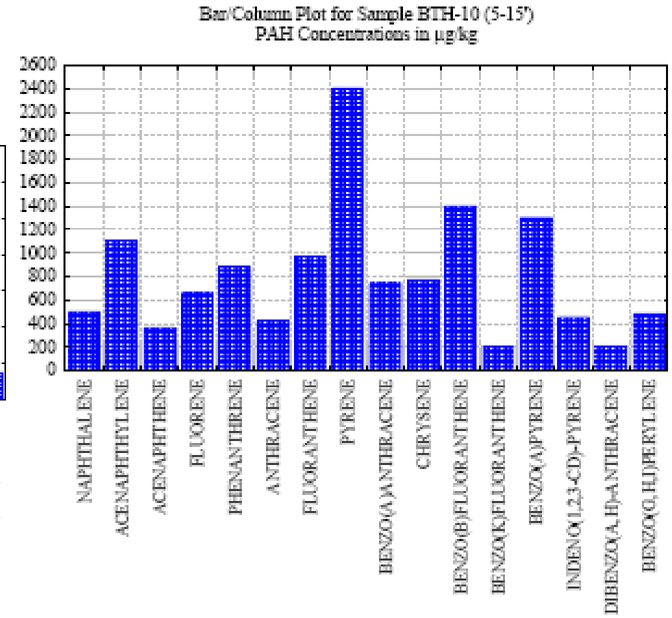


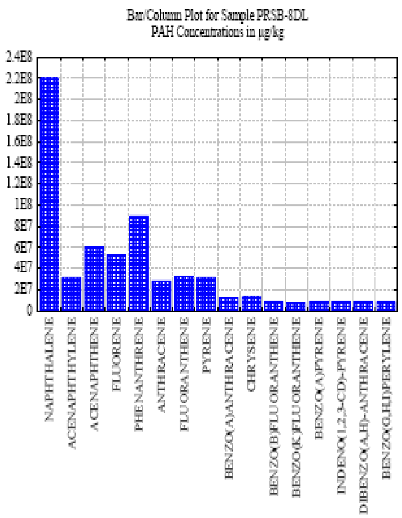
PAH Ratios for Cache La Poudre River Samples vs.Sample TP-2, 11.5'

