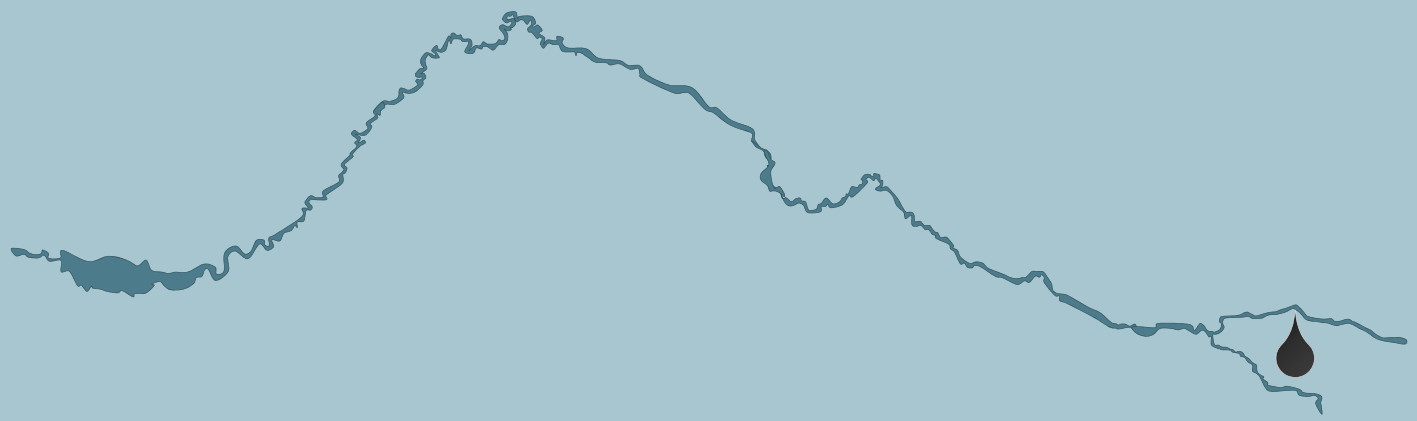
# RESPONSE TECHNOLOGIES FOR OIL SANDS PRODUCTS

