Upstream Oil and Gas Spills to Boreal Wetland Environments – Best Practices and Evolving Tools

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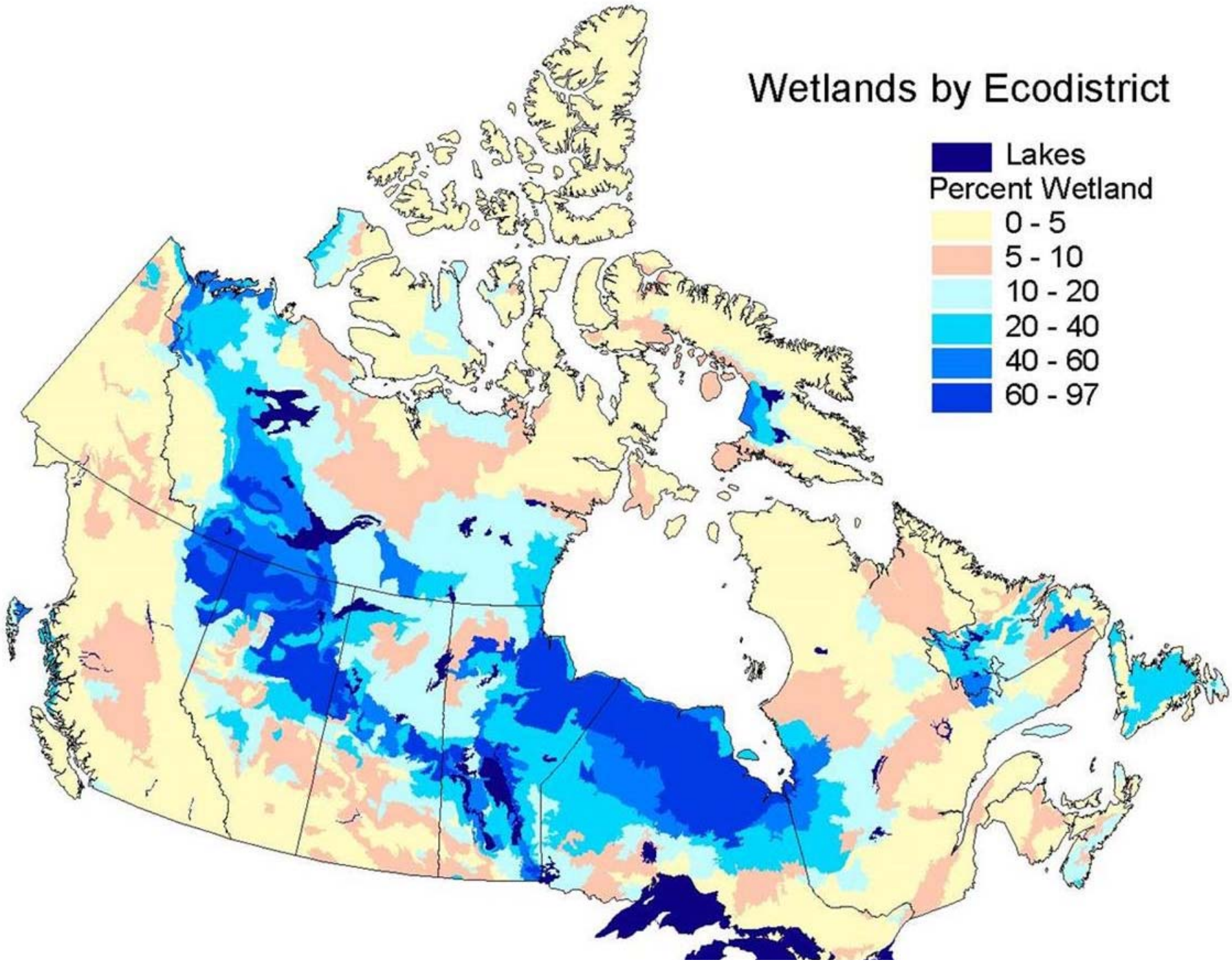
RemTech 2015

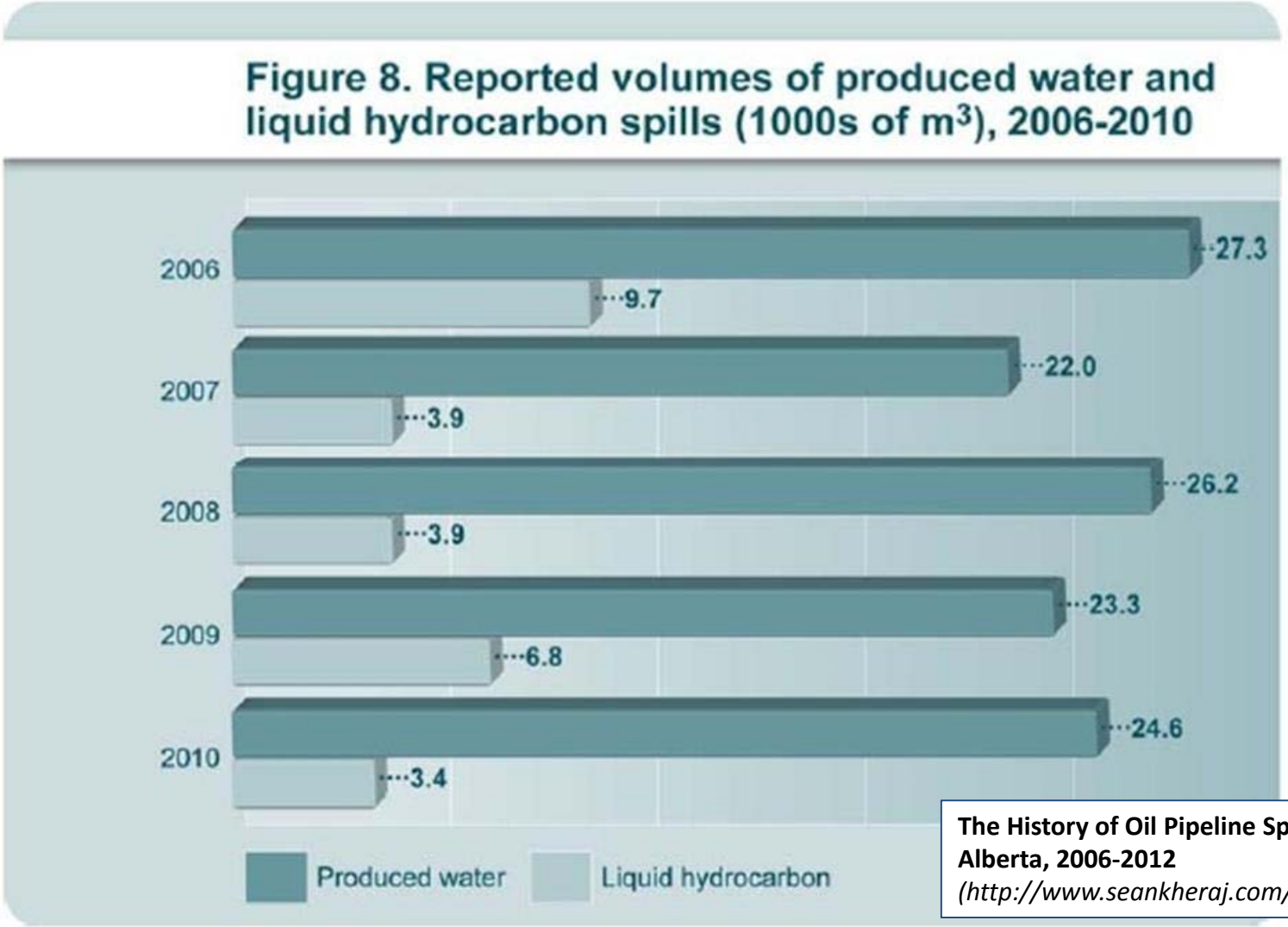
HEMMERA

Outline

1. **Lessons Learned:** Adapting our assessment and risk management / remediation approaches to salt (and hydrocarbon) release sites in boreal wetlands
2. **Spills:** Strategic guidance for transitioning from emergency response/recovery to risk management
3. **R&D update:** Development of alternative salt standards under the BC Contaminated Sites Regulation for assessing releases to wetlands in NE BC

