Welcome to the CLU-IN Internet Seminar

NARPM Presents...Using Science to Find Solutions at Superfund Sites - The Benefit of EPA and USGS Collaboration

Sponsored by: U.S. EPA Office of Superfund Remediation and Technology Innovation

Delivered: April 19, 2012, 1:00 PM - 3:00 PM, EDT (17:00-19:00 GMT)

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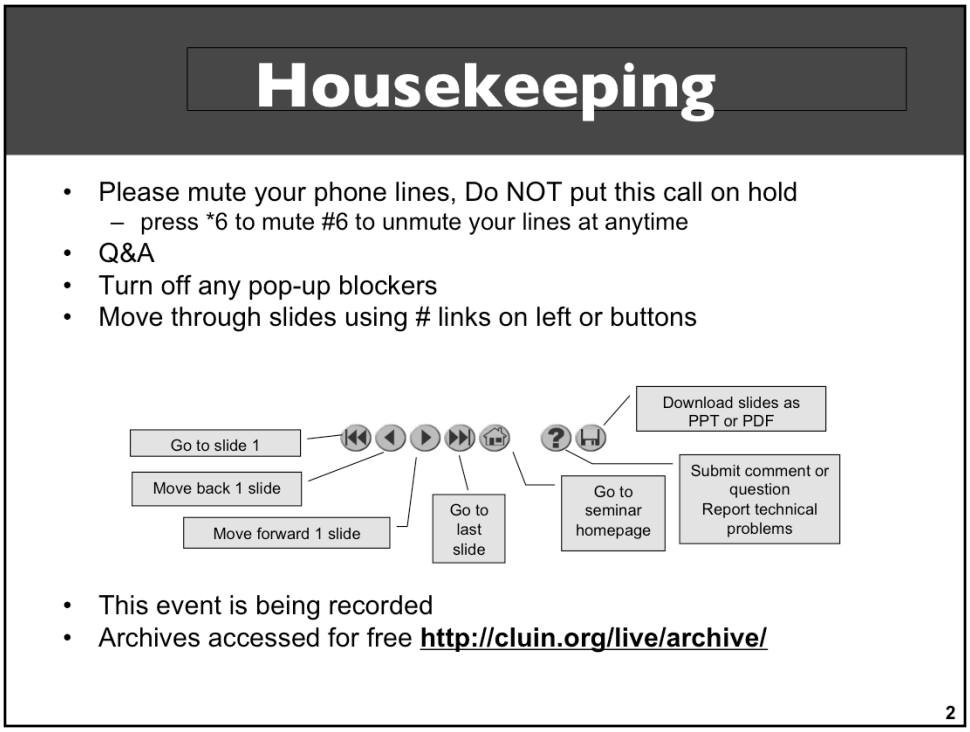
Visit the Clean Up Information Network online at www.cluin.org

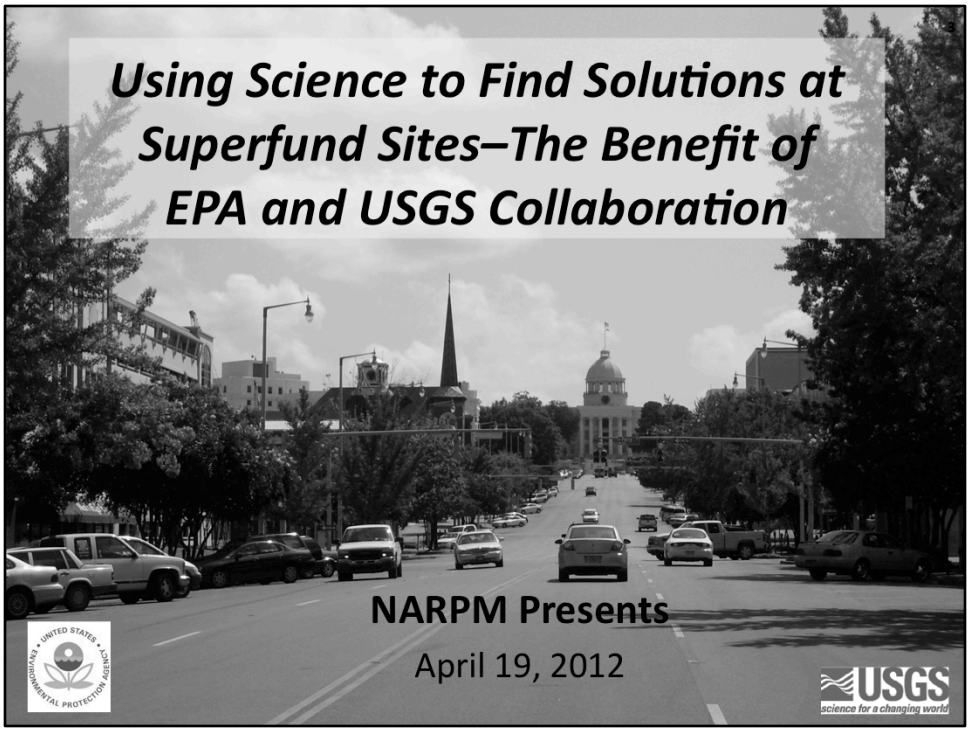


Although I'm sure that some of you have these rules memorized from previous CLU-IN events, let's run through them quickly for our new participants.

Please mute your phone lines during the seminar to minimize disruption and background noise. If you do not have a mute button, press *6 to mute #6 to unmute your lines at anytime. Also, please do NOT put this call on hold as this may bring delightful, but unwanted background music over the lines and interupt the seminar.

You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments. To submit comments/questions and report technical problems, please use the ? Icon at the top of your screen. You can move forward/ backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1st and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our agenda, speaker information, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today's presentation materials.

With that, please move to slide 3.


Using Science to Find Solutions at Superfund Sites–The Benefit of EPA and USGS Collaboration
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April 19, 2012
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4
Rusty Kestle
Scott Miller
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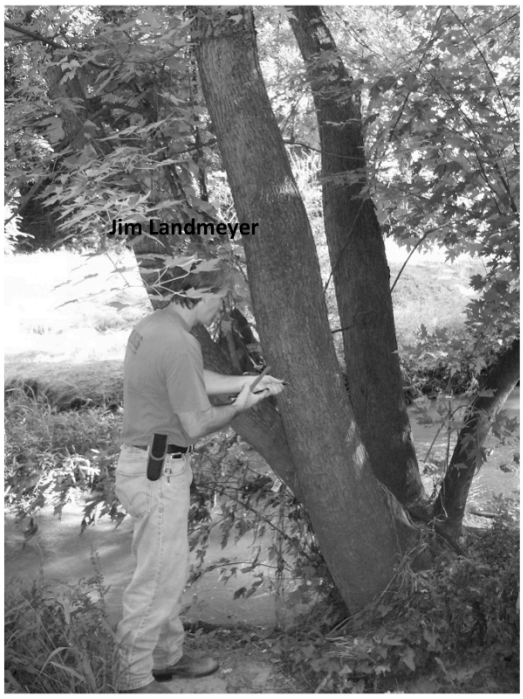

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Challenges for RPMs at Superfund Sites:

- "low-hanging" fruit has been picked
- Who are the PRPs?
- Are there potential VI issues?

- Case Study at the Capital City Plume (CCP) Site, Montgomery, AL

In 2008, EPA Region IV asked the USGS the following question:

"Why are PCE and TCE concentrations in groundwater at the Capital City Plume (CCP) Site not going down?"

…almost 17 years had gone by since initial detection of PCE in a PSW

1991–92	PCE was detected in public-supply well 9W in April 1991 at a concentration of 7.1 µg/L and at 21 µg/L in wells 9W and 9E in May 1992; both wells are in the upper part of the shallow aquifer; detections were reported by the MWWSSB.[a]
1992	Well 9W was taken out of service because of PCE contamination.
September 1993	Workers were overcome at about 25 feet below land surface by vapors during soil excavation for the RSA Energy Plant at the northeastern intersection of Monroe Street and McDonough Street. Contaminated soil was excavated and removed.[a]
October 1993	ADEM Phase I Investigation.[a]
November 1993	ADEM Phase II Investigation.[a]
February 1995	The ADEM preliminary assessment confirms detection of PCE in shallow groundwater near the RSA Energy Plant.[a]
1996	The RSA Tower is built between the intersection of Monroe Street, McDonough Street, Lawrence Street, and Madison Avenue, near the RSA Energy Plant.
	ADEM recommends that the CCP Site be considered for the Superfund list.
1997	Well 9E was taken out of service because of PCE detections.[a]
	A CPI ceases printing operations at the southeastern intersection of Washington Avenue and Lawrence Street.
2000	The USEPA proposes to list the CCP Site on the NPL.
	The USEPA begins a remedial investigation (RI).[b]
2001	The USEPA collects additional soil samples at the RSA Energy Plant.
2002	PCE is detected in Cypress Creek during USEPA sampling.
	City of Montgomery begins Feasibility Study.[c]
	A CPI relocates from the southeastern intersection of Washington Avenue and Lawrence Street to a location on Moulton Street.
2003	The Montgomery County Commission initiates an Environmental Site Assessment of a piece of property once occupied by a CPI at the southeastern intersection of Washington Avenue and Lawrence Street. A CPI that used various offset printing presses ceased operation at the intersection of Washington Avenue and McDonough Street.
2007	The City of Montgomery initiates a groundwater sampling event. Results indicate continued detections of PCE in wells.[a]

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U.S. Geological Survey

- Department of the Interior bureau
- Science organization – no regulatory or land management responsibilities
- Impartial data
- Mission
  - The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

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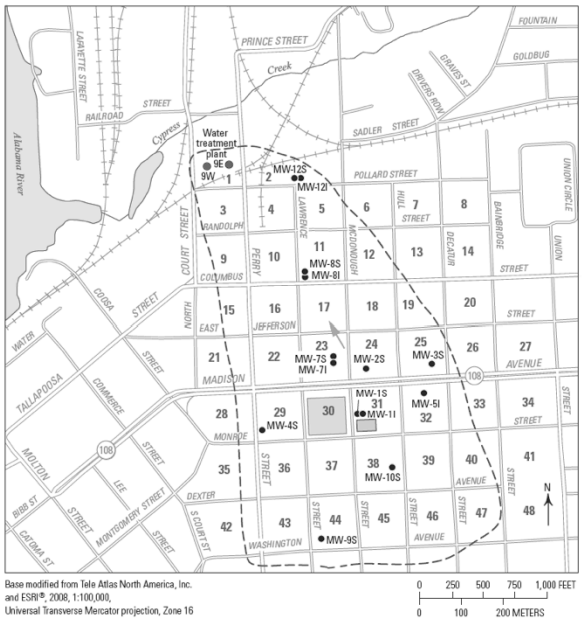
"…**source** of contamination not known…"

A common problem at some Superfund sites

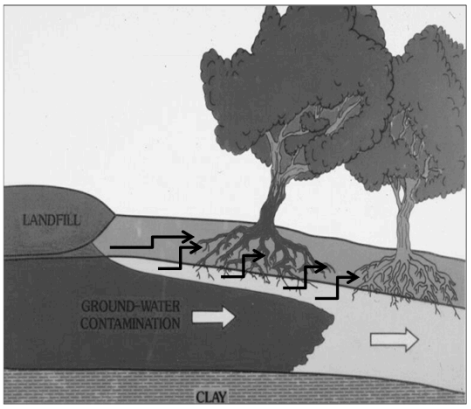
Objective Approach - 2008



Topographic and hydrologic divides.