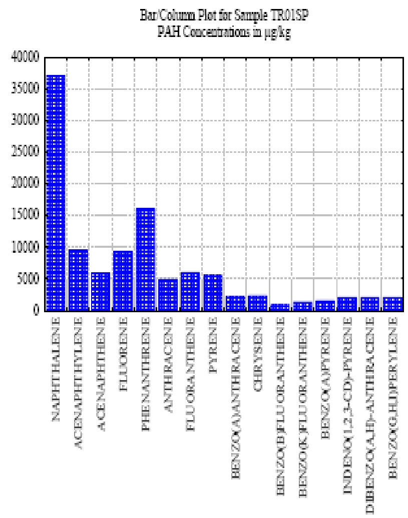


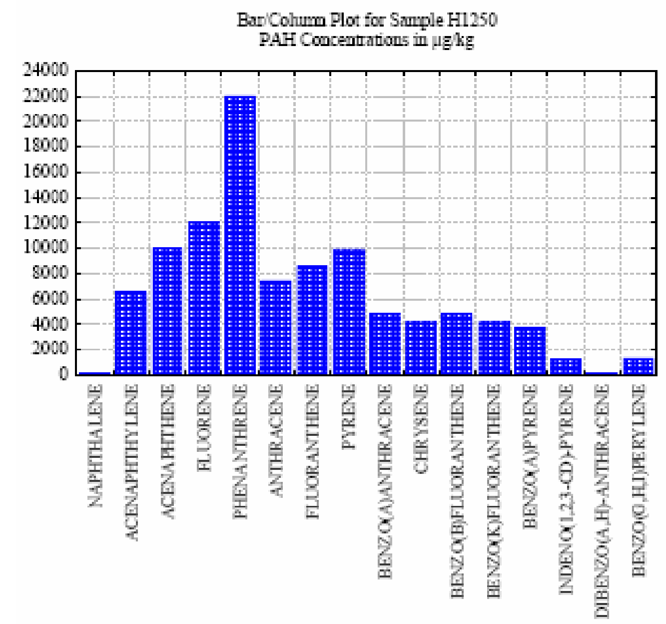








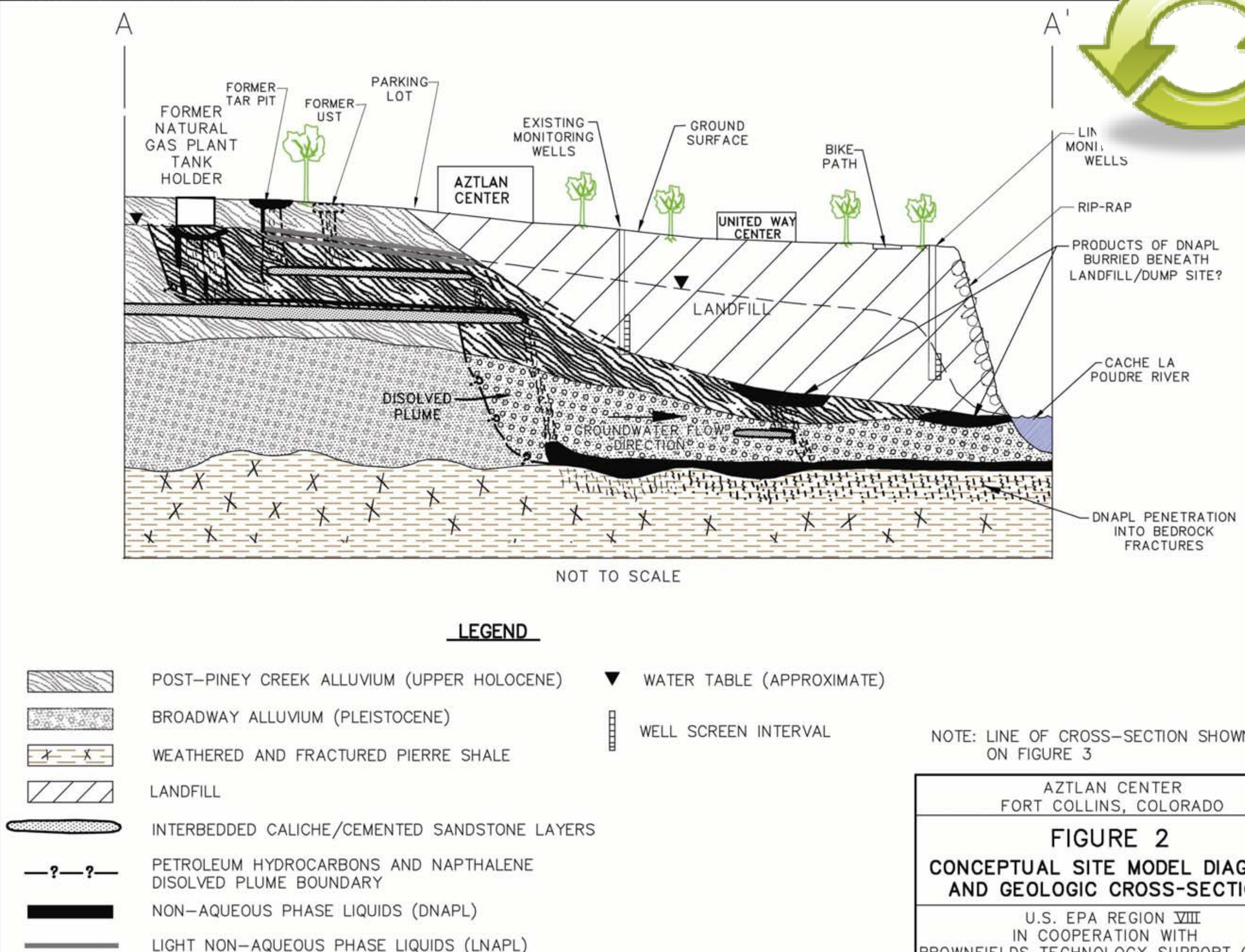




TBA – Key Findings

- Geophysical survey pointed to limited potential for dumping spots beneath the landfill adjacent to the river
  - » Significant “coal tar” now flowing in river
- Direct push ground water grab samples indicated
  - » Dissolved plumes reach the river
  - » PCE in ground water not previously identified
    - — Potential up-gradient source
    - — Complicating formal closure of historic landfill
- Still no clear path for MGP waste migration to the river
- Only 2 of existing 17 site wells reached shale bedrock - existing CSM (geology/bedrock surface) unclear
- City still very determined to make use of property
- Product fingerprinting - sufficient to stimulate PRP action

R:\EPA\Aztlan Center\ Figure 2 Aztlan-csm_recover.dwg 02/03/2004 Vincent.Cavanaugh DN