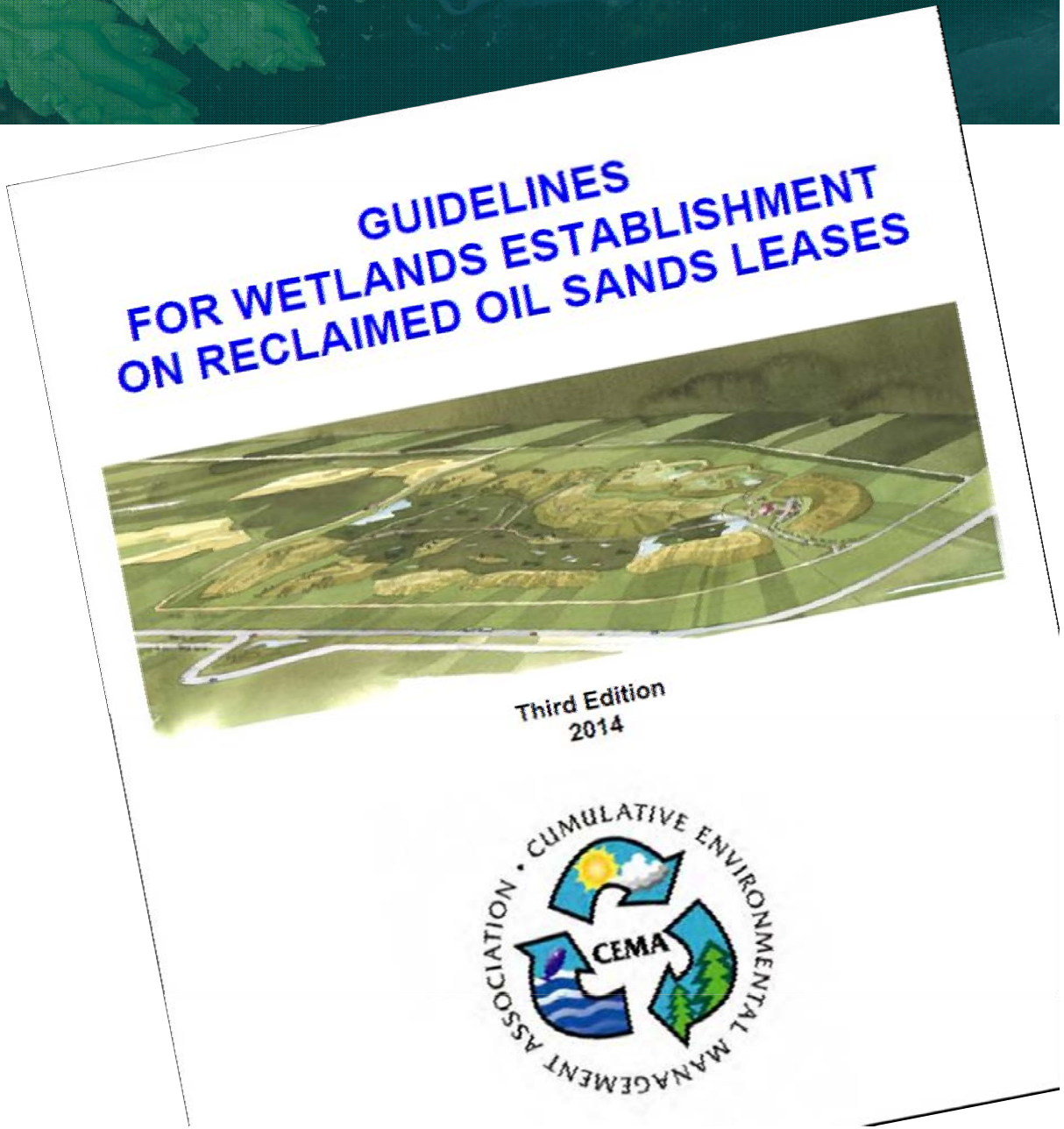

Wetlands by Ecodistrict
Lakes
Percent Wetland
0 - 5
5 - 10
10 - 20
20 - 40
40 - 60
60 - 97

Background



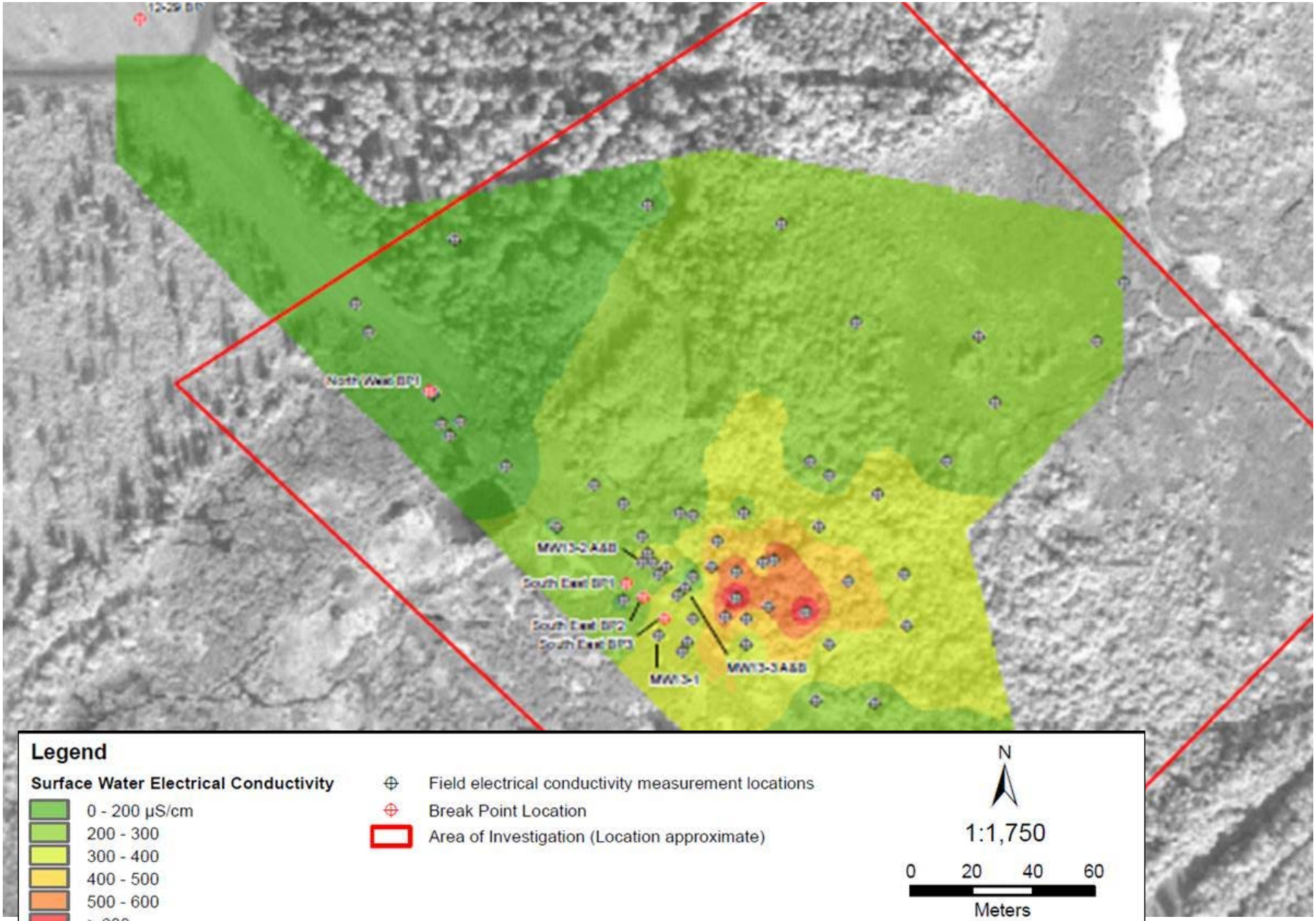
The History of Oil Pipeline Spills in Alberta, 2006-2012
(http://www.seankheraj.com/?p=1257)

Parallel issues for oil sands dry and wet reclamation



Outline

1. **Lessons Learned:** **Adapting our assessment and risk management / remediation approaches for salt (and hydrocarbon) releases to boreal wetlands**



Legend

Surface Water Electrical Conductivity

- 0 - 200 µS/cm
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- > 600

- Field electrical conductivity measurement locations
- Break Point Location
- Area of Investigation (Location approximate)

N

1:1,750

0 20 40 60

Meters

Spatial interpolation completed using IDW with a maximum radius of 200 m.