## ENBRIDGE OIL SPILL CASE STUDY

## KALAMAZOO RIVER, MICHIGAN

December 4, 2012

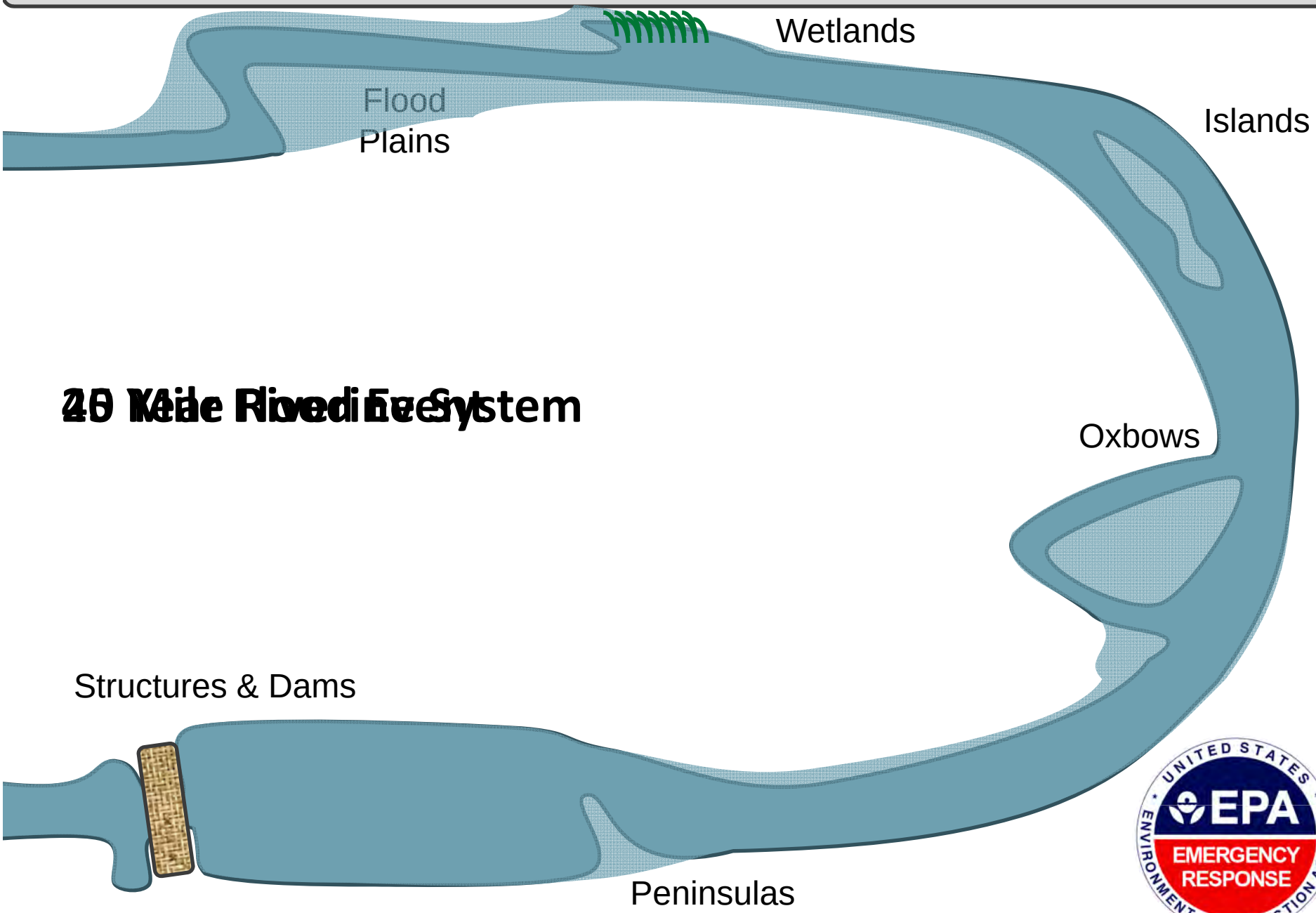


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EPA
EMERGENCY RESPONSE

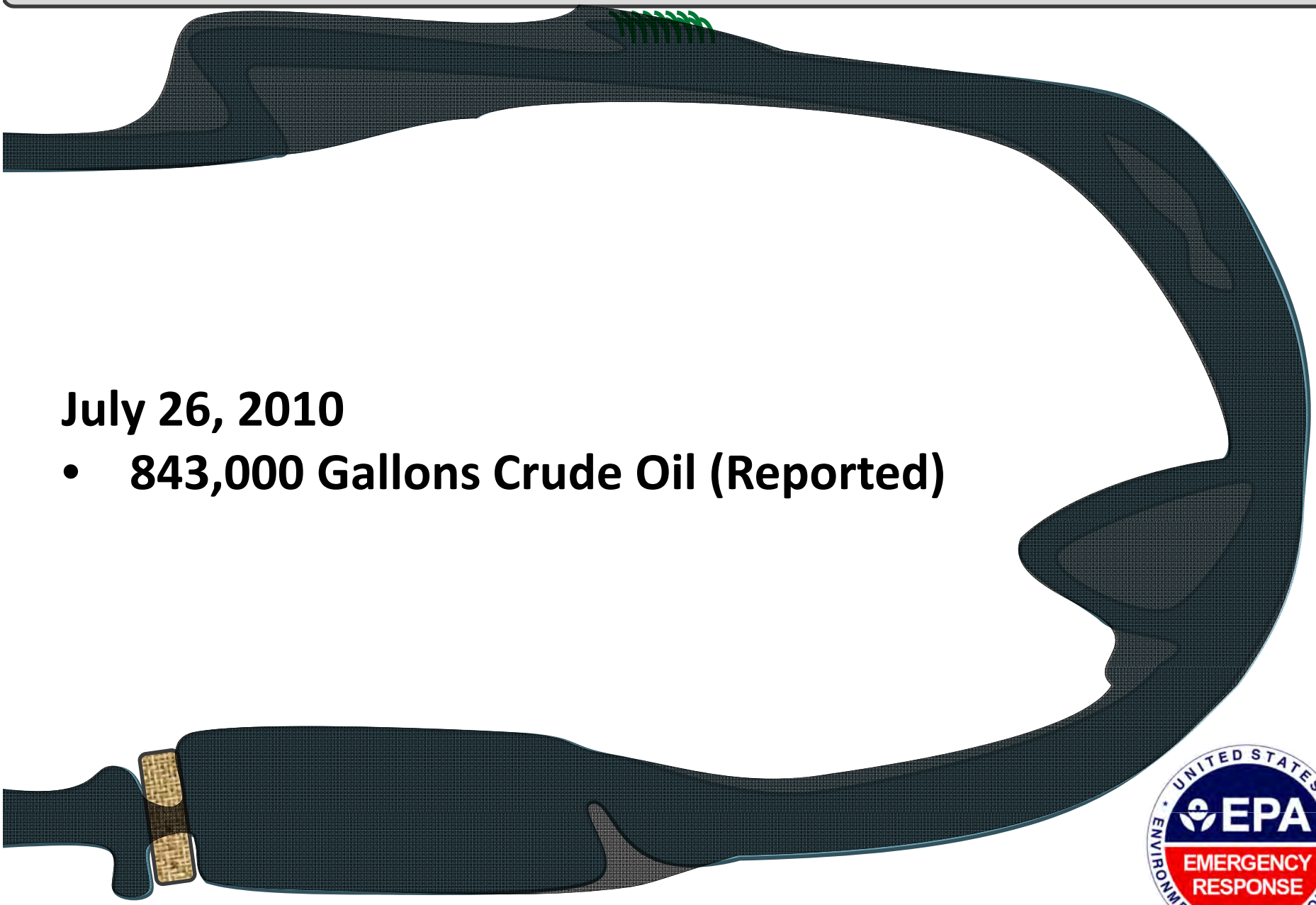
# What Happened?
# Day 1: July 26, 2010

# Oil Spill Conceptual Model

River Characteristics



# Oil Spill Conceptual Model Initial Release

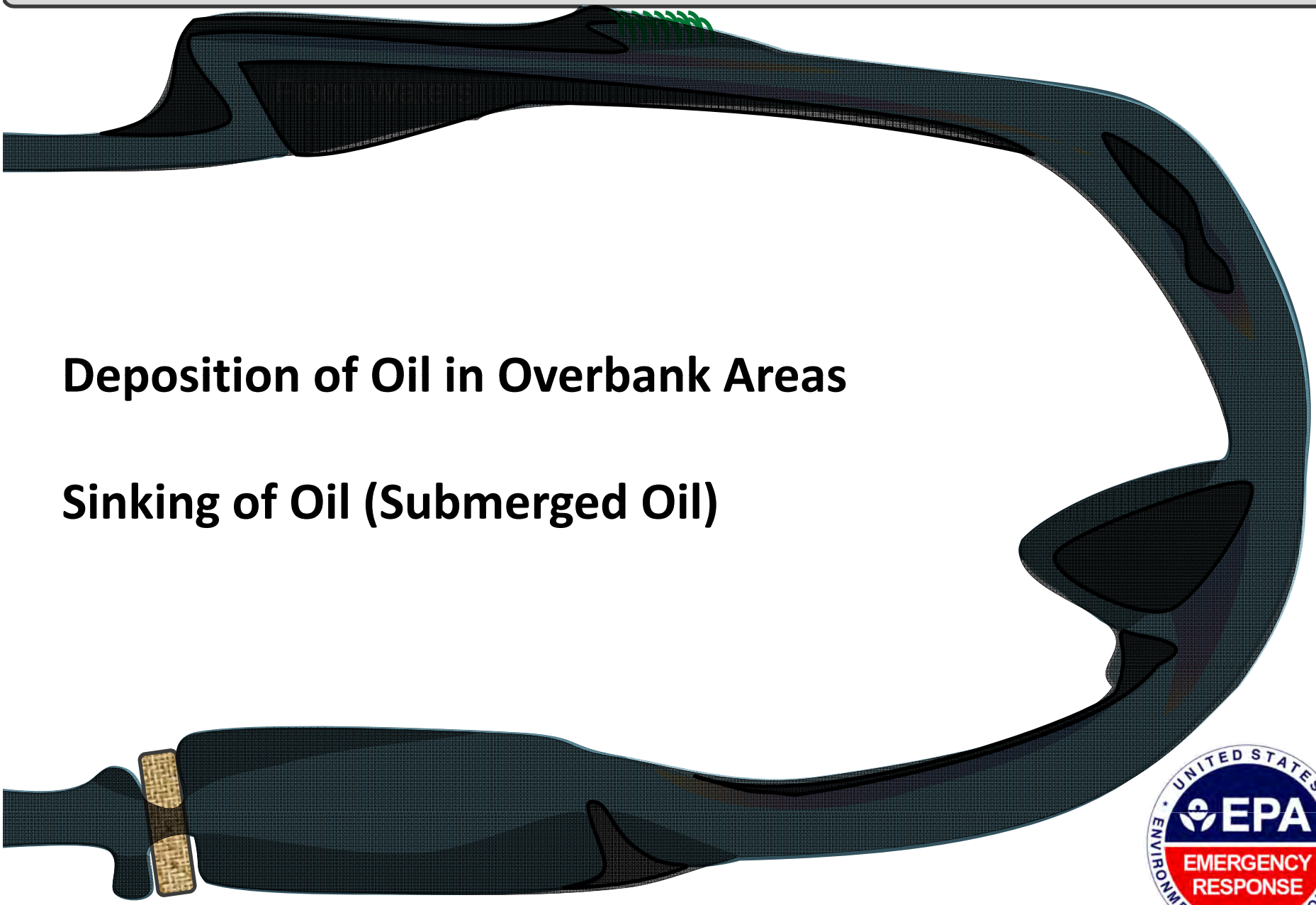


**July 26, 2010**

- **843,000 Gallons Crude Oil (Reported)**

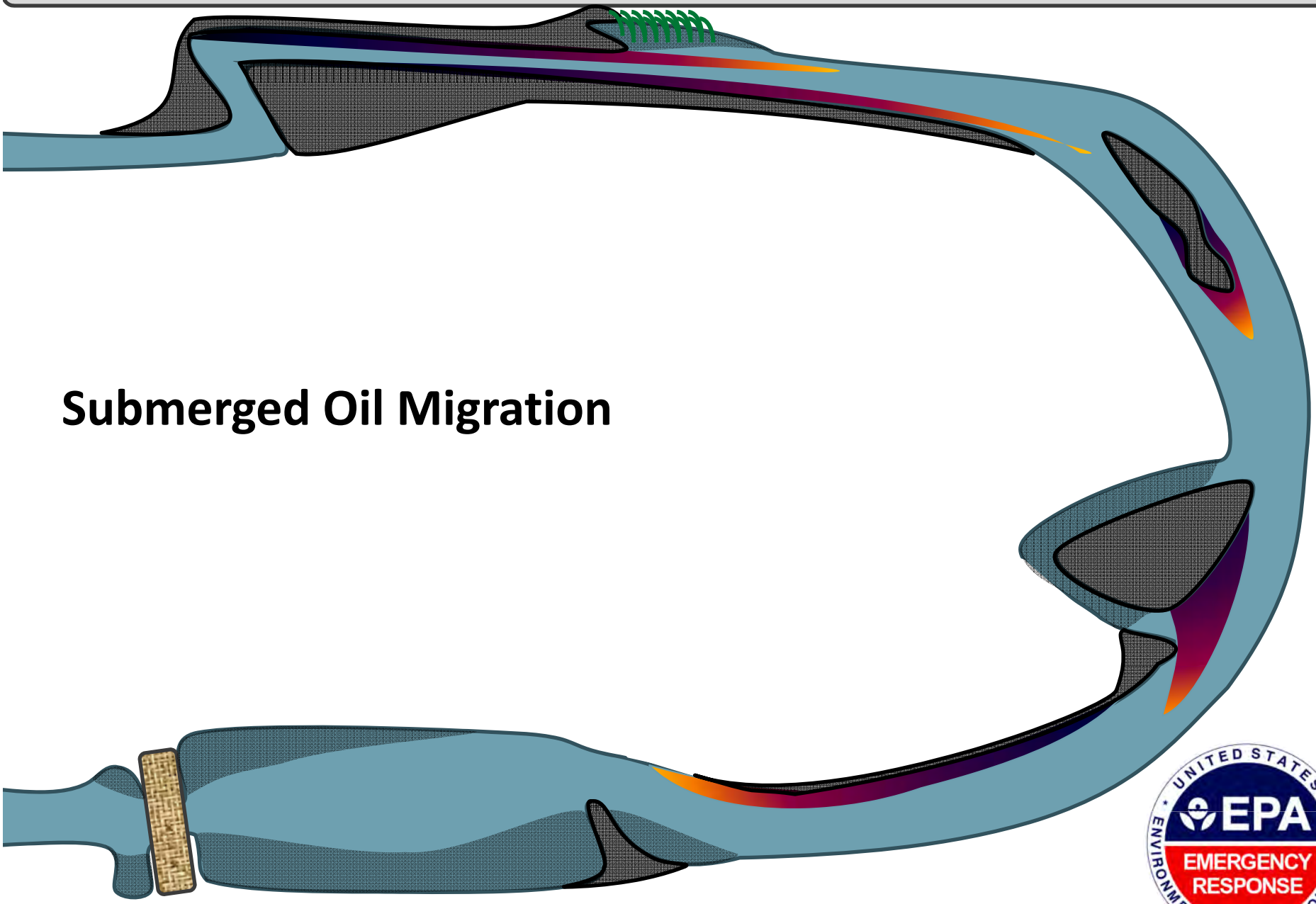
# Oil Spill Conceptual Model

Depositional Areas