NOTE: LINE OF CROSS-SECTION SHOWN ON FIGURE 3

AZTLAN CENTER
FORT COLLINS, COLORADO

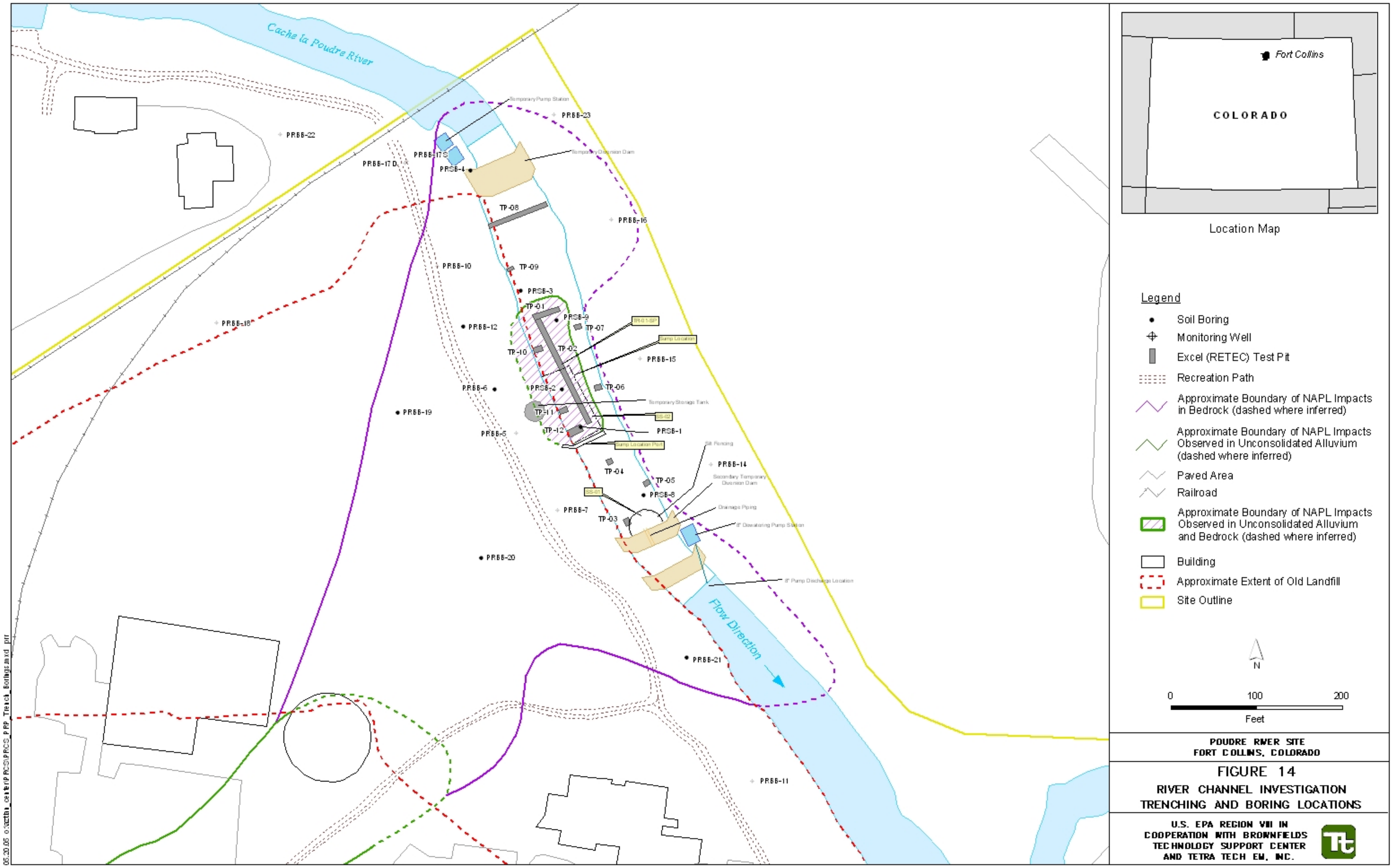
FIGURE 2

CONCEPTUAL SITE MODEL DIAGRAM AND GEOLOGIC CROSS-SECTION

U.S. EPA REGION VIII
IN COOPERATION WITH
BROWNFIELDS TECHNOLOGY SUPPORT CENTER

EPA Site Investigation (SI) and PRP River Investigation

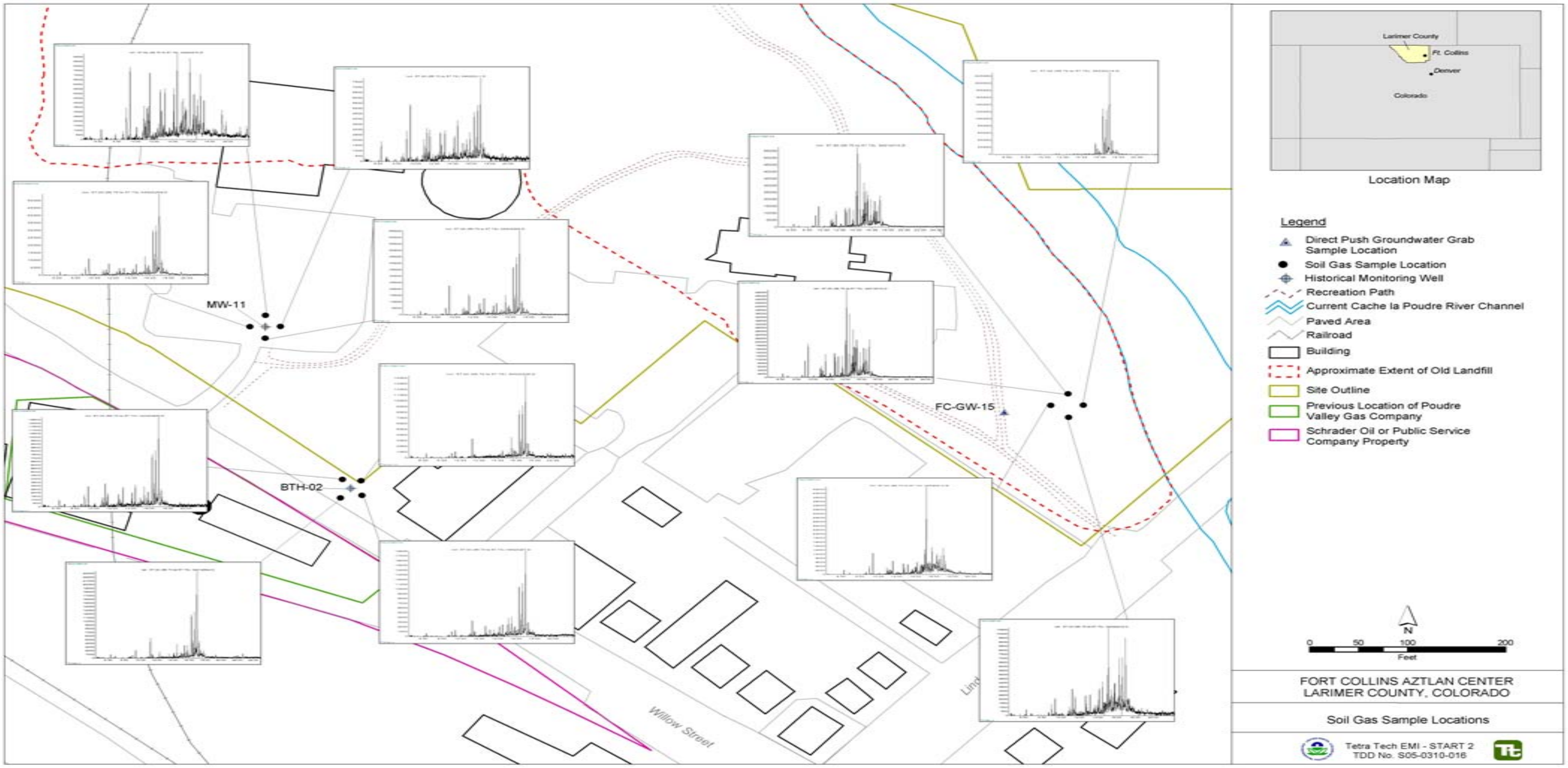
- A PRP lead river investigation and EPA SI were planned and implemented simultaneously
- Drilling, stream diversions, and trenching was conducted by PRP along and in the river
- During the EPA SI:
  - » Passive soil gas (DMA and Survey)
    - – To target potential source areas
  - » Bedrock drilling
  - » Additional geophysical survey
    - – Resistivity, map bedrock surface/competency
  - » Passive diffusion bags were installed along the river
    - – Shallow ground water to surface water pathway


Cache la Poudre River
Flow Direction
PRSB-23
PRSB-22
PRSB-17S
PRSB-17D
PRSB-4
TP-08
PRSB-16
PRSB-10
TP-09
PRSB-3
TP-01
PRSB-9
TP-07
PRSB-18
PRSB-12
TP-10
TP-02
PRSB-15
PRSB-6
PRSB-2
TP-06
PRSB-19
TP-11
TP-12
PRSB-1
PRSB-5
TP-04
PRSB-14
TP-05
PRSB-8
PRSB-7
TP-03
PRSB-20
PRSB-21
PRSB-11
Fort Collins
COLORADO
Location Map
Legend
Soil Boring
Monitoring Well
Excel (RETEC) Test Pit
Recreation Path
Approximate Boundary of NAPL Impacts in Bedrock (dashed where inferred)
Approximate Boundary of NAPL Impacts Observed in Unconsolidated Alluvium (dashed where inferred)
Paved Area
Railroad
Approximate Boundary of NAPL Impacts Observed in Unconsolidated Alluvium and Bedrock (dashed where inferred)
Building
Approximate Extent of Old Landfill
Site Outline
N
0
100
200
Feet
POUDRE RIVER SITE
FORT COLLINS, COLORADO
FIGURE 14
RIVER CHANNEL INVESTIGATION
TRENCHING AND BORING LOCATIONS
U.S. EPA REGION VIII IN
COOPERATION WITH BROWNFIELDS
TECHNOLOGY SUPPORT CENTER
AND TETRA TECH EM, INC.