Basic concept:

- Tree roots take up water, gasses, and associated contaminants from the subsurface.
- The contaminants move up the trunk.
- Tree coring provides a sample of the groundwater and soil gas beneath the tree.



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Method has been peer-reviewed and published

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Prepared in cooperation with the U.S. Environmental Protection Agency
Measurement and Monitoring for the 21st Century Initiative

User's Guide to the Collection and Analysis of Tree Cores to Assess the Distribution of Subsurface Volatile Organic Compounds

Scientific Investigations Report 2008–5088

U.S. Department of the Interior
U.S. Geological Survey

Environmental Science & Technology — FEATURE

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Phytoforensics, Dendrochemistry, and Phytoscreening: New Green Tools for Delineating Contaminants from Past and Present

Joel G. Burken*
Missouri University of Science and Technology, Rolla, Missouri, United States
Don A. Vroblesky
United States Geological Survey, Columbia, South Carolina, United States
Jean Christophe Balouet
Environment International, Paris, France

ABSTRACT: As plants evolved to be extremely proficient in mass transfer with their surroundings and survive as earth's dominant biomass, they also accumulate and store some contaminants from surroundings, acting as passive samplers. Novel applications and analytical methods have been utilized to gain information about a wide range of contaminants in the biosphere soil, water, and air, with information available on both past (dendrochemistry) and present (phytoscreening). Collectively these sampling approaches provide rapid, cheap, ecologically friendly, and overall "green" tools termed "Phytoforensics".

Plants interact intimately with their environment, extracting water, CO_2, macro- and micronutrients from their surroundings, even when these life essentials are present at minute concentrations. Extraction processes also collect contaminants from surrounding water, air, and soil. Innovative sampling and analytical approaches have been developed to assess contamination extent and document pollution history. Sampling is rapid, fast, inexpensive, and causes little or no discernible damage to personal property or ecological systems we protect.

Vascular plants develop an extensive subsurface root system and an expansive aerial network of leaves both with transcendus surface area. The surface area of both roots and leaves of our earth's plants have greater surface area than the footprint of earth's land surface. The extensive network linking the subsurface and atmosphere provides all nutrients, water, and CO_2 necessary for the growth of the vast majority of the earth's terrestrial biomass.[1] The linkage between the subsurface and air provided by vascular plants is the largest biologically mediated energy-transfer process on terrestrial earth, and the transfer is certainly not passive. The active transport of groundwater to and into root systems is fueled by evapotranspiration, driven primarily by solar and wind energy. Over 60% of annual precipitation is evapotranspired back to the atmosphere, meaning plants remove more terrestrial water than all river flows combined.[2] Based on an understanding of plants' interactions with surroundings, plants have been used as indicators of their environments for millennia, back to Roman times when willow and poplar stands indicated the presence of a shallow groundwater table and a good location for placement of drinking wells.

As plants transpire water, many dissolved constituents are translocated concurrently. Thus, the water and wood of a tree is partly a reflection of groundwater chemistry, as depicted in Figure 1. This concept has been applied in recent research and applications using plants as bioindicators to map environmental pollutants,[3] termed "phytomonitoring" or "phytoscreening".[4] These methods target organic contaminants in plant tissues as indicators of soil,

Published: June 14, 2011

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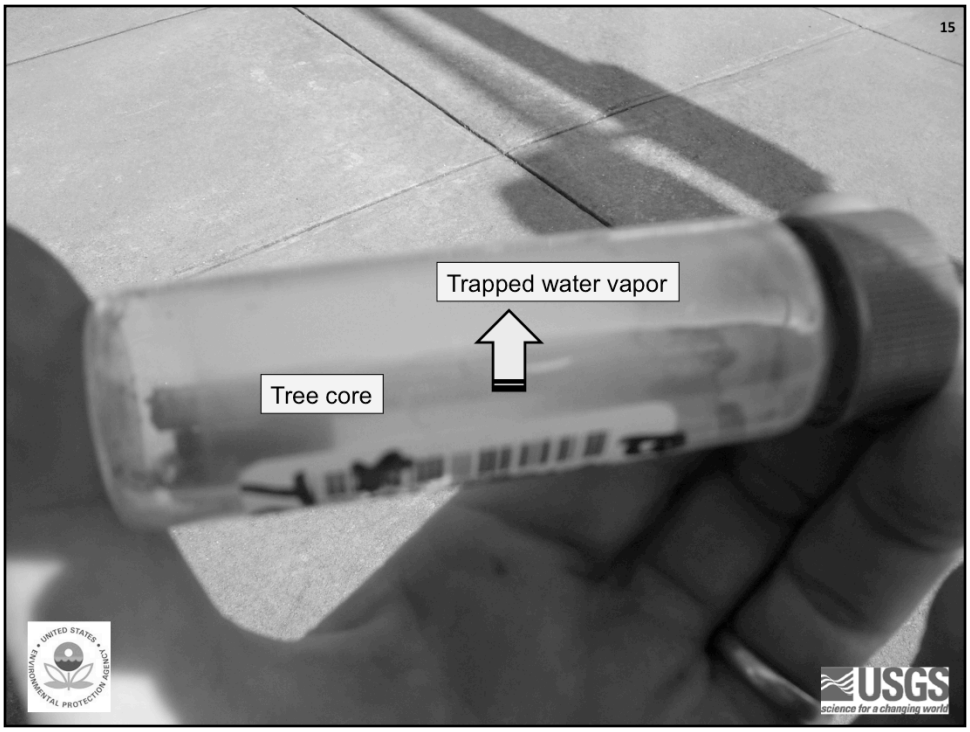
15
Trapped water vapor
Tree core
USGS
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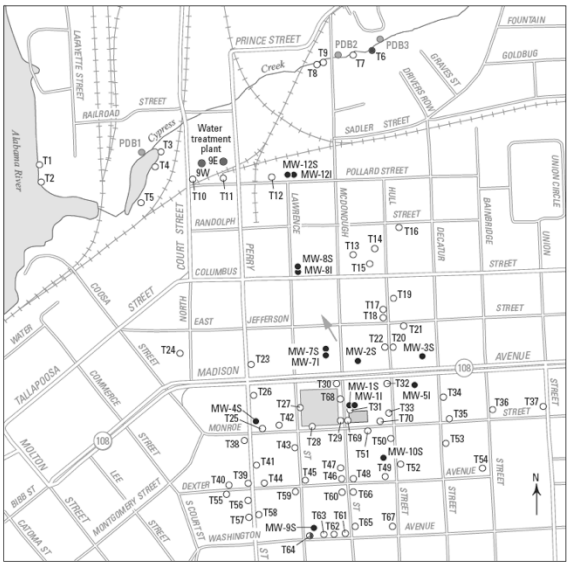
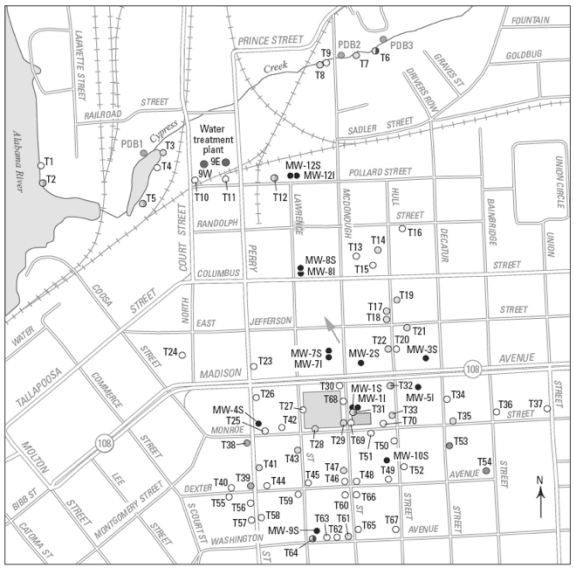
Data -2008



T24○ Tree-core and identifier, August 2008

PDB1◉ Passive diffusion bag (PDB) sampler and identifier

Data - 2008



Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

Tree-core identifier with VOC detected above MRL in vial headspace containing a tree core

- T19 Trichloroethylene (TCE)
- T39 Perchloroethylene (PCE)
- T32 TCE and PCE
- T6 TCE and cis-1,2-dichloroethylene (cis-1,2-DCE)
- T52 Benzene or toluene

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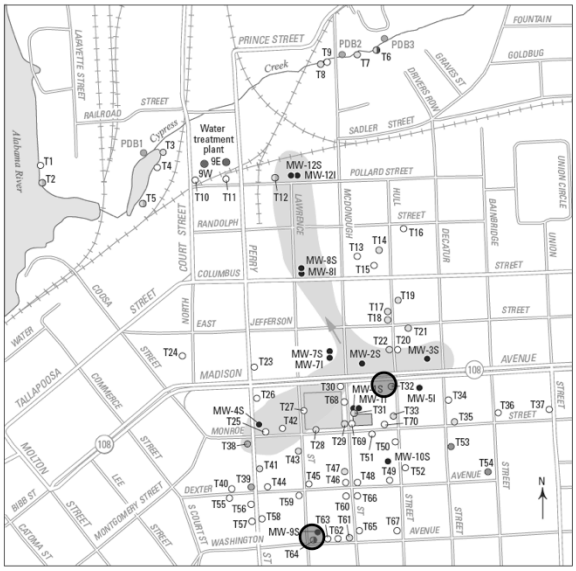
Result

1. PCE and TCE detected **upgradient** of previously mapped groundwater "plume" locations

Data - 2008


PRINCE STREET
FOUNTAIN
GOLDBUG
PDB1
PDB2
PDB3
Water treatment plant
MW-12S
MW-12I
POLLARD STREET
SADLER STREET
RAILROAD STREET
Alabama River
Cypress Creek
RANDOLPH
COLUMBUS
COURT STREET
MW-9S
MW-9I
MW-7S
MW-7I
MW-2S
MW-3S
MW-5I
MW-4S
MW-10S
MADISON AVENUE
JEFFERSON
MONROE
DEXTER
WASHINGTON
MOLTON STREET
MONTGOMERY STREET
TALLAPOOSA STREET
COMMERCE STREET
WATER STREET
COOSA STREET
LEE STREET
BIBB ST
CATOMA ST
S COURT ST
UNION CIRCLE
Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16
0 250 500 750 1,000 FEET
0 100 200 METERS
N