Aerial Image: ESRI Bing Maps 2010 Digital Globe

Lessons Learned

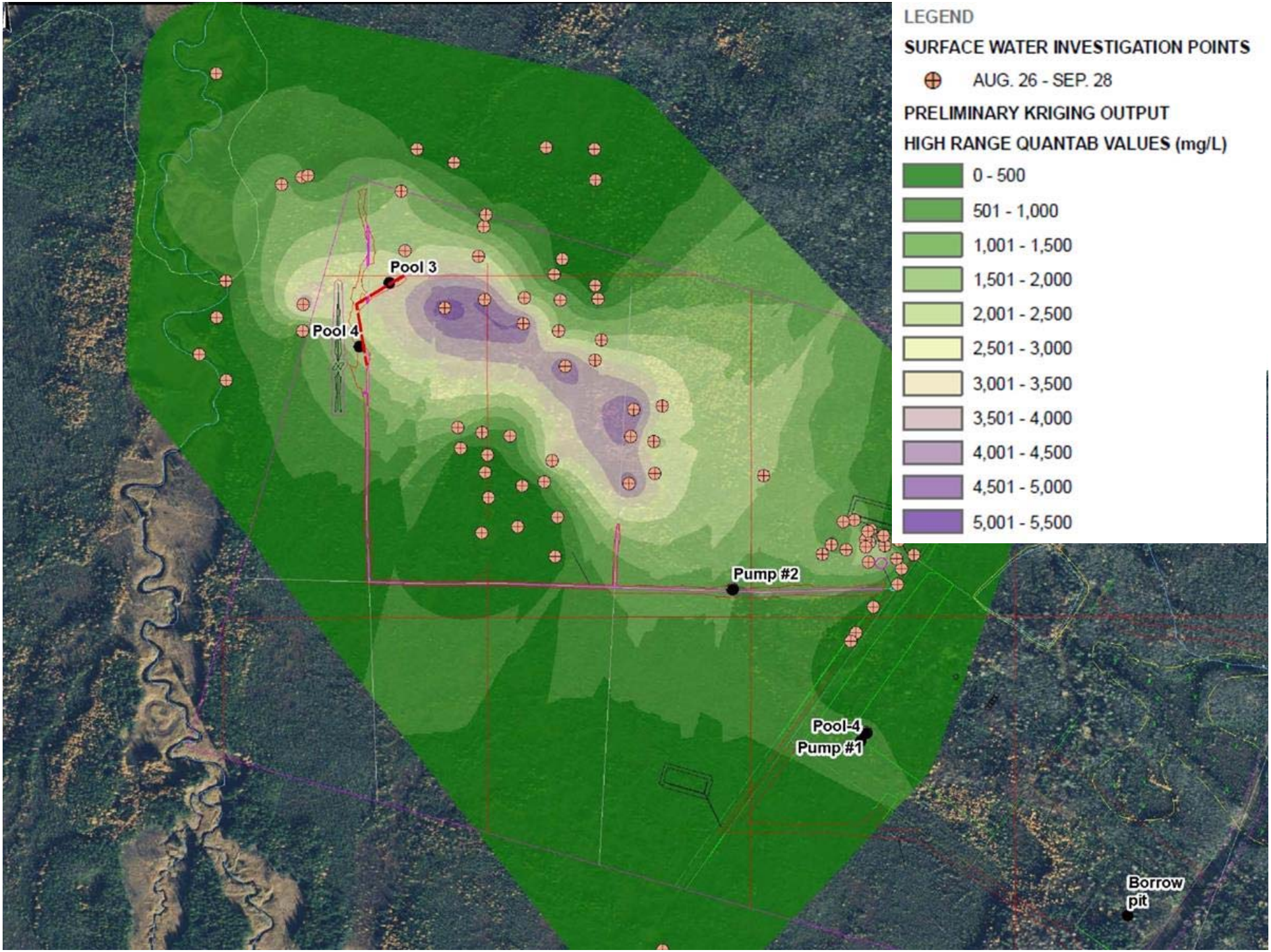
Physical disturbance during spill response or to remove contaminated media may be counter-productive to ecological restoration/site reclamation goals

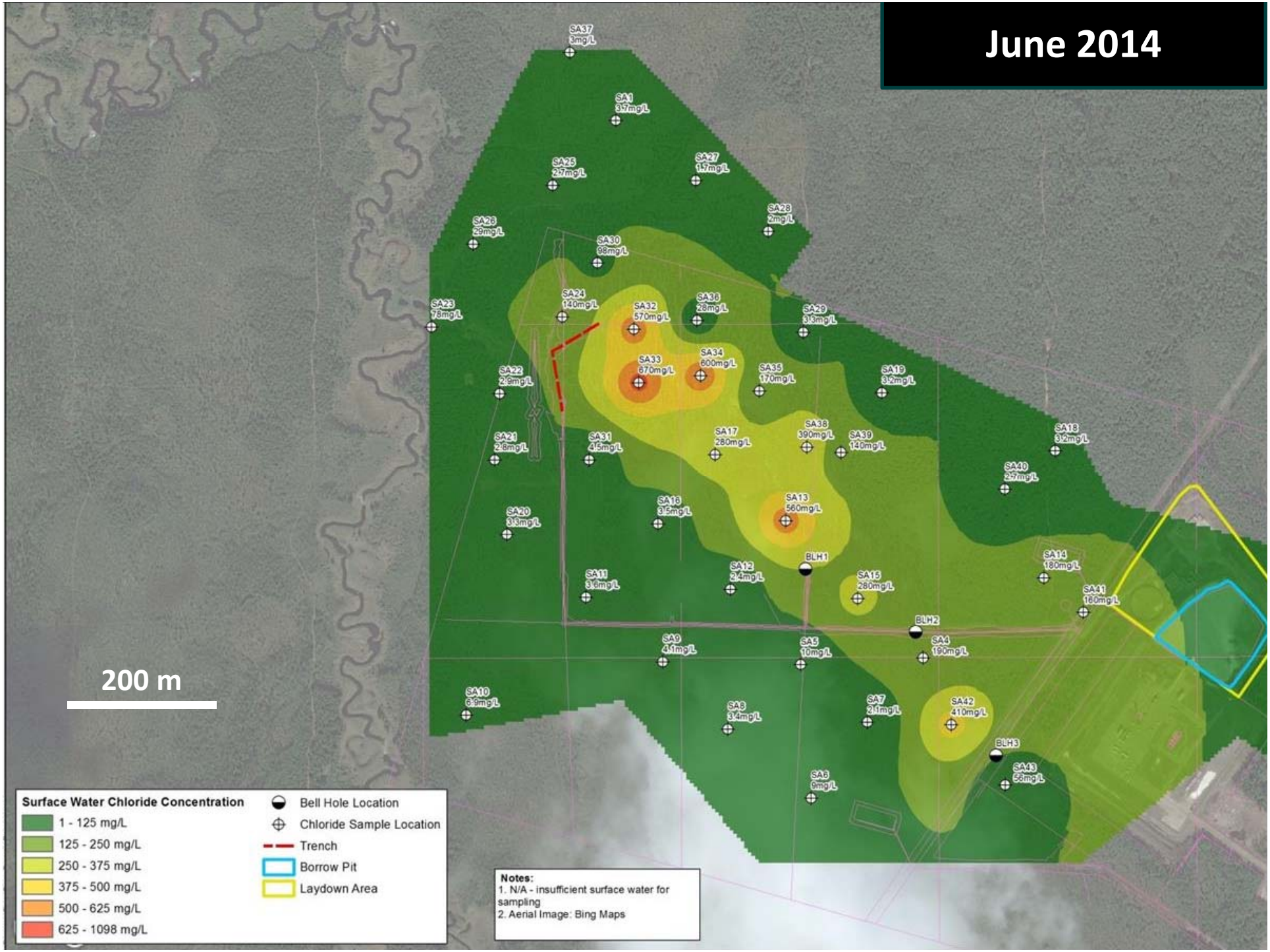
Lessons Learned

Standardized contaminant hydrogeological assessment approaches are mostly a waste of time and money

