Targeted Maintenance Efforts to Ensure a Decade of Successful Passive Treatment

Robert W. Nairn

Boren Distinguished Professor and Viersen Presidential Professor

CREW Director

Bryan Page, Brandon Holzbauer-Schweitzer, and Nicholas Shepherd

THE UNIVERSITY OF OKLAHOMA
CIVI ET REIPUBLICAE
1890

The UNIVERSITY of OKLAHOMA
Gallogly College of Engineering
School of Civil Engineering and Environmental Science

CREW
Center for Restoration of Ecosystems and Watersheds
University of Oklahoma


Study Site


Water doesn’t flow downhill

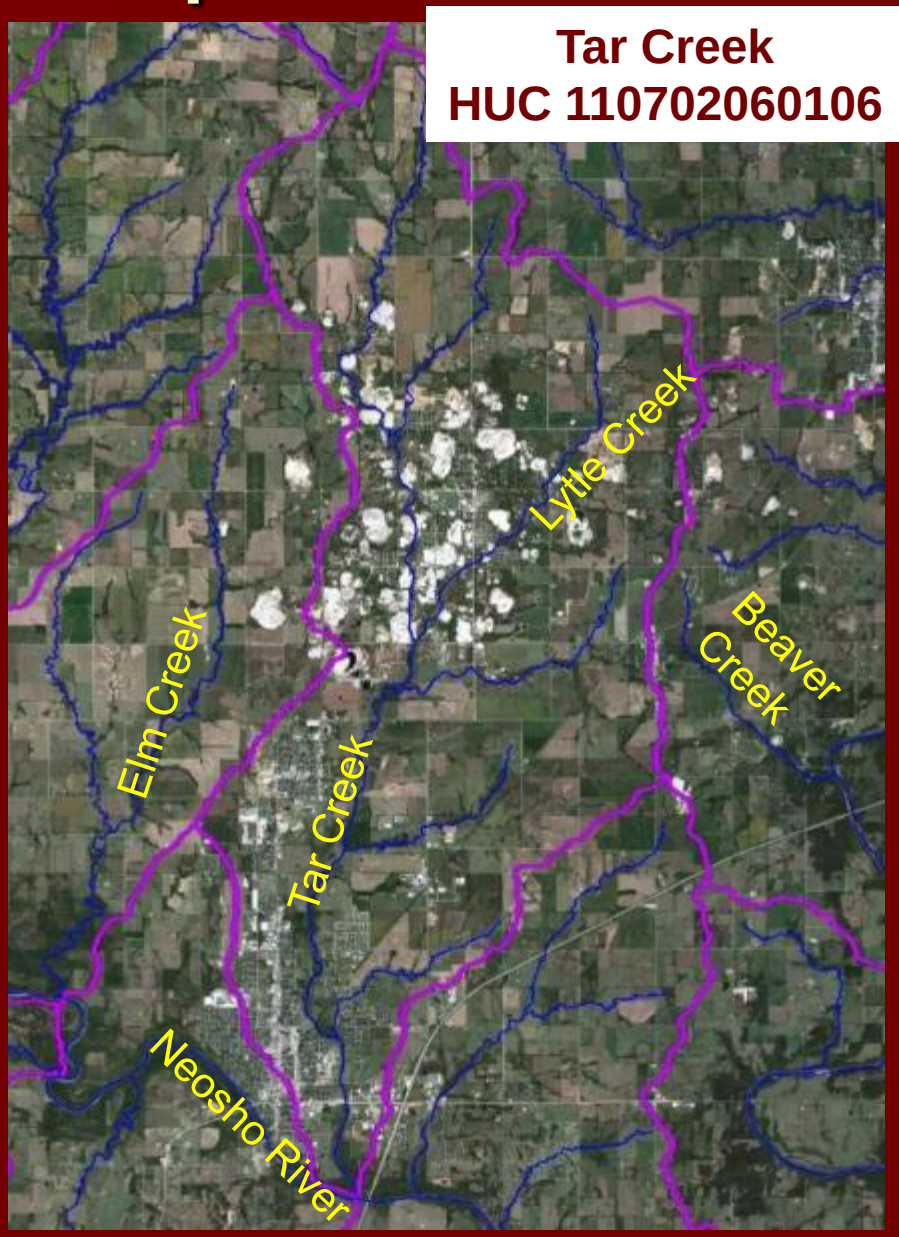

It doesn’t flow downgradient either

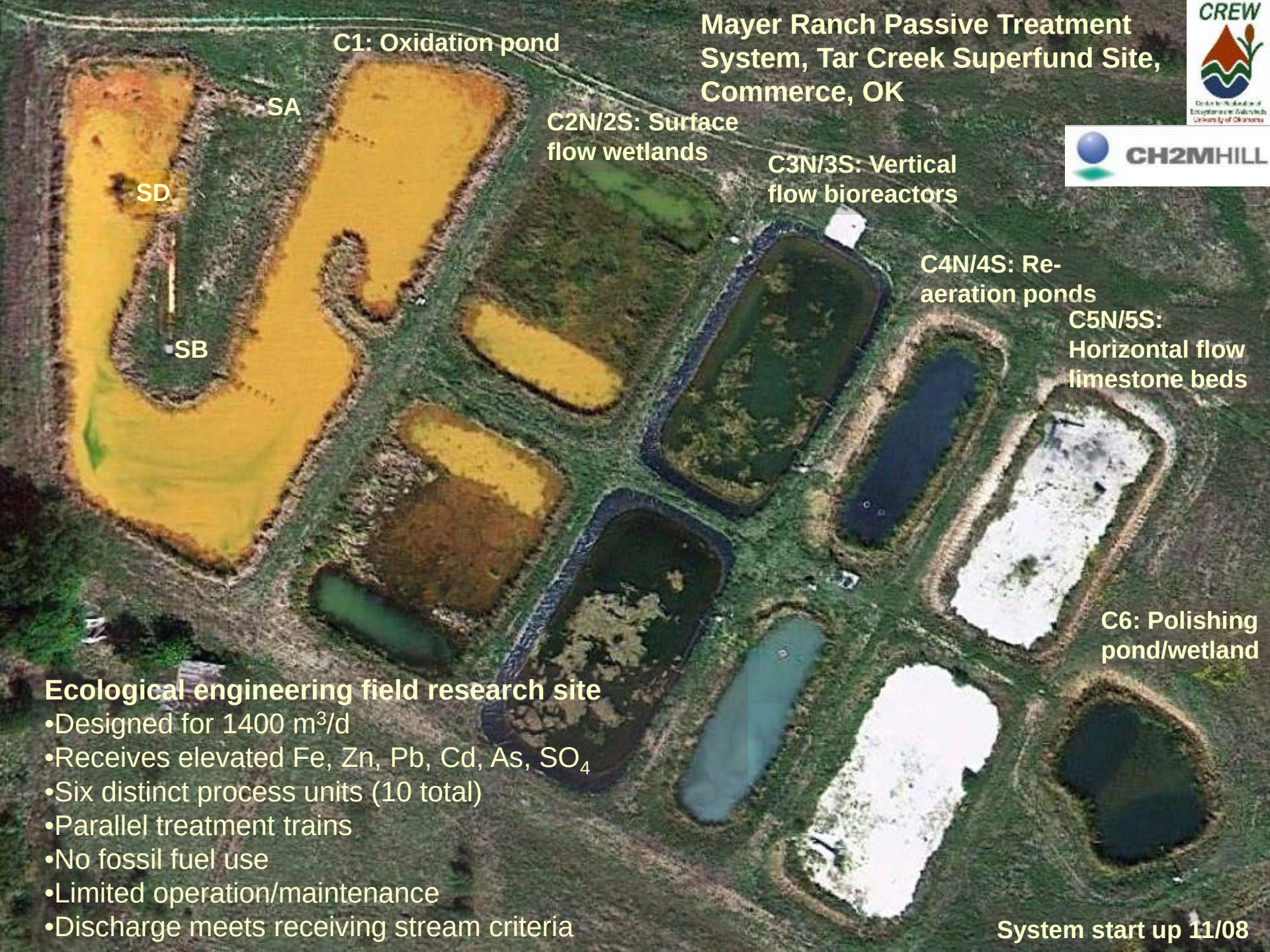

Conclusions


Study Site

Tar Creek (OK) Superfund Site

- Tri-State Pb-Zn Mining District
- National Priorities List (1983)
- 137 km^2 watershed
- Elevated Fe, Zn, Cd, Pb, As in water, soils, wastes, and biota
- Ten Native American Tribes
- Mining “mega-site”




Mayer Ranch Passive Treatment System, Tar Creek Superfund Site, Commerce, OK
CREW
CH2MHILL
C1: Oxidation pond
SA
SD
SB
C2N/2S: Surface flow wetlands
C3N/3S: Vertical flow bioreactors
C4N/4S: Re-aeration ponds
C5N/5S: Horizontal flow limestone beds
C6: Polishing pond/wetland
Ecological engineering field research site
•Designed for 1400 m3/d
•Receives elevated Fe, Zn, Pb, Cd, As, SO4
•Six distinct process units (10 total)
•Parallel treatment trains
•No fossil fuel use
•Limited operation/maintenance
•Discharge meets receiving stream criteria
System start up 11/08

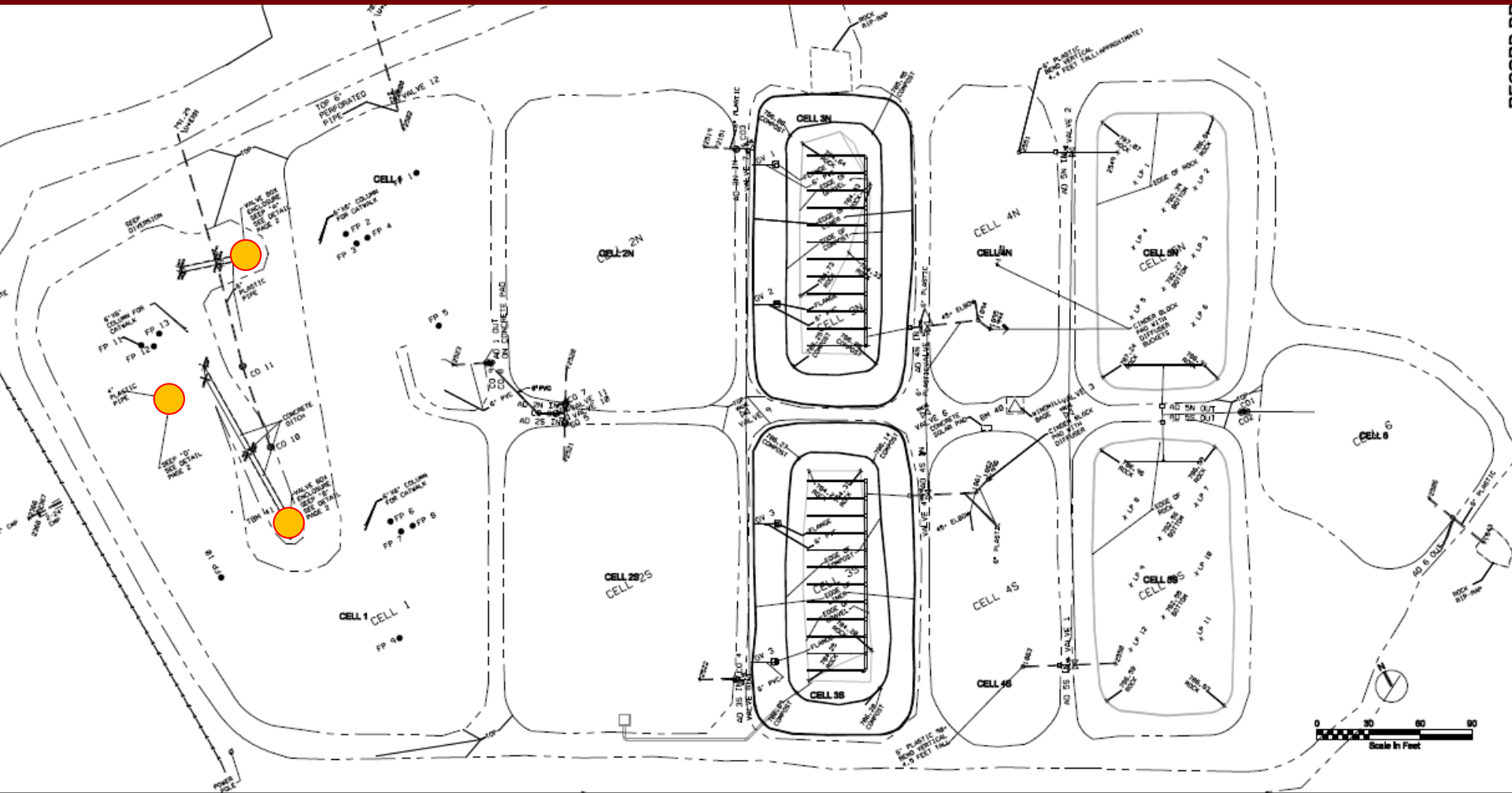
Mayer Ranch Passive Treatment System

- USEPA funding 2004-10
- 10 process units
  - 8 in parallel trains
  - Coupled oxidative-reductive mechanisms
  - Solar- and wind-powered re-aeration
- First PTS in entire Tri-State Mining District
- Continuous operation since 11/2008
- Long-term CREW ecological engineering research site