20
USGS
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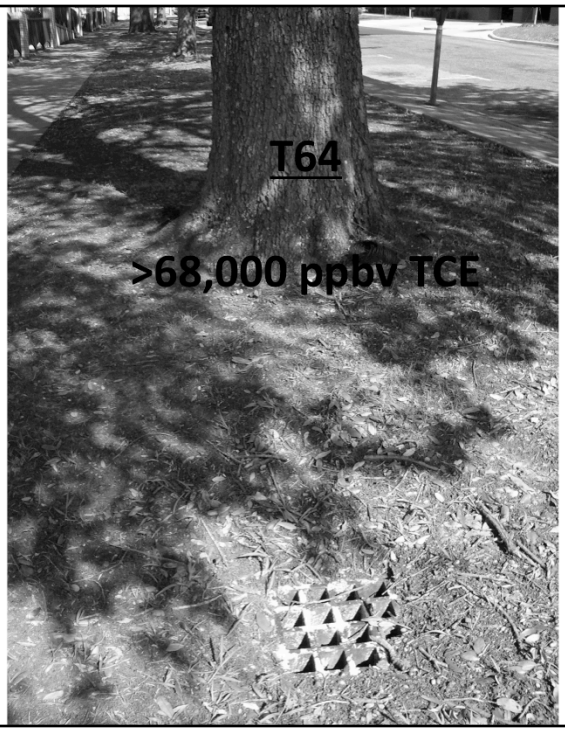
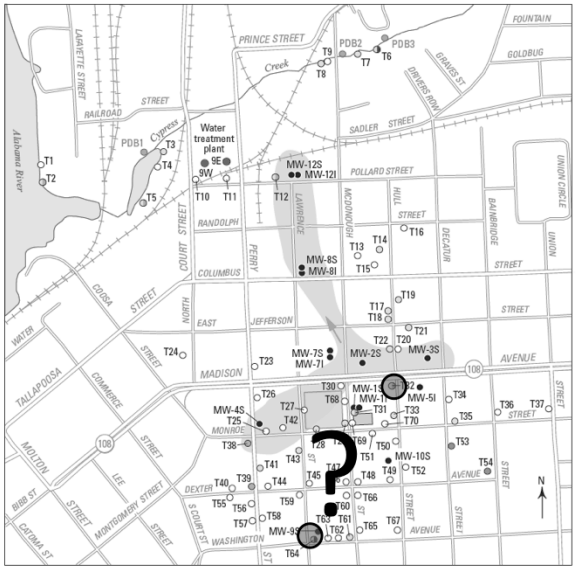
Washington Ave.


T64
>68,000 ppbv TCE

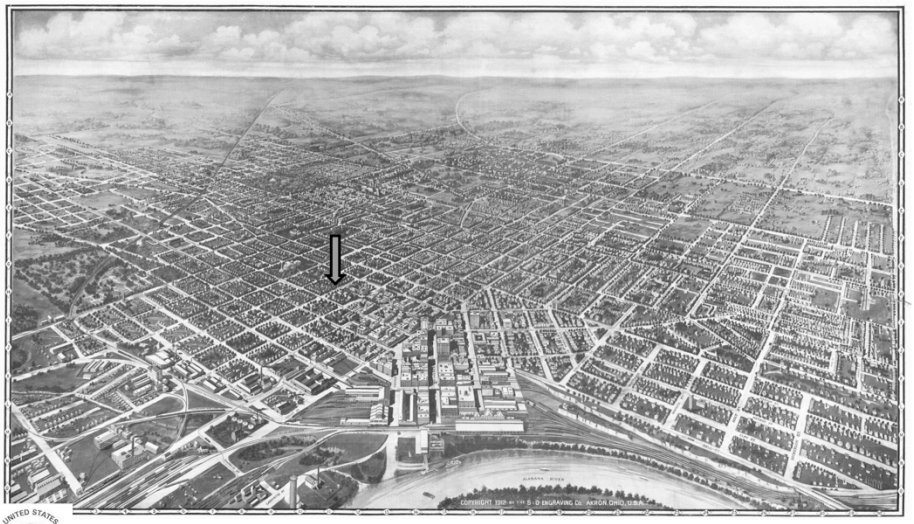
2008


PRINCE STREET
FOUNTAIN
GOLDBUG
LAFAYETTE STREET
RAILROAD
STREET
Creek
PDB1
PDB2
PDB3
Cypress
Water treatment plant
9E
9W
SADLER STREET
DRIVERS RAMP
GRAVES ST
Alabama River
MW-12S
MW-12I
POLLARD STREET
UNION CIRCLE
COURT STREET
RANDOLPH
LAWRENCE
MCDONOUGH
HULL
DECATUR
BAINBRIDGE
UNION
COLUMBUS
FERRY
MW-8S
MW-8I
COOSA
NORTH
EAST
JEFFERSON
WATER
MADISON
MW-7S
MW-7I
MW-2S
MW-3S
AVENUE
TALLAPOOSA
COMMERCE
MW-4S
MW-1S
MW-5I
MONROE
MOLTON
LEE
DEXTER
MW-10S
BIBB ST.
MONTGOMERY
S COURT ST
WASHINGTON
MW-9S
CATOMA ST.
N
Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16
0 250 500 750 1,000 FEET
0 100 200 METERS

1887

Looking at Land Use History

1912



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25
Dexter Ave.
USGS
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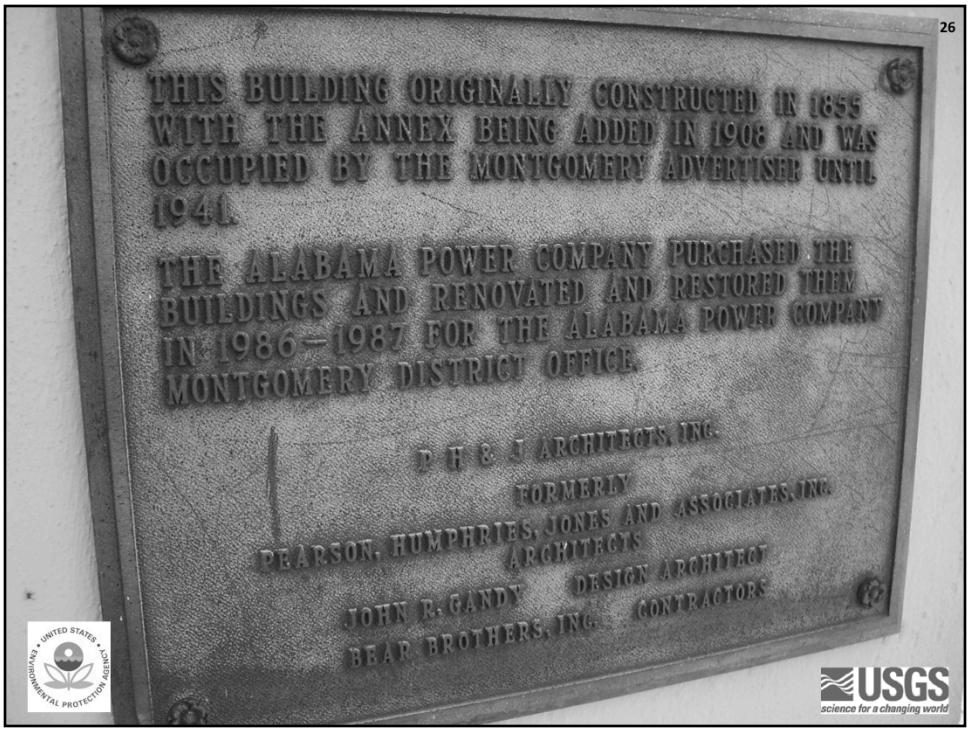
26
THIS BUILDING ORIGINALLY CONSTRUCTED IN 1855
WITH THE ANNEX BEING ADDED IN 1908 AND WAS
OCCUPIED BY THE MONTGOMERY ADVERTISER UNTIL
1941.
THE ALABAMA POWER COMPANY PURCHASED THE
BUILDINGS AND RENOVATED AND RESTORED THEM
IN 1986–1987 FOR THE ALABAMA POWER COMPANY
MONTGOMERY DISTRICT OFFICE.
P H & J ARCHITECTS, INC.
FORMERLY
PEARSON, HUMPHRIES, JONES AND ASSOCIATES, INC.
ARCHITECTS
JOHN P. GANDY DESIGN ARCHITECT
BEAR BROTHERS, INC. CONTRACTORS
USGS
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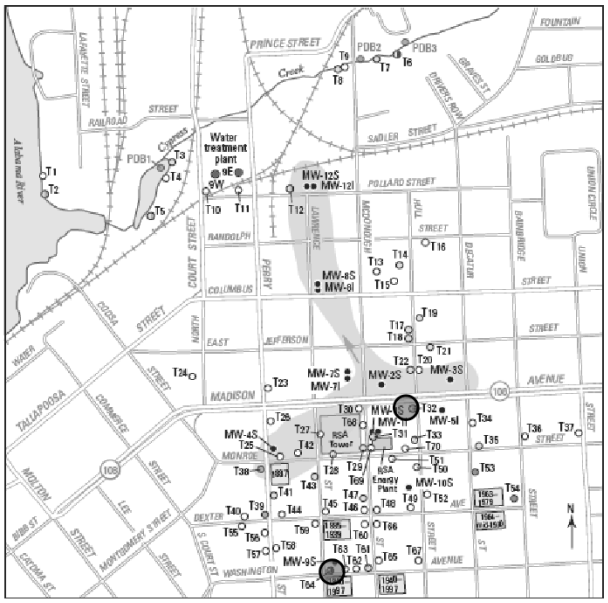
Data - 2008

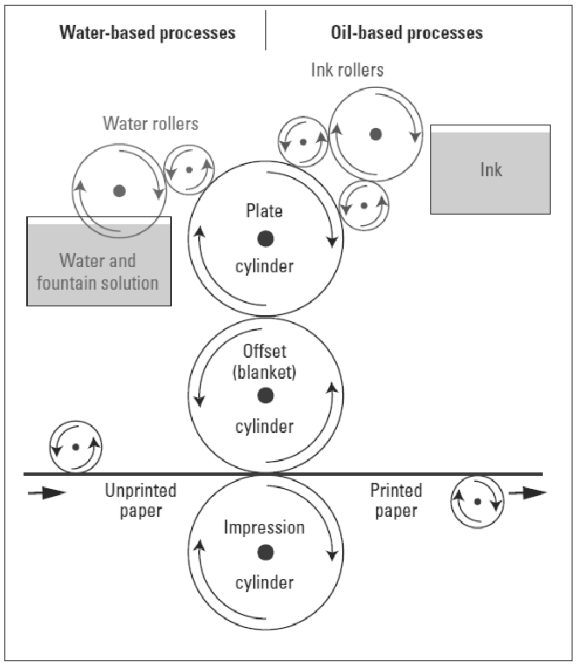


Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

Result

1. PCE and TCE detected **upgradient** of groundwater "plume" locations
2. PCE and TCE detected near locations of former **printing** operations

How would Printing be related to PCE and TCE?


Water-based processes
Oil-based processes
Ink rollers
Water rollers
Ink
Plate
cylinder
Water and
fountain solution
Offset
(blanket)
cylinder
Unprinted
paper
Printed
paper
Impression
cylinder

Blanket wash

1) Toluene
2) Methyl Ethyl Ketone (MEK)
3) Glycol Ethers
4) Xylene (mixed isomers)
5) Tetrachloroethylene
6) Methyl Isobutyl Ketone (MIBK)
7) Methanol
8) 1,1,1-Trichloroethane (TCA)
9) Dichloromethane
10) Ethylene Glycol

Fountain Solutions

Result

1. PCE and TCE detected **upgradient** of groundwater "plume" locations
2. PCE and TCE detected near locations of former **printing** operations
3. PCE and TCE were used by printing operations

What was done with the daily waste stream?