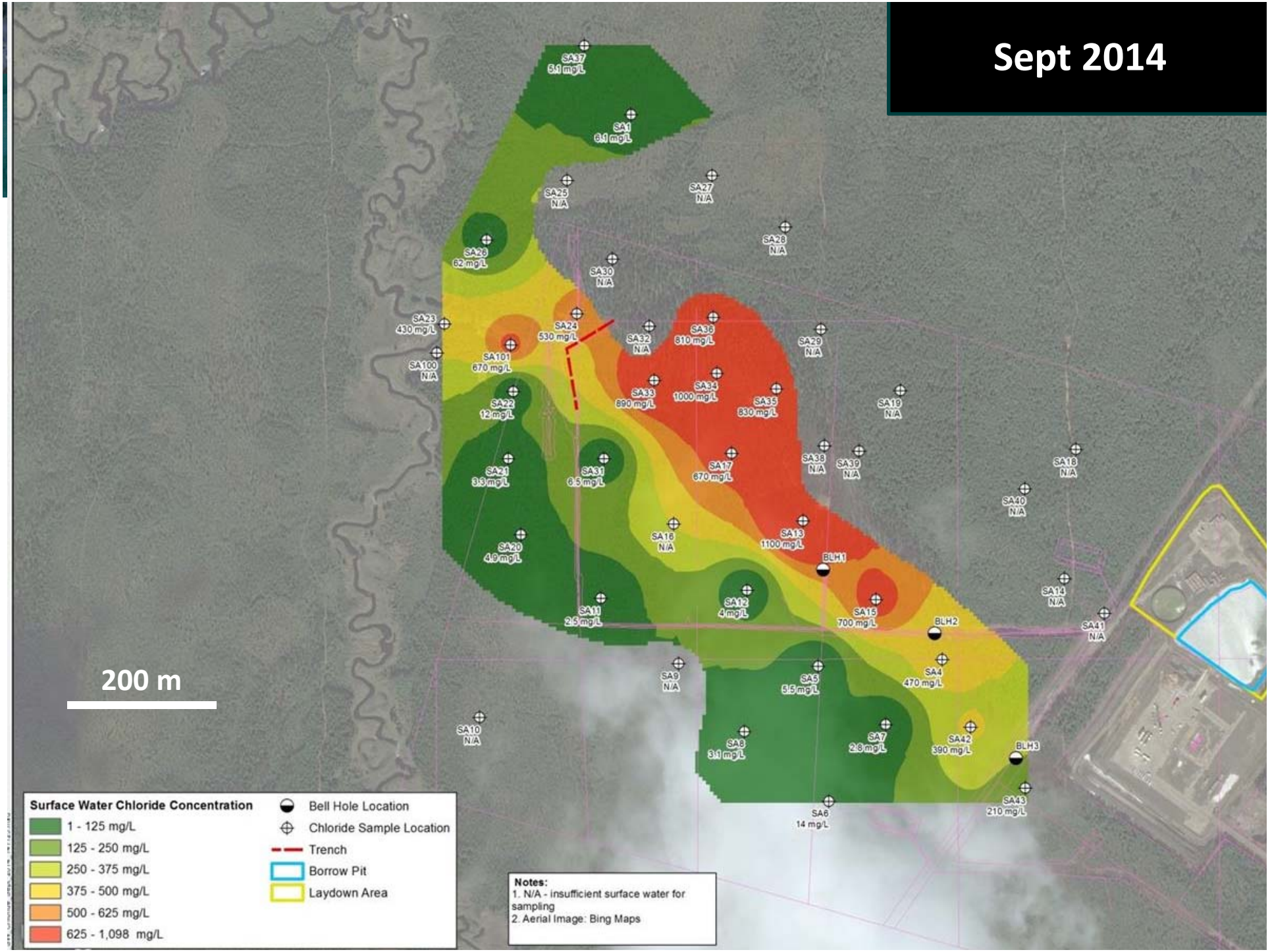
Lessons Learned

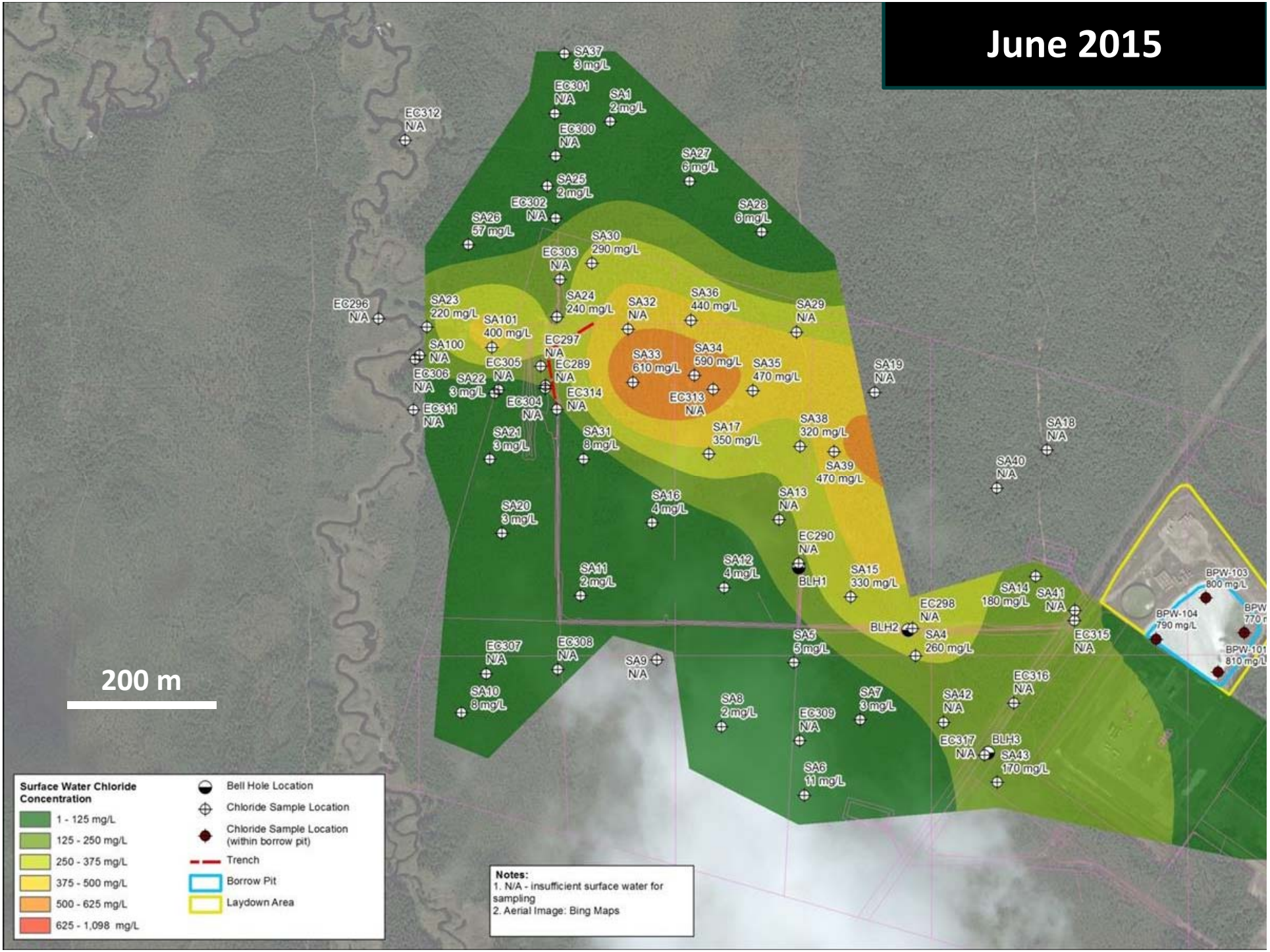
Following termination of pump back, spatiotemporal aspects of salt concentrations in the upper wetland reflect one part lateral transport of salt mass and two parts water balance