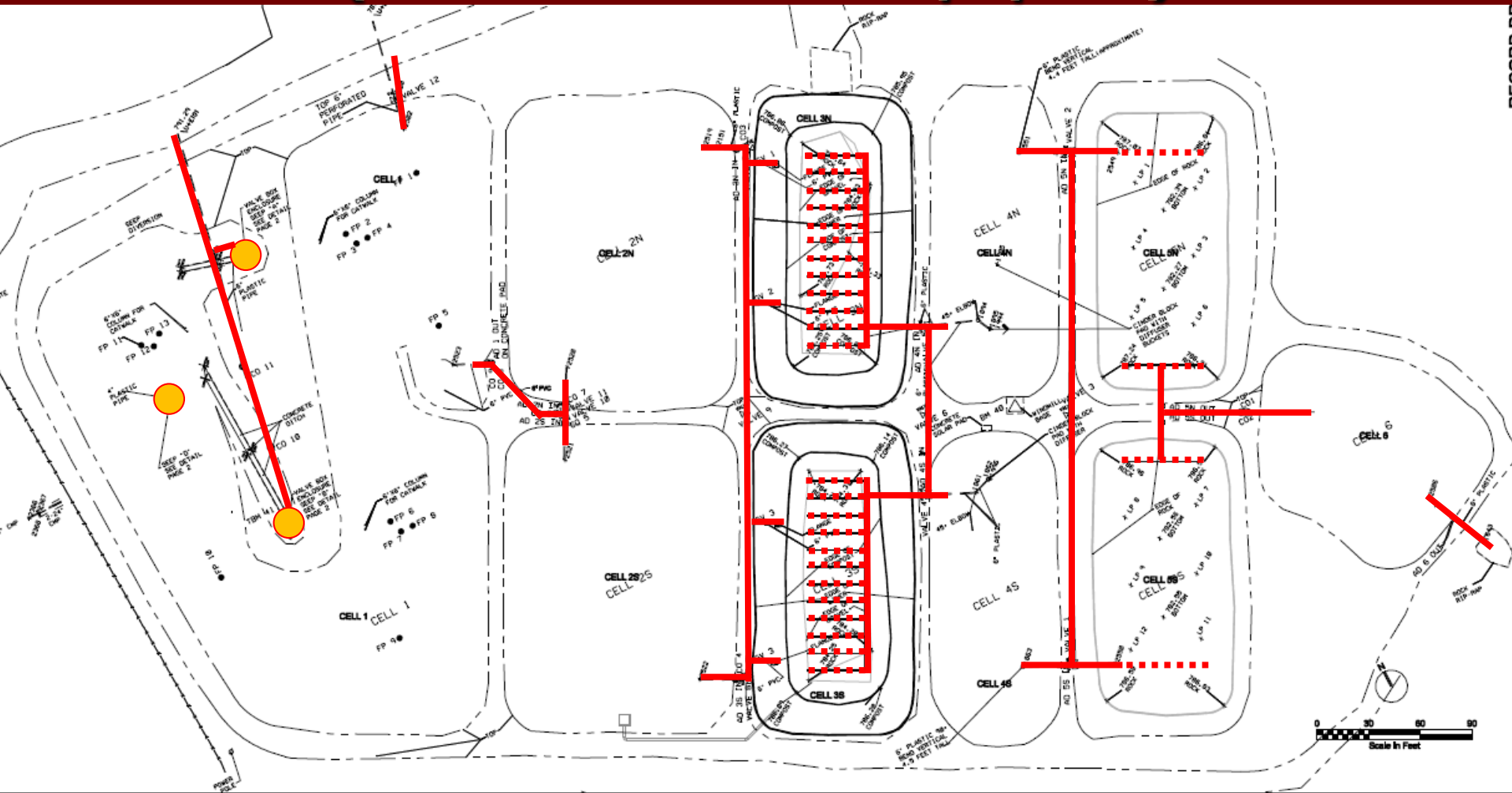
MRPTS Water Quality Changes

	In	Out
pH	5.95	7.02
Tot. Alk. (mg/L)	393	224
Net Alk. (mg/L)	29	224
Fe (mg/L)	192	0.13
Zn (mg/L)	11	0.25
Ni (mg/L)	0.97	0.15
Cd (μg/L)	17	<PQL
Pb (μg/L)	60	<PQL
As (μg/L)	64	<PQL
SO_4^{-2} (mg/L)	2239	2057

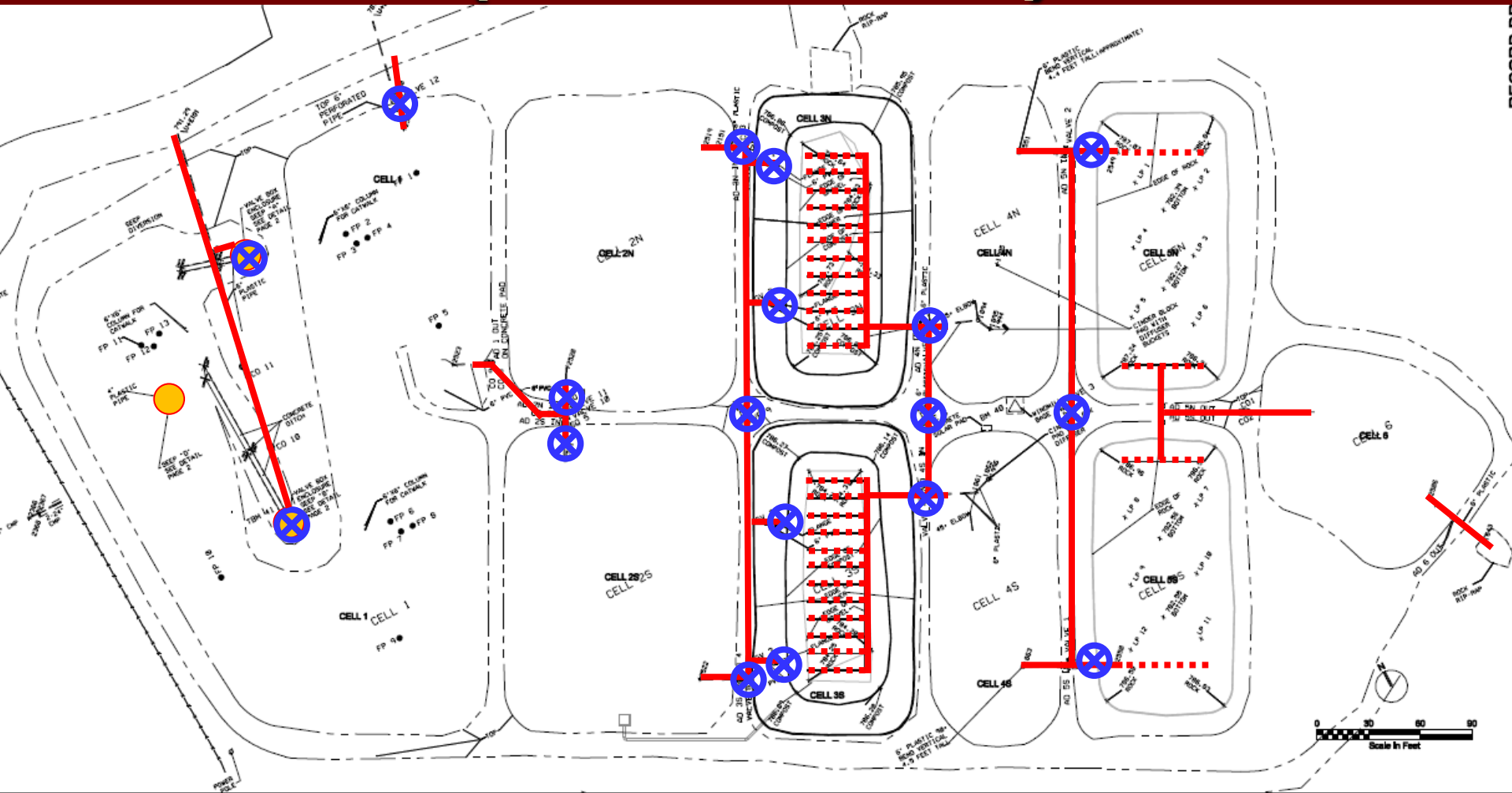
Extensive Ability to Manipulate Water Levels and Control Flows



Extensive Ability to Manipulate Water Levels and Control Flows (lots of buried pipes)



Extensive Ability to Manipulate Water Levels and Control Flows (lots of valves)



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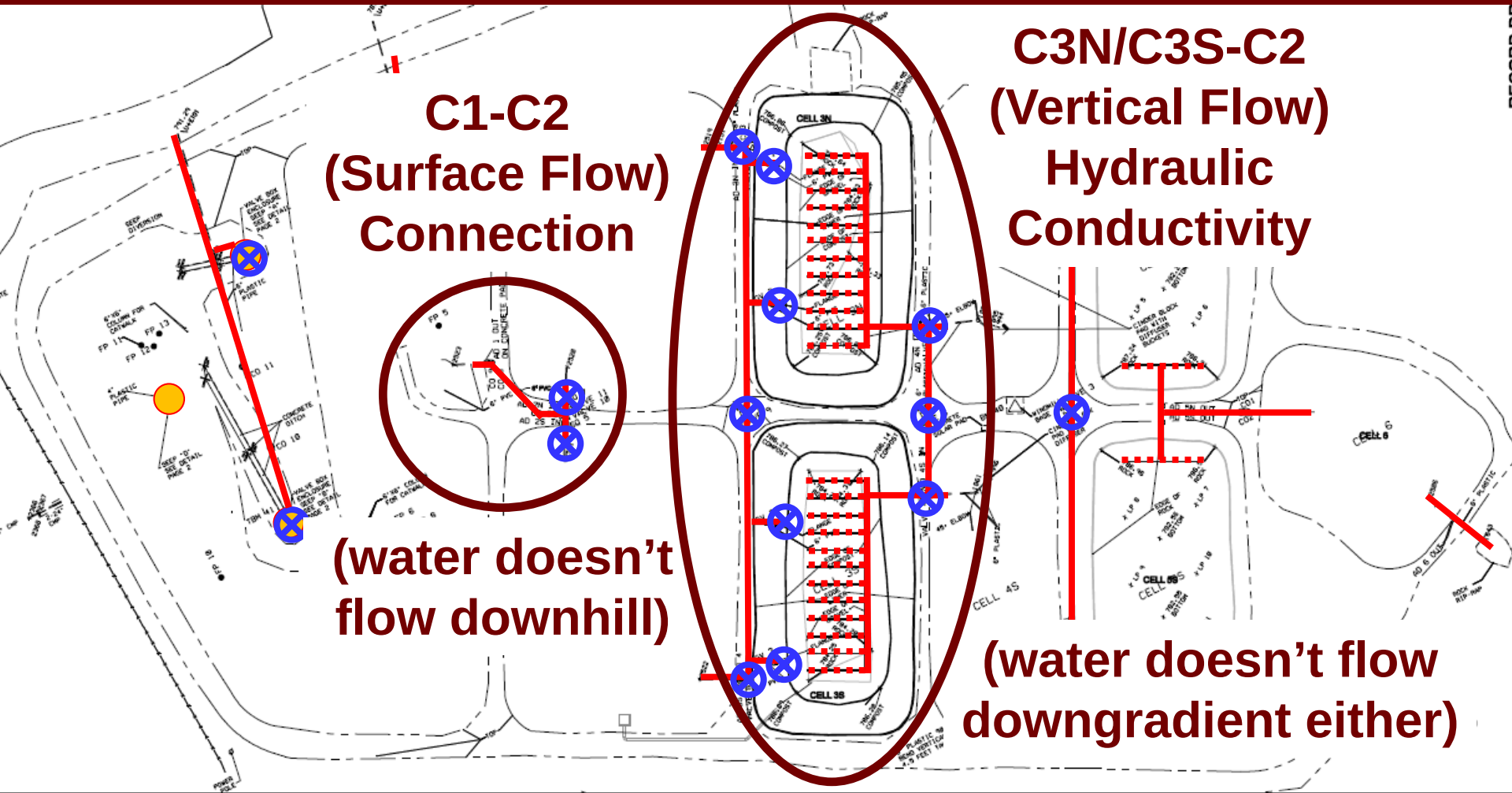


Water doesn’t flow downhill

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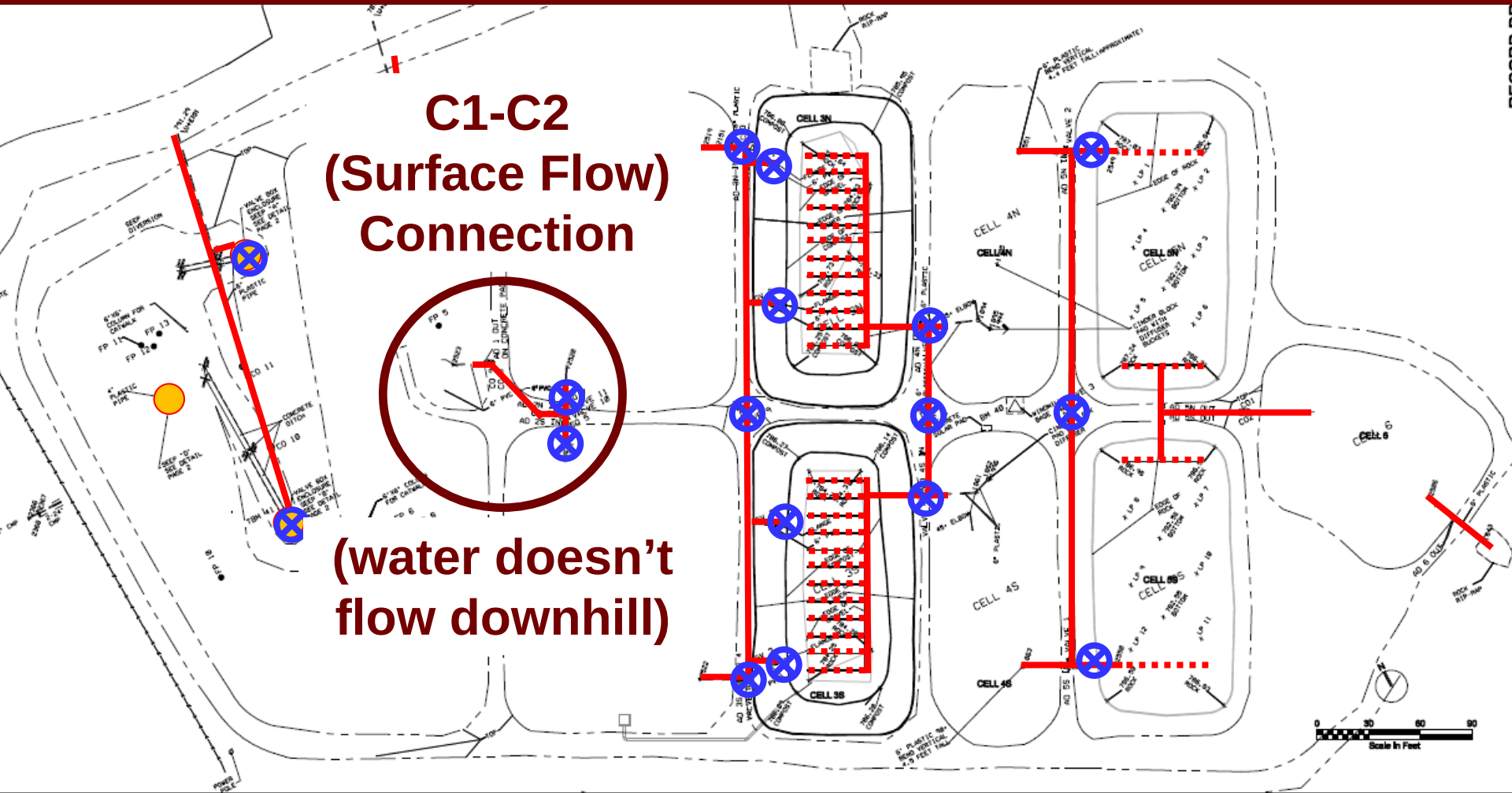