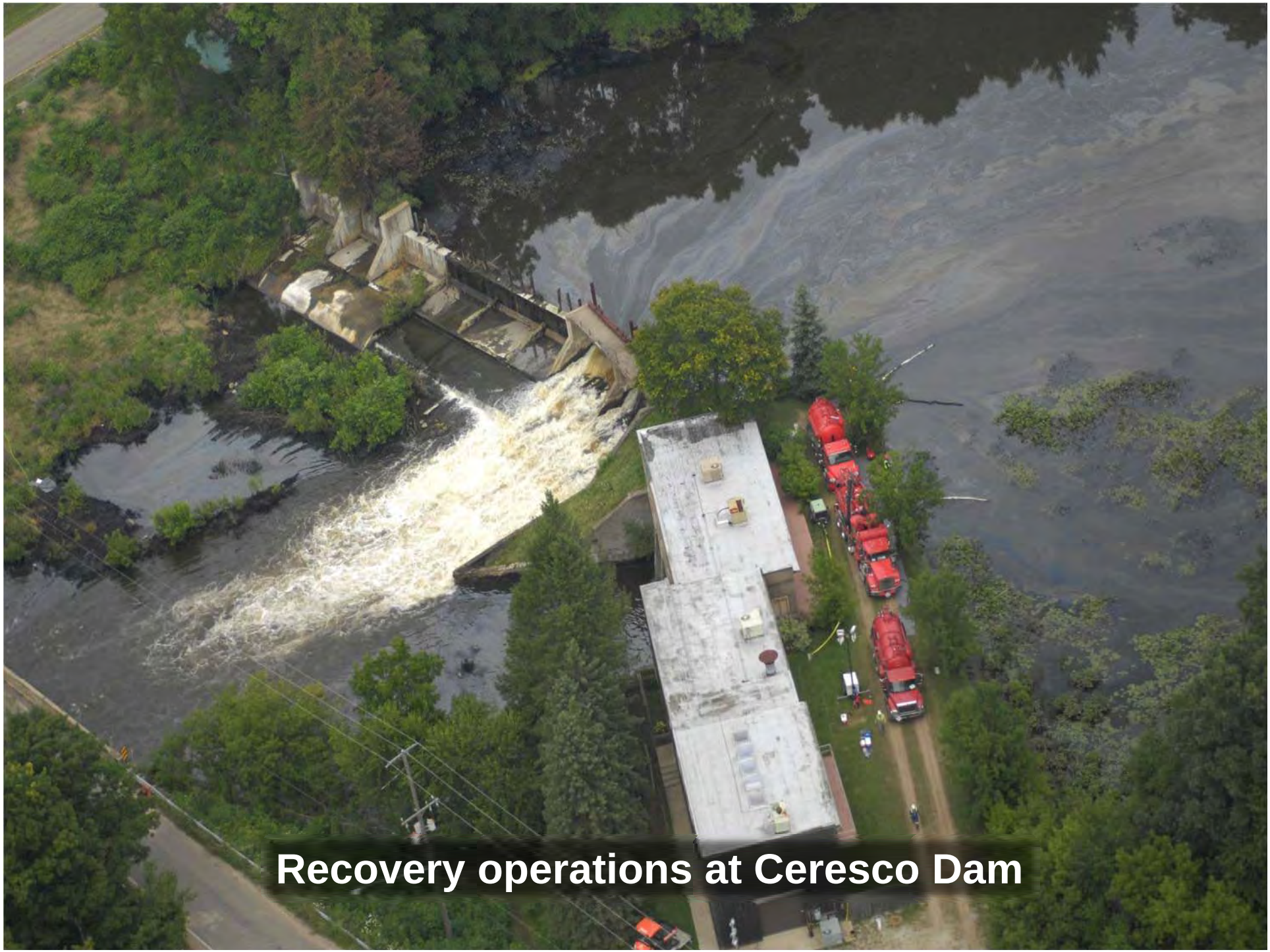


**Deposition of Oil in Overbank Areas**

**Sinking of Oil (Submerged Oil)**



# Submerged Oil Migration



Recovery operations at Ceresco Dam

# AIR MONITORING AND SAMPLING

Public Health: Benzene

- Enbridge Line 6B Oil – Tar Sands Crude with Diluent additive
- Diluent containing benzene @ 30% additive to Line 6B Crude Oil
- Public Health concern for residents and workers during first 30 days
- Thousands of air monitoring readings collected
- Hundreds of air samples collected
- Voluntary evacuation at 60 residences