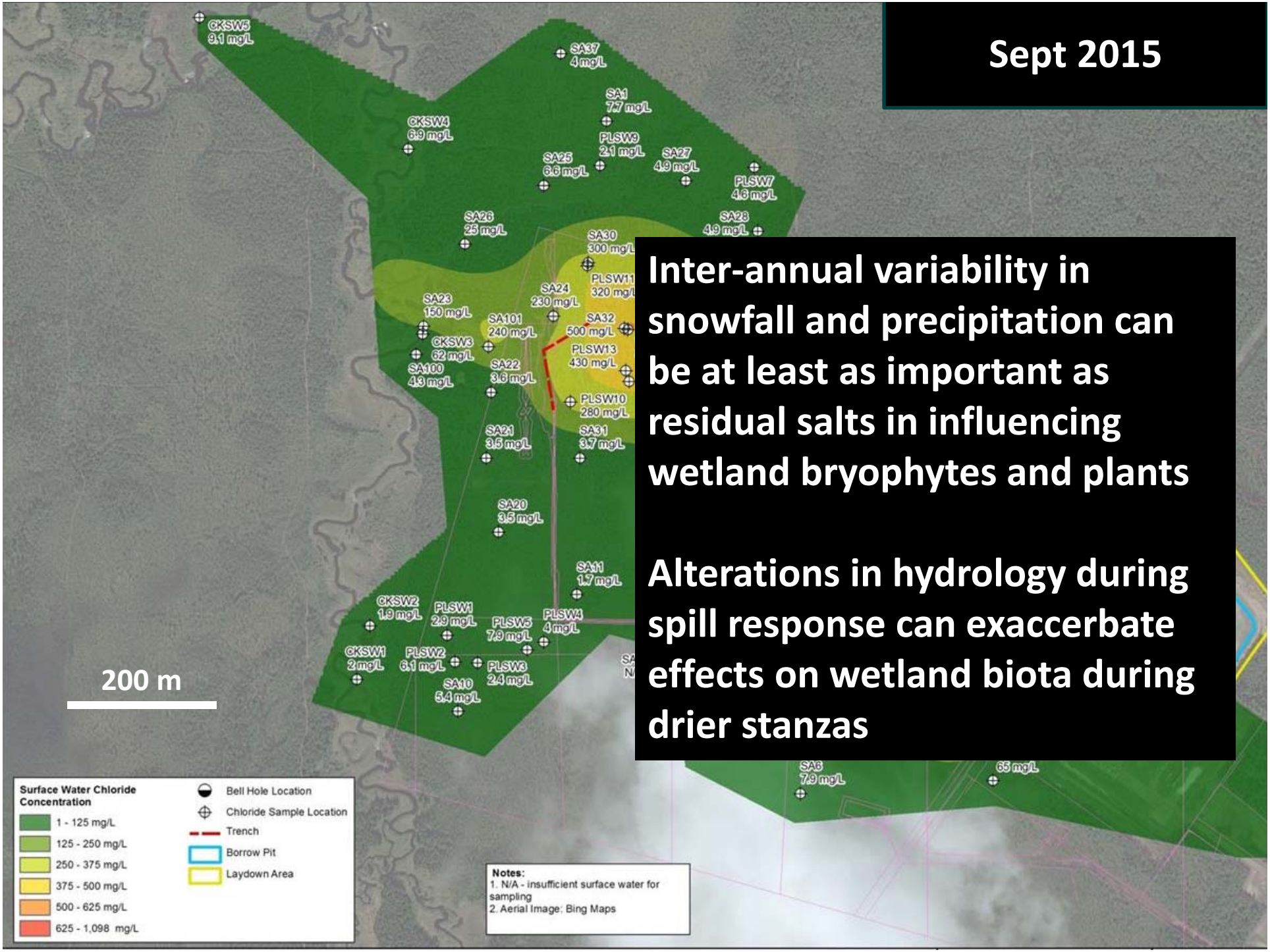

LEGEND
SURFACE WATER INVESTIGATION POINTS
AUG. 26 - SEP. 28
PRELIMINARY KRIGING OUTPUT
HIGH RANGE QUANTAB VALUES (mg/L)
0 - 500
501 - 1,000
1,001 - 1,500
1,501 - 2,000
2,001 - 2,500
2,501 - 3,000
3,001 - 3,500
3,501 - 4,000
4,001 - 4,500
4,501 - 5,000
5,001 - 5,500
Pool 3
Pool 4
Pump #2
Pool-4
Pump #1
Borrow
pit


June 2014
SA37 3mg/L
SA1 37mg/L
SA25 27mg/L
SA27 17mg/L
SA28 2mg/L
SA26 29mg/L
SA30 98mg/L
SA23 78mg/L
SA24 140mg/L
SA32 570mg/L
SA38 28mg/L
SA29 33mg/L
SA33 670mg/L
SA34 600mg/L
SA35 170mg/L
SA19 32mg/L
SA22 2.9mg/L
SA21 2.8mg/L
SA31 45mg/L
SA17 280mg/L
SA38 390mg/L
SA39 140mg/L
SA18 32mg/L
SA40 27mg/L
SA20 33mg/L
SA16 35mg/L
SA13 560mg/L
BLH1
SA14 180mg/L
SA11 3.8mg/L
SA12 24mg/L
SA15 280mg/L
SA41 160mg/L
BLH2
SA9 4.1mg/L
SA5 10mg/L
SA4 190mg/L
SA10 0.9mg/L
SA8 3.4mg/L
SA7 21mg/L
SA42 410mg/L
BLH3
SA43 56mg/L
SA6 9mg/L
200 m
Surface Water Chloride Concentration
1 - 125 mg/L
125 - 250 mg/L
250 - 375 mg/L
375 - 500 mg/L
500 - 625 mg/L
625 - 1098 mg/L
Bell Hole Location
Chloride Sample Location
Trench
Borrow Pit
Laydown Area
Notes:
1. N/A - insufficient surface water for sampling
2. Aerial Image: Bing Maps

Sept 2014


SA37 5.1 mg/L
SA1 6.1 mg/L
SA25 N/A
SA27 N/A
SA28 N/A
SA26 62 mg/L
SA30 N/A
SA23 430 mg/L
SA24 530 mg/L
SA32 N/A
SA36 810 mg/L
SA29 N/A
SA100 N/A
SA101 670 mg/L
SA33 890 mg/L
SA34 1000 mg/L
SA35 830 mg/L
SA19 N/A
SA22 12 mg/L
SA21 3.9 mg/L
SA31 6.5 mg/L
SA17 670 mg/L
SA38 N/A
SA39 N/A
SA18 N/A
SA40 N/A
SA16 N/A
SA13 1100 mg/L
BLH1
SA20 4.9 mg/L
SA14 N/A
SA12 4 mg/L
SA15 700 mg/L
BLH2
SA41 N/A
SA11 2.5 mg/L
SA9 N/A
SA5 5.5 mg/L
SA4 470 mg/L
SA10 N/A
SA8 3.1 mg/L
SA7 2.8 mg/L
SA42 390 mg/L
BLH3
SA43 210 mg/L
SA6 14 mg/L
200 m
Surface Water Chloride Concentration
1 - 125 mg/L
125 - 250 mg/L
250 - 375 mg/L
375 - 500 mg/L
500 - 625 mg/L
625 - 1,098 mg/L
Bell Hole Location
Chloride Sample Location
Trench
Borrow Pit
Laydown Area
Notes:
1. N/A - insufficient surface water for sampling
2. Aerial Image: Bing Maps


June 2015
SA37 3 mg/L
EC301 N/A
SA1 2 mg/L
EC312 N/A
EC300 N/A
SA27 6 mg/L
SA25 2 mg/L
EC302 N/A
SA28 6 mg/L
SA26 57 mg/L
SA30 290 mg/L
EC303 N/A
EC296 N/A
SA23 220 mg/L
SA24 240 mg/L
SA32 N/A
SA36 440 mg/L
SA29 N/A
SA101 400 mg/L
EC297 N/A
SA100 N/A
SA33 610 mg/L
SA34 590 mg/L
SA35 470 mg/L
SA19 N/A
EC305 N/A
EC289 N/A
EC306 N/A
SA22 3 mg/L
EC313 N/A
EC314 N/A
EC304 N/A
EC311 N/A
SA38 320 mg/L
SA18 N/A
SA17 350 mg/L
SA21 3 mg/L
SA31 8 mg/L
SA39 470 mg/L
SA40 N/A
SA16 4 mg/L
SA13 N/A
SA20 3 mg/L
EC290 N/A
SA12 4 mg/L
SA11 2 mg/L
BLH1
SA15 330 mg/L
SA14 180 mg/L
SA41 N/A
BPW-103 800 mg/L
BPW-104 790 mg/L
EC298 N/A
BLH2
SA4 260 mg/L
SA5 5 mg/L
EC315 N/A
EC307 N/A
EC308 N/A
SA9 N/A
EC316 N/A
SA10 8 mg/L
SA8 2 mg/L
SA7 3 mg/L
SA42 N/A
EC309 N/A
EC317 N/A
BLH3
SA43 170 mg/L
SA6 11 mg/L
200 m
Surface Water Chloride Concentration
1 - 125 mg/L
125 - 250 mg/L
250 - 375 mg/L
375 - 500 mg/L
500 - 625 mg/L
625 - 1,098 mg/L
Bell Hole Location
Chloride Sample Location
Chloride Sample Location (within borrow pit)
Trench
Borrow Pit
Laydown Area
Notes:
1. N/A - insufficient surface water for sampling
2. Aerial Image: Bing Maps