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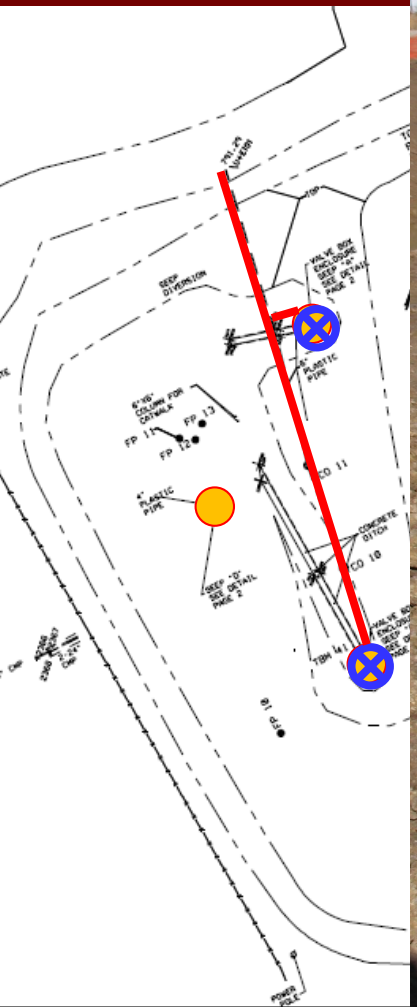

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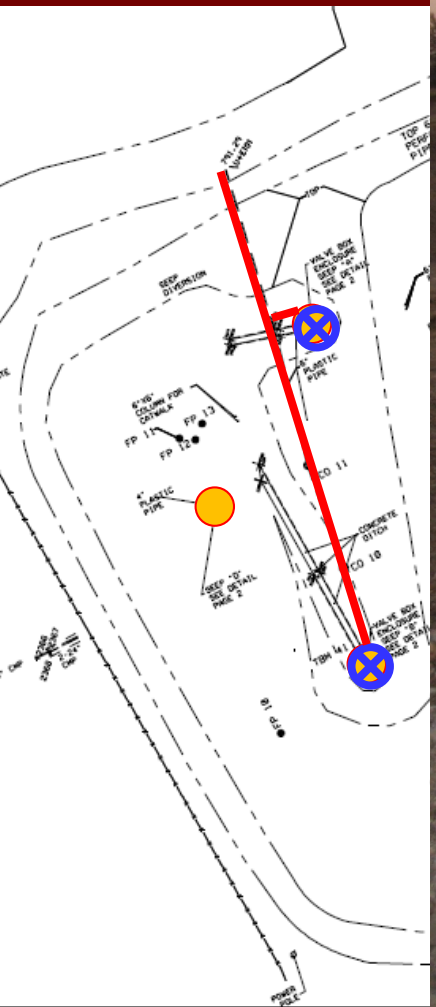

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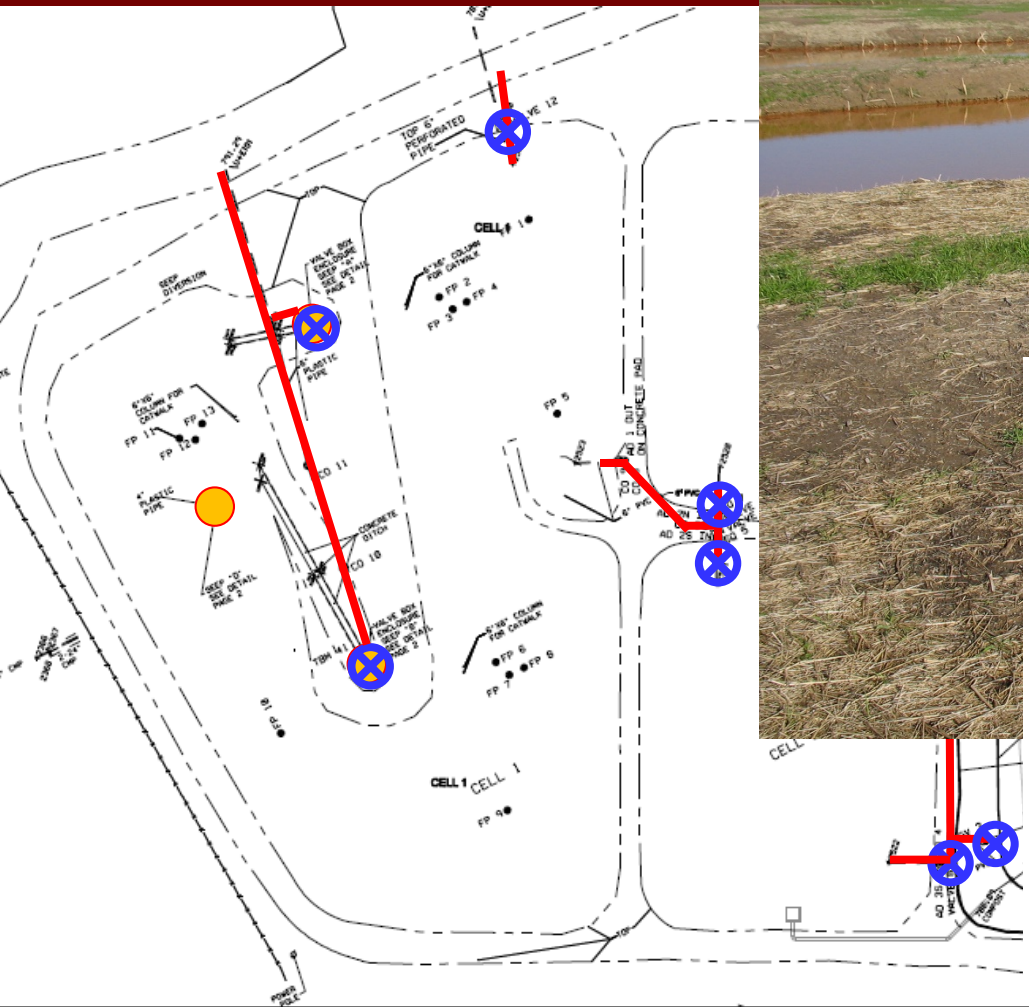
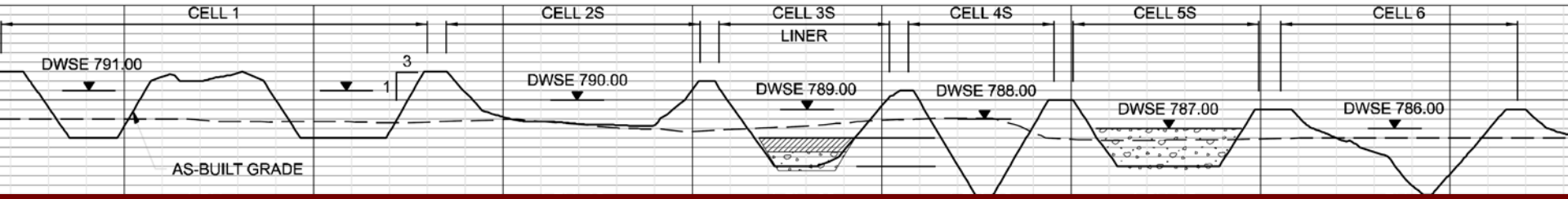
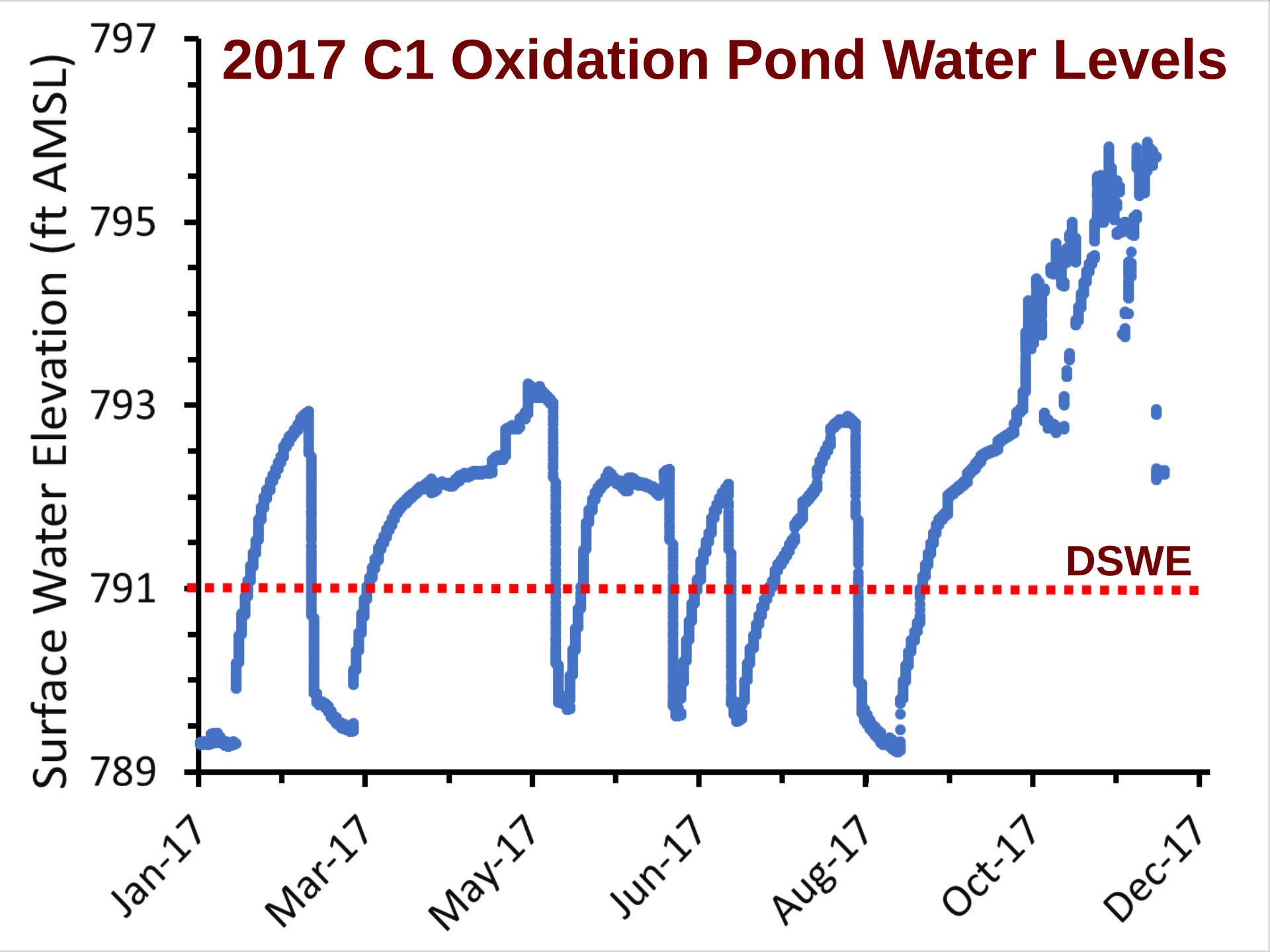
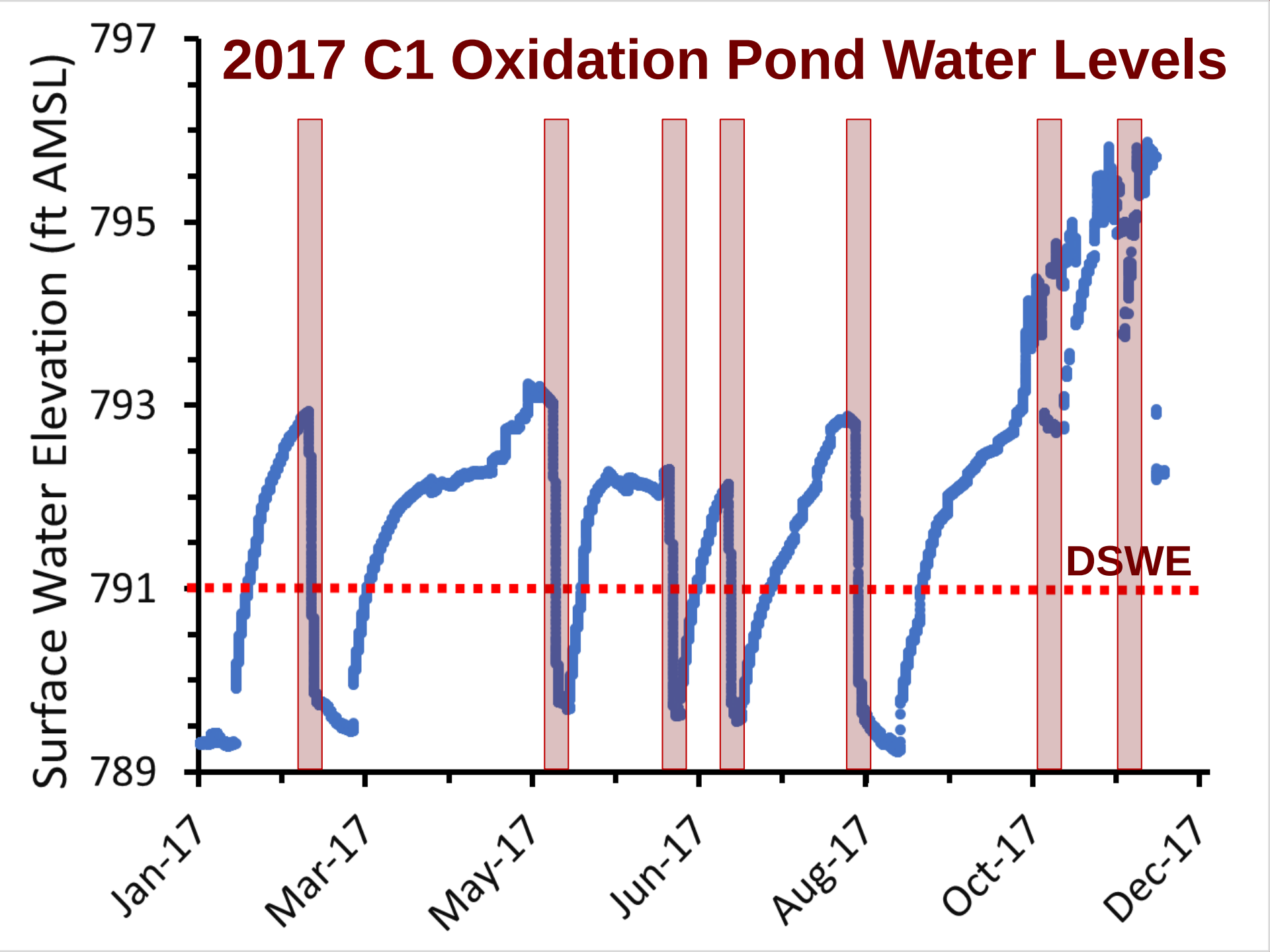