# AIR MONITORING AND SAMPLING



- Air monitoring conducted using:
  - MultiRAEs
  - Benzene UltraRAEs
  - AreaRAEs
  - Draeger tubes
  - HAPSites

- Air Sampling conducted using:
  - Summa Canisters
  - Tedlar Bags – Mobile Lab

- Evacuation and Re-entry Decision Trees Established

- Benzene – main public health driver

- Evacuation Action Level – 200 ppbv benzene when monitoring
  60 ppbv benzene when sampling

- Reoccupation Action Level – 6 ppbv benzene – sampling

*60 ppb is based on a 10-fold adjustment of the ATSDR intermediate MRL (6 ppb).*

# Overbank Assessment

Evolution: SCAT

**2010** | **2011** | **2012**

SPILL → **SCAT**

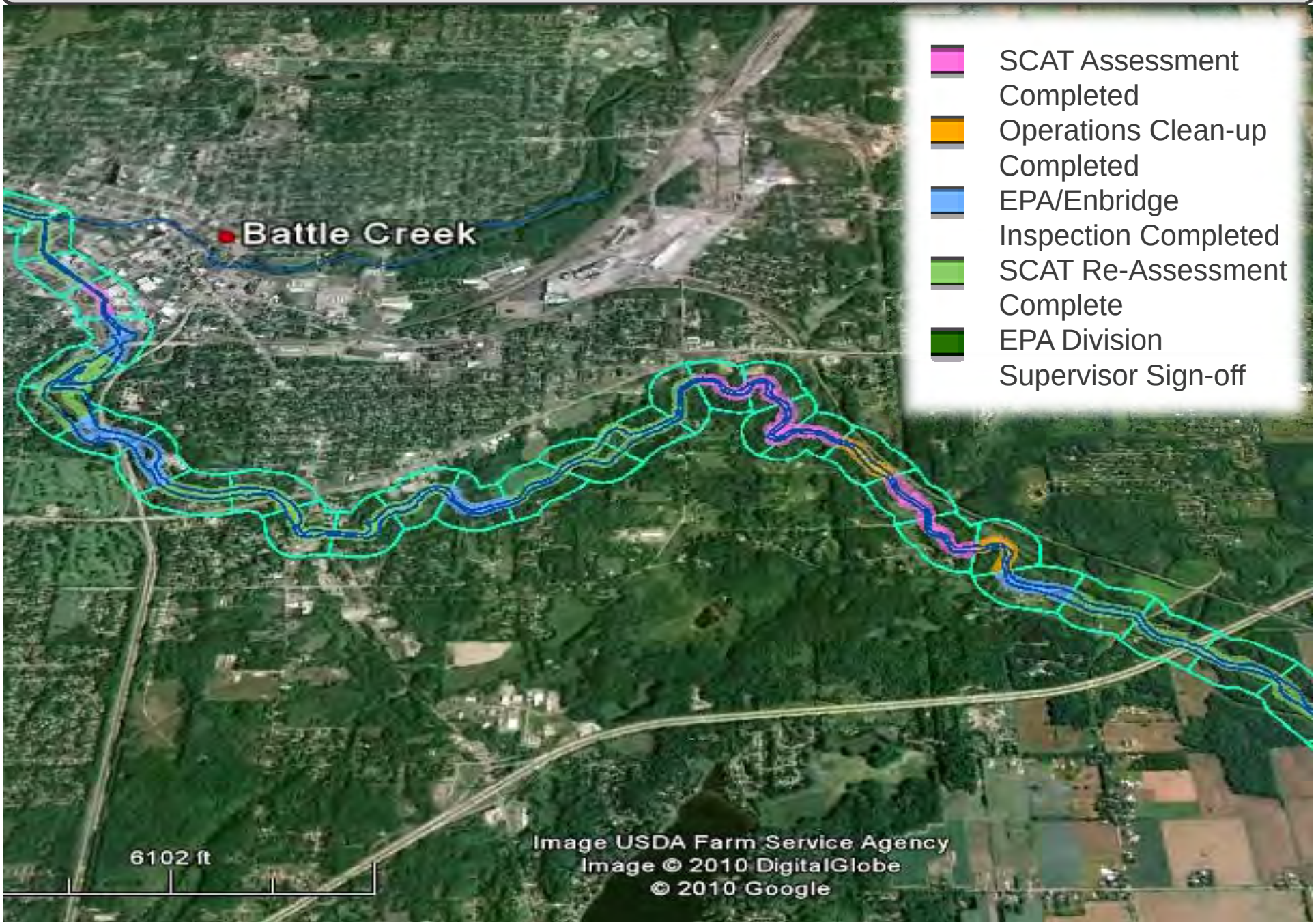
**S**horeline
**C**leanup
**A**ssessment
**T**echnique

A systematic approach that uses standard terminology to collect data on shoreline oiling conditions and supports decision-making for shoreline cleanup

- NOAA/USCG assessment technique adapted for a riverine system
- 5 Phases
  1. SCAT Assessment
  2. Operations Clean-up
  3. EPA/Enbridge Inspection
  4. SCAT Re-Assessment
  5. EPA Division Supervision Sign-off

Rapid Assessment of **Entire Valley**, with Specific Emergency Cleanup Recommendations

# SCAT Progress Tracking



# SCAT Progress Tracking

Division C

| Group | MP | Shoreline Clean-Up Completed | Overbank Areas Clean-Up Completed | Comments / Forecast Dates | Submitted for EPA Division Supervisor Sign-off |
|---|---|---|---|---|---|
| Group 1 (4.00 mi) | 2.25 | | | | |
| | 2.50 | | | | |
| | 2.75 | | | | |
| | 3.00 | | | | |
| | 3.25 | | | Alpha Island SOTF | |
| | 3.50 | | | | |
| | 3.75 | | | | |
| | 4.00 | | | | |
| | 4.25 | | | SOTF, Echo Island Safety Restricted | |
| | 4.50 | | | | |
| | 4.75 | | | | |
| | 5.00 | | | | |
| | 5.25 | | | | |
| | 5.50 | | | | |
| | 5.75 | | | | |
| | 6.00 | | | | |
| Group 2 (3.75 mi) | 6.25 | | | | |
| | 6.50 | | | | |
| | 6.75 | | | | |
| | 7.00 | | | | |
| | 7.25 | | | | |
| | 7.50 | | | | |
| | 7.75 | | | | |
| | 8.00 | | | | |
| | 8.25 | 90% | | Island Safety Restricted | |
| | 8.50 | | | | |
| | 8.75 | | | | |
| | 9.00 | | | | |
| | 9.25 | | | | |
| | 9.50 | | | | |
| | 9.75 | | | | |
| Group 3 (2.25 mi) | 10.00 | | | | |
| | 10.25 | | | | |
| | 10.50 | 100% | | SCAT Pt. EPS038 remains | |
| | 10.75 | 100% | | OB not complete | |
| | 11.00 | | | | |
| | 11.25 | 100% | | SCAT Pt. EPA053 remains, OB not complete | |
| | 11.50 | 100% | | | |
| | 11.75 | 100% | | OB not complete | |
| | 12.00 | 100% | | OB not complete | |
| Group 4 (5.25 mi) | 12.25 | | | | |
| | 12.50 | | | | |
| | 12.75 | | | | |
| | 13.00 | | | | |
| | 13.25 | | | | |
| | 13.50 | | | | |
| | 13.75 | | | | |
| | 14.00 | | | | |
| | 14.25 | | | | |
| | 14.50 | | | | |
| | 14.75 | | | | |
| | 15.00 | | | | |
| | 15.25 | | | | |
| | 15.50 | | | | |
| | 15.75 | | | | |
| | 16.00 | 100% | | | |
| | 16.25 | | | | |
| | 16.50 | | | | |
| | 16.75 | | | | |
| | 17.00 | | | | |
| | 17.25 | | | | |

| SCAT Process | Percent Complete | Cumulative Sections Completed 9/17 | 9/16 | 9/15 | 9/14 | 9/13 | 9/12 | 9/11 | 9/10 | 9/9 | 9/8 | 9/7 | 9/6 | 9/5 | 9/4 | 9/3 | 9/2 | 9/1 | 8/31 | 8/30 | Total at Completion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCAT Assessment Completed (Step 1) | 100% | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 60 | 47 | 47 | 39 | 31 | 61 |
| Operations Clean-Up Completed (Step 2) | 87% | 53 | 53 | 52 | 41 | 35 | 33 | 23 | 20 | 19 | 19 | 16 | 11 | 24 | 21 | 22 | 20 | 20 | 19 | 19 | 61 |
| Enbridge/EPA Inspection Completed (Step 3) | 84% | 51 | 46 | 41 | 32 | 24 | 22 | 21 | 19 | 16 | 11 | 11 | 11 | 8 | 8 | 9 | 6 | 6 | 6 | 6 | 61 |
| SCAT Re-Assessment Completed (Step 4) | 72% | 44 | 34 | 31 | 24 | 20 | 17 | 17 | 13 | 11 | 11 | 10 | 6 | 4 | 4 | 3 | 2 | 2 | 2 | 2 | 61 |
| EPA Division Supervisor Sign-Off (Step 5) | 2% | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 61 |