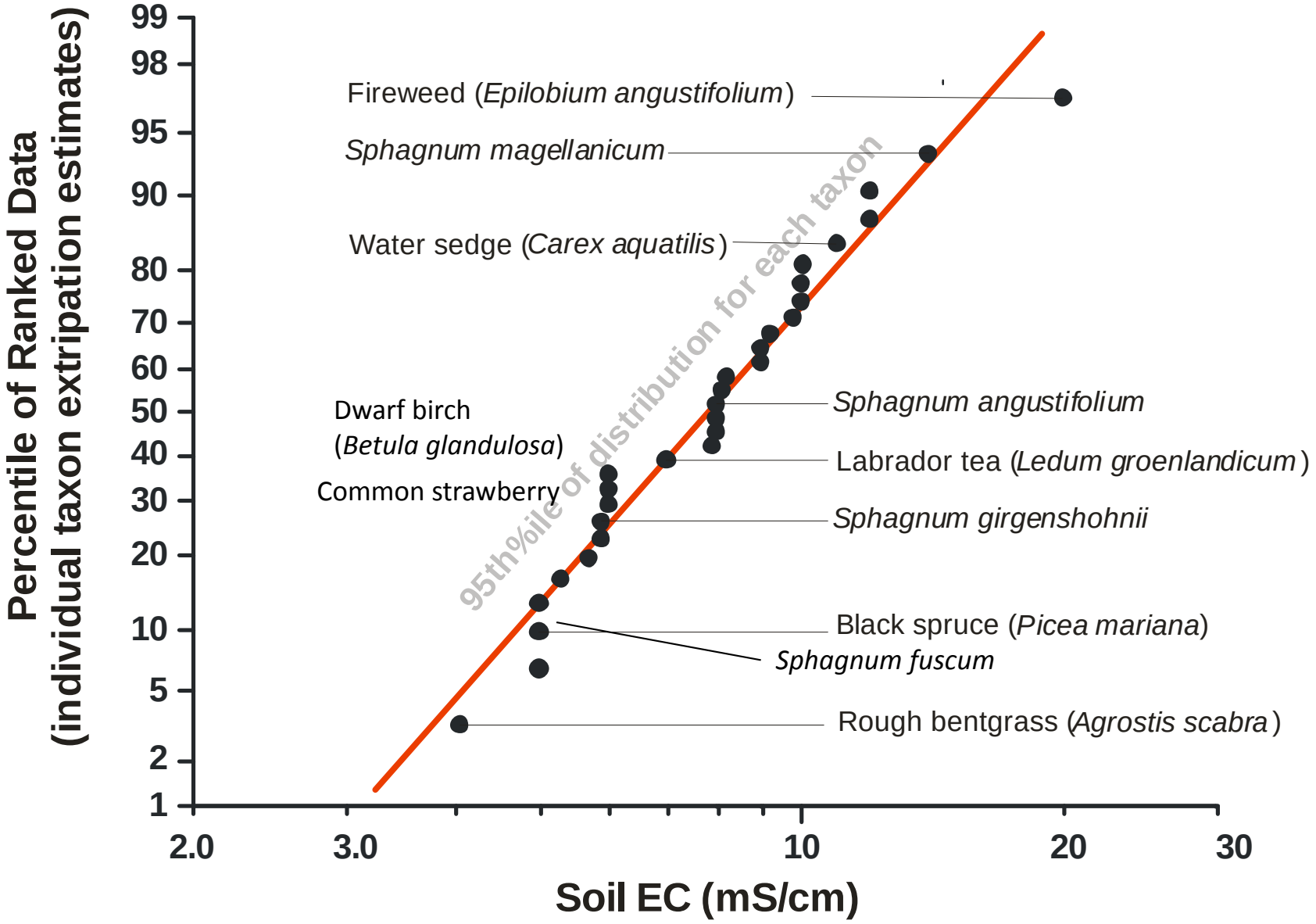

Sept 2015
Inter-annual variability in snowfall and precipitation can be at least as important as residual salts in influencing wetland bryophytes and plants
Alterations in hydrology during spill response can exaccerbate effects on wetland biota during drier stanzas
CKSW5 9.1 mg/L
SA37 4 mg/L
SA1 7.7 mg/L
CKSW4 6.9 mg/L
PLSW9 2.1 mg/L
SA25 6.6 mg/L
SA27 4.9 mg/L
PLSW7 4.6 mg/L
SA26 25 mg/L
SA28 4.9 mg/L
SA30 300 mg/L
PLSW11 320 mg/L
SA24 230 mg/L
SA23 150 mg/L
SA101 240 mg/L
SA32 500 mg/L
CKSW3 62 mg/L
PLSW13 430 mg/L
SA100 4.3 mg/L
SA22 3.6 mg/L
PLSW10 280 mg/L
SA21 3.5 mg/L
SA31 3.7 mg/L
SA20 3.5 mg/L
SA11 1.7 mg/L
CKSW2 1.9 mg/L
PLSW1 2.9 mg/L
PLSW5 7.9 mg/L
PLSW4 4 mg/L
CKSW1 2 mg/L
PLSW2 6.1 mg/L
PLSW3 2.4 mg/L
SA10 5.4 mg/L
200 m
SA6 7.9 mg/L
65 mg/L
Surface Water Chloride Concentration
1 - 125 mg/L
125 - 250 mg/L
250 - 375 mg/L
375 - 500 mg/L
500 - 625 mg/L
625 - 1,098 mg/L
Bell Hole Location
Chloride Sample Location
Trench
Borrow Pit
Laydown Area
Notes:
1. N/A - insufficient surface water for sampling
2. Aerial Image: Bing Maps

Lessons Learned

Salinization of peatlands profoundly influences nutrient availability and the plants that initially recolonize the kill zone

Lessons Learned

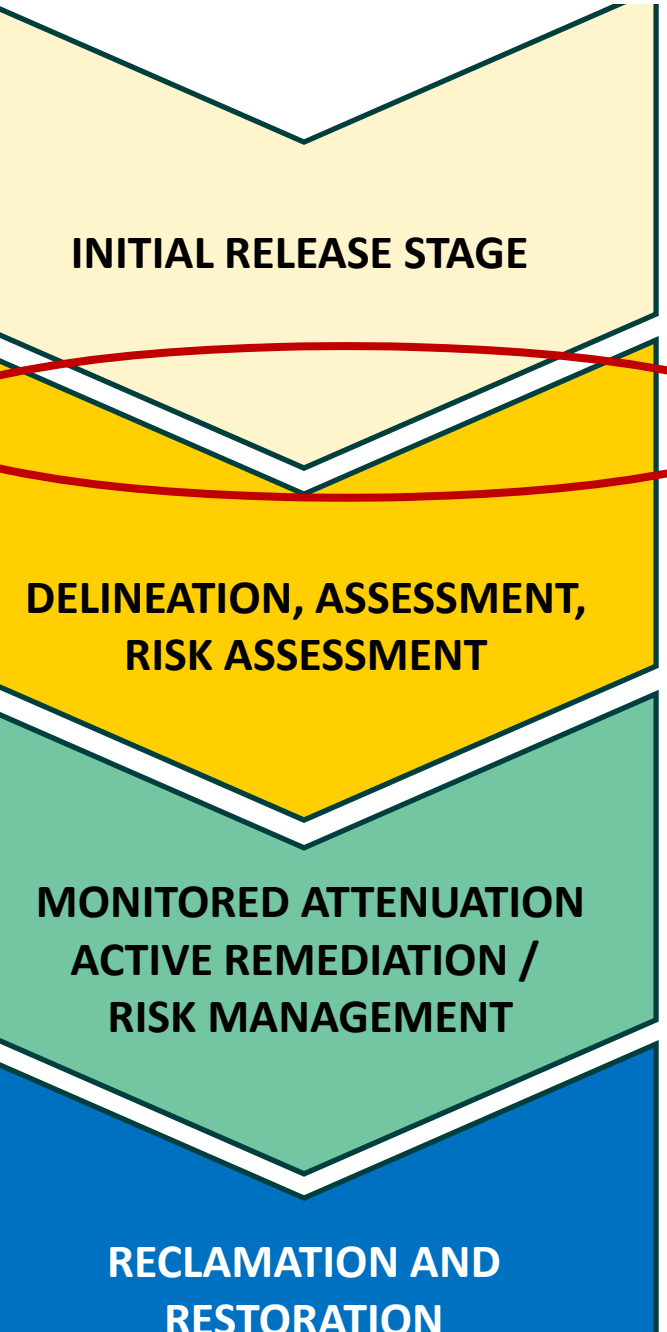
Most important assessment endpoint is vegetation recovery potential



Relative sensitivity of different taxa is directly relevant for assessing degree of site impairment and recovery

Outline

2. **Spills:** **Strategic guidance for transitioning from emergency response/recovery to risk management**



Maximize recovery of contaminant mass in immediate release area (source control), while minimizing other disturbances detrimental to wetland restoration goals.

