Use of Unmanned Aerial Vehicles to Monitor Ebullition-Facilitated NAPL Transport

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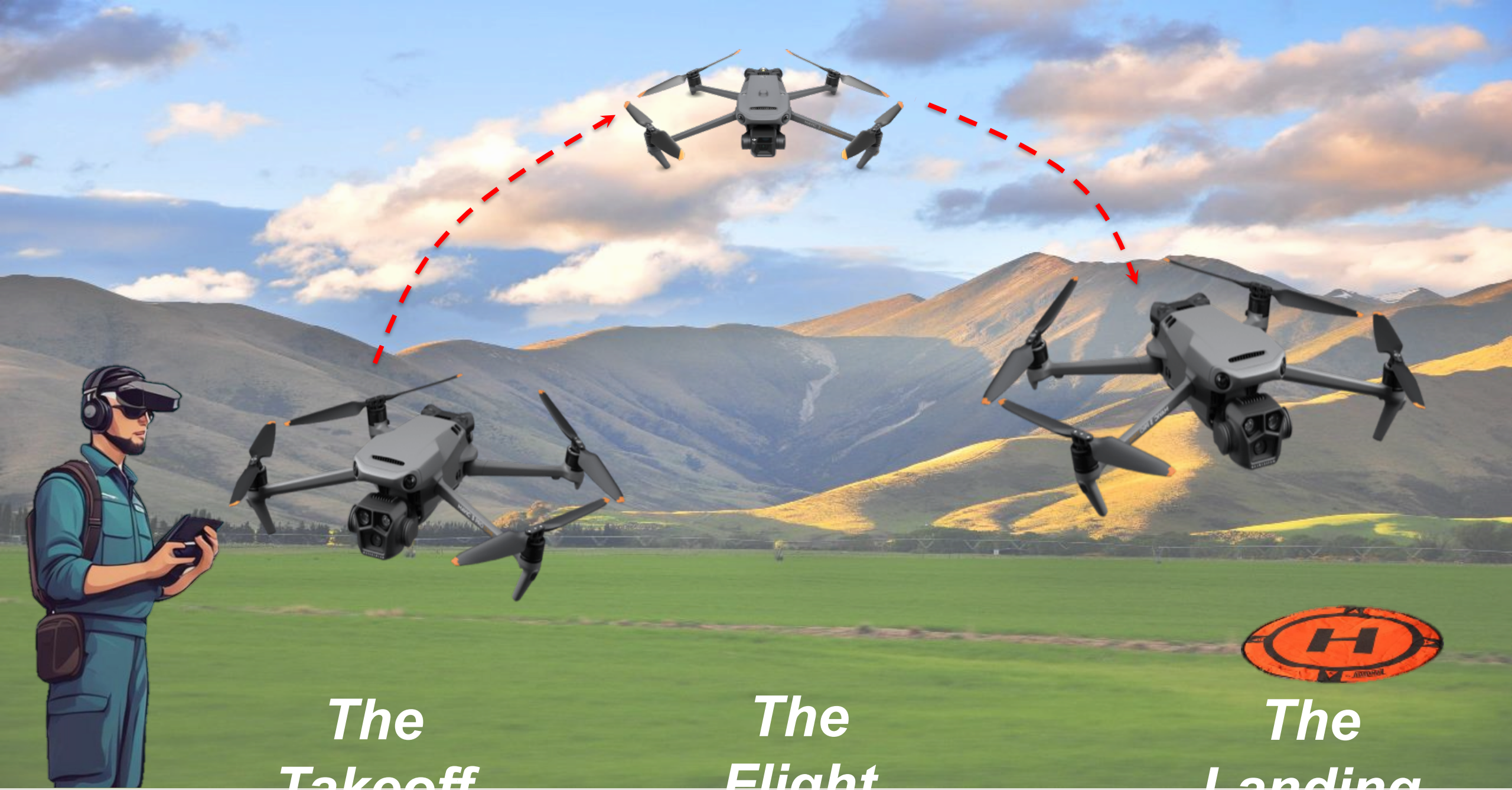
GEI Consultants