***SCAT Initial Assessment**

* 0 - 1/4 sections remaining

*** Operations Clean-up**

* 8 - 1/4 sections remaining

***Enbridge/EPA Inspection**

* 10 - 1/4 sections remaining

***SCAT Re-assessment**

* Deadline - September 22
* 17 - 1/4 sections remaining
* 4 Must complete daily

# Then What?
# Day 40 through Day 607

**Overbank Work**

**Submerged Oil Work**

**Removal and disposal of 186,000 $yd^3$ of impacted soil and debris**

Talmadge Creek

# Overbank Assessment Evolution: SORT

| 2010 | | 2011 | 2012 |
|---|---|---|---|
| SPILL → | SCAT → | SORT | |

**S**horeline
**C**leanup
**A**ssessment
**T**echnique

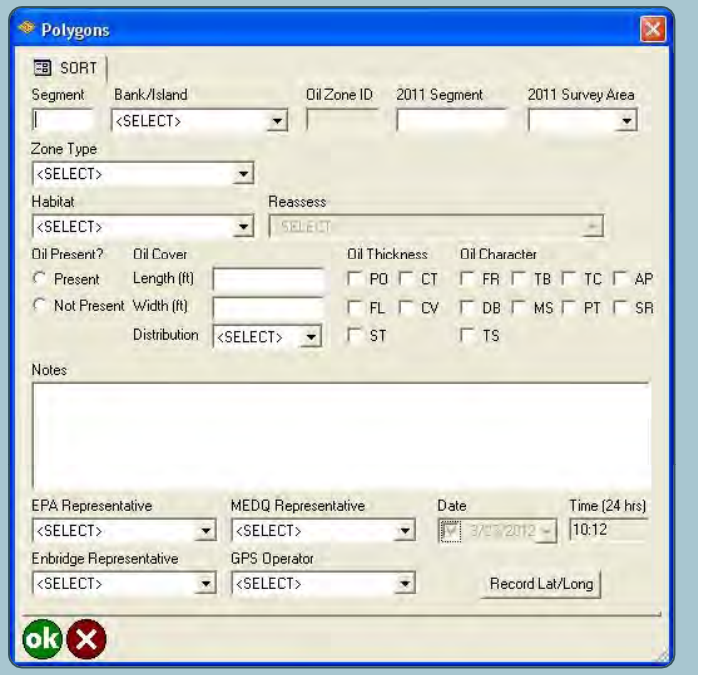
**S**horeline
**O**verbank
**R**eassessment
**T**echnique

Rapid Assessment of **Entire Valley**, with Specific Emergency Cleanup Recommendations

Reassessment of **Entire Valley** Constrained by Inundation Modeling

# SORT Basic Information Captured By SORT

1. In what habitat does the oil reside?
2. How much oil is there?
   - Thickness and %Cover
3. What is the condition of the oil?



# SORT Classification Field Guide

Shoreline/Overbank

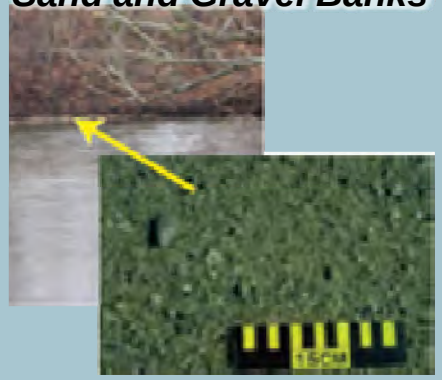
Emergent Herbaceous

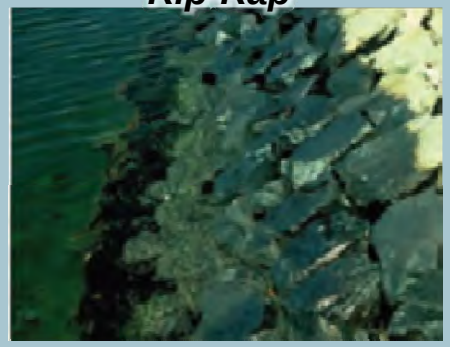
Scrub-Shrub

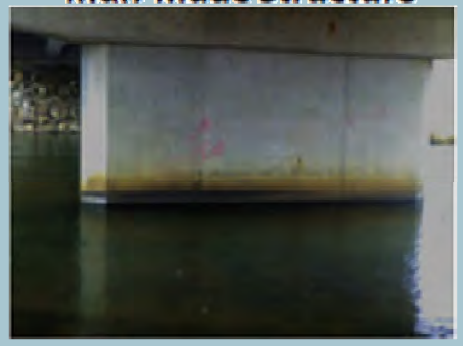
Swamp

Lawn/Maintained Land

Low Vegetated Bank


Sand and Gravel Banks


Rip-Rap


Man-Made Structure

Habitats:

1. Emergent Herbaceous Wetland
2. Scrub Shrub (woody veg<20’ tall)
3. Swamp (woody veg > 20’ tall)
4. Lawn/Maintained Land (parks, residential lawns, pastures, ect.)
5. Low Vegetated Bank (dipping or flat river banks with roots, grasses, ect.)
6. Sand and Gravel Banks
7. Rip-Rap
8. Man-Made Structures (bridges, dams, ect)

# SORT Classification Field Guide

Shoreline/Overbank | Emergent Herbaceous | Scrub-Shrub | Swamp | Lawn/Maintained Land

10 cm

Oil Distribution

| | | |
|---|---|---|
| C | Continuous | 91 - 100% |
| B | Broken | 51 - 90% |
| P | Patchy | 11 - 50% |
| S | Sporadic | 1 - 10% |
| T | Trace | <1% |

***Extra Guidelines:***

When mapping oil coats and covers on rooted vegetation (Stems, Tree Trunks in Emergent Herbaceous, Scrub-Shrub, Swamp) use "TAR" for oil type. An additional descriptor, TS-trunks and stems, should be checked as well.

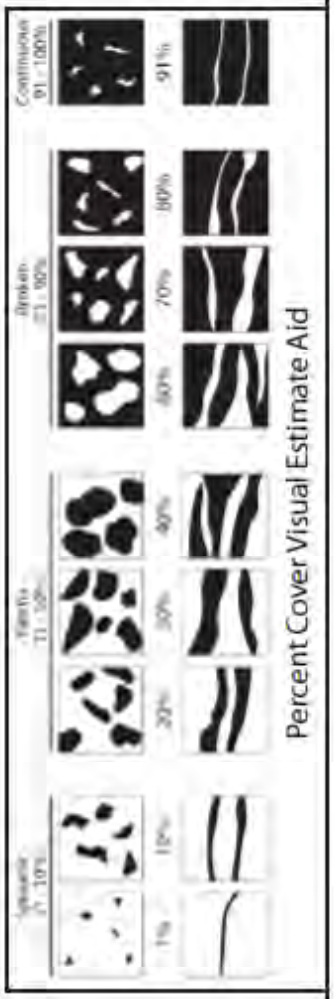
Tar balls and Patties must have a thickness of "CV-Cover" recorded

Surface Oiling Descriptors - Thickness

| | |
|---|---|
| PO | Pooled Oil (fresh oil or mousse > 1 cm thick) |
| CV | Cover (oil or mousse from >0.1 cm to <1 cm on any surface) |
| CT | Coat (visible oil <0.1 cm, which can be scraped off with fingernail) |
| ST | Stain (visible oil, which cannot be scraped off with fingernail) |
| FL | Film (transparent or iridescent sheen, or oily film) |

Surface Oiling Descriptors - Type

| | |
|---|---|
| FR | Fresh Oil (unweathered, liquid oil) |
| MS | Mousse (emulsified oil occurring over broad areas) |
| TB | Tarballs (discrete accumulations of oil <10 cm in diameter) |
| PT | Patties (discrete accumulations of oil >10 cm in diameter) |
| TC | Tar (highly weathered oil, of tarry, nearly solid consistency) |
| SR | Surface Oil Residue (non-cohesive, heavily oiled surface sediments, characterized as soft, incipient asphalt pavements) |
| AP | Asphalt Pavement (cohesive, heavily oiled surface sediments) |
| NO | No Oil |
| DB | Debris: logs, vegetation, rubbish, garbage, and response items such as booms |
| TS | Trunks and Stems |




6. Sand and Gravel Banks
7. Rip-Rap
8. Man-Made Structures (bridges, dams, ect)

MP 5.92 Excavation

# Overbank Assessment

Evolution: ReSORT

| 2010 | | 2011 | 2012 |
|---|---|---|---|
| SPILL → | SCAT → | SORT → | ReSORT (SORT2012) |

**S**horeline
**C**leanup
**A**ssessment
**T**echnique

**S**horeline
**O**verbank
**R**eassessment
**T**echnique

Revisiting SORT

Rapid Assessment of **Entire Valley**, with Specific Emergency Cleanup Recommendations

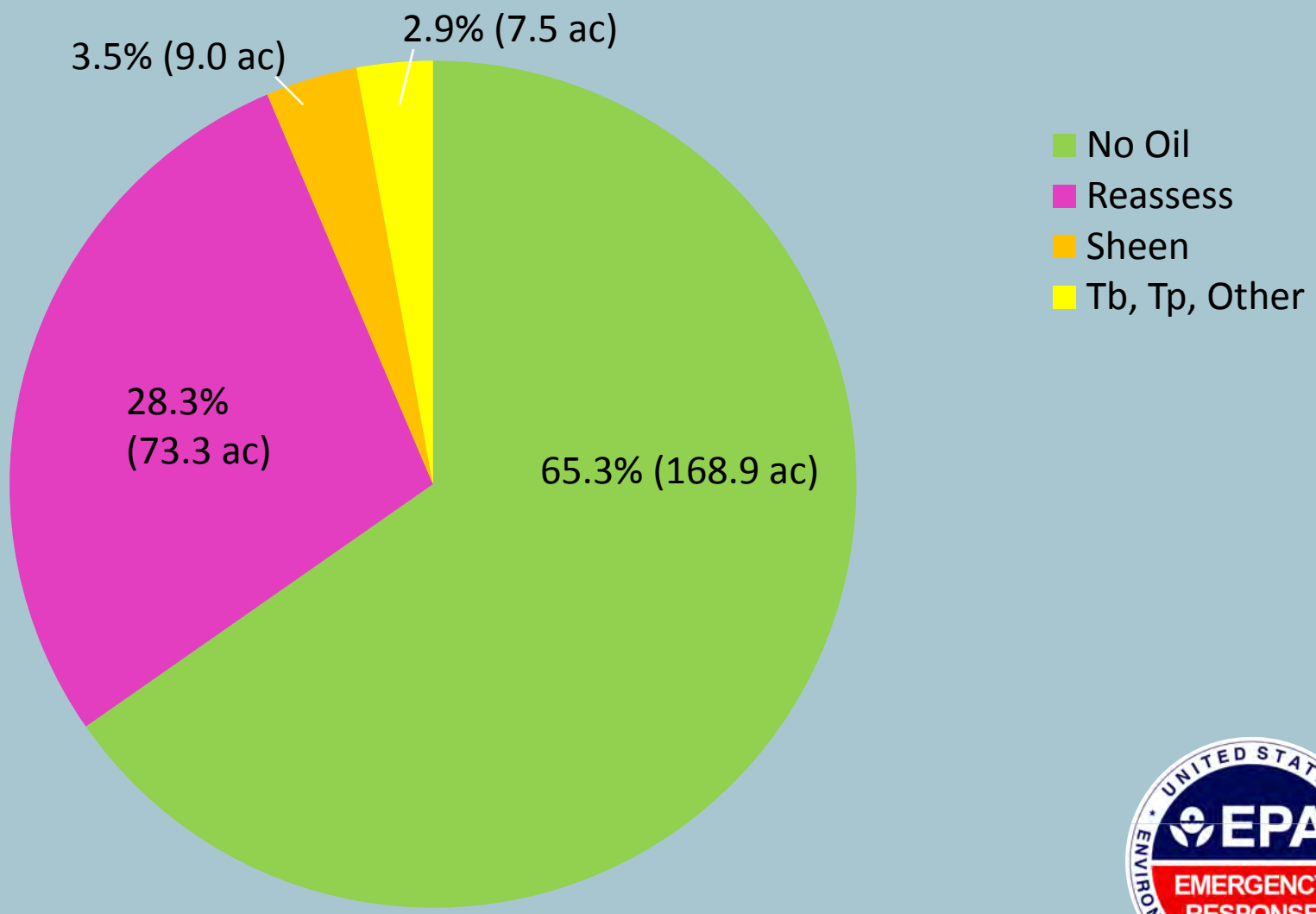
Reassessment of **Entire Valley** Constrained by Inundation Modeling