- "…dumped down drain…"
- "…washed in machine…"
- Floor sumps
- Picked up by Safety Kleen starting inlate 1960s

(quotes from responses to EPA Section 104(e) Information Requests)

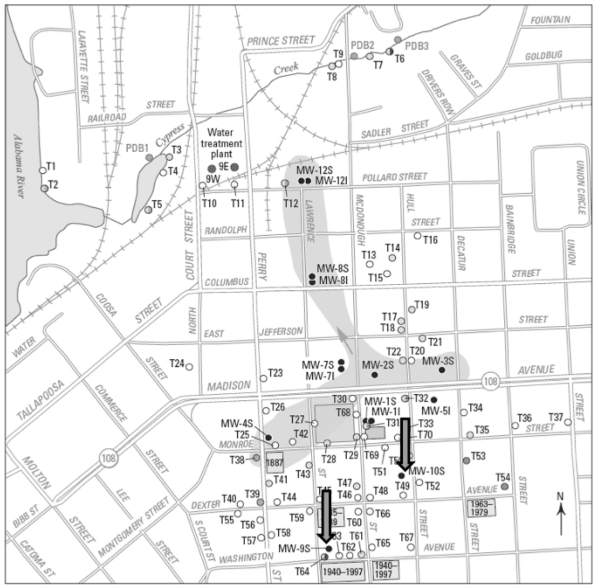
Result

1. PCE and TCE detected **upgradient** of groundwater "plume" locations
2. PCE and TCE detected near locations of former **printing** operations
3. PCE and TCE were used by printing operations
4. Disposal down **drains**

How did this behavior result in contamination of the subsurface nearby and, ultimately, groundwater?

Surface — soil — groundwater pathway

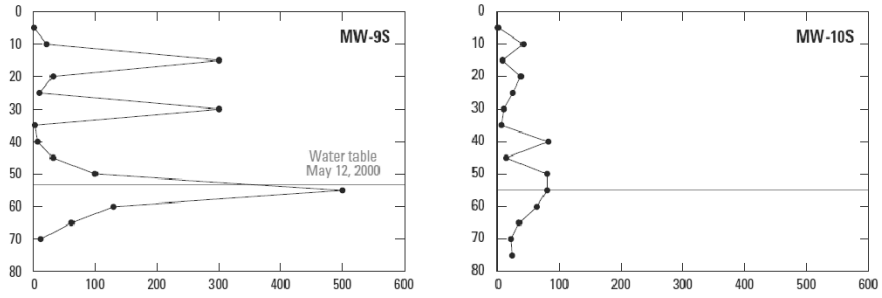
2008



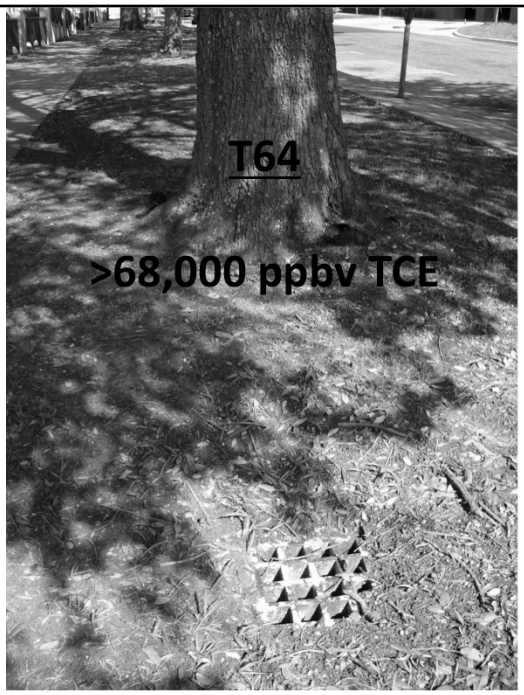
Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

0 250 500 750 1,000 FEET
0 100 200 METERS

Data -EPA RI, 2000



VOCs, ppm



2008

Older subsurface drainage grate


2011
USGS Track-mounted
Geoprobe
T64
USGS
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40
BENSEAL
Vapor Implant
USGS
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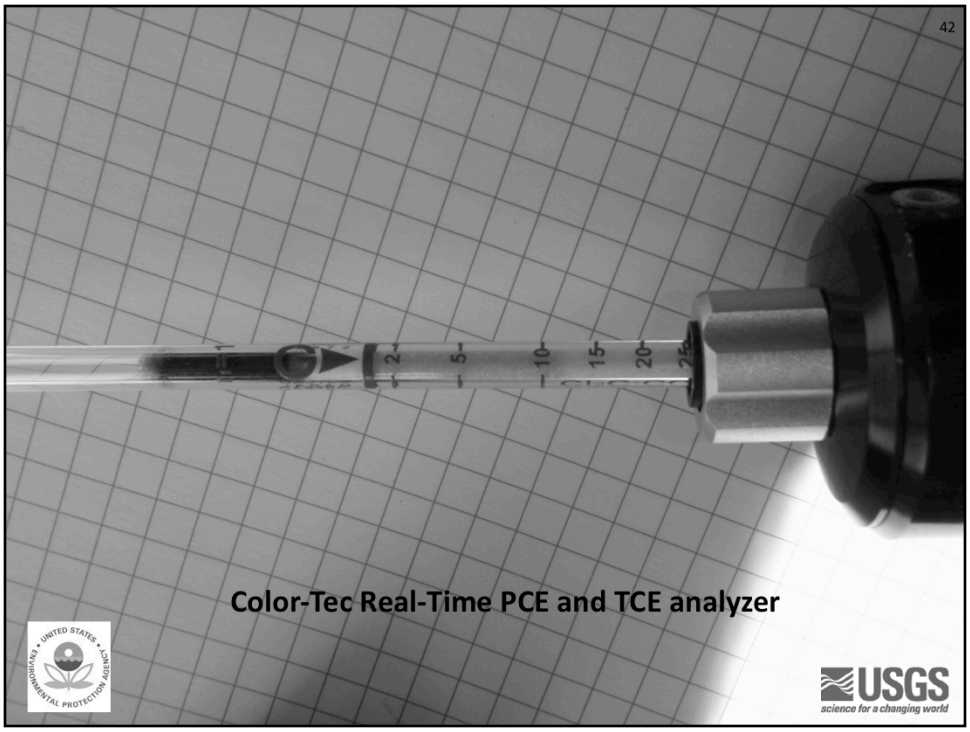
41
1.9
Hand-held PID
USGS
science for a changing world