Water Surface Elevations



- Staff gauges
- Data-recording pressure transducers
  - Solinst Leveloggers
  - Barometric pressure-corrected
  - 30-minute data collection intervals
  - Deployed in every PTS unit and receiving stream


2017 C1 Oxidation Pond Water Levels
Surface Water Elevation (ft AMSL)
797
795
793
791
789
DSWE
Jan-17
Mar-17
May-17
Jun-17
Aug-17
Oct-17
Dec-17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Aug-17
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Dec-17


2009


2017


2017


2017


2017

Pipe is clogged? Snake it!

- Rented sewer snake
- Tried every head attachment known to man
- Cloudy water, but no evidence of clog
- Reestablished flow for a few days/weeks

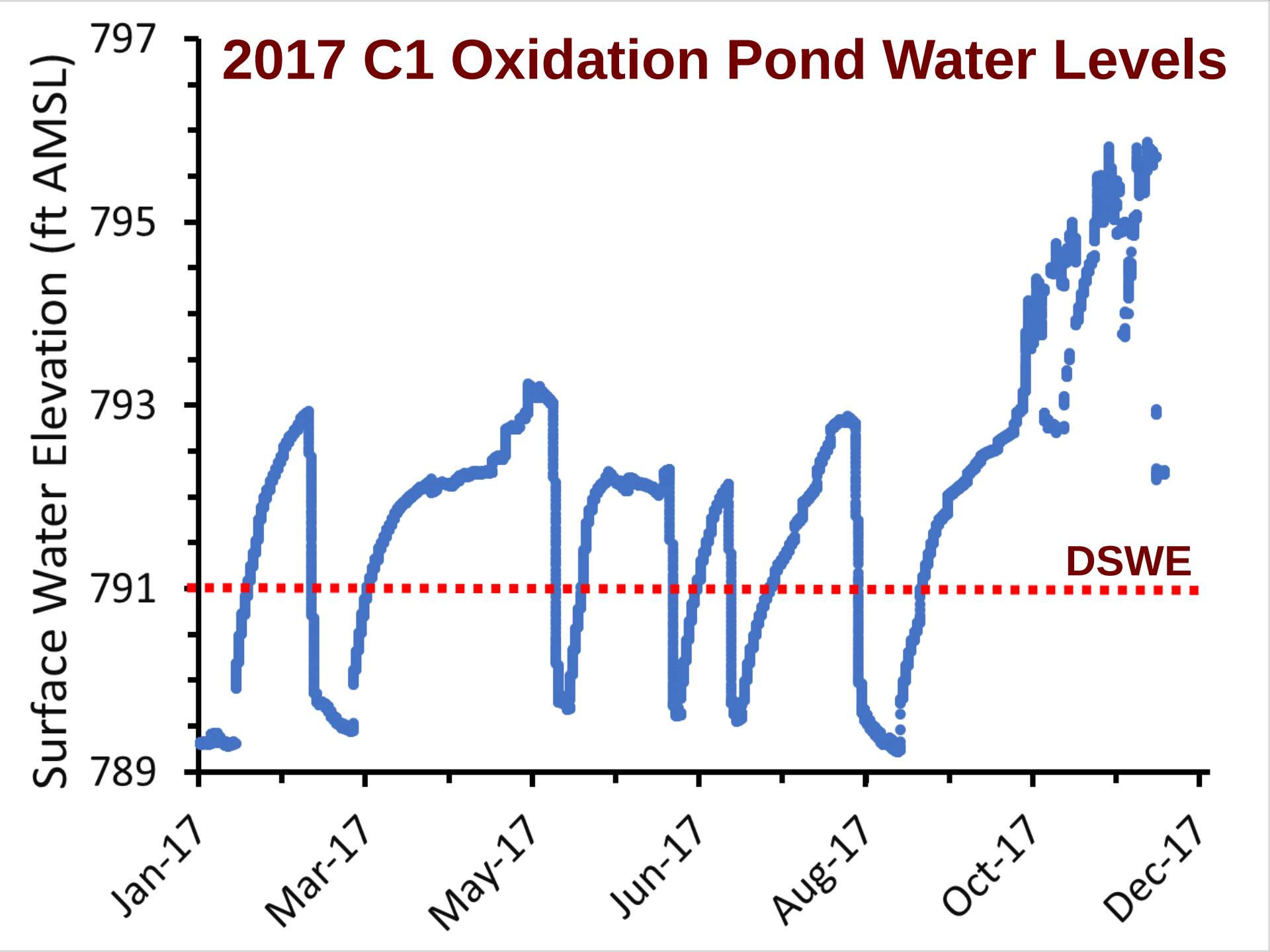
Pipe is clogged? Jet it!

- Down-sized 3” trash pump outflow to 1” with PVC fittings
- Cloudy water (and lots of it!), but no evidence of clog
- Reestablished flow for a few days/weeks

Pipe is clogged? Let's see...

- Rented sewer camera
- Pipe stained, but no obstruction

Reestablished flow for a few days/weeks!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Jan-17
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May-17
Jun-17
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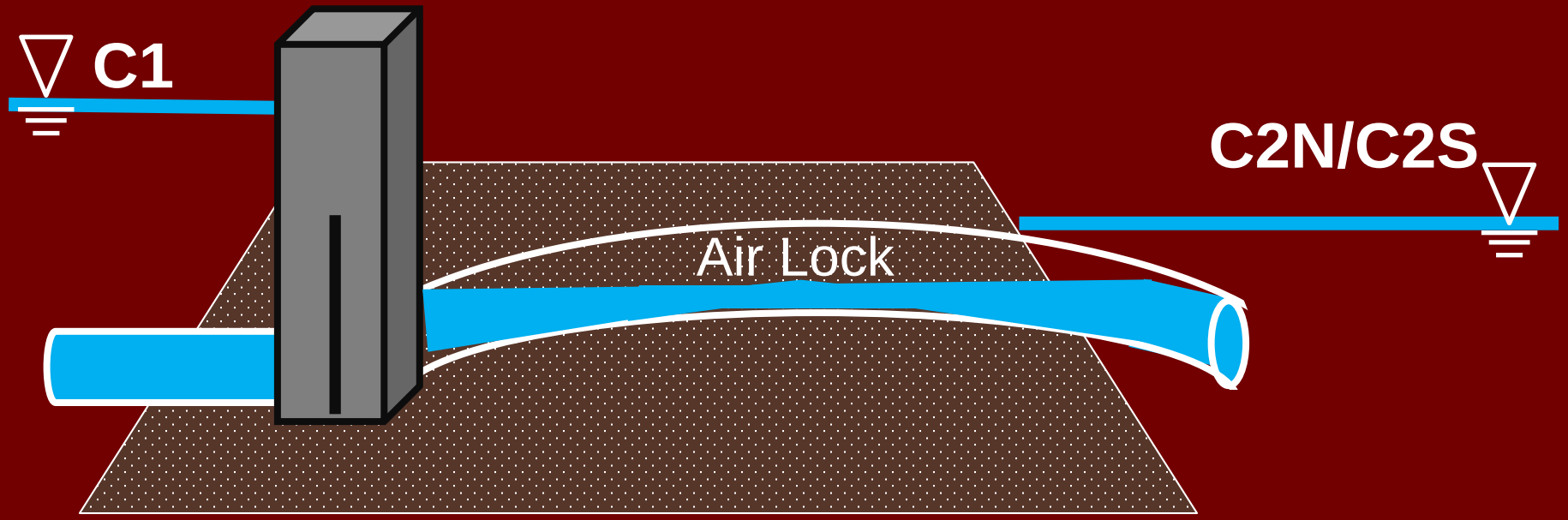
Oct-17
Dec-17

What is buried out there?



PTS O&M with Limited *(No)* budget, No Time and Thoughts to the Future

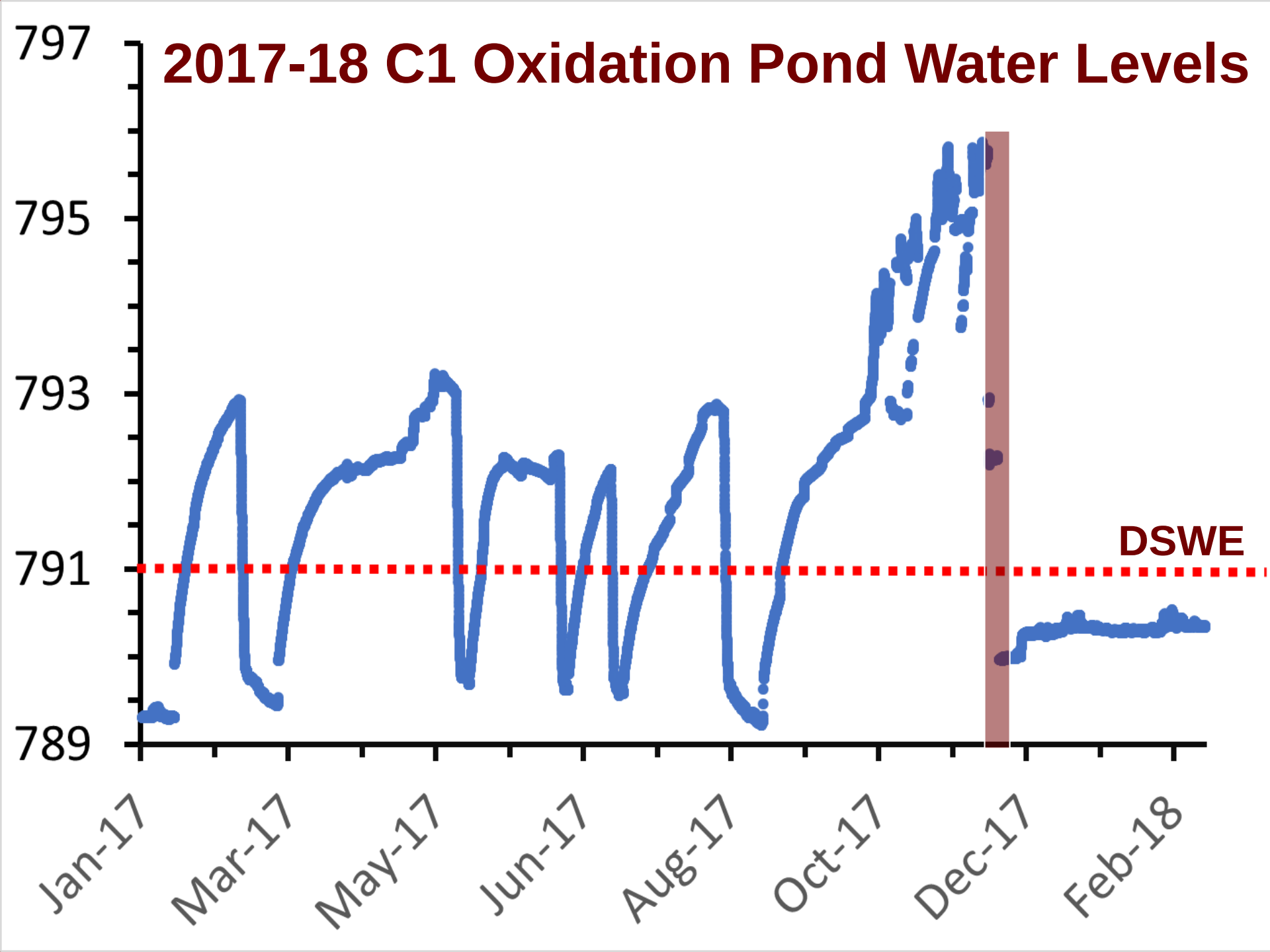
- Leave existing infrastructure in place, but take off-line
- Open berm and install straight short pipes
- Install inlet (not inline) AgriDrain structures with weirs
- Set identical weir elevations to split flows evenly into C2N/C2S
- Cross our fingers...