Revisiting **Specific Areas** based on Previous Two efforts

# ReSORT

- Target Based Approach (426 target areas)
  - Areas of excavation
  - Areas that were covered with water during SORT
  - Areas where Film, or Sheen were noted in SORT
- Consensus in the Field:
  - No more “When In Doubt Map it out”
- Established Sheen Testing Protocol
- Goal: Two Intense Weeks

# ReSORT Results and Observations



# ReSORT Target Areas

426 target sites: 258.78 acres to be surveyed

# ReSORT Results and Observations

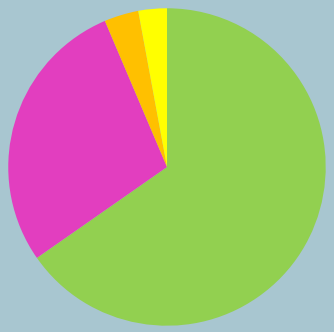
2011 SORT

2012 ReSORT

Sheen Observed

Tb, Tp, Other Observed

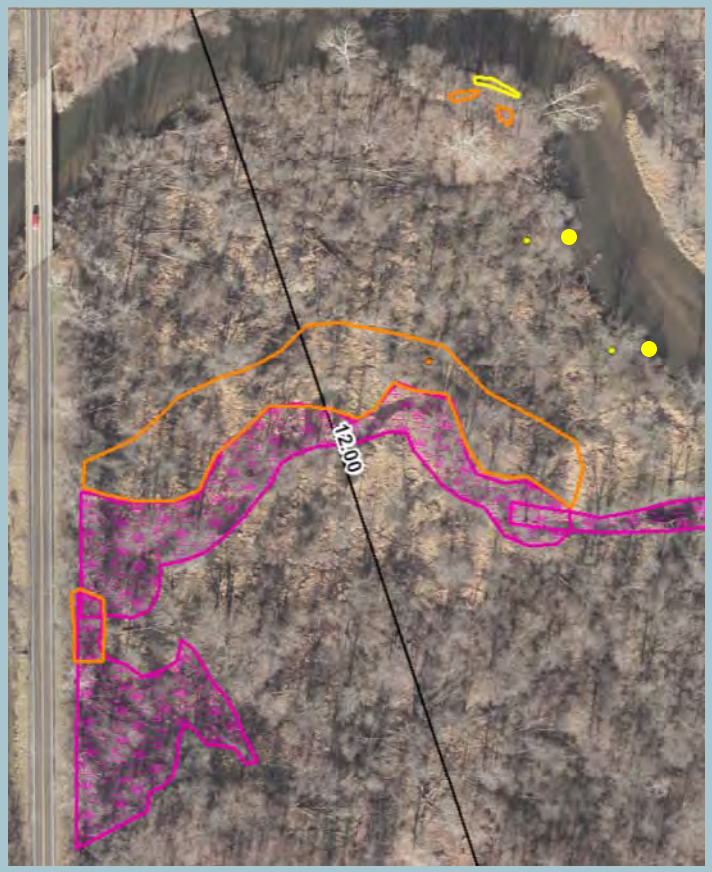
Reassess



# ReSORT Results and Observations

2011 SORT

2012 ReSORT



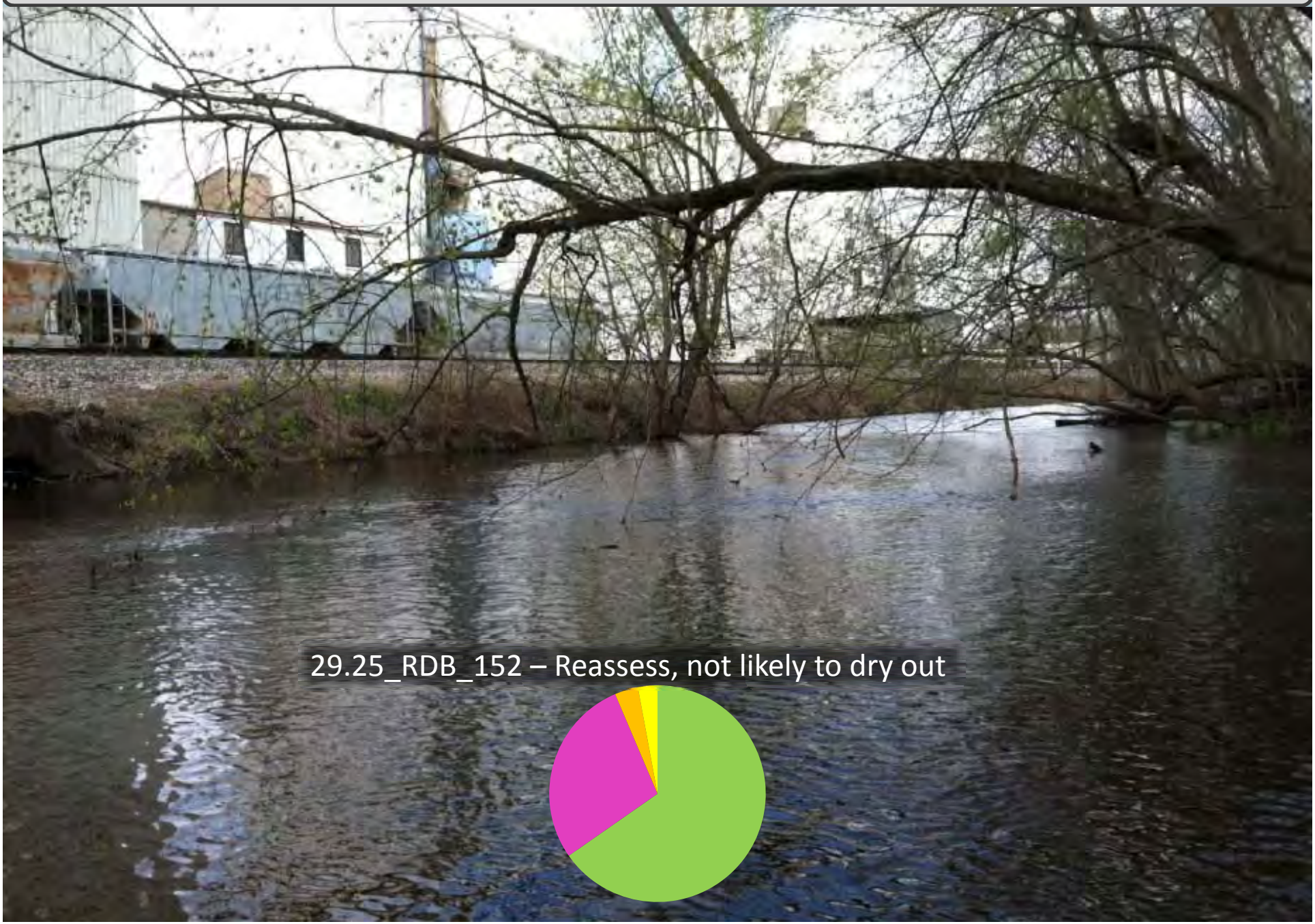

Sheen Observed

Tb, Tp, Other Observed

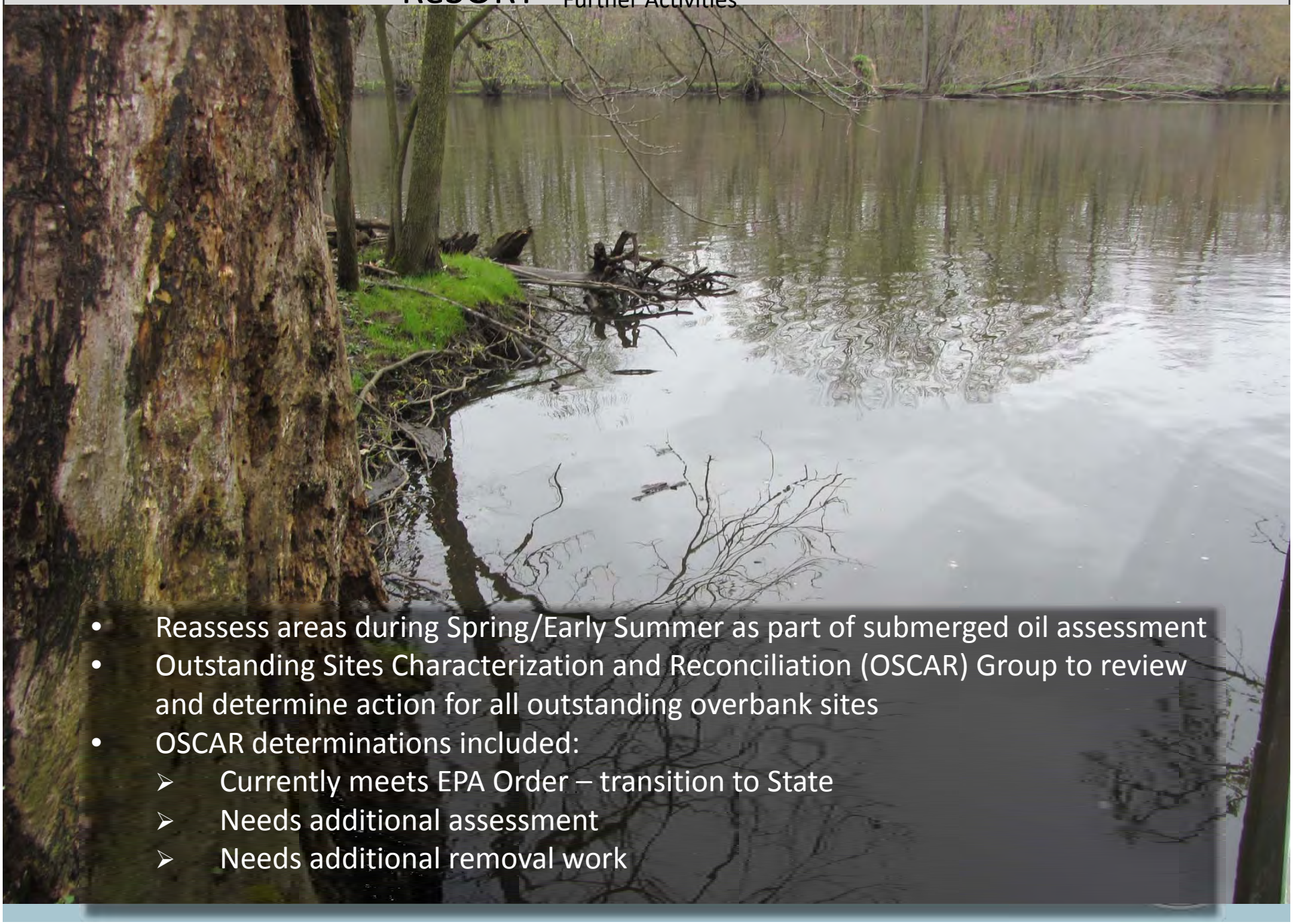
Reassess

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY EPA EMERGENCY RESPONSE

# ReSORT Results and Observations



# ReSORT Further Activities



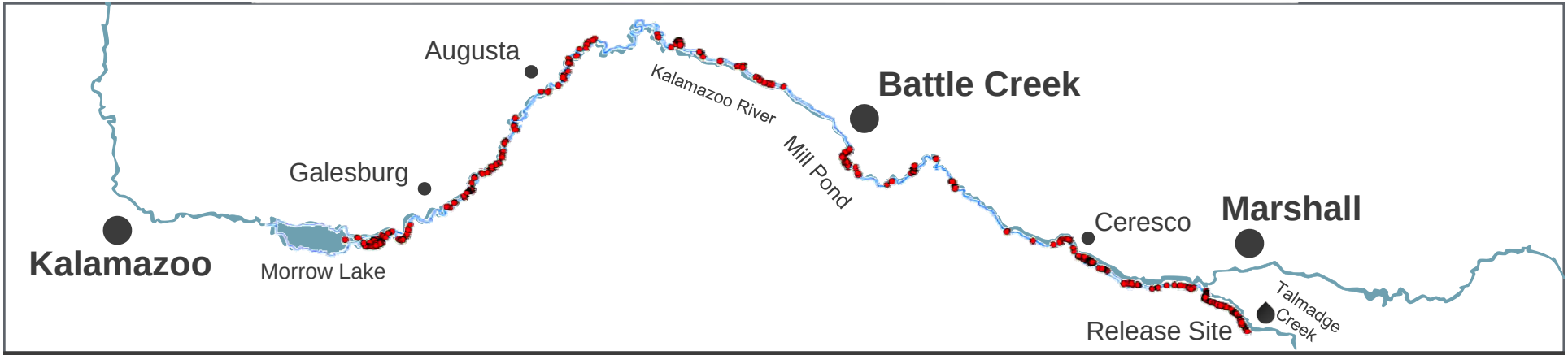
- Reassess areas during Spring/Early Summer as part of submerged oil assessment
- Outstanding Sites Characterization and Reconciliation (OSCAR) Group to review and determine action for all outstanding overbank sites
- OSCAR determinations included:
  - Currently meets EPA Order – transition to State
  - Needs additional assessment
  - Needs additional removal work

# Submerged Oil Assessment

## Identification of Oil

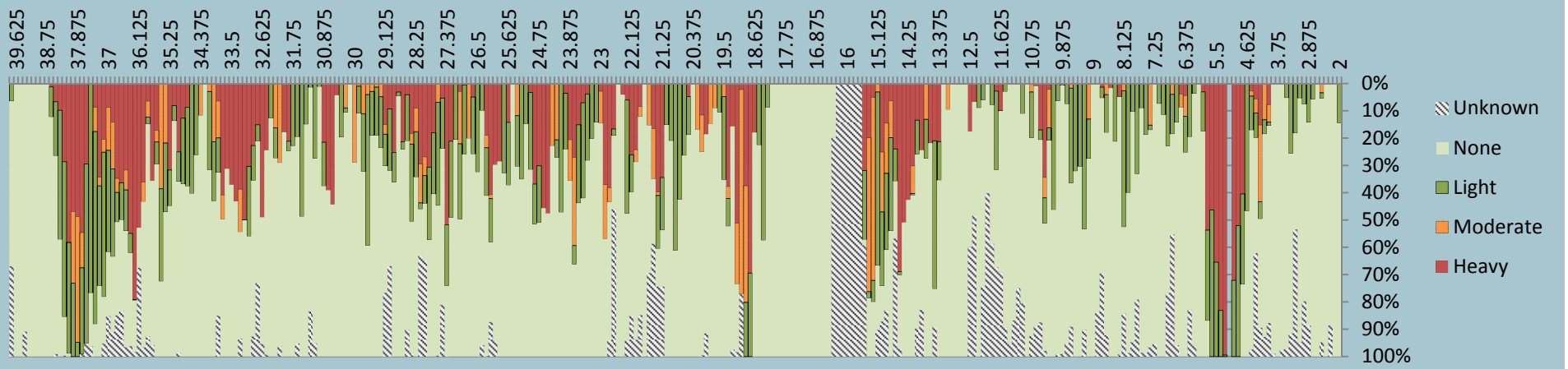
- Poling (3,500+ points)
- Coring (500+ cores)
- 18 priority areas identified