42
Color-Tec Real-Time PCE and TCE analyzer
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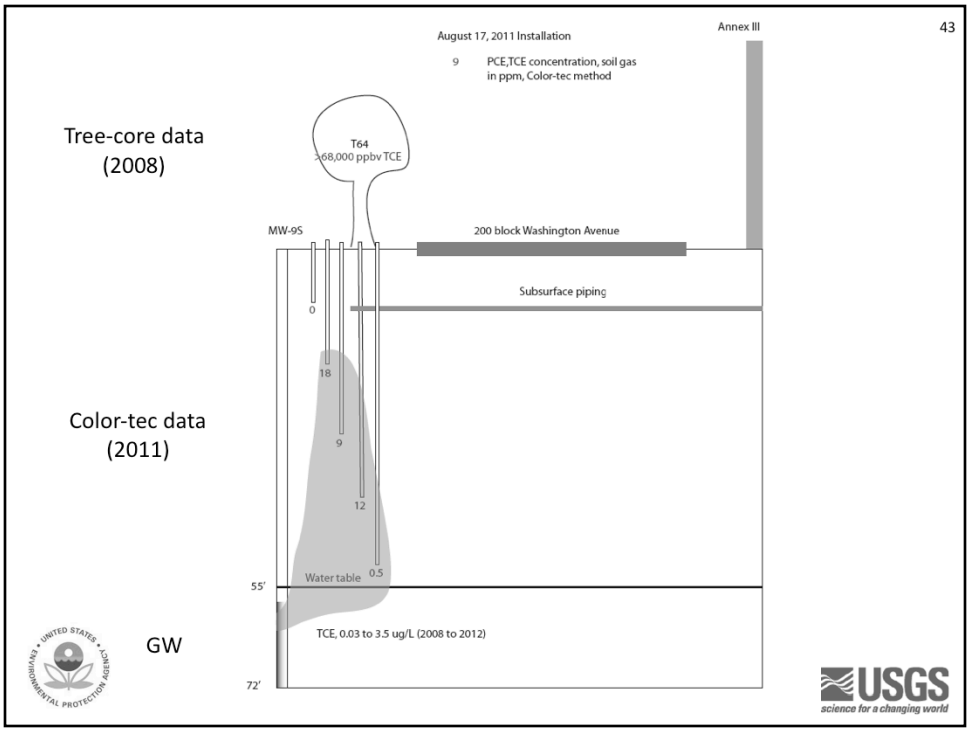
Annex III
43
August 17, 2011 Installation
9 PCE,TCE concentration, soil gas in ppm, Color-tec method
Tree-core data (2008)
T64
>68,000 ppbv TCE
MW-9S
200 block Washington Avenue
Subsurface piping
0
18
9
12
0.5
Color-tec data (2011)
Water table
55'
TCE, 0.03 to 3.5 ug/L (2008 to 2012)
GW
72'
USGS
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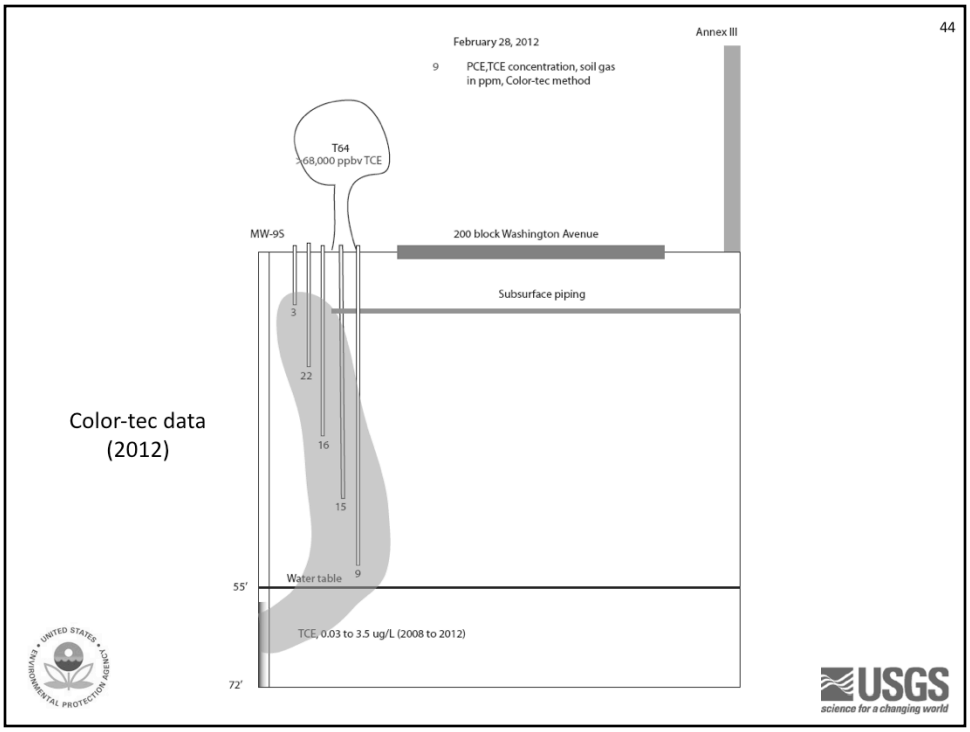
Annex III
February 28, 2012
9 PCE,TCE concentration, soil gas in ppm, Color-tec method
T64
>68,000 ppbv TCE
MW-9S
200 block Washington Avenue
Subsurface piping
3
22
16
15
9
Water table
55'
TCE, 0.03 to 3.5 ug/L (2008 to 2012)
72'
Color-tec data (2012)
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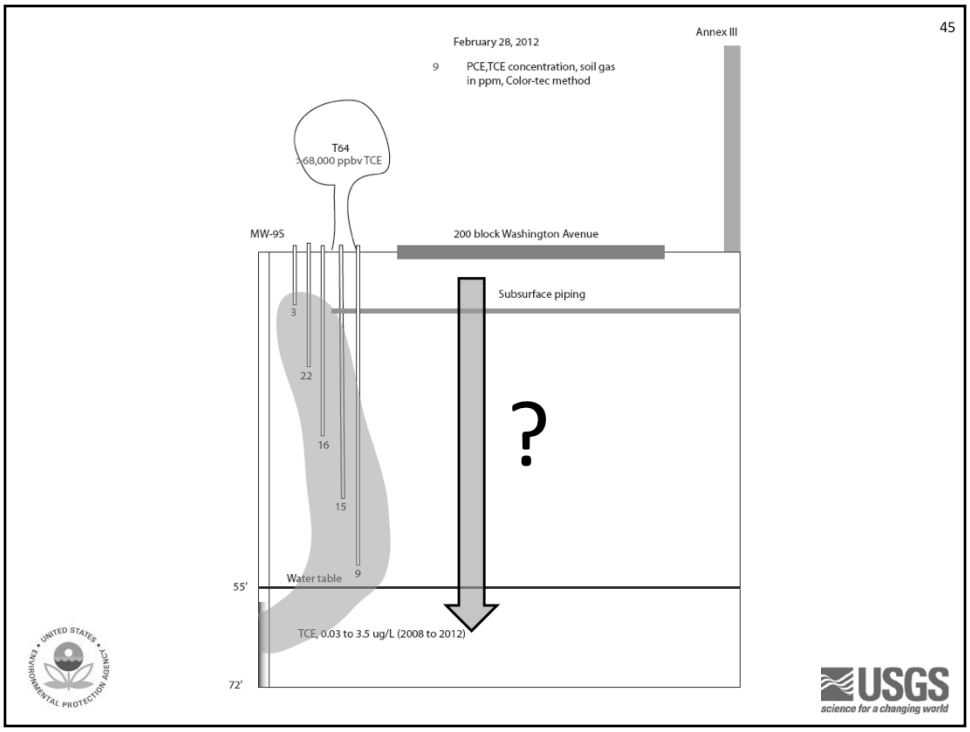
Annex III
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9 PCE,TCE concentration, soil gas in ppm, Color-tec method
T64
>68,000 ppbv TCE
MW-9S
200 block Washington Avenue
Subsurface piping
3
22
16
15
9
?
Water table
55'
TCE, 0.03 to 3.5 ug/L (2008 to 2012)
72'
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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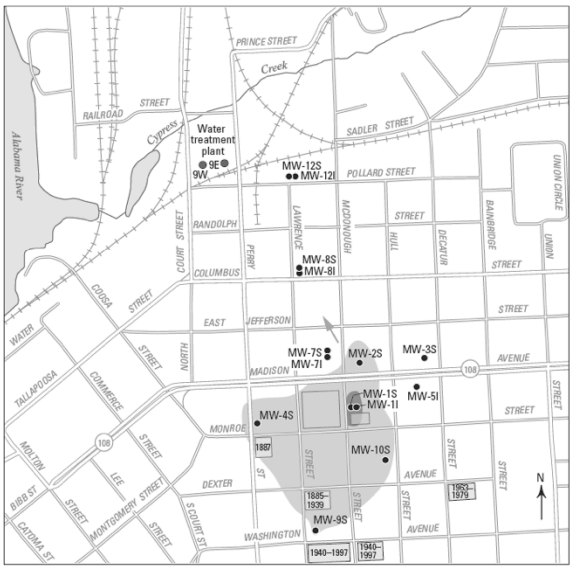

Chloroform in groundwater—
In micrograms per liter,
April–May 2009

> 1

> 35

Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

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Chloroform in groundwater?

- Chloroform added to water at the water plant
- Treated water has 2 to 44 ug/L
- MW-1S = 37.3 ug/L
- MW-1S has pH near 7.3 (all other wells less than 6)

Chloroform in groundwater?

- How did treated municipal water get to the water table?
- Possible cracks, root penetration (leakage) in sewer system
- Common to many municipal SS around the country.


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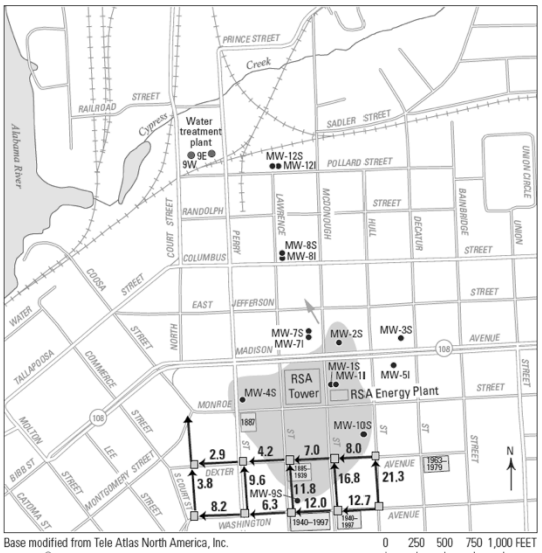
So what?

A tracer of what has been put into the sewer (treated water and/or wastes) at **land surface** in upgradient area can enter the **water table**



2.9 ← Sanitary sewer system gradient, in percent, flow direction, and subsurface junction box

Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

0 250 500 750 1,000 FEET
0 100 200 METERS

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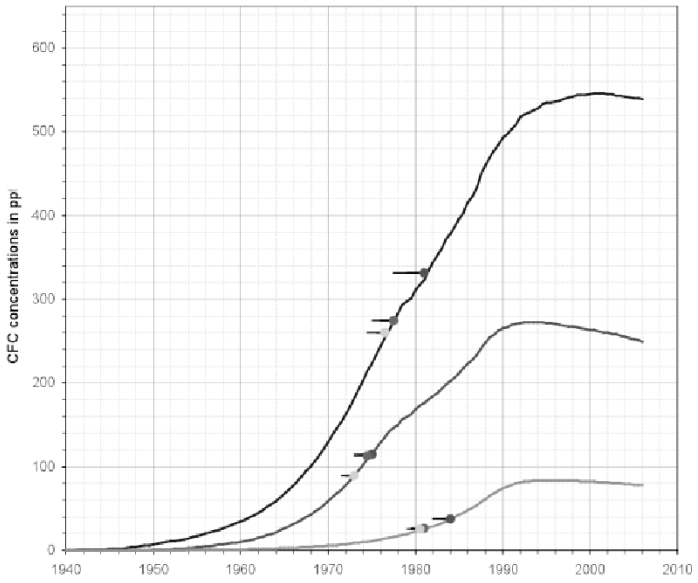
What about the timing of the release(s)?

- Years businesses operated related to age of plume?

CFCs in groundwater

- CFC (-11 and -113) are man-made
- All water older than 1940 has 0 ug/L CFCs
- If detected in water, it is no older than 1940
- CFC are in recharge everywhere


CFC concentrations in pp
600
500
400
300
200
100
0
1940
1950
1960
1970
1980
1990
2000
2010
Year of recharge

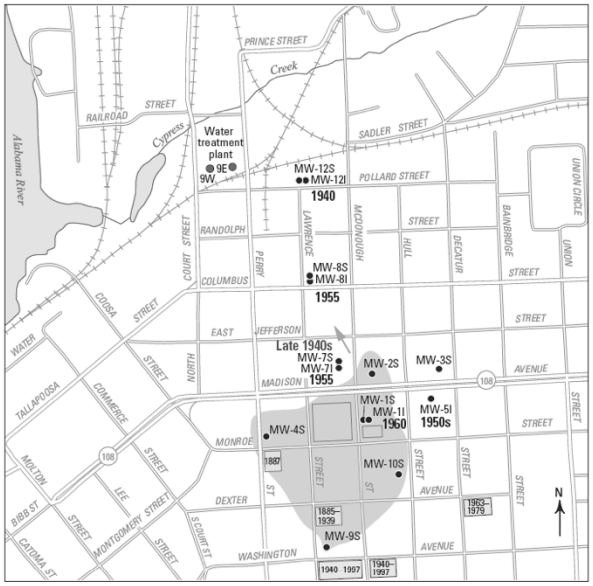
CFCs in groundwater at CCP Site

- Present in only the **shallow** well
- Not present in all wells
- In groundwater at concentrations greater than possible for equilibrium with CFC-enriched air
- CFCs are enriched over urban areas (USGS Fact Sheet 022-02)

CFCs in groundwater

So what?

CFC-enriched water is further evidence of stormwater or sewer pipes leakage from land surface to groundwater, and the timing of occurrence.