KOMATSU
17 2:20PM

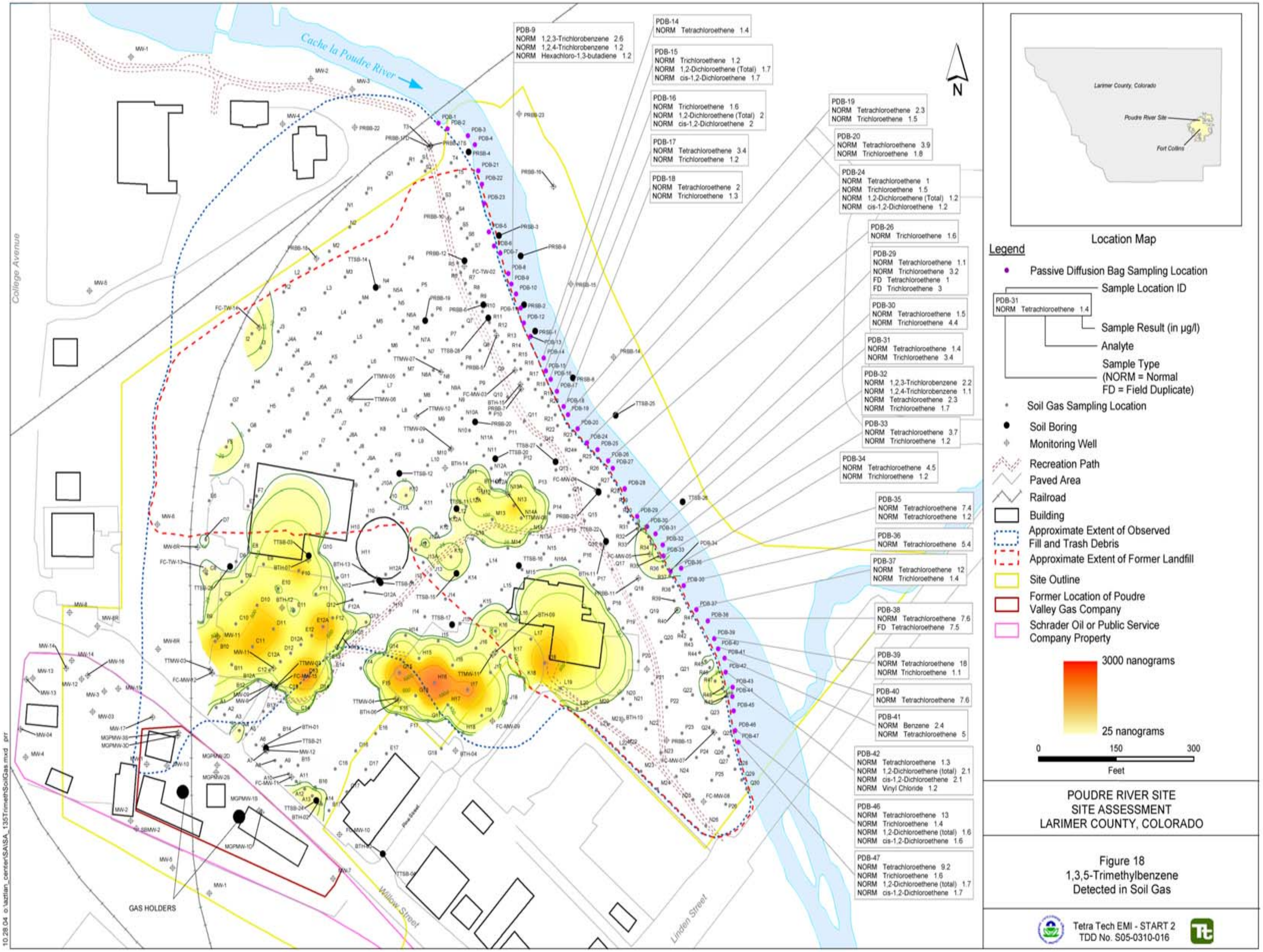

17 10:54 AM

Demonstration of Methods Applicability for Soil Gas

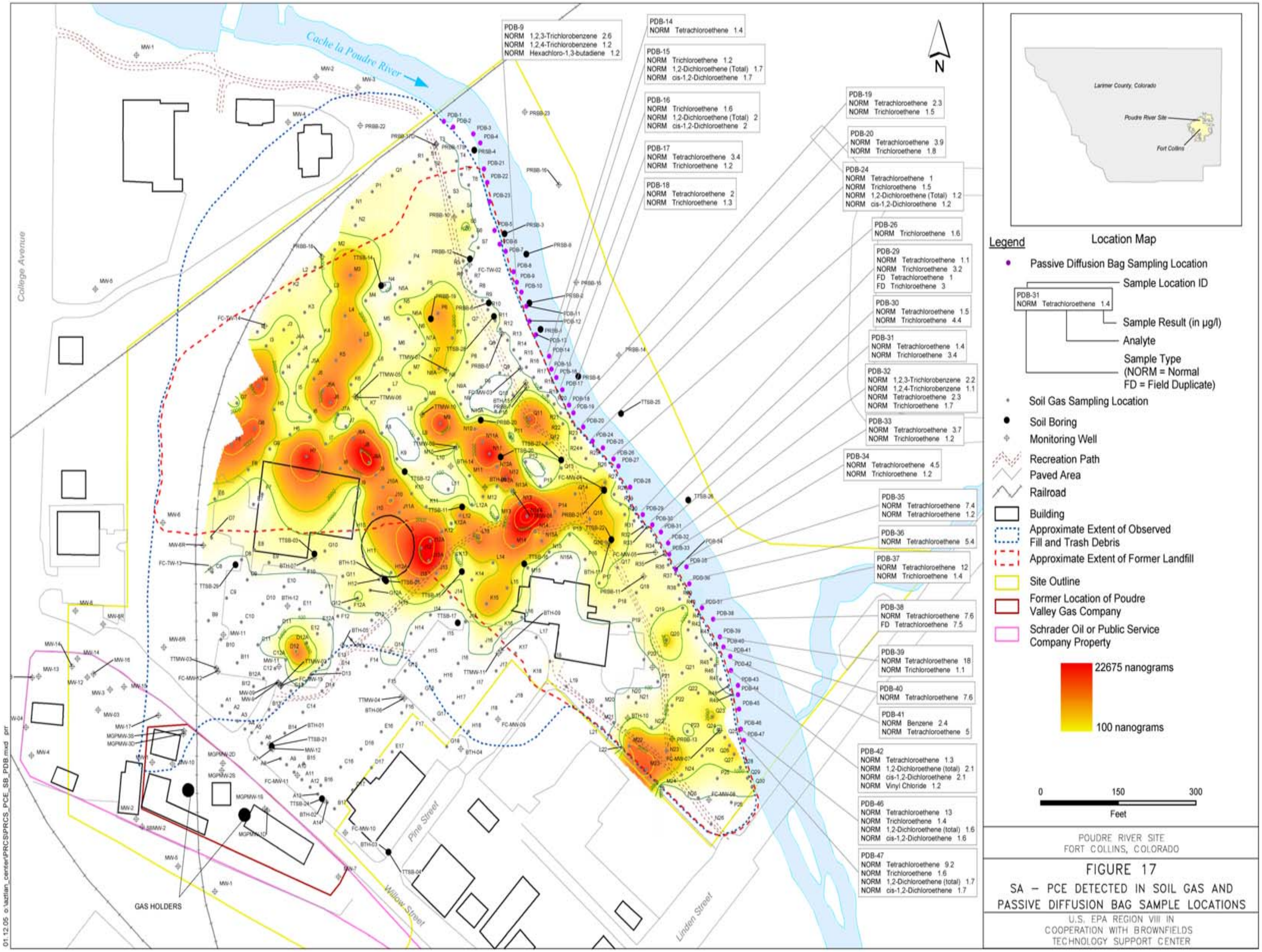


Soil Gas Sampling Locations and Chromatographs

Soil Gas Survey and Passive Bag Sampling Locations



10.28.04 o:\aztlan_center\SA\SA_135TrimethSoilGas.mxd prr



POUDRE RIVER SITE
FORT COLLINS, COLORADO

FIGURE 17
SA – PCE DETECTED IN SOIL GAS AND PASSIVE DIFFUSION BAG SAMPLE LOCATIONS

U.S. EPA REGION VIII IN COOPERATION WITH BROWNFIELDS TECHNOLOGY SUPPORT CENTER

EPA SI Bedrock Investigation

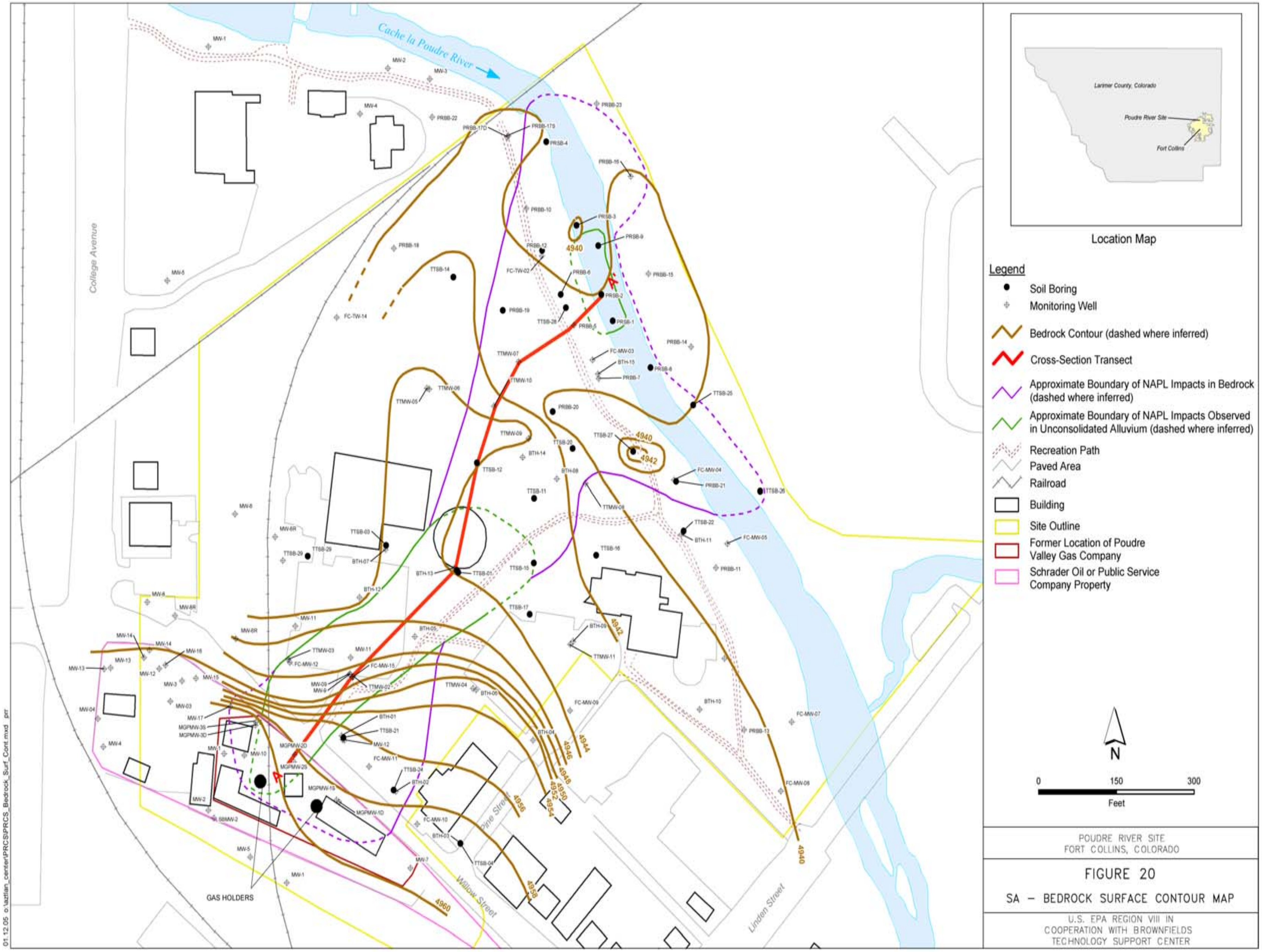
- Results of soil gas, geophysics, and trenching used to drive dynamic bedrock investigation
- Augered bore holes were advanced in strategic areas optimized using collaborative information
  - »Presence of NAPL in bedrock evaluated using visual observations and UV light box
- Boreholes were advanced deep into the bedrock based on results of trenching into bedrock near the river

And We Found................

- NAPL on a number of auger flights
  - » Some boreholes filled with NAPL and material could be collected with bailers
- NAPL sank down through the alluvium into bedrock and flowed towards the river through fractures
- Near the river the upward flow of ground water moved NAPL to top of river bed sediments
- The NAPL- coal tar material from the MGP
  - » Mixed with gasoline and diesel components in some areas, increased mobility

We Also Found.....................

- NAPL in river sediments over a 300’ stretch
- Underneath the river in the bedrock over a 600’ stretch
- NAPL has migrated slightly past the river in deep bedrock (20-25’ bgs) fractures
- “Them Beverly Hillbillies ain’t got nothin’ on us” M.Hentschel, City of FC