Leave Existing Infrastructure in Place

Small Trackhoe and Experienced Work CREW


Short Open Pipes

Inlet AgriDrains and Short Open Pipes


2017-18 C1 Oxidation Pond Water Levels
797
795
793
791
789
DSWE
Jan-17
Mar-17
May-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18


It doesn’t flow
downgradient either

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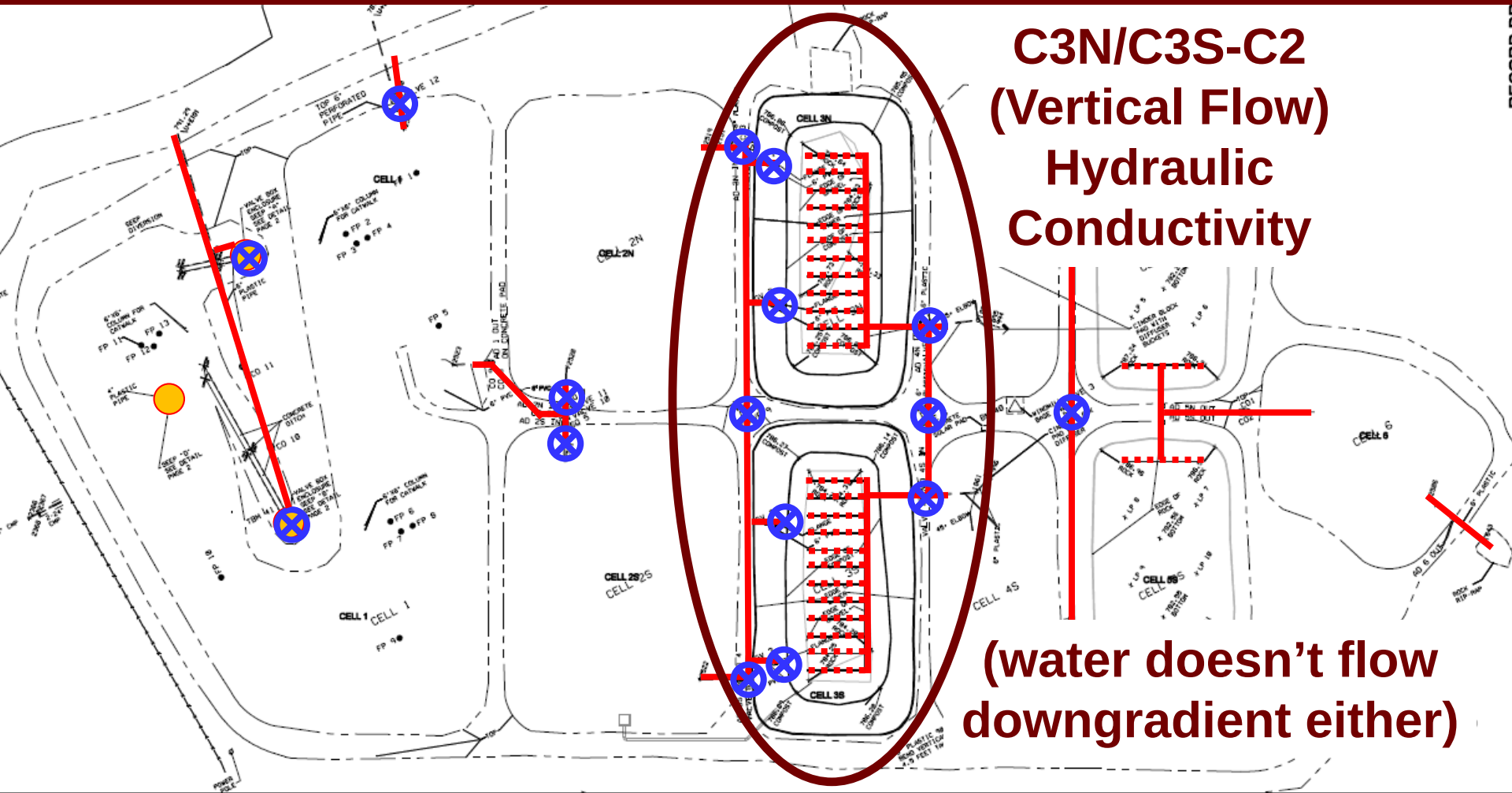

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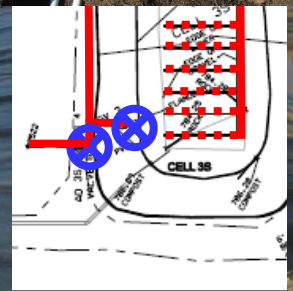



45% hard wood chips
10% manufactured limestone sand
45% spent mushroom substrate


GET A LOAD OF THIS

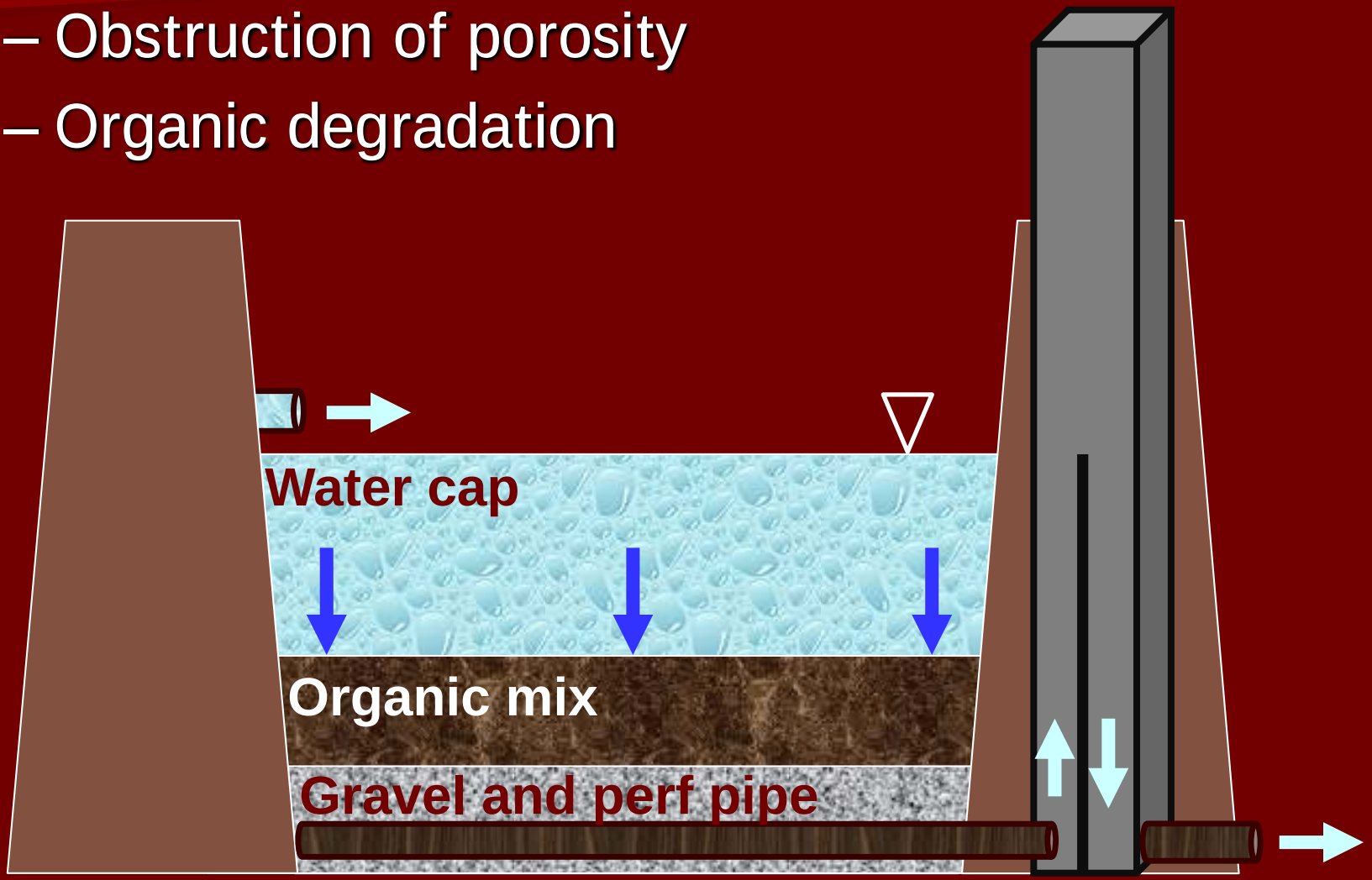

2009


2017


2017
?
?

What else is buried out there?

- Decrease in K over time
  - Obstruction of porosity
  - Organic degradation



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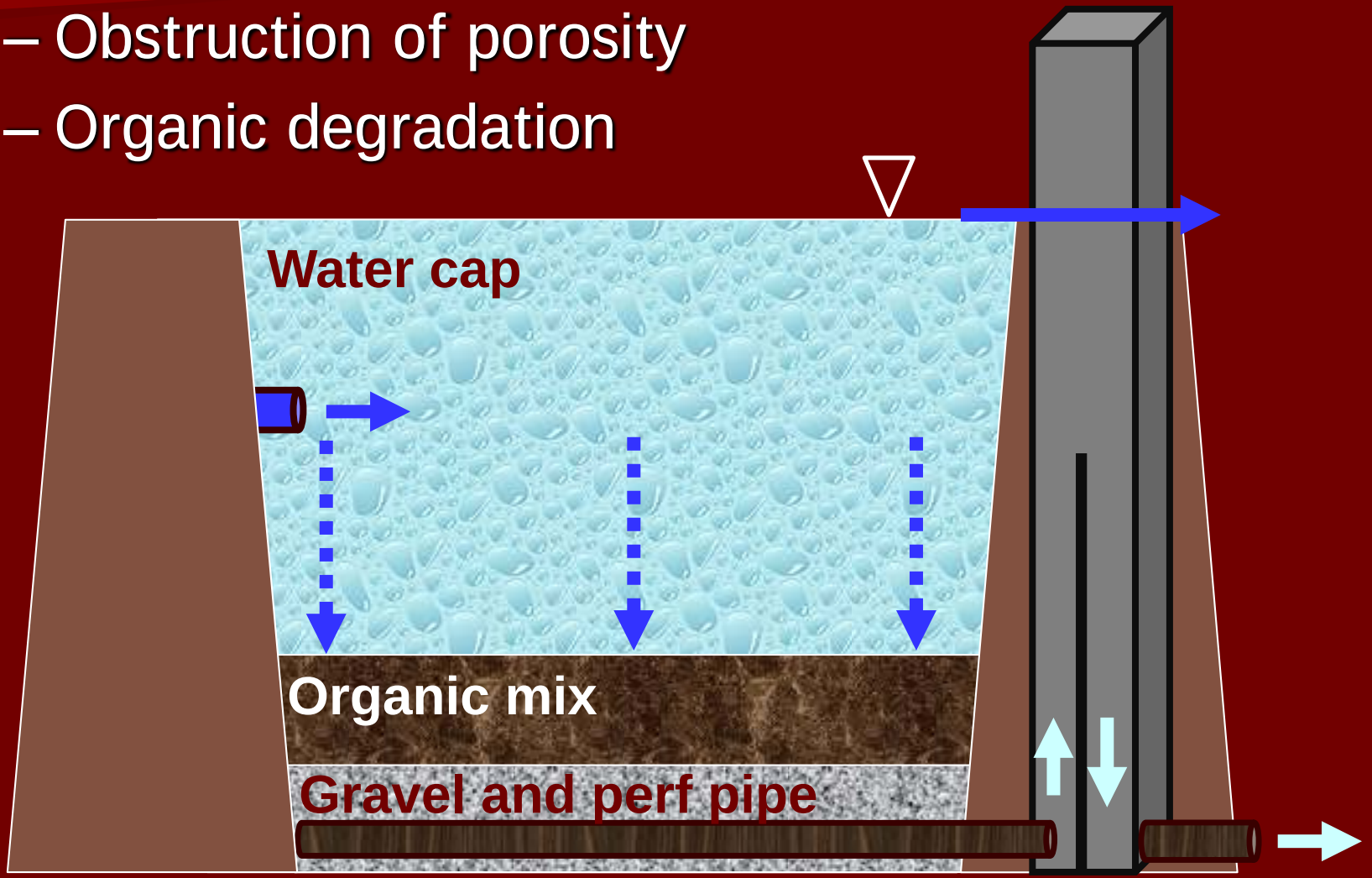
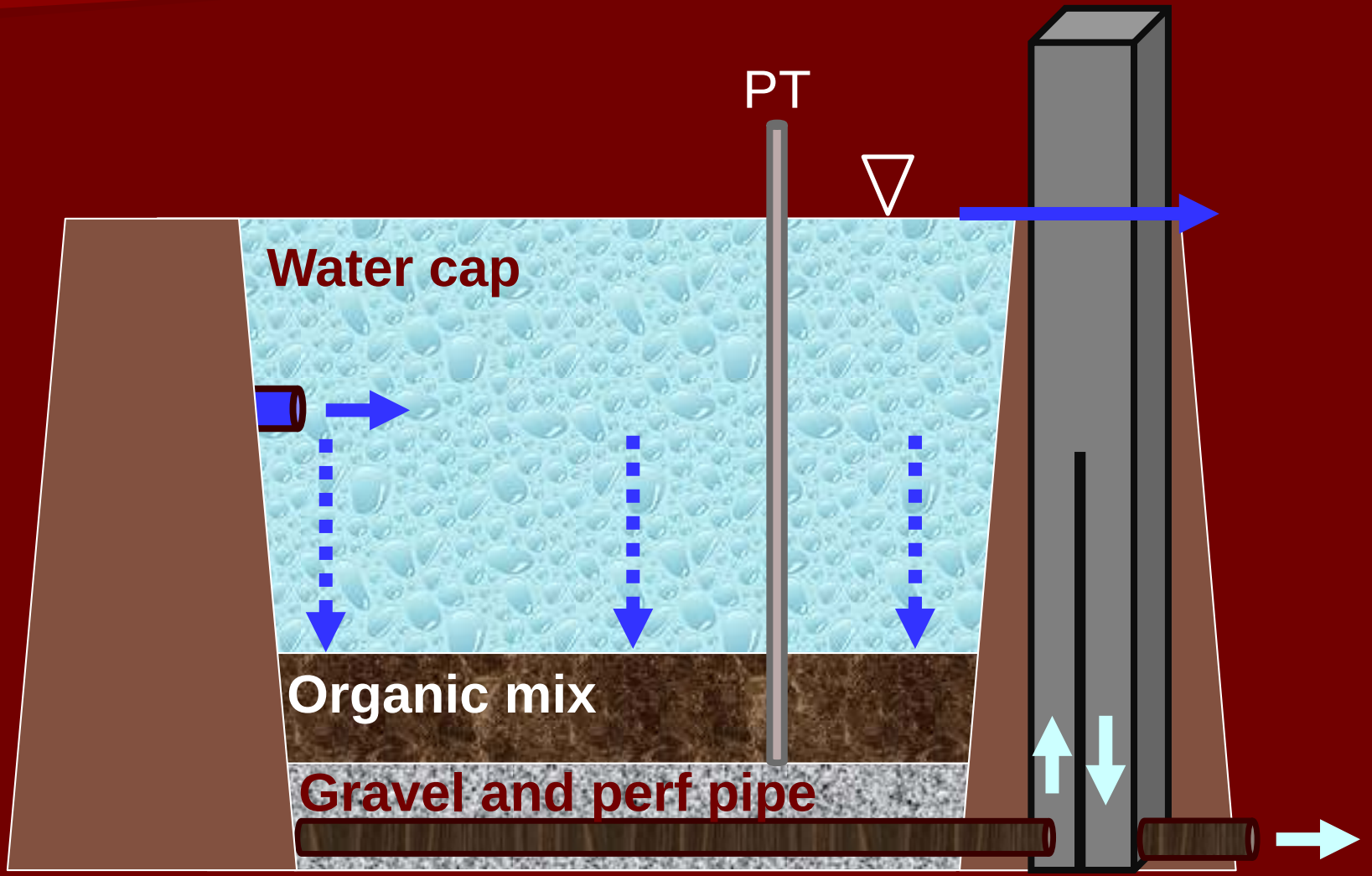