01.2010

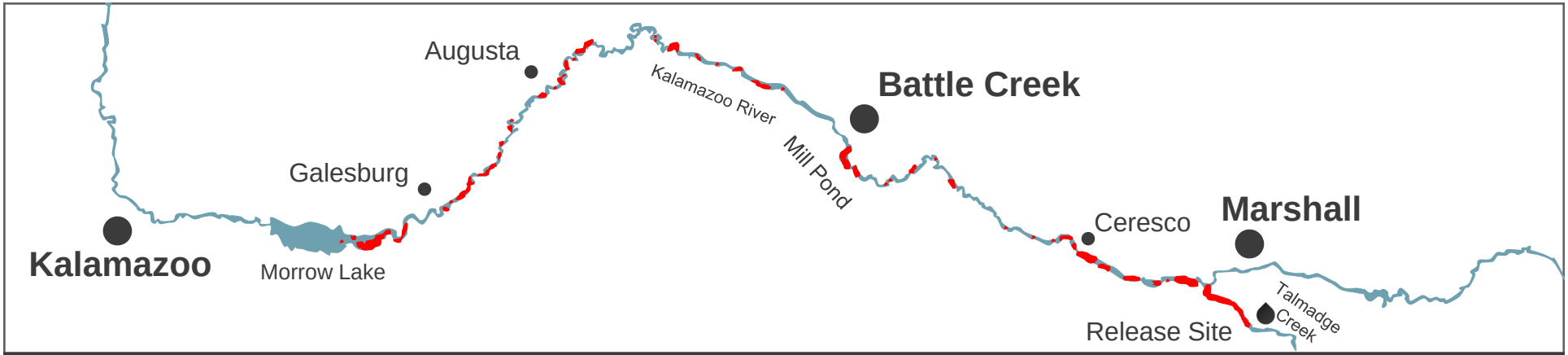



# Summary of Work 2011

Submerged Oil – Distribution by Area

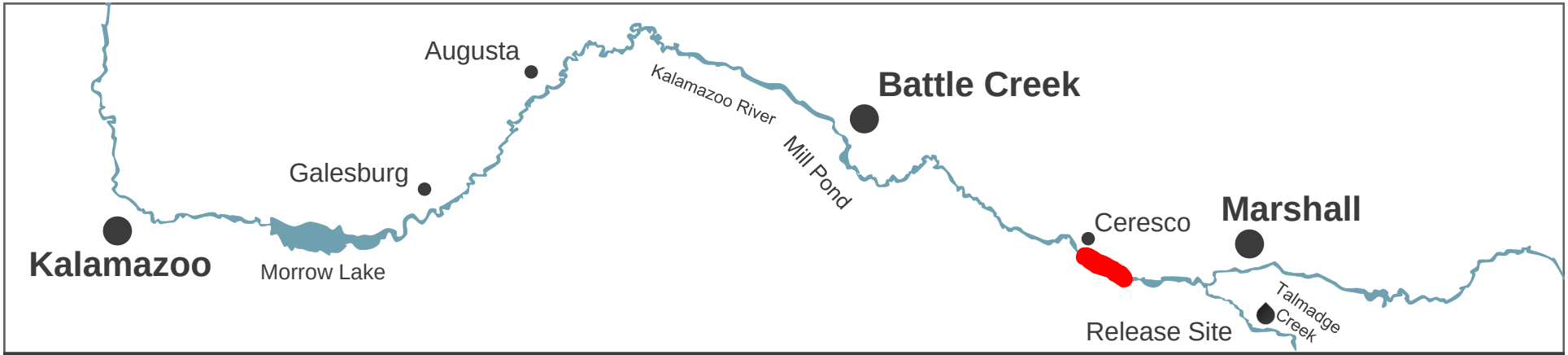



**Spring 2011**



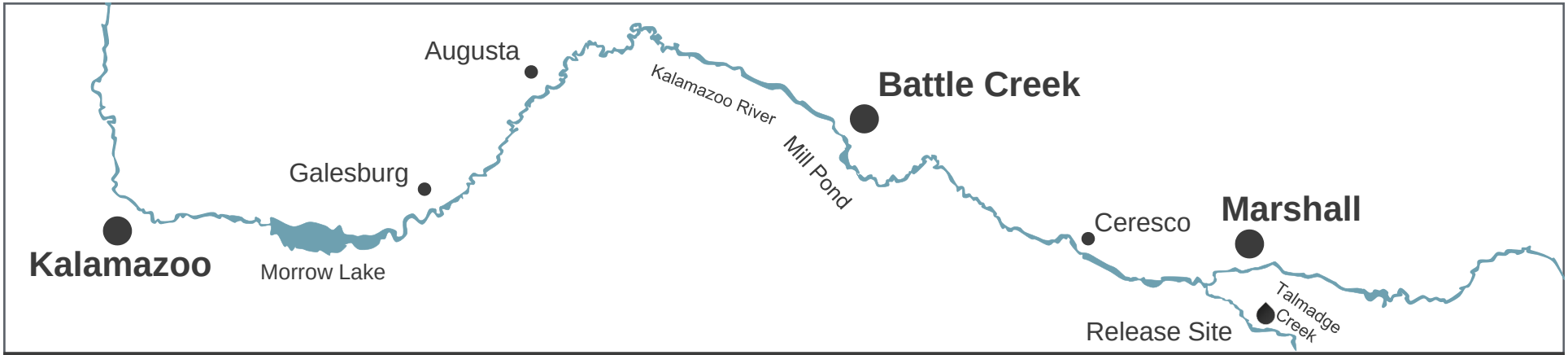

# Submerged Oil

2011 Recovery Techniques



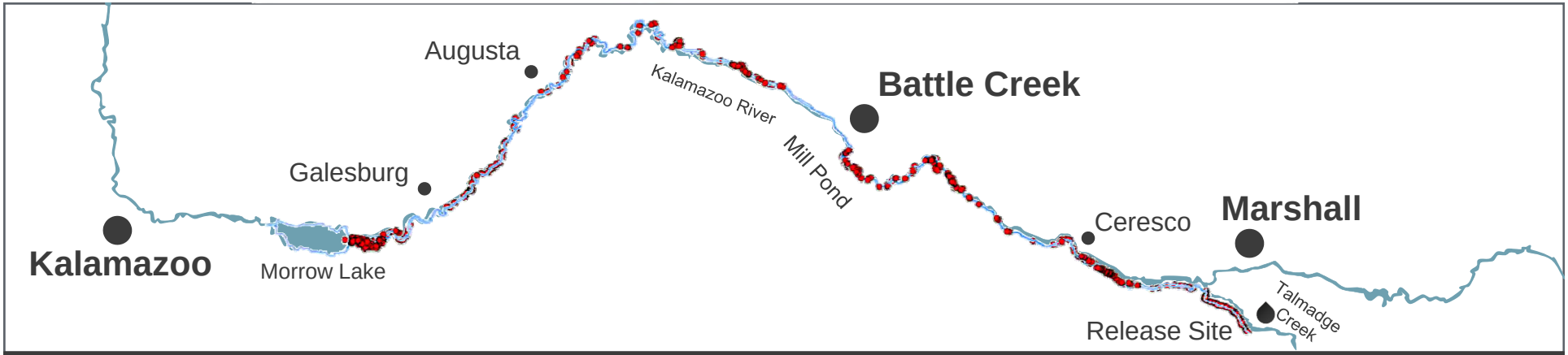

# Submerged Oil

Ceresco Recovery




# Submerged Oil

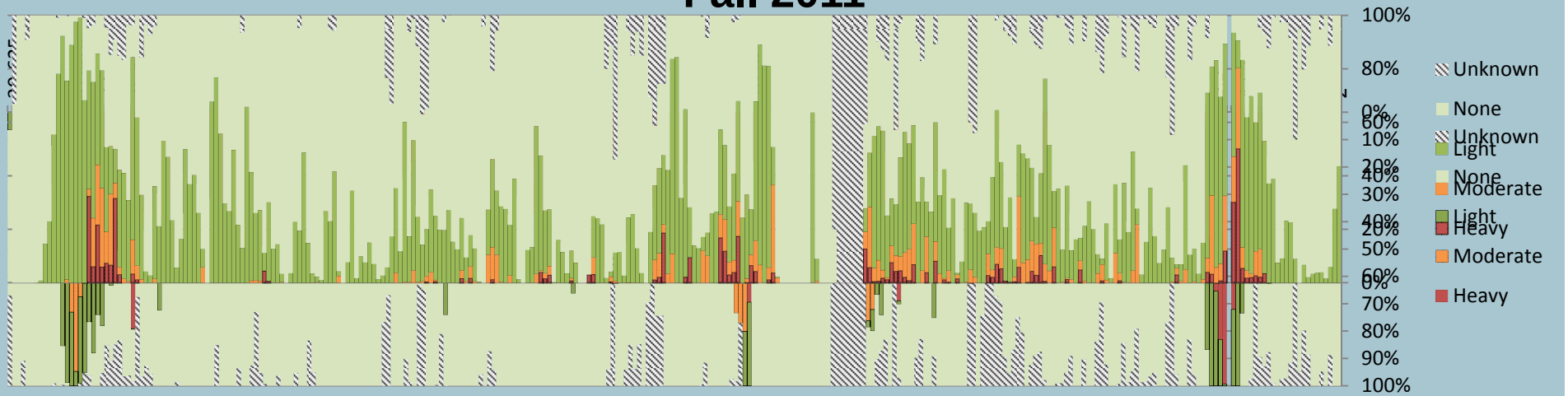
Morrow Lake Recovery



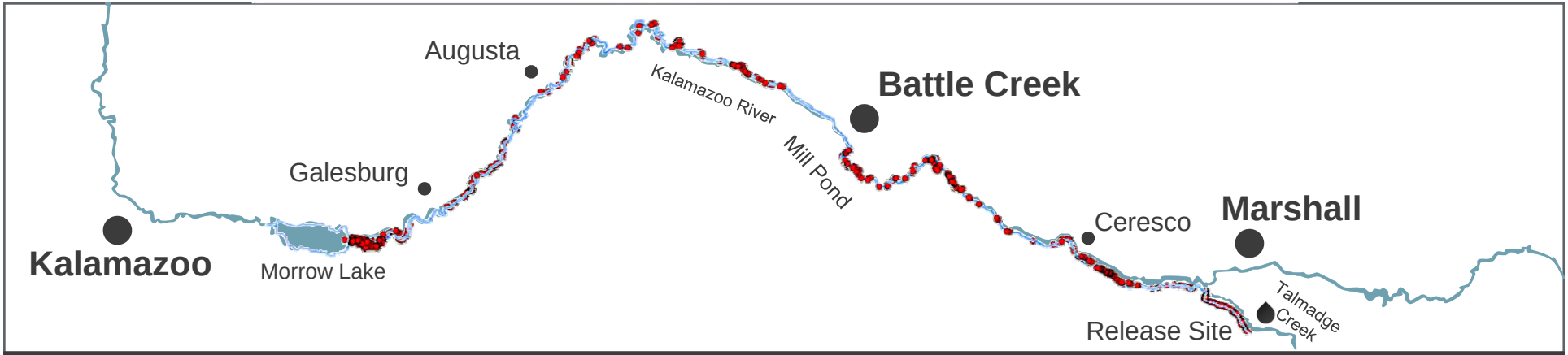

# Summary of Work 2011

Submerged Oil – Distribution by Area

## Fall 2011

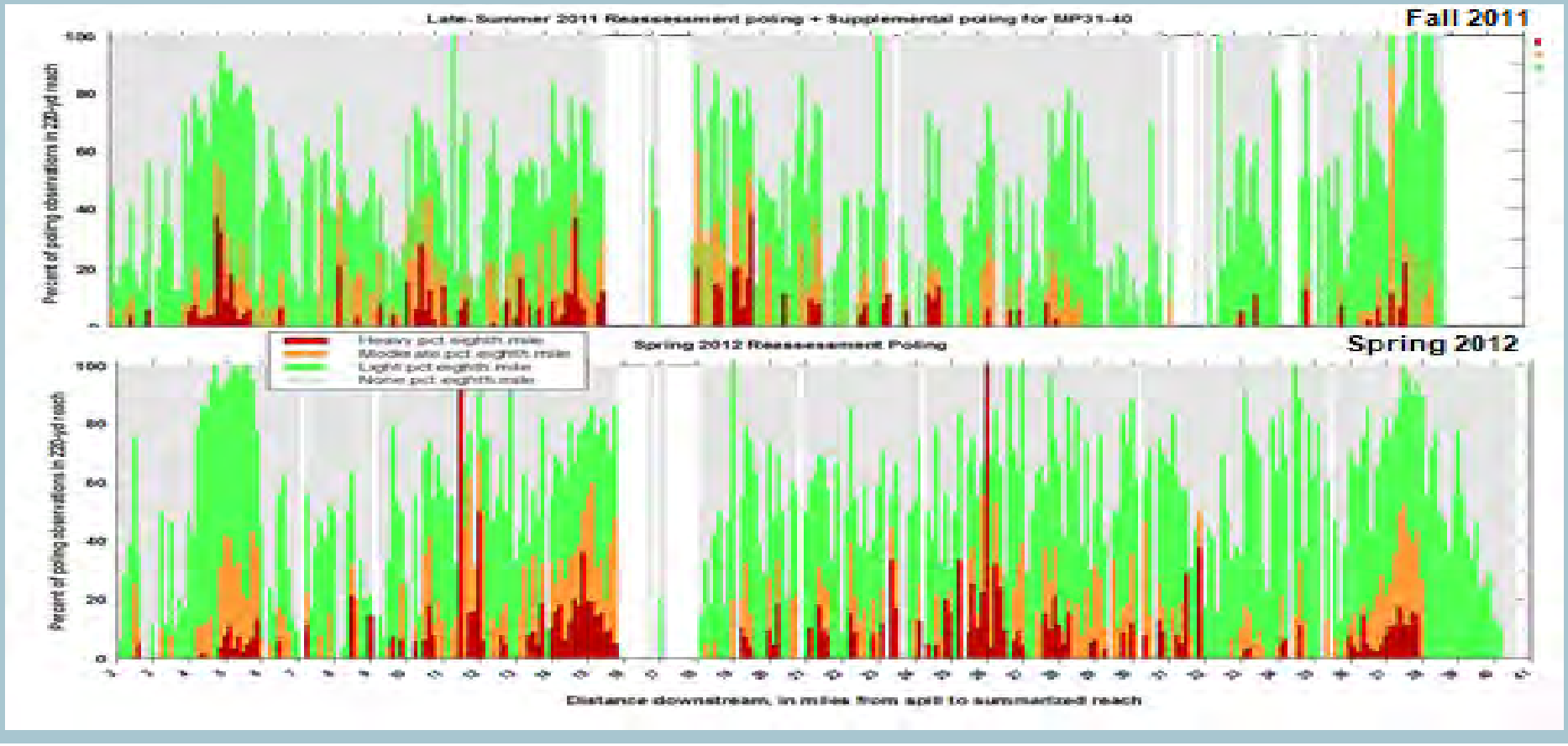


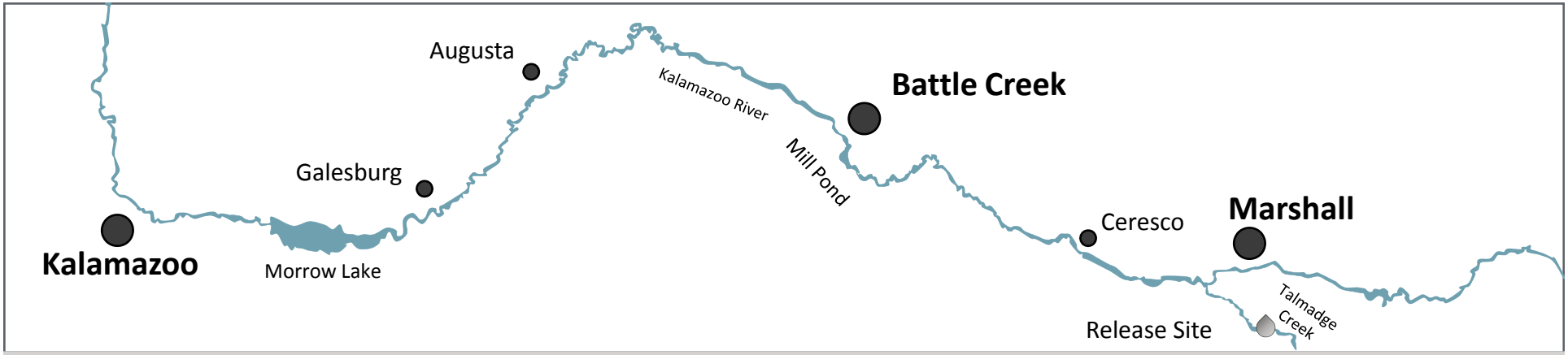

## Spring 2011




# Summary of Work 2011

Submerged Oil – Distribution by Area

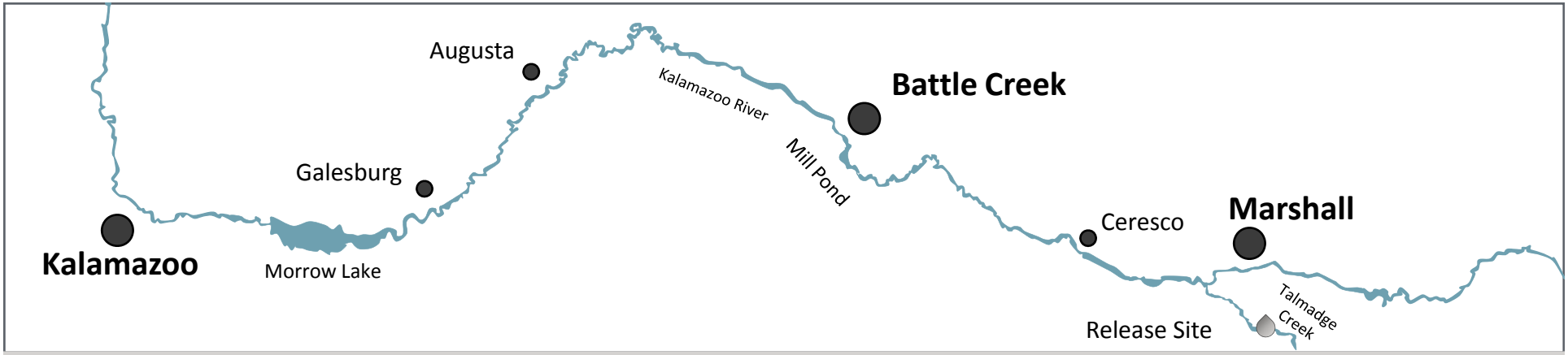





## Conducted Scientific Studies during 2012

- Net Environmental Benefit Analysis (NEBA)
- Submerged Oil Quantification Study
- UV-Epifluorescence Microscopy Study
- Biodegradation Study
  - This study was commissioned by the FOSC through the U.S. EPA Environmental Response Team (ERT) and led by Mark Sprenger

Note, the above studies have not been finalized and are not yet available for public release




# Net Environmental Benefit Analysis

## NEBA

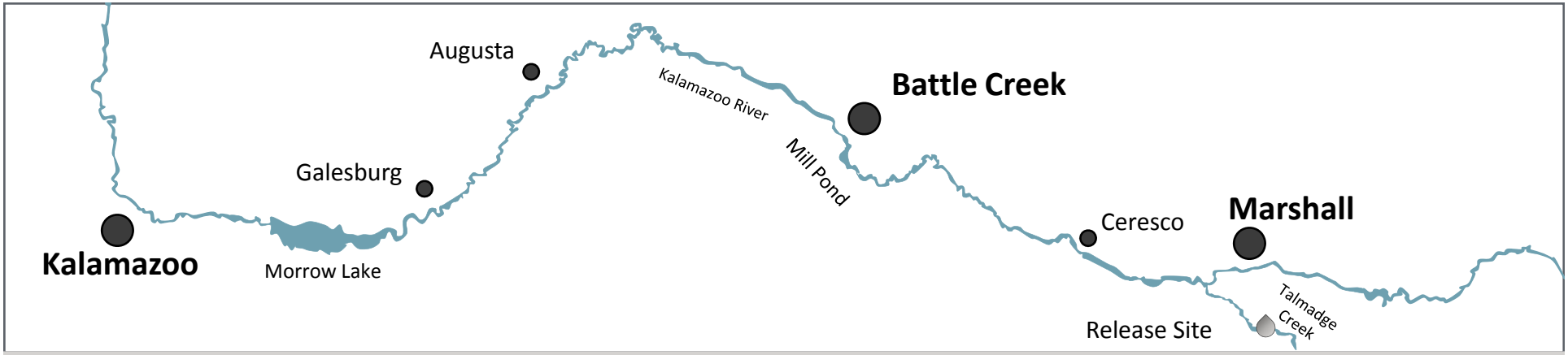
- Weighs the environmental risks associated with leaving residual submerged oil in place as compared to ecological impacts resulting from additional oil recovery actions.

- Addresses only potential ecological effects. Does not address human health impacts or other designated uses of a water body.

- Addresses habitats and considers resource impact on most sensitive species affected by oil and;