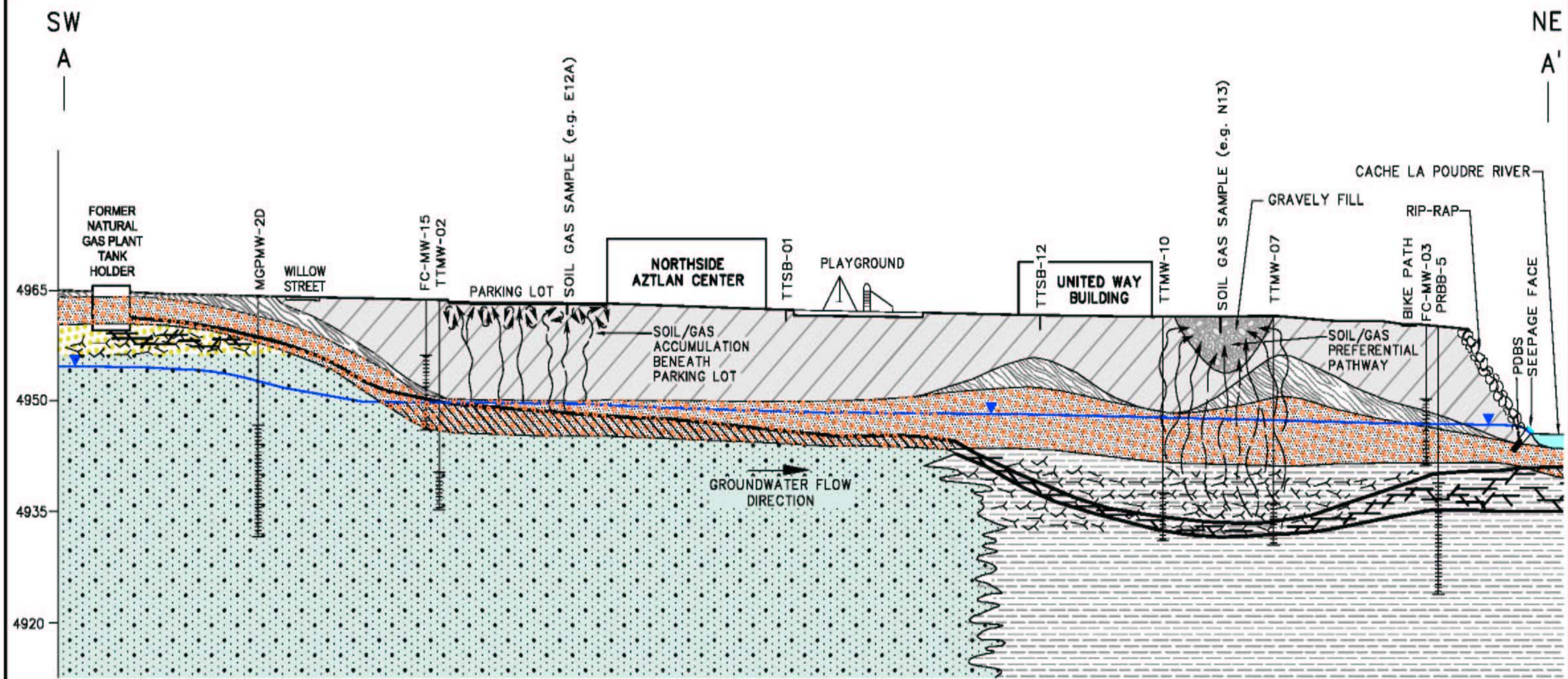


POUDRE RIVER SITE
FORT COLLINS, COLORADO

FIGURE 20

SA – BEDROCK SURFACE CONTOUR MAP

U.S. EPA REGION VIII IN COOPERATION WITH BROWNFIELDS TECHNOLOGY SUPPORT CENTER



LEGEND

- WATER TABLE (APPROXIMATE)
- POST-PINEY CREEK ALLUVIUM (UPPER HOLOCENE)
- BROADWAY ALLUVIUM (PLEISTOCENE)
- MASSIVE GLAUCANITIC SANDSTONE (PIERRE SHALE)
- LAMINATED SILTY SANDSTONE/SILTSTONE (PIERRE SHALE)
- LAMINATED, FRACTURED SILTY SANDSTONE (PIERRE SHALE)
- LANDFILL MATERIAL
- DNAPL-COAL TAR
- HIGHLY WEATHERED FRACTURED SANDSTONE (PIERRE SHALE)
- DENSE NON-AQUEOUS PHASE LIQUID (DNAPL)
- PDBS — PASSIVE DIFUSSION BAG SAMPLER
- WELL SCREEN INTERVAL
- COAL TAR

NO SCALE
HORIZONTAL VERTICAL
1:5 APPROXIMATE VERTICAL EXAGGERATION

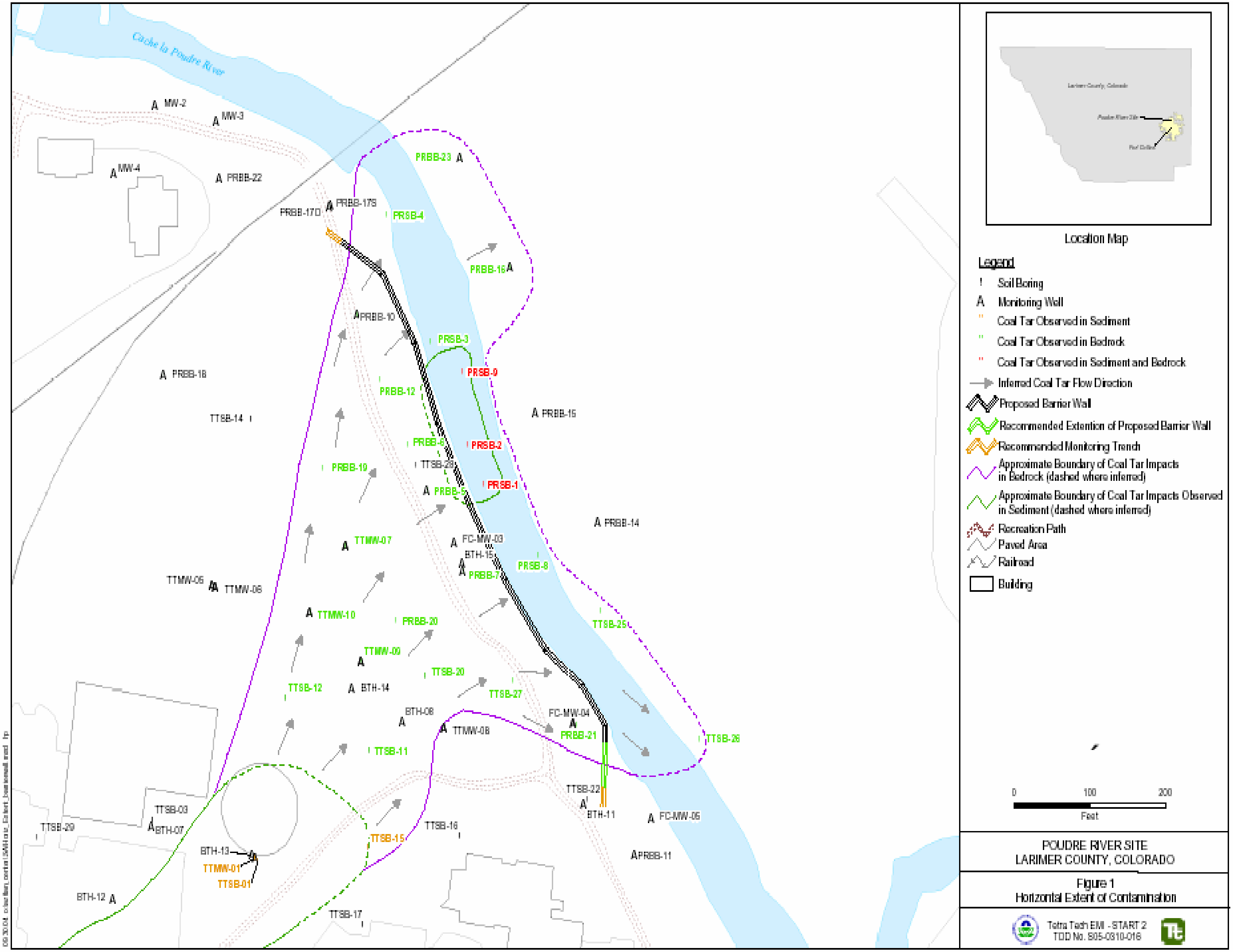
POUDRE RIVER SITE
FORT COLLINS, COLORADO

FIGURE 21
FINAL CONCEPTUAL SITE MODEL AND CROSS-SECTION

U.S. EPA REGION VIII
IN COOPERATION WITH
BROWNFIELDS TECHNOLOGY SUPPORT CENTER

So… After Some Friendly Negotiations Stakeholders Decided To……..