Estimated Hydraulic Conductivity (K)

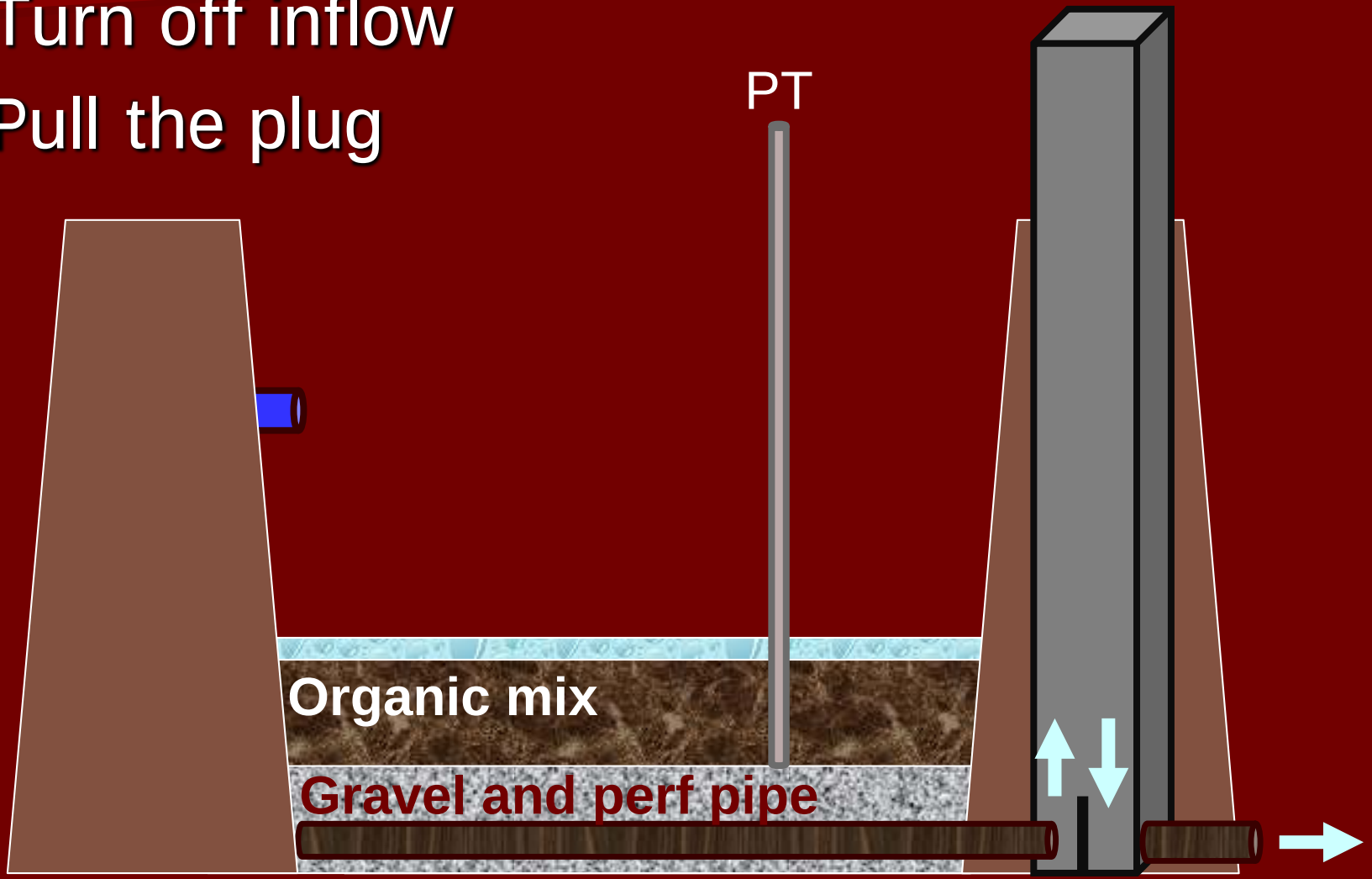
- Field-falling head tests
- Slug tests
- Modified single-ring infiltrometer
- Laboratory-falling head tests