PRINCE STREET
Creek
RAILROAD
STREET
Cypress
Water treatment plant
9E
9W
SADLER STREET
MW-12S
MW-12I
1940
POLLARD STREET
UNION CIRCLE
Alabama River
RANDOLPH
LAWRENCE
McDONOUGH
HULL
DECATUR
BAINBRIDGE
STREET
UNION
COURT STREET
PERRY
COLUMBUS
MW-8S
MW-8I
1955
COOSA
STREET
EAST
JEFFERSON
WATER
Late 1940s
MW-7S
MW-7I
1955
MW-2S
MW-3S
AVENUE
NORTH
MADISON
108
TALLAPOOSA
COMMERCE
STREET
MW-1S
MW-1I
1960
MW-5I
1950s
MONROE
MW-4S
MILTON
LEE
1887
MW-10S
DEXTER
1885–1939
1953–1979
BIBB ST
MONTGOMERY
SCHUYLER
MW-9S
WASHINGTON
AVENUE
CATOMA ST
1940–1997
1940–1997
N
Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16
0 250 500 750 1,000 FEET
0 100 200 METERS
Groundwater recharge date, based on CFC concentration, May 2010
Late 1940s Shallow well
1955 Intermediate well
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SF_6 in groundwater

- Sulfur hexafluoride (SF_6) is a gas present at trace levels in the atmosphere that has natural and anthropogenic sources
- the detection of SF_6 in groundwater indicates the presence of water recharged since the 1970s

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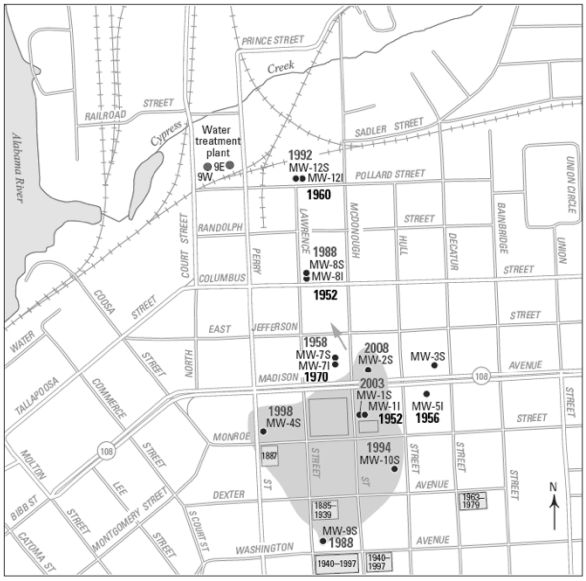
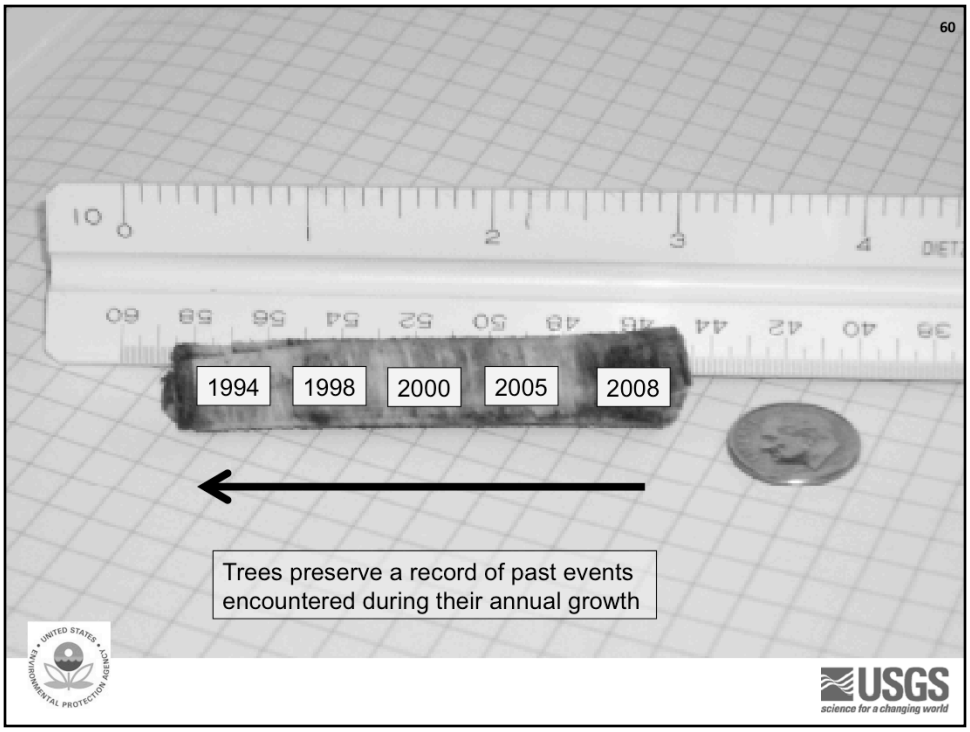


Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

0 250 500 750 1,000 FEET

0 100 200 METERS

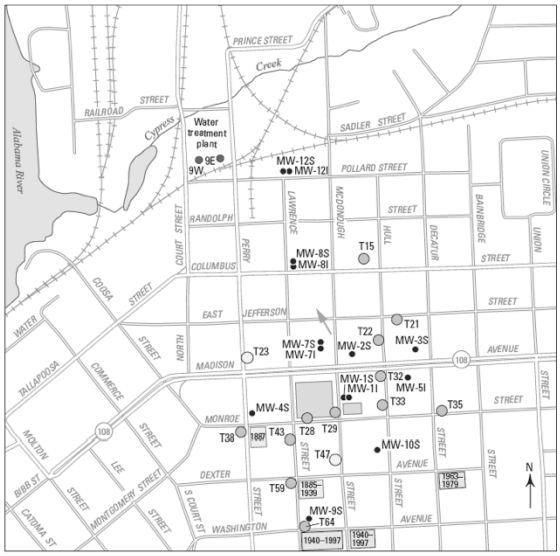

60
1994
1998
2000
2005
2008
Trees preserve a record of past events
encountered during their annual growth
USGS
science for a changing world

Contaminants preserved?

- Inorganics, yes
- Organics, no
- But
- PCE and TCE leave behind Cl-, yes

- Caveat – some inorganics are transported within the tree over space and time

2009



Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

0 250 500 750 1,000 FEET

0 100 200 METERS


63
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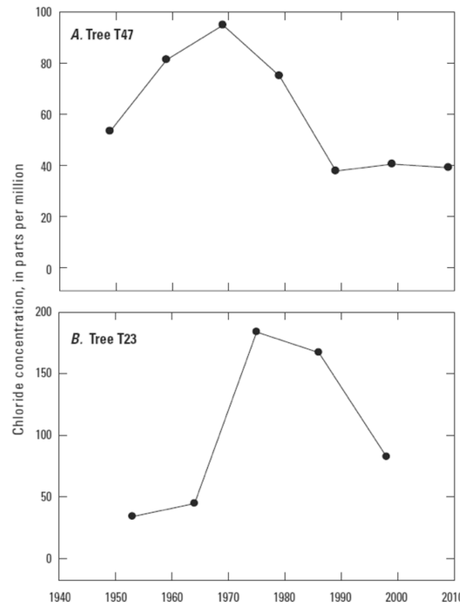
64

2009

Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

0 250 500 750 1,000 FEET
0 100 200 METERS



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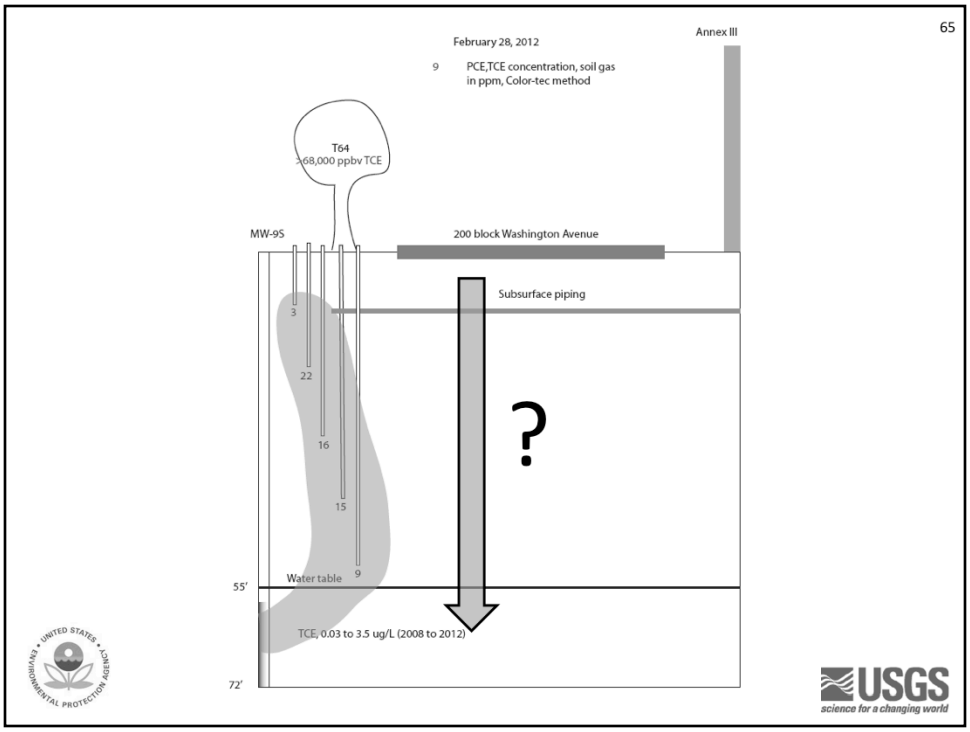
65
Annex III
February 28, 2012
9 PCE,TCE concentration, soil gas in ppm, Color-tec method
T64
>68,000 ppbv TCE
MW-9S
200 block Washington Avenue
Subsurface piping
3
22
16
15
9
?
Water table
55'
TCE, 0.03 to 3.5 ug/L (2008 to 2012)
72'
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66
T64
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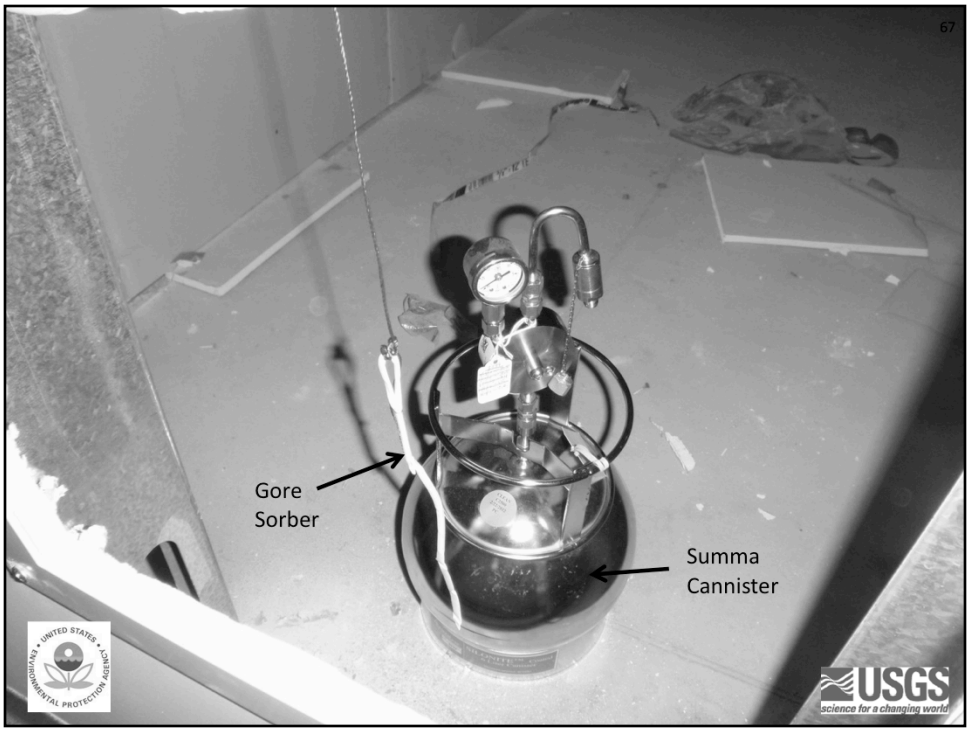
67
Gore
Sorber
Summa
Cannister
USGS
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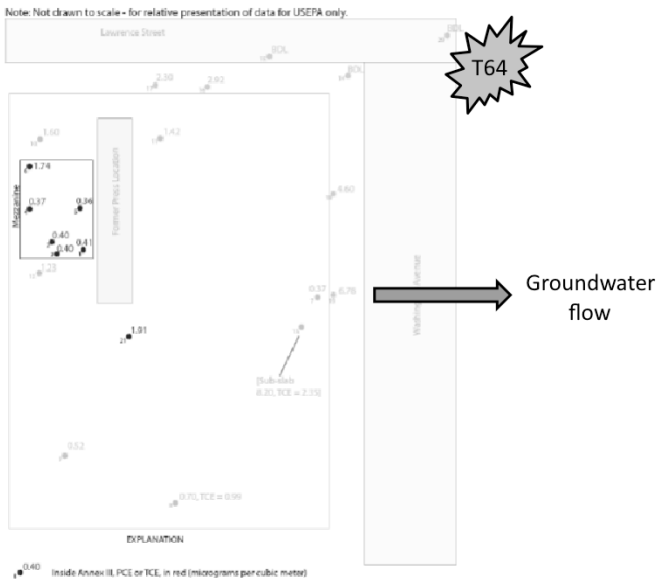
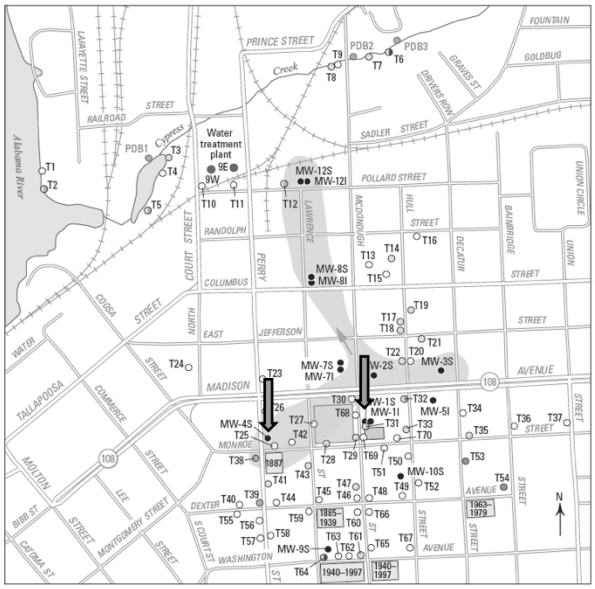
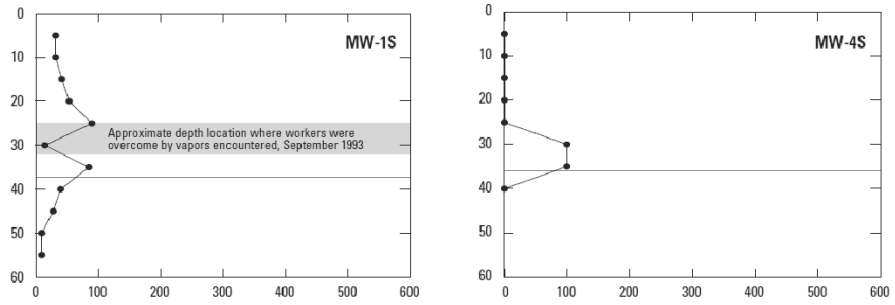