- Excavate the contaminated sediments and bedrock in and underneath the river
- Install a vertical sheet pile barrier with hydraulic controls to intercept the NAPL
- Provide for long-term water treatment
- Not try to dig up the source area



Cache la Poudre River
MW-2
MW-3
MW-4
PRBB-22
PRBB-23
PRBB-17D
PRBB-17S
PRSB-4
PRBB-16
PRBB-10
PRSB-3
PRSB-9
PRBB-18
PRBB-12
PRBB-15
TTSB-14
PRBB-6
PRSB-2
TTSB-28
PRBB-19
PRSB-1
PRBB-5
PRBB-14
TTMW-07
FC-MW-03
BTH-15
PRSB-8
PRBB-7
TTMW-05
TTMW-06
TTSB-25
TTMW-10
PRBB-20
TTMW-09
TTSB-20
TTSB-12
BTH-14
TTSB-27
BTH-08
FC-MW-04
TTMW-08
PRBB-21
TTSB-26
TTSB-22
BTH-11
FC-MW-05
TTSB-03
TTSB-29
BTH-07
TTSB-15
TTSB-16
BTH-13
TTMW-01
TTSB-01
PRBB-11
BTH-12
TTSB-17
Location Map
Larimer County, Colorado
Poudre River Site
Fort Collins
Legend
Soil Boring
Monitoring Well
Coal Tar Observed in Sediment
Coal Tar Observed in Bedrock
Coal Tar Observed in Sediment and Bedrock
Inferred Coal Tar Flow Direction
Proposed Barrier Wall
Recommended Extention of Proposed Barrier Wall
Recommended Monitoring Trench
Approximate Boundary of Coal Tar Impacts in Bedrock (dashed where inferred)
Approximate Boundary of Coal Tar Impacts Observed in Sediment (dashed where inferred)
Recreation Path
Paved Area
Railroad
Building
0
100
200
Feet
POUDRE RIVER SITE
LARIMER COUNTY, COLORADO
Figure 1
Horizontal Extent of Contamination
Tetra Tech EMI - START 2
TDD No. S05-0310-016

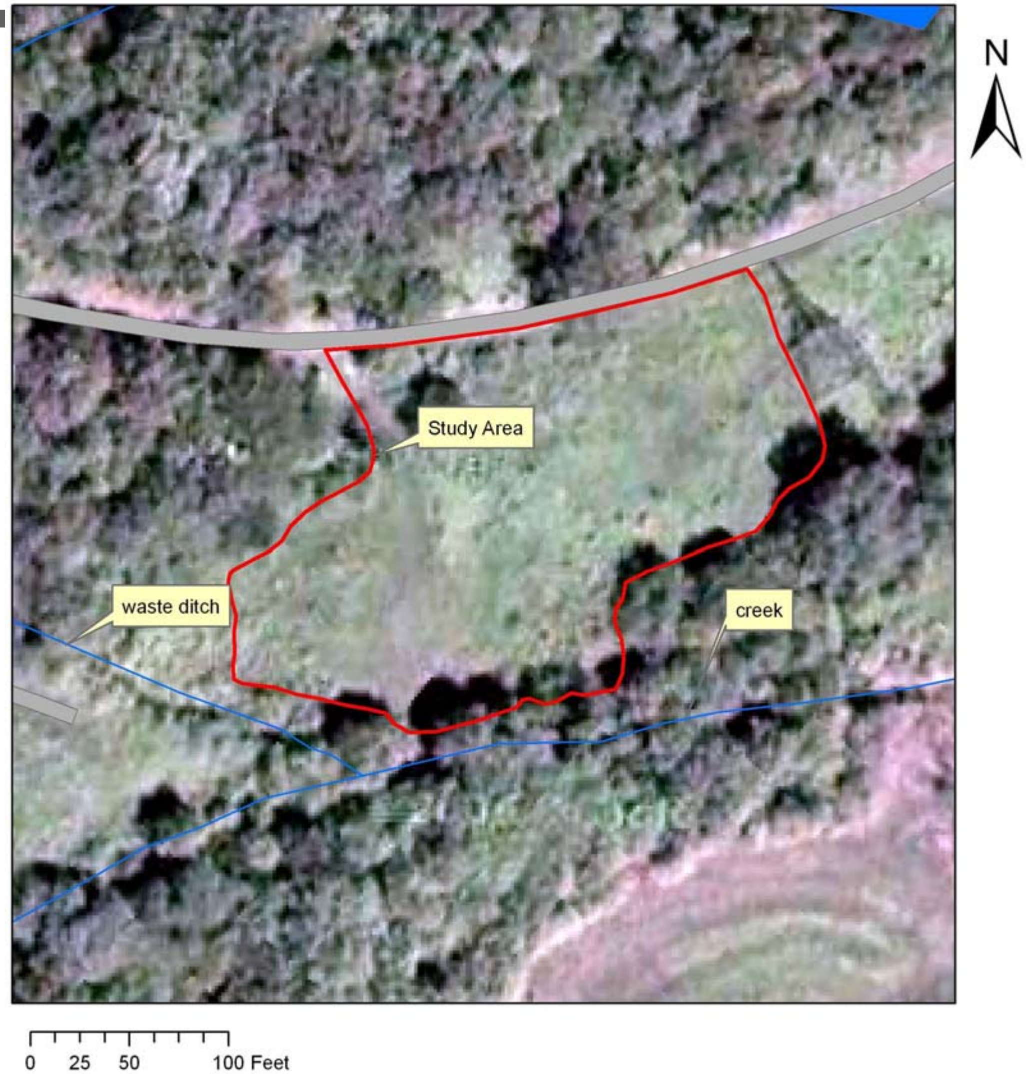

Genie

Summary

- Characterization finished in less than 1 year
  - » Only possible with a good CSM, invested/involved stakeholders, and dynamic work strategies
- Remedy in place a year after completion of investigation
- Redevelopment of new recreation center completed in 2007
- Need for long term water treatment and or source removal will be evaluated based on data to be collected over the next 5 years