Field-Falling Head Tests

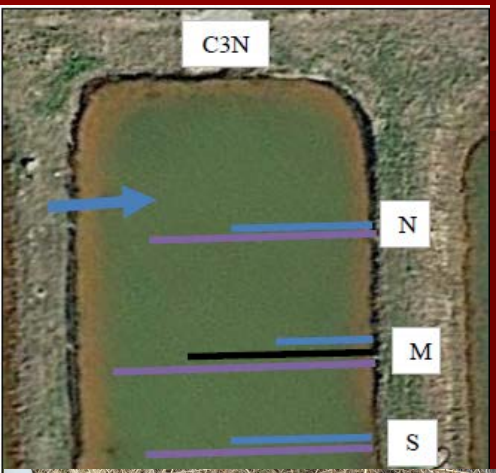


Field-Falling Head Tests

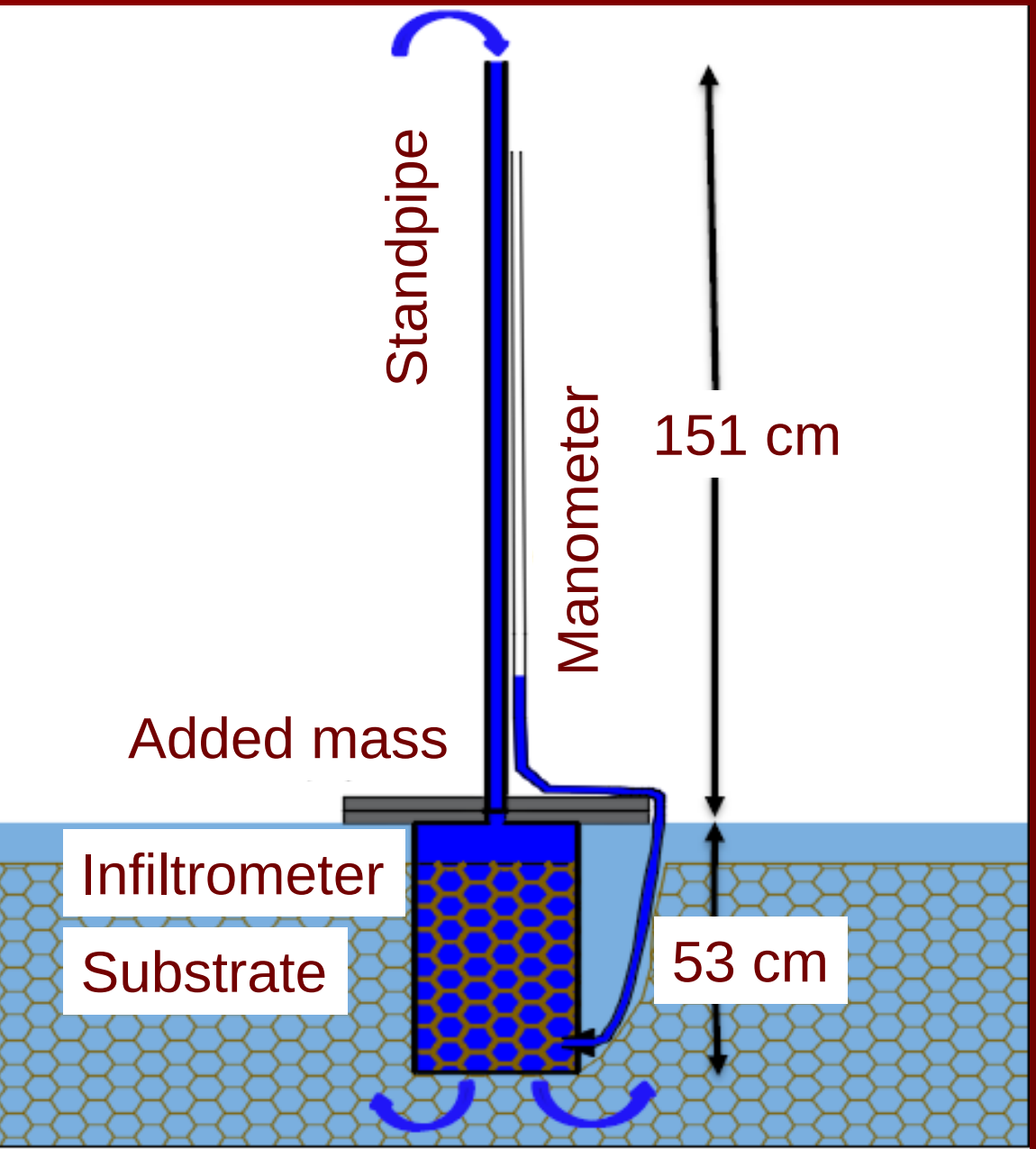
- Turn off inflow
- Pull the plug



Slug Test

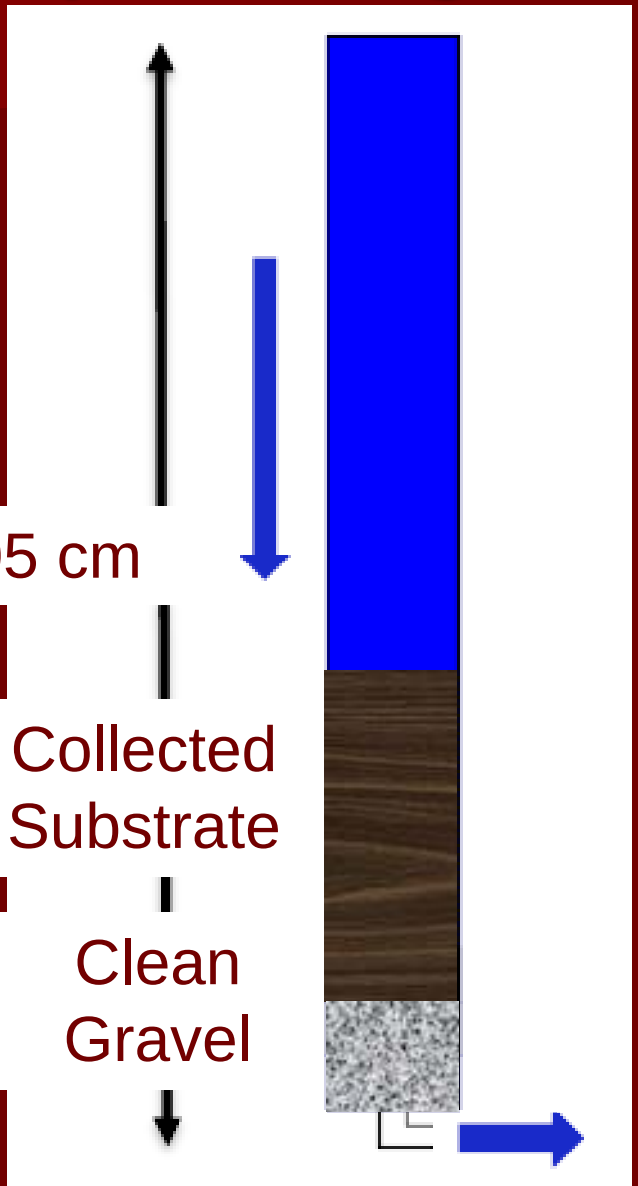


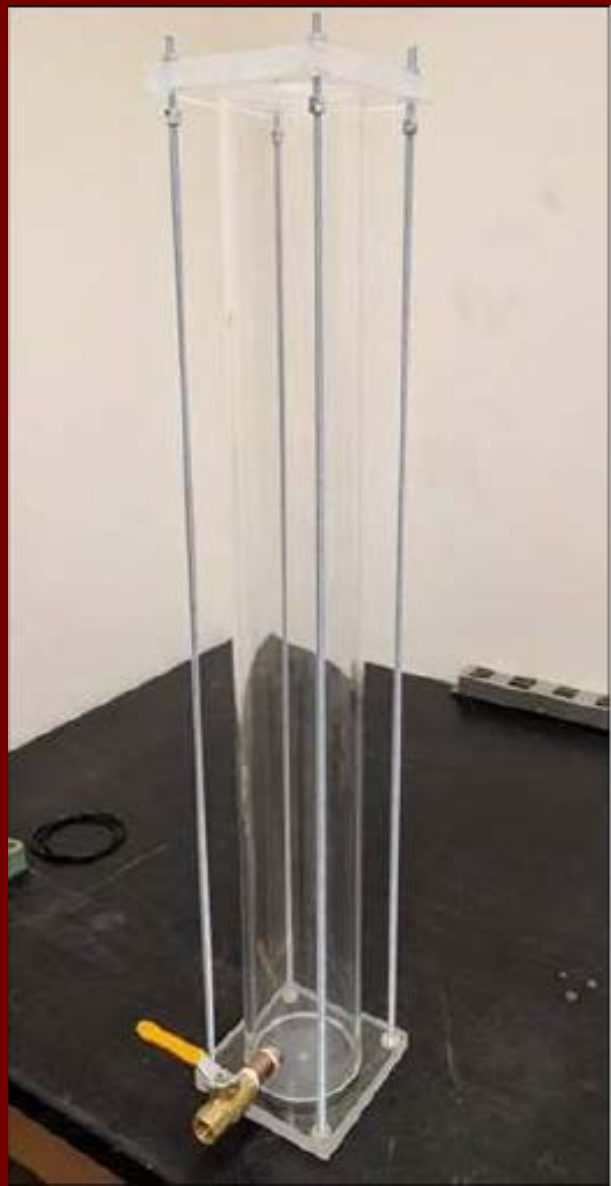
Modified Infiltrometer



Laboratory Falling Head Tests

- Klute and Dirkson (1986)
- ASTM 28-4.2





Decreases in Hydraulic Conductivity

	K (m/day)	
	C3N VFBR	C3S VFBR
2008 (pre-construction)		
Laboratory-Falling Head	4.77	4.77
2016 (8-years operation)		
Laboratory-Falling Head	0.51	---
Field-Falling Head	0.13	0.31
Modified Infiltrometer	0.19	0.17
Slug Test	1.25	0.43

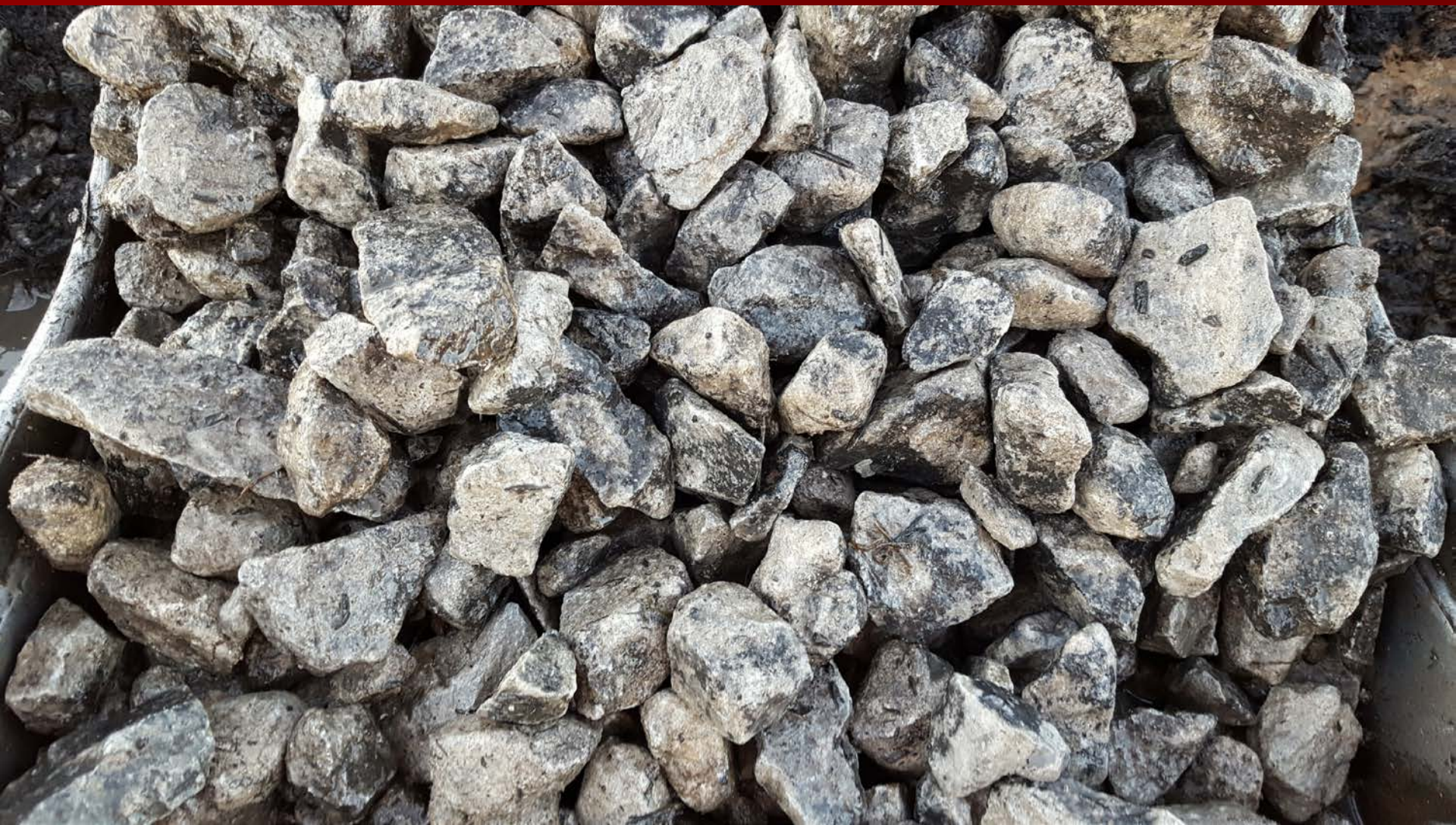
Restore Hydraulic Conductivity!

Flip the Substrate

Intact 9-yr Old Substrate

Little Loss of Depth

Clean Underdrain Stone



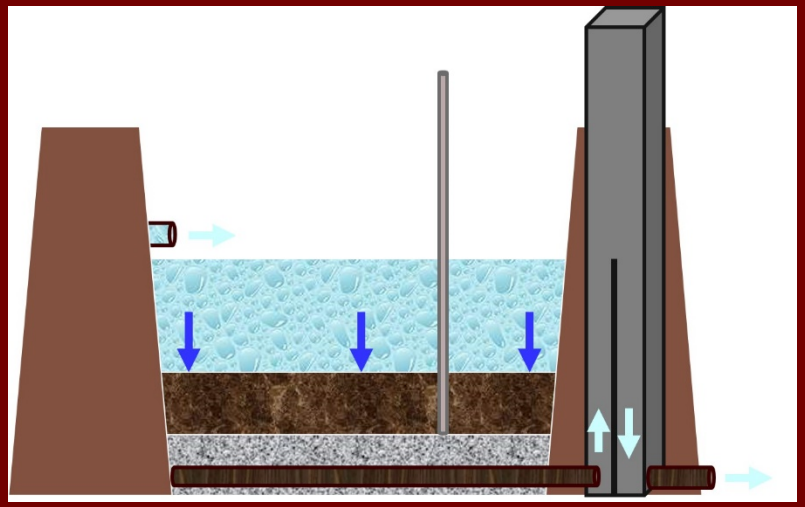
Degraded Material Near C3S-In

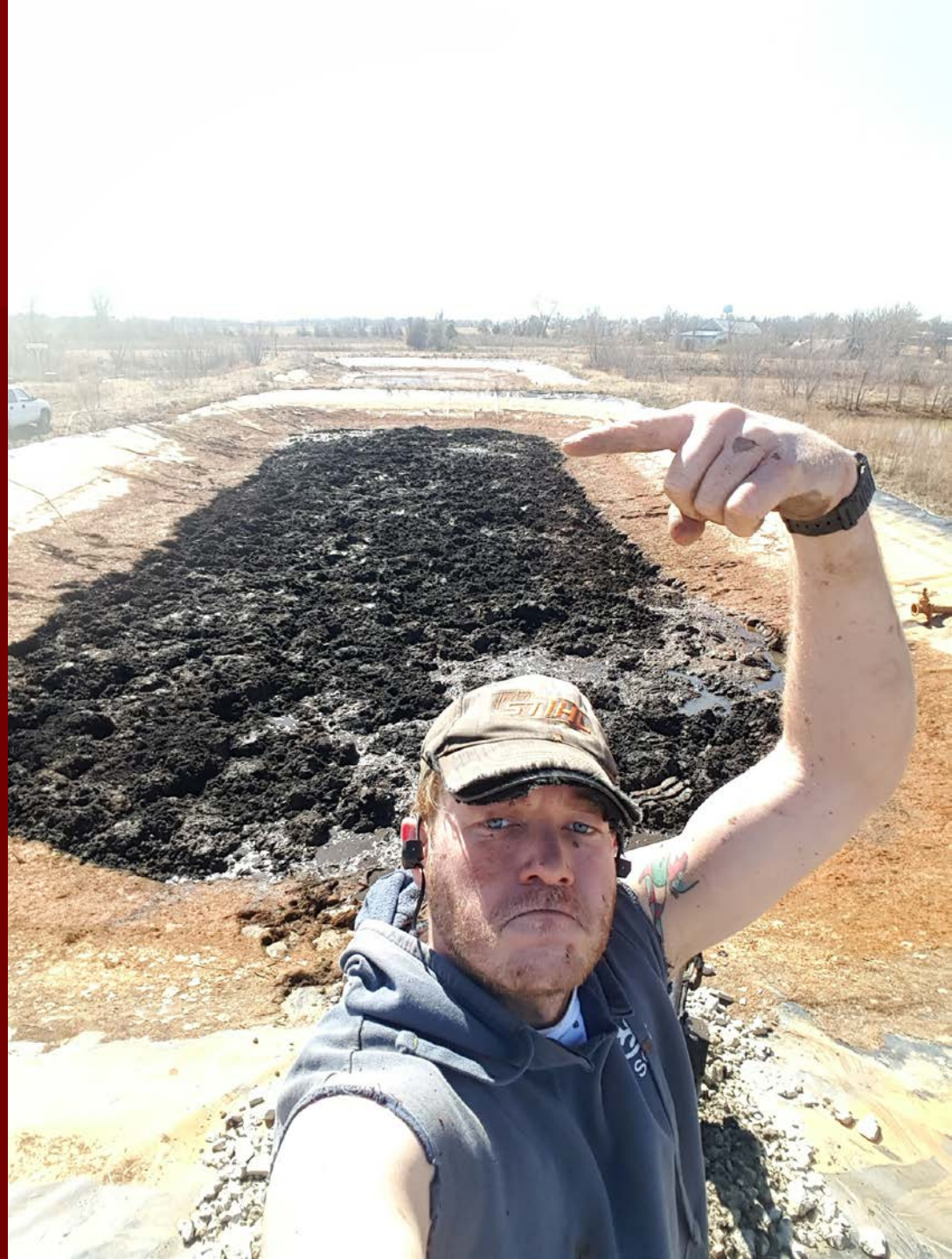
Substrate Flipped

Substrate Flipped

Proud Co-Author

- Field-Falling Head Test





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Field-Falling Head	0.13	0.31
Modified Infiltrometer	0.19	0.17
Slug Test	1.25	0.43
2017 (after flipping)		
Field-Falling Head	4.5	4.5