Understand what ecological receptors are at risk. Establish the short-term zone of impact (impacted baseline)

Understand the expected ecosystem trajectory relative to reclamation goals. Evaluate the pros and cons of more active versus more passive approaches.

Confirm that contaminant-related barriers to wetland succession and function are no longer present.

	Advantages	Disadvantages
ctive emediation: HC, salt mass emoval through umpback, etc.	• *Recovers contaminant mass* • *Limits spread, including transport to surface water bodies*	• *Exaccerbates physical disturbance* • *Can result in significant hydrological disturbance including wetland dewatering*
assive: Ionitored atural ttenuation	• *Minimizes further hydrological and physical disturbance*	• *May be accompanied by residual contaminant levels that are not conducive to reclamation goals*

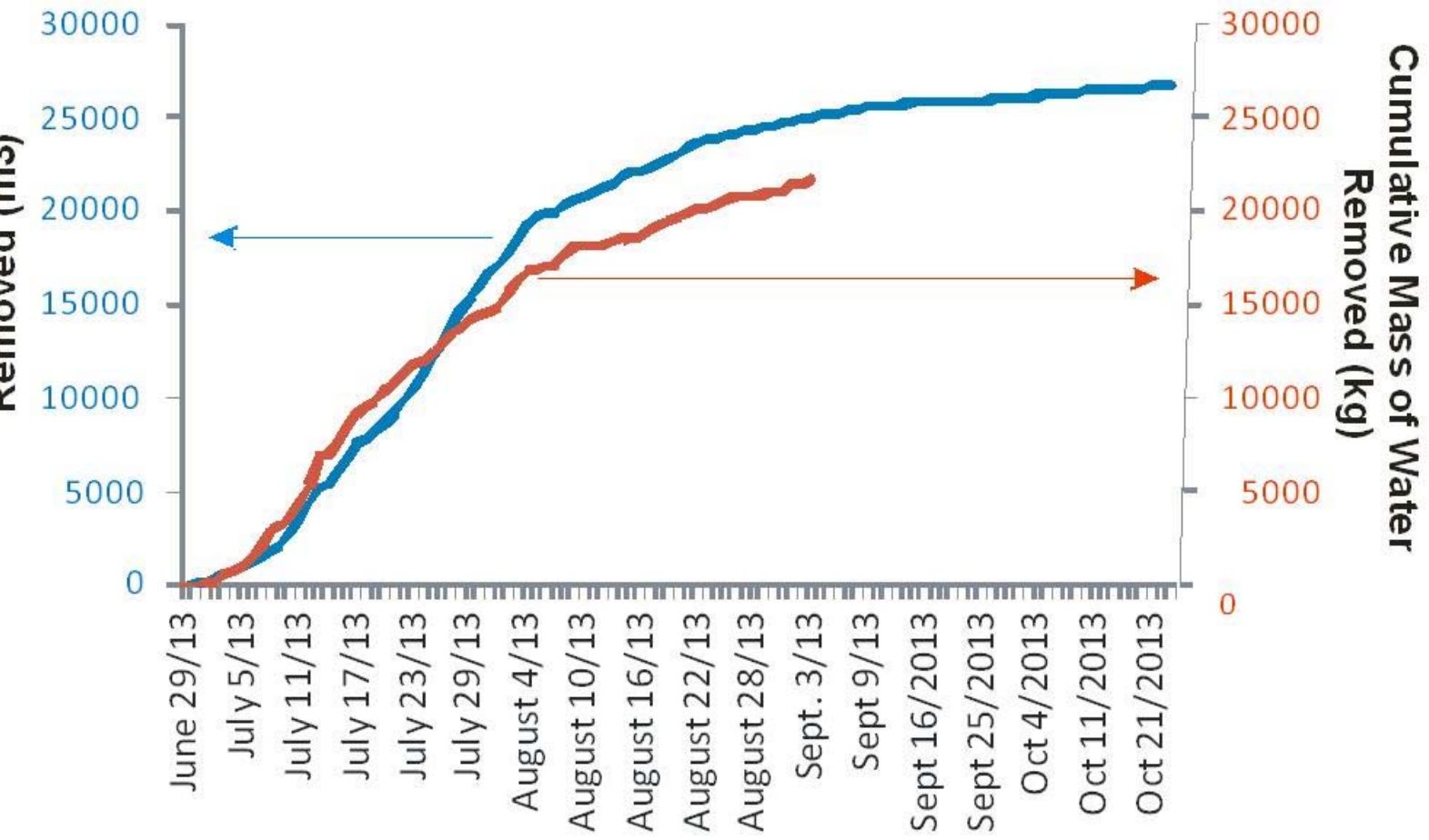
iteria for Cessation of Active Mass Recovery

Efficacy of further contaminant mass removal

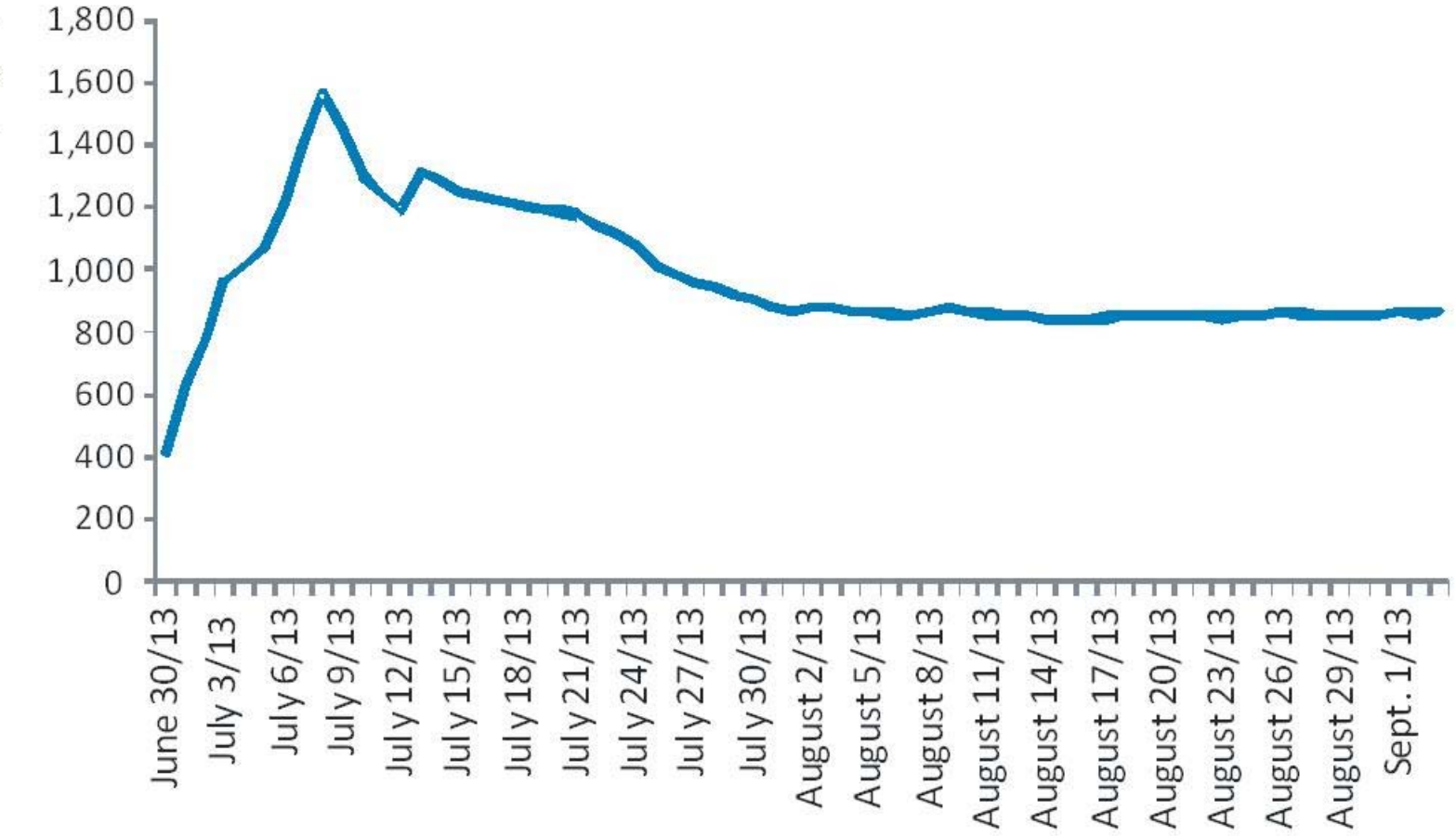
Expectations for limiting contaminant transport into surface water bodies that contain aquatic life