What about downgradient?

2008


PRINCE STREET
FOUNTAIN
GOLDBUG
DRAKES ST
DRIVERS ROAD
SADLER STREET
POLLARD STREET
UNION CIRCLE
UNION STREET
BAINBRIDGE STREET
DECATUR STREET
HUTCHINSON STREET
LAWRENCE STREET
PERRY STREET
COURT STREET
RANDOLPH
COLUMBUS
JEFFERSON
MADISON
MONROE
DEXTER
WASHINGTON
NORTH EAST WATER STREET
COURSA STREET
COMMERCE STREET
TALLAPOOSA STREET
MOULTON STREET
LEE STREET
MONTGOMERY STREET
S COURT ST
CHESTNUT ST
RAILROAD STREET
LAFAYETTE STREET
Alabama River
Cypress Creek
Water treatment plant
PDB1
PDB2
PDB3
MW-12S
MW-12I
MW-8S
MW-8I
MW-7S
MW-7I
MW-2S
MW-1S
MW-1I
MW-3S
MW-5I
MW-4S
MW-10S
MW-9S
1887
1885–1939
1940–1997
1963–1979
AVENUE
108
N
Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16
0 250 500 750 1,000 FEET
0 100 200 METERS

Data - EPA RI, 2000



VOCs, ppm

Result

1. PCE and TCE detected **upgradient** of groundwater "plume" locations
2. PCE and TCE detected near locations of former **printing** operations
3. PCE and TCE were used by printing operations
4. Disposal down **drains**
5. **Soil-gas** more contaminated by PCE/TCE upgradient

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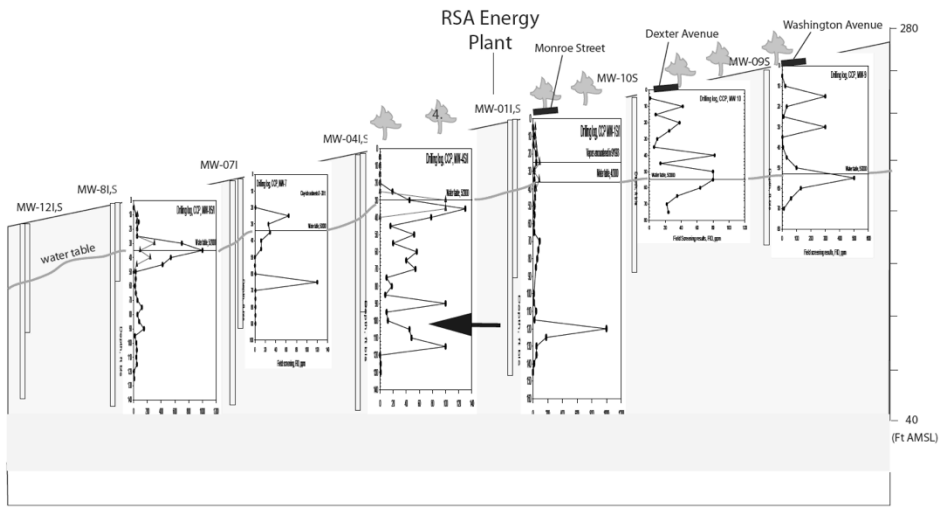
Conceptual Model

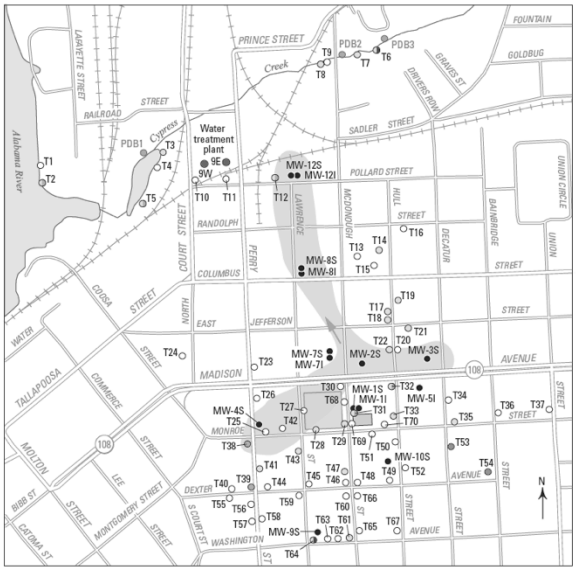


Vertical and horizontal exagerrated.
Final figure will have common datum.

Groundwater sampling

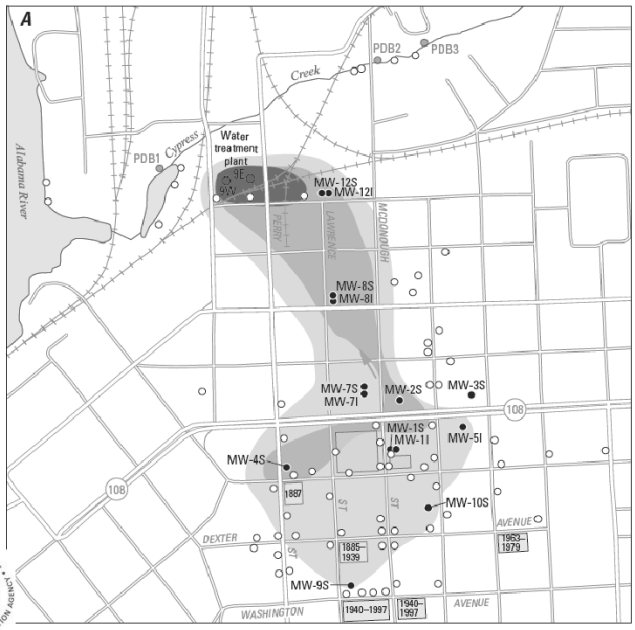
PCE and TCE

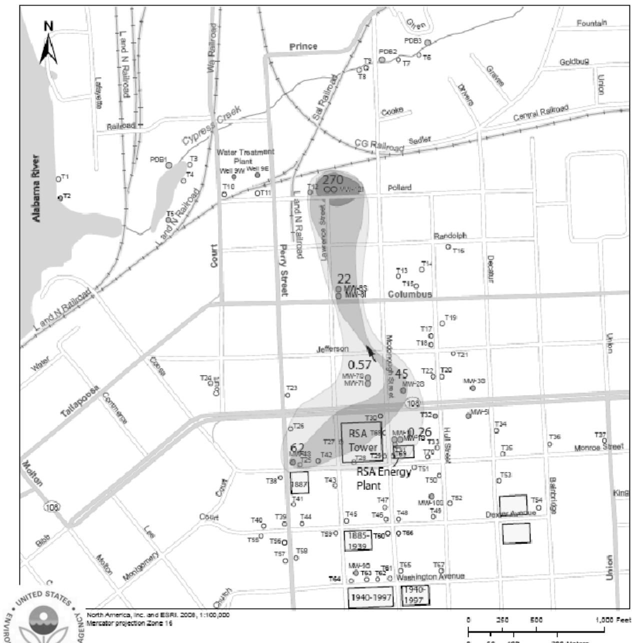
Data - 2008



Base modified from Tele Atlas North America, Inc. and ESRI®, 2008, 1:100,000, Universal Transverse Mercator projection, Zone 16