Conclusions

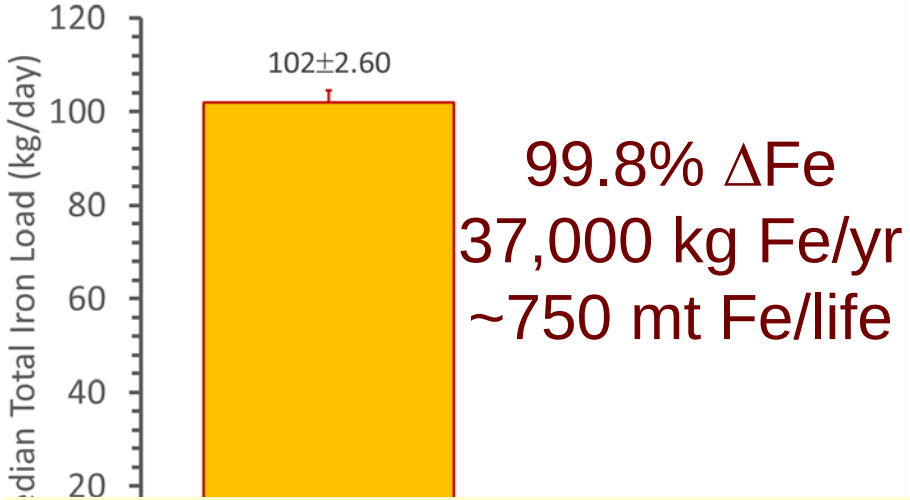
Conclusions

- Reestablished surface flow connection between C1 and C2N/C2S
  - Eliminated buried flowpath
  - Installed inlet weir structures
  - One week of down time
- Reestablished C3N/C3S VFBR hydraulic conductivity
  - Flipped organic substrate
  - No evidence of underdrain failure
  - Ten days of down time

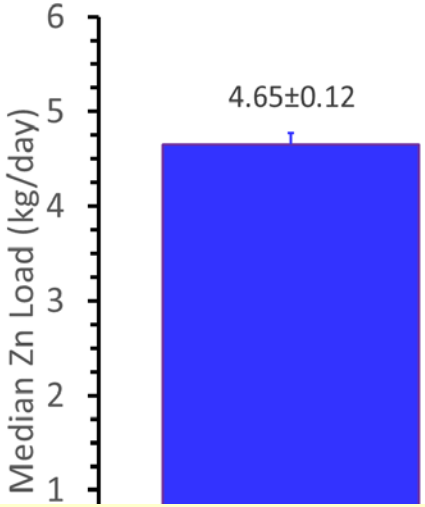
“Major” O&M Costs

	C1-C2N/C2S Surface	C3N/C3S VFBR
2 x 8” x 5’ Inlet AgriDrains	$1200	---
Equipment (Takeuchi TB153)	$1500	$1900
Stone (for ramp)	---	$700
Labor	$1000	$1500
Misc. (pipe, fuel etc.)	$700	$200
Total	$4400	$4000

Mayer Ranch PTS - COCs

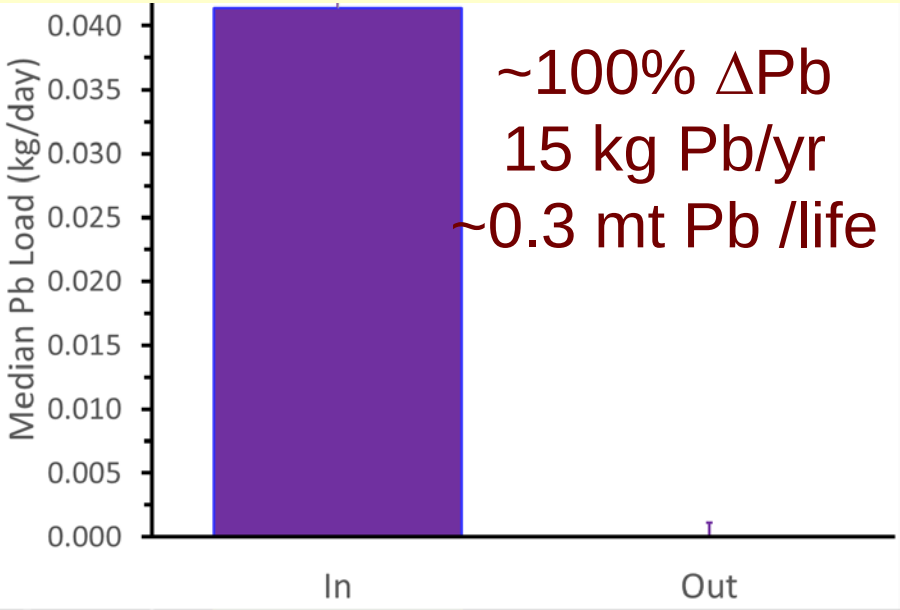


99.8% ΔFe
37,000 kg Fe/yr
~750 mt Fe/life

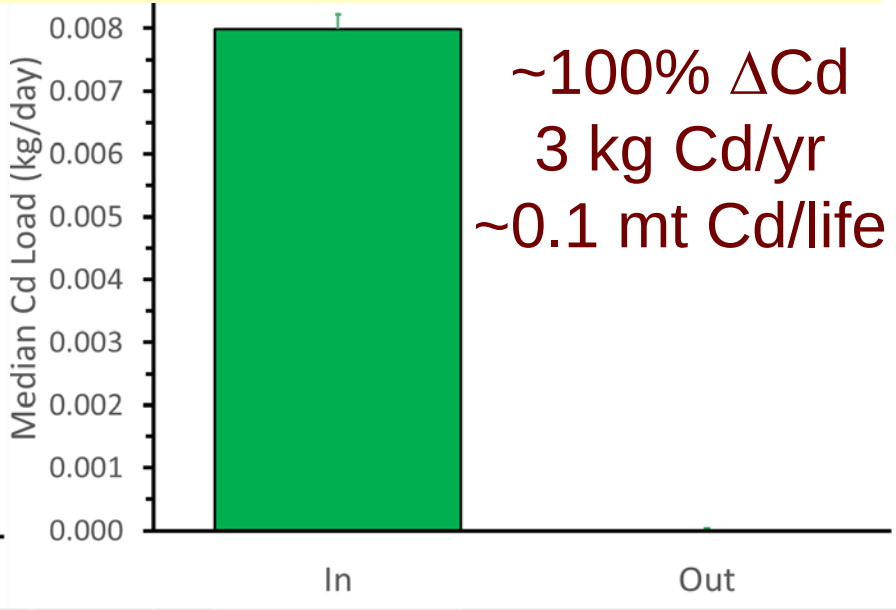


98.6% ΔZn
1700 kg Zn/yr
~35 mt Zn/life

"Major" O&M < $10K ($840/yr)
All monitoring and regular O&M ~ $10K/yr

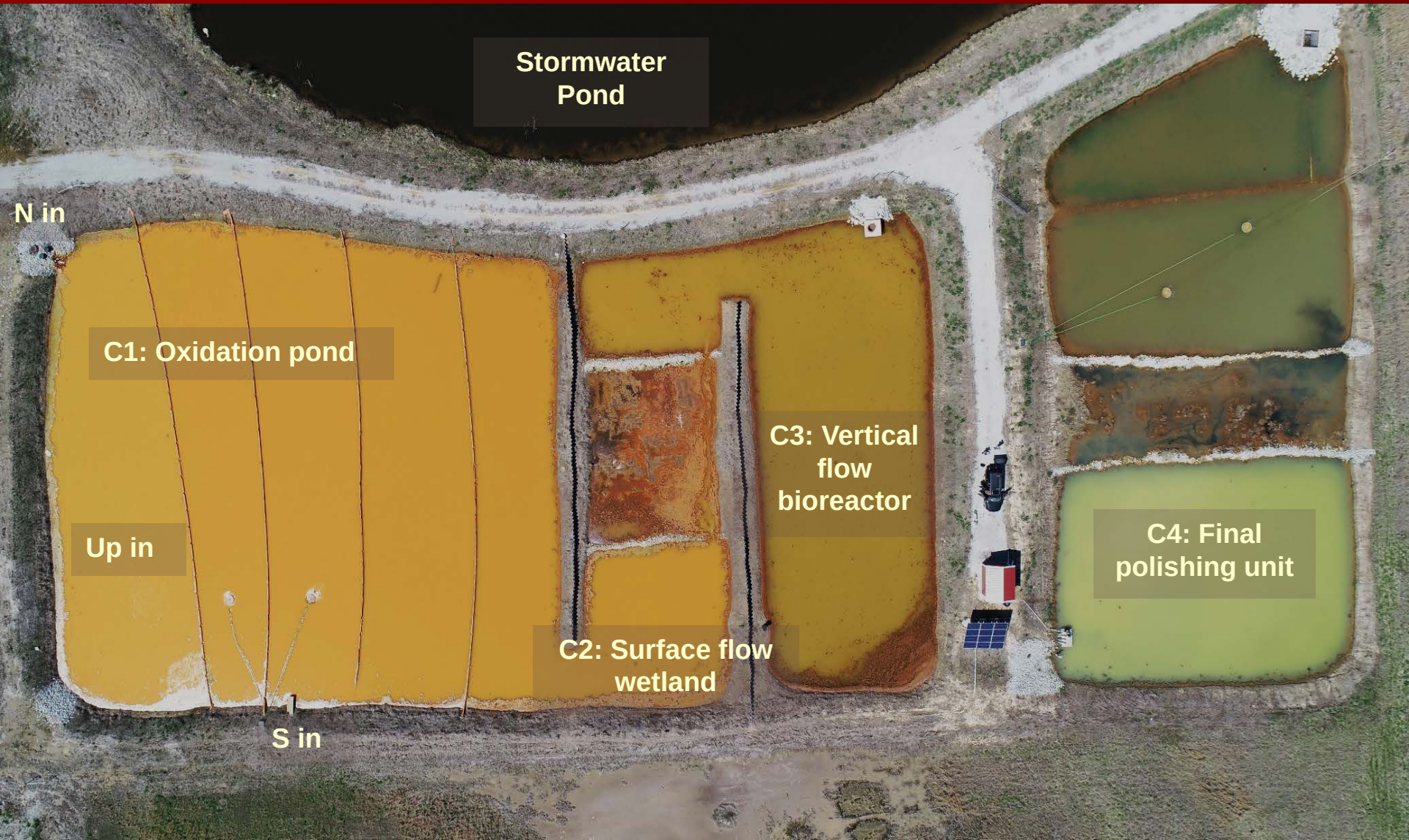


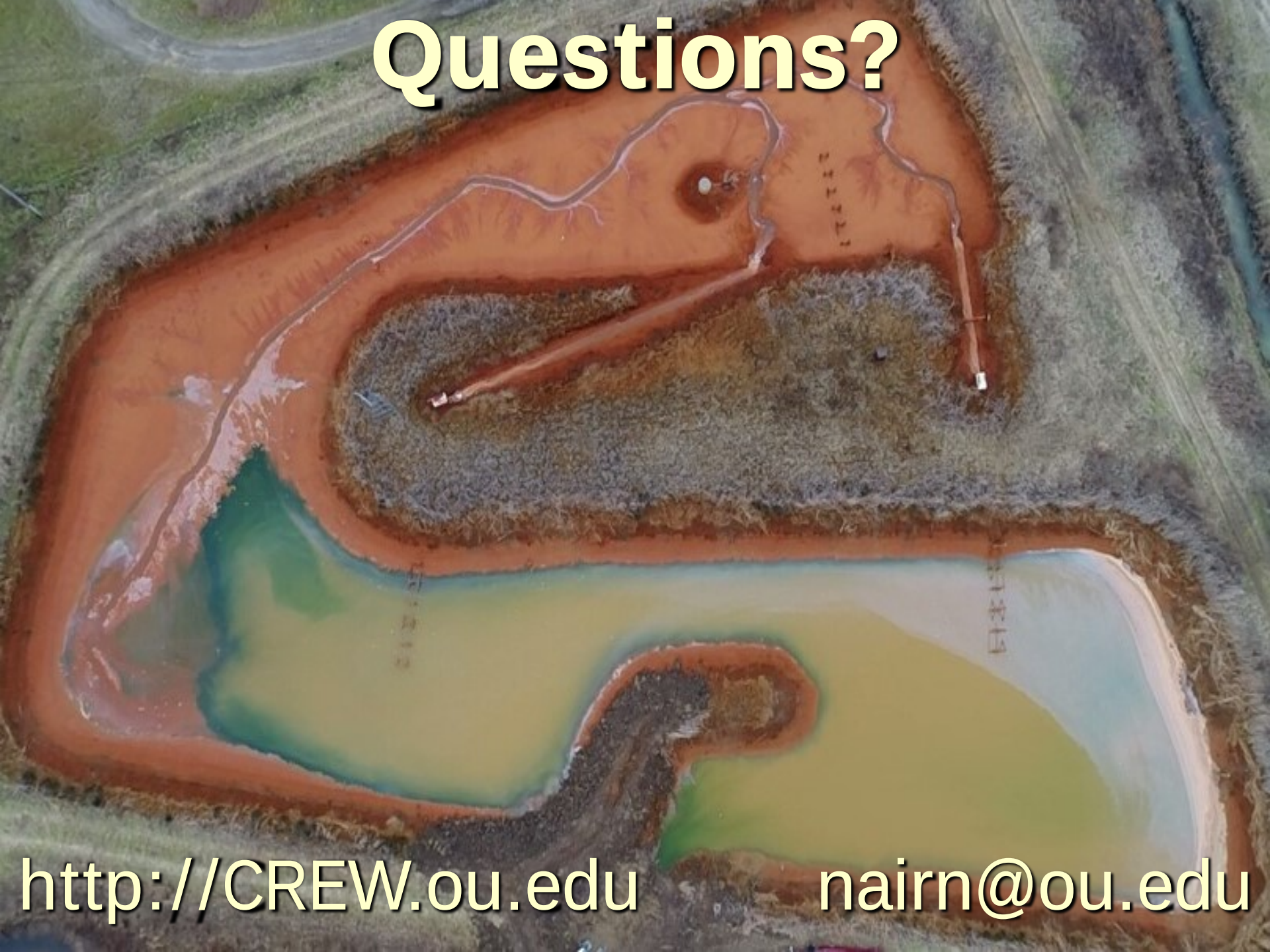
~100% ΔPb
15 kg Pb/yr
~0.3 mt Pb /life



~100% ΔCd
3 kg Cd/yr
~0.1 mt Cd/life

Southeast Commerce PTS




Questions?
http://CREW.ou.edu
nairn@ou.edu