Expectations about plume stability

riteria for Cessation of Active Mass Recovery



riteria for Cessation of Active Mass Recovery



umulative running average for chloride concentration in

Outline

R&D update: Development of alternative salt standards under the BC Contaminated Sites Regulation for assessing releases to wetlands in NE BC

sh Columbia Contaminated Sites Regulation – Matrix Standards for Chloride Ion (mg/kg as sat. paste)

	Agricultural	Urban Parkland	Residential	Commercial	Industrial
AN HEALTH PROTECTION					
e of contaminated soil	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g	> 1 000 mg/g
ndwater used for drinking	90	90	90	90	90
RONMENTAL PROTECTION					
ty to soil invertebrates and s	**350**	**350**	**350**	**2,500**	**2,500**
ock ingesting soil and fodder	NS				
r microbial functional rment	NS				
ndwater flow to surface used by aquatic life	**550**	**550**	**550**	**550**	**550**
ndwater used for livestock ing	200				


ROYAL ROADS UNIVERSITY
Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation
June 2002
Report to the British Columbia
Ministry of Water, Land and Air Protection,
Ministry of Transportation and Highways,
British Columbia Buildings Corporation, and the
Canadian Association of Petroleum Producers
and Jan Addison, Ph.D.

Proposed project objectives

- *Derive an alternative suite of salt ion numerical standards within the CSR framework that are better focused on wetland as opposed to terrestrial upland soil systems.*
- *Develop accompanying guidance on site conditions under which the alternative numerical standards could be applied, as well as precluding conditions for their use.*

Proposed Methodology

Task 1: Develop guidance on when it is appropriate to use an alternative CSR salt standard (for shallow groundwater/soil solution), expressed in mg/L.

Task 2: Derive alternative set of CSR standards based on (i) salt ion exposures within water collected directly from the active rooting zone in non-ephemeral wetlands; (ii) scientific evaluation of thresholds of effects to boreal wetland bryophytes and vascular plants (functionally equivalent CSST 1996 to the soil invertebrate and plant direct exposure scenario)

Task 3: Develop proposed additions to CSR Schedule 5, along with detailed technical guidance on appropriate use of the alternative solution-based salt guidelines.

Need to clearly and unambiguously:

- Differentiate between upland and wetland environments (bog, fen, marsh, swamp) (*challenges with ephemeral wetlands)*

- Differentiate between wetland systems/site areas that support significant aquatic life productivity and those that do not

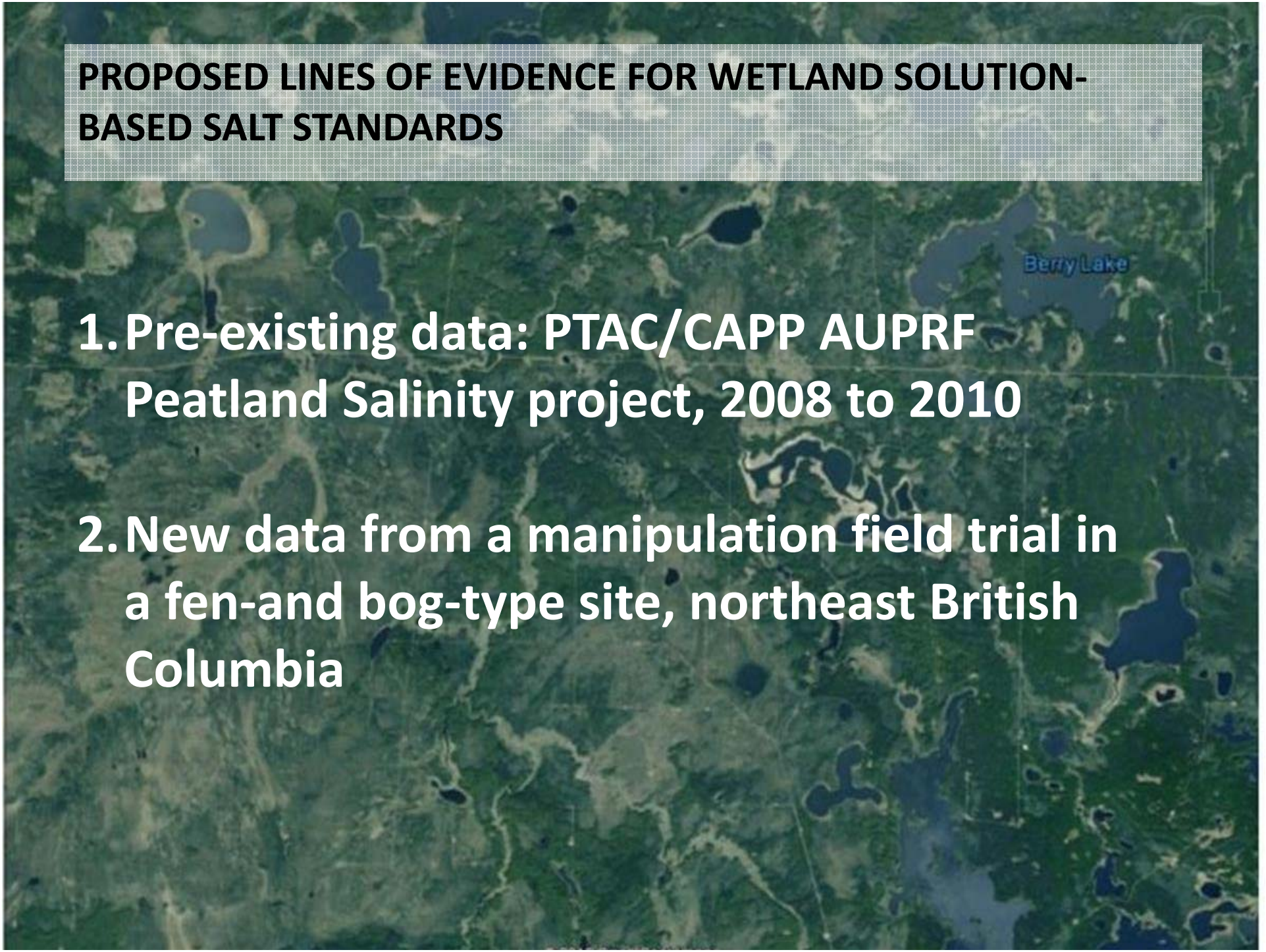
- Characterize wetland type using simple field observations according to Canadian/BC wetland classification system

Alternative salt standards for wetland plant and bryophyte protection

- Assumes protection goals based on maintaining growth/productivity of wetland forming bryophytes and plants (e.g. *Sphagnum* mosses, dominant herbs and shrubs)

- Up to three lines of evidence for defining ecologically protective management thresholds

PROPOSED LINES OF EVIDENCE FOR WETLAND SOLUTION-BASED SALT STANDARDS



1. Pre-existing data: PTAC/CAPP AUPRF Peatland Salinity project, 2008 to 2010

2. New data from a manipulation field trial in a fen-and bog-type site, northeast British Columbia

Thank you. Questions?

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