Study Area

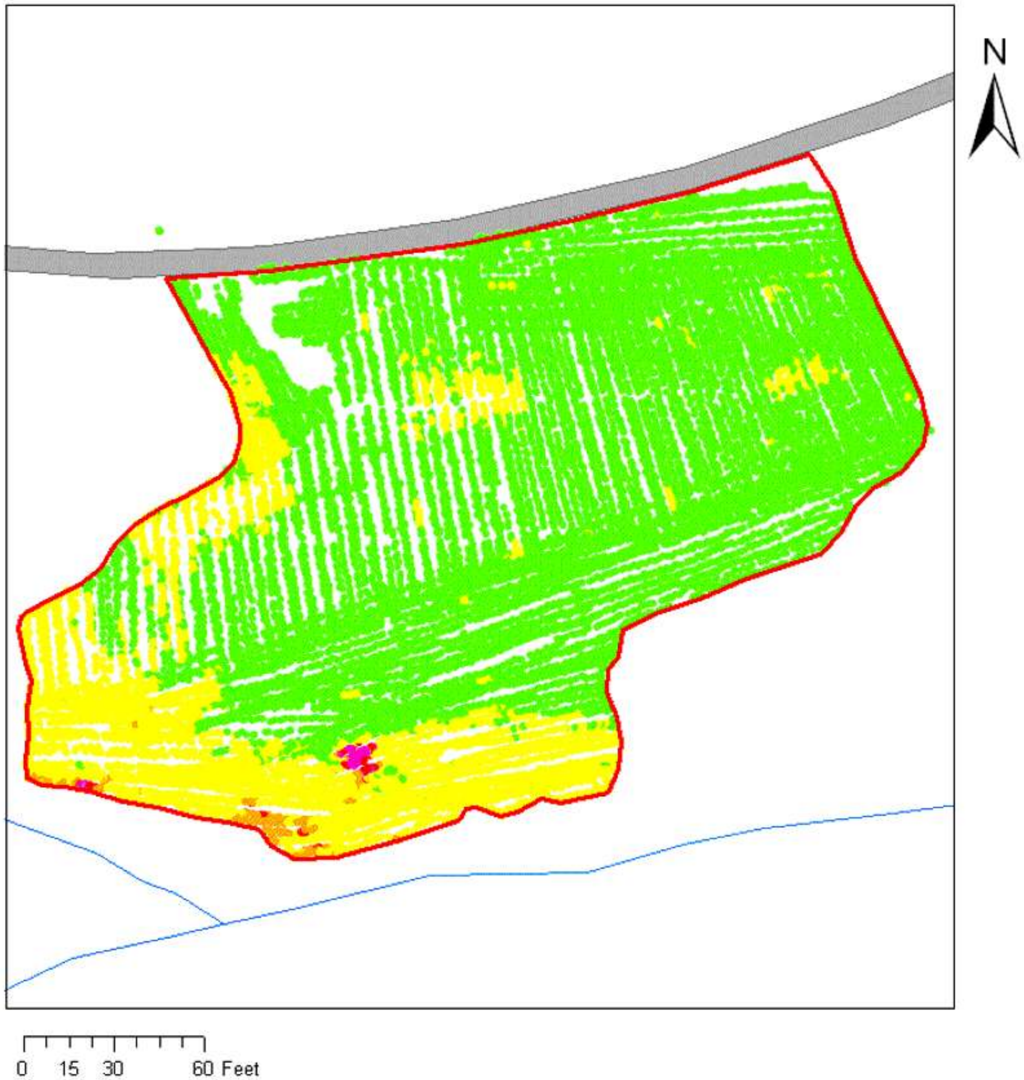
- approximately 1 acre
- mostly grassland
- bordered by waste ditch on west and creek to the south
- concern is sediment spoils from ditch and creek
- spoils placement probably 20 to 30 years ago



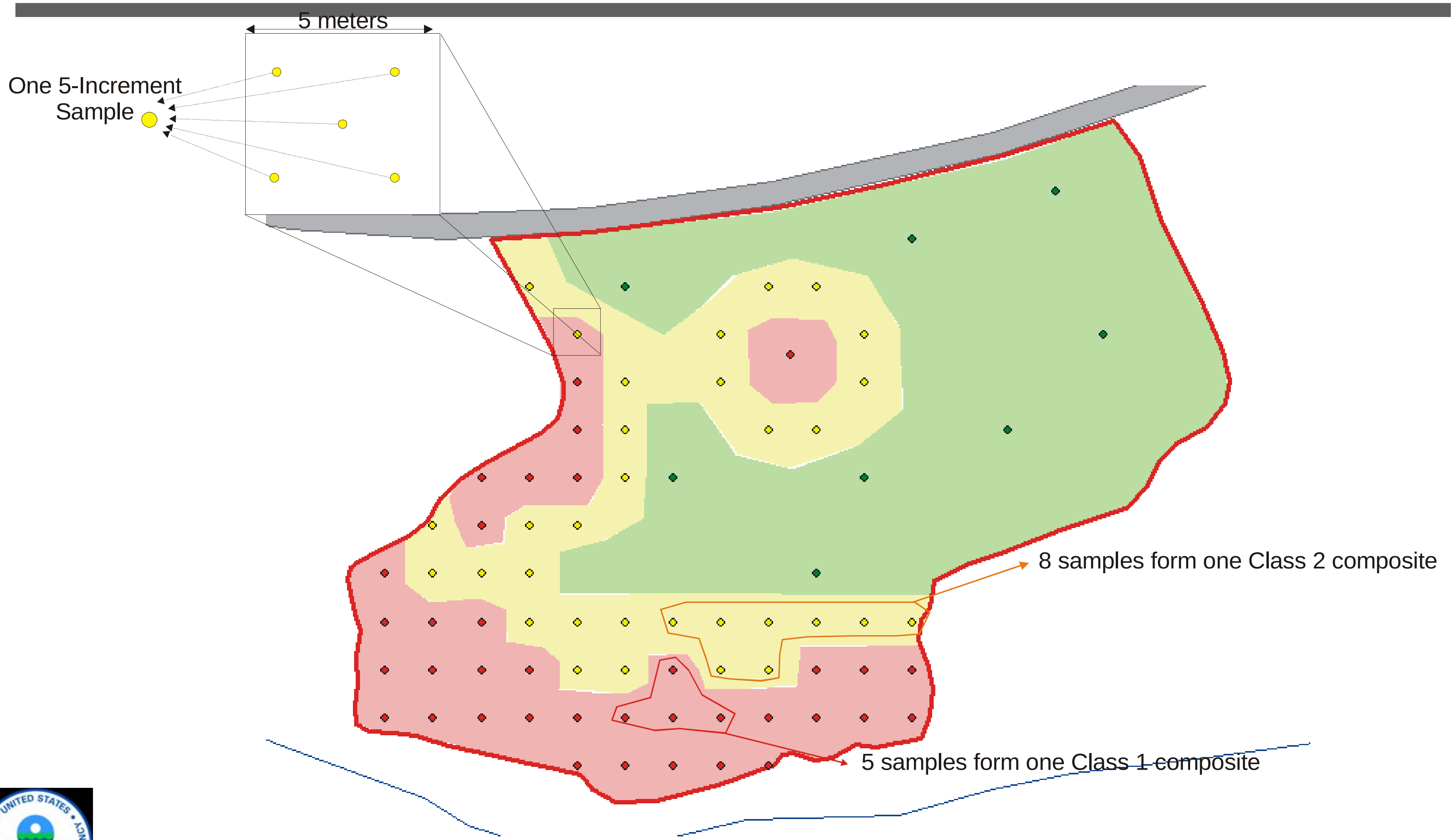
Multiple Real Time Technologies Were Deployed

- Field Instrument for Detecting Low Energy Radiation (FIDLER) – uranium
- In Situ Gamma Spec – uranium
- X-Ray Fluorescence – uranium
- Abraxis Test Kits – total PCBs

FIDLER Provided Insight Into Where Surface Contamination Might Be...



MI/Compositing Strategy…



Results...

- One Class 1 composite failed, requiring analysis of splits
- Rest passed, however the Class 1 exposure unit as a whole failed its average comparison
- 385 increments pulled, resulting in 77 MI samples, producing 18 composites for analysis, resulting in 23 XRF/PCB test kit analyses