The Takeoff
The Flight
The Landing

The Background

Organic-rich material

+

High temperatures enhancing decomposition

+

Pressures favoring gas bubbles

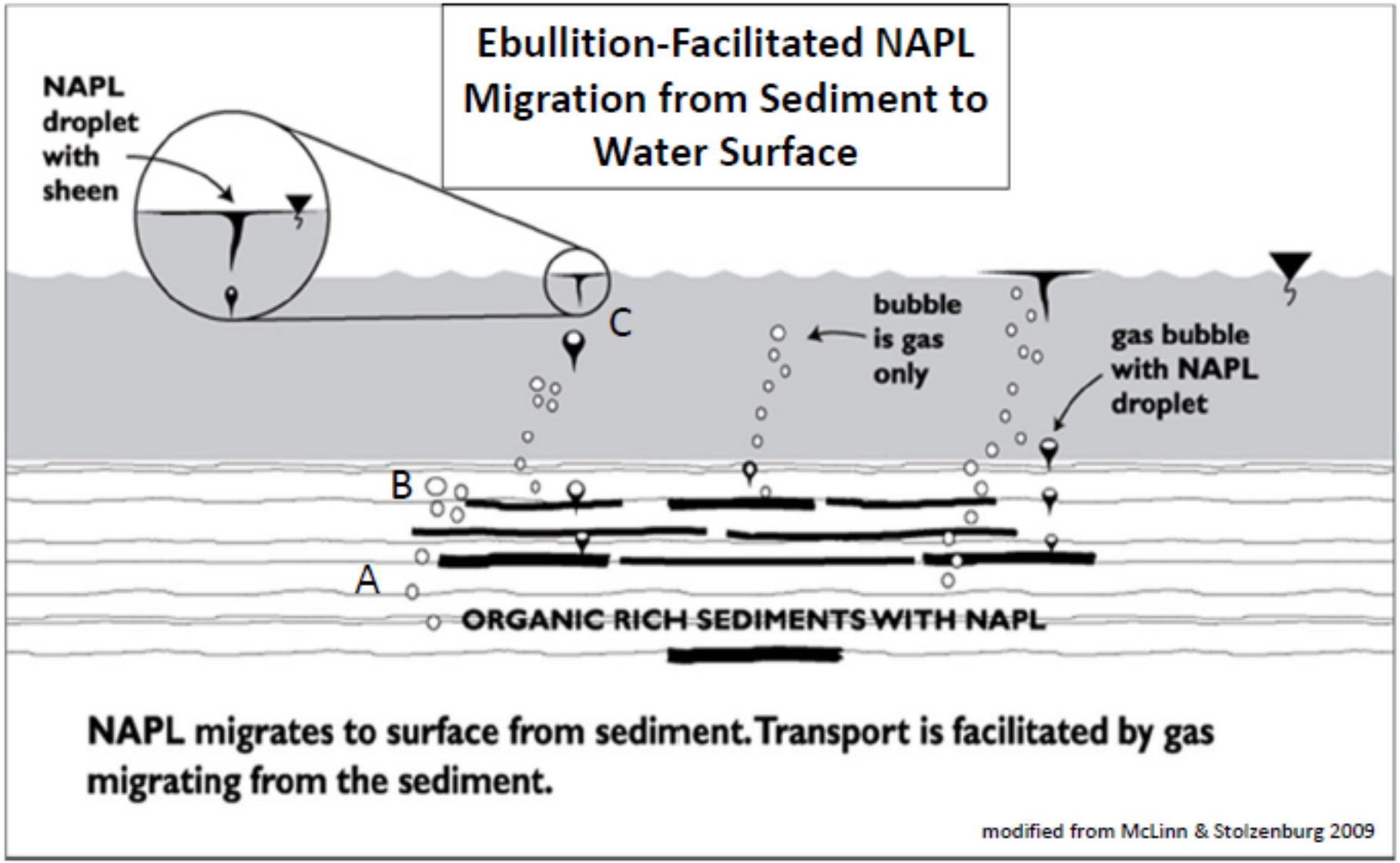
+

Sediment characteristics (fracturing)