- Evaluates potential impacts from specific submerged oil recovery actions.

- Process led by Faith Fitzpatrick (USGS) as one of three site Science Coordinators. Documents were prepared by members of the Scientific Support Coordination Group (SSCG) including MDEQ, USGS, EPA, USFWS and the Kalamazoo River Watershed Council




# Submerged Oil Quantification

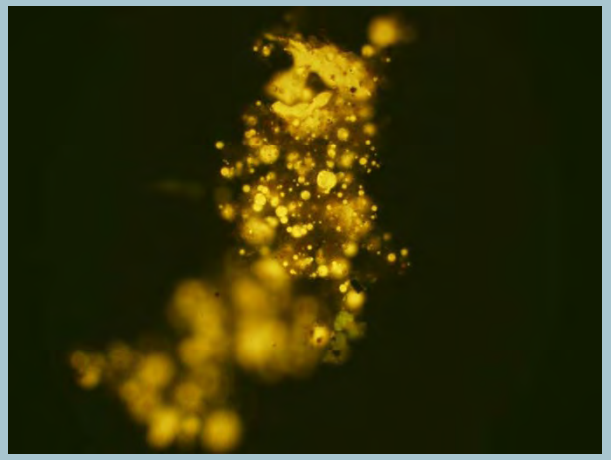
## Stratified Sediment Sampling

Generalized Random Tessellation Survey (GRTS)

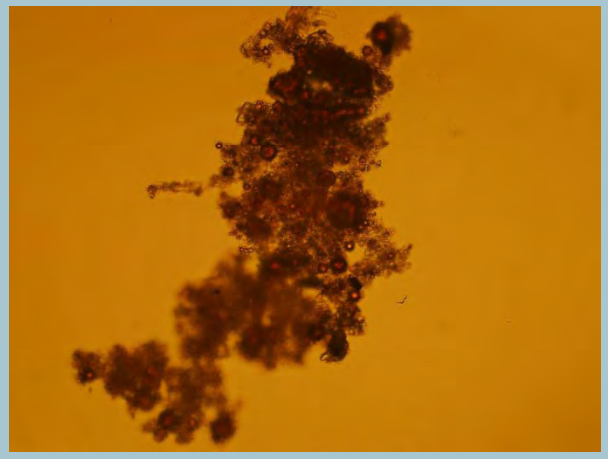
Coring locations were selected using a GRTS model.

- The coring locations were randomly selected from heavy/moderate and light/none polygons within the 10 different stratified geomorphic units (i.e. Impounded waters, depositional backwaters, oxbows, etc.)
- Stratified – likely to reduce variance of the oil estimate.
- Spatially balanced – across the entire site.
- Study led by U.S. EPA and Enbridge with support from oil spill forensic chemistry experts supporting EPA (Greg Douglas from Newfields) and Enbridge (Ann Arbor Technical Services)

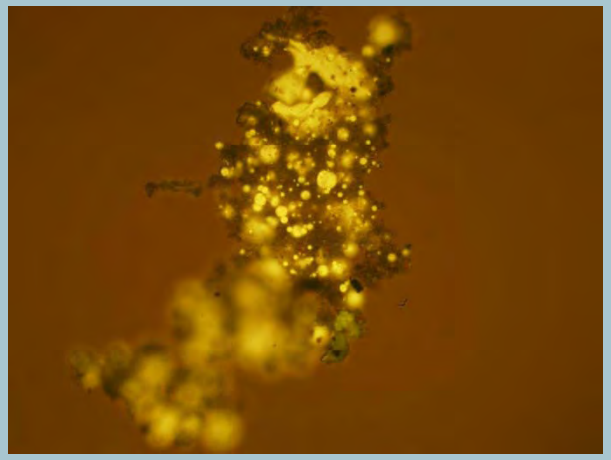
# Photomicrographs of Line 6B Oil-Mineral Aggregates (OMA)



UV epifluorescence



Bright field transmitted light



Combined illumination

Oil-mineral aggregates are oil droplets stabilized by fine mineral particles.

Dr. Ken Lee (Fisheries and Oceans Canada) prepared this OMA in his laboratory using Line 6B oil and Kalamazoo River sediments.

Study commissioned by the FOSC through the Scientific Support Coordination Group (SSCG) – Dr. Ken Lee is a member of the SSCG

# 2012 Sheen Management at Ceresco Dam Impoundment