PCE Data - USGS, 2009





EXPLANATION

Perchloroethylene (PCE) > 0.03 ug/L
2010 EPA sampling

PCE > 10 ug/L, April-May 2009.
2010 EPA sampling

PCE > 100 ug/L, April-May 2009
2010 EPA sampling

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EXPLANATION

Perchloroethylene (PCE) > 0.03 ug/L
2011 EPA sampling

PCE > 10 ug/L, April-May 2009.
2011 EPA sampling

PCE > 100 ug/L, April-May 2009
2011 EPA sampling

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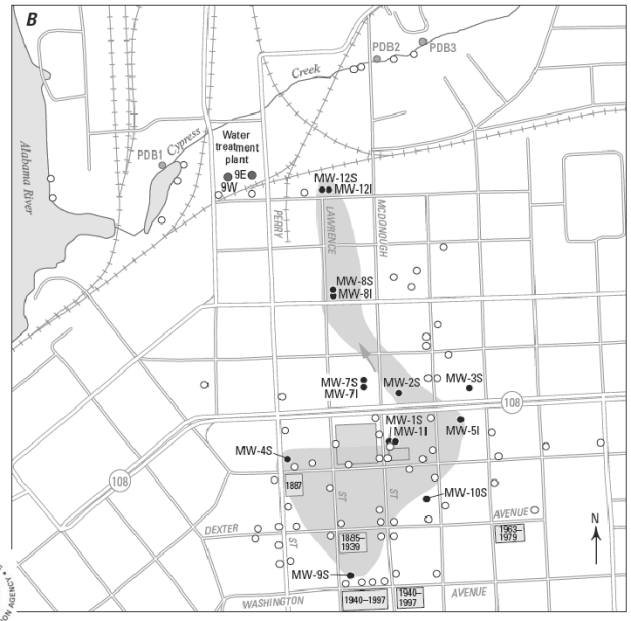
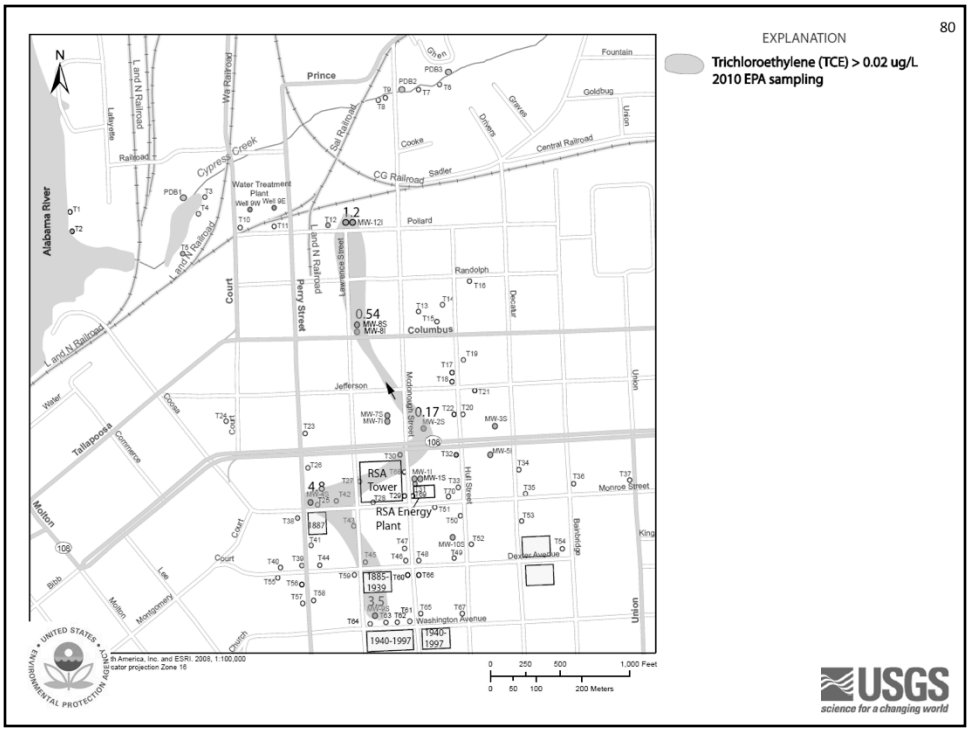
TCE Data - USGS, 2009




80
EXPLANATION
Trichloroethylene (TCE) > 0.02 ug/L
2010 EPA sampling
N
Alabama River
Prince
Fountain
Goldbug
Cypress Creek
Water Treatment Plant
Pollard
Randolph
Columbus
Jefferson
Monroe Street
Washington Avenue
Dexter Avenue
Court
Perry Street
Tallapoosa
Commerce
Molton
Union
RSA Tower
RSA Energy Plant
1.2
0.54
0.17
4.8
3.5
1940-1997
1885-1939
1887
0 250 500 1,000 Feet
0 50 100 200 Meters
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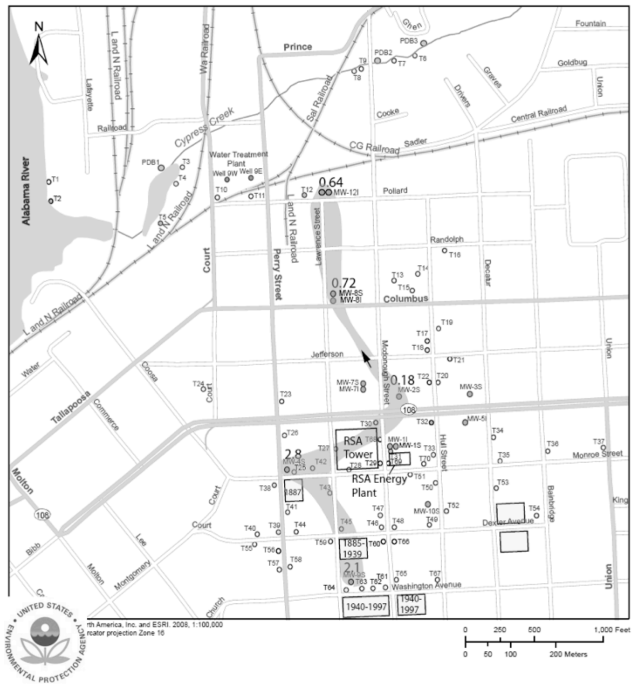

EXPLANATION

Trichloroethylene (TCE) > 0.02 ug/L 2011 EPA sampling

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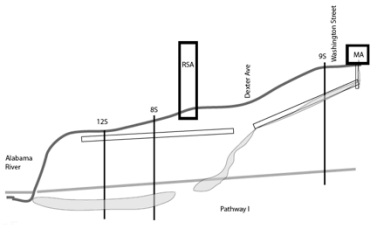
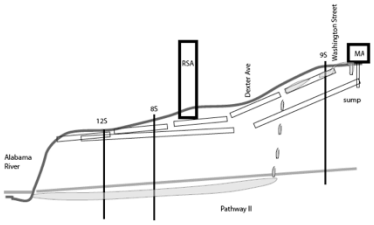
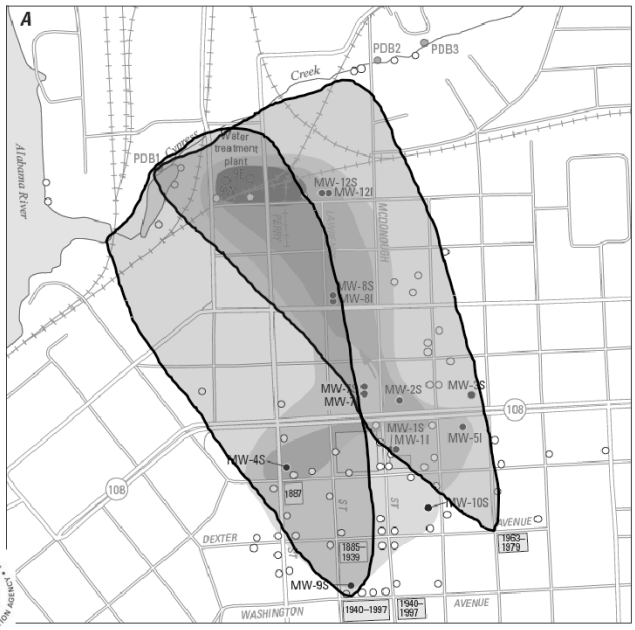
To recap

- **Where?** Potential source(s) and locations
- **How?** Pathway (land surface to groundwater)
- **When?**

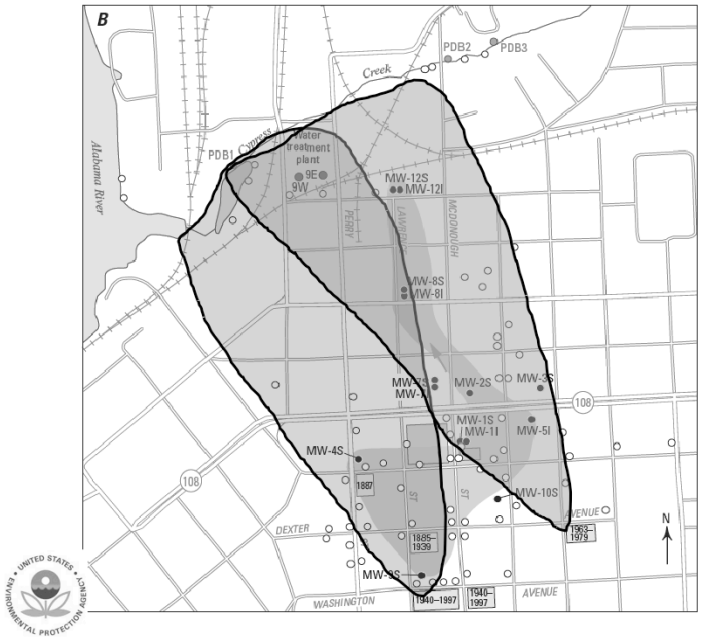




PCE Data - USGS, 2009



TCE Data - USGS, 2009



Science-based Data:

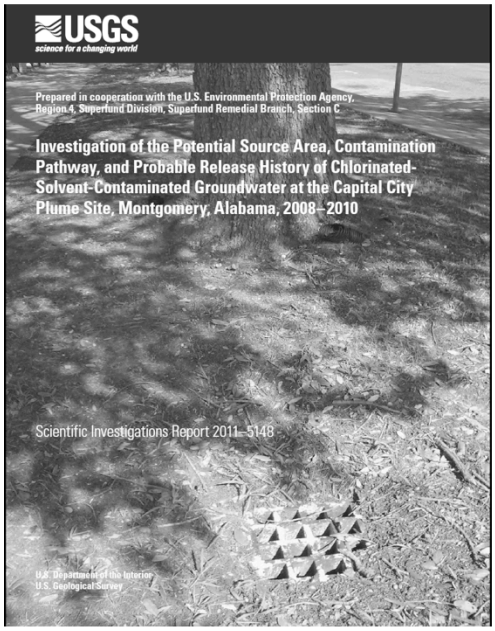
- Tree cores
- Geoprobing, geophysics, ground and downhole
- Vapor Implants
- PID, portable field GCs
- Color-Tec field results
- Chloroform as tracer of recharge
- CFCs, SF_6 to age date groundwater
- Dendrochronology
- Air sampling
- Soil-gas sampling

EPA and USGS Collaboration

- IAG
- Need-specific Work Authorizations
- Access through USGS contact to ALL the USGS capabilities and expertise across 50 states

Other EPA-USGS examples:

- **Region VII**; Riverfront Superfund site, New Haven, Missouri
- **Region IV**; Alabama Plating Site, Vincent, AL
- **Region V**; Co-location agreement
- **Region III;** Standard Chlorine of Delaware



http://pubs.usgs.gov/sir/2011/5148/

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- Please complete the **Feedback Form** to help ensure events like this are offered in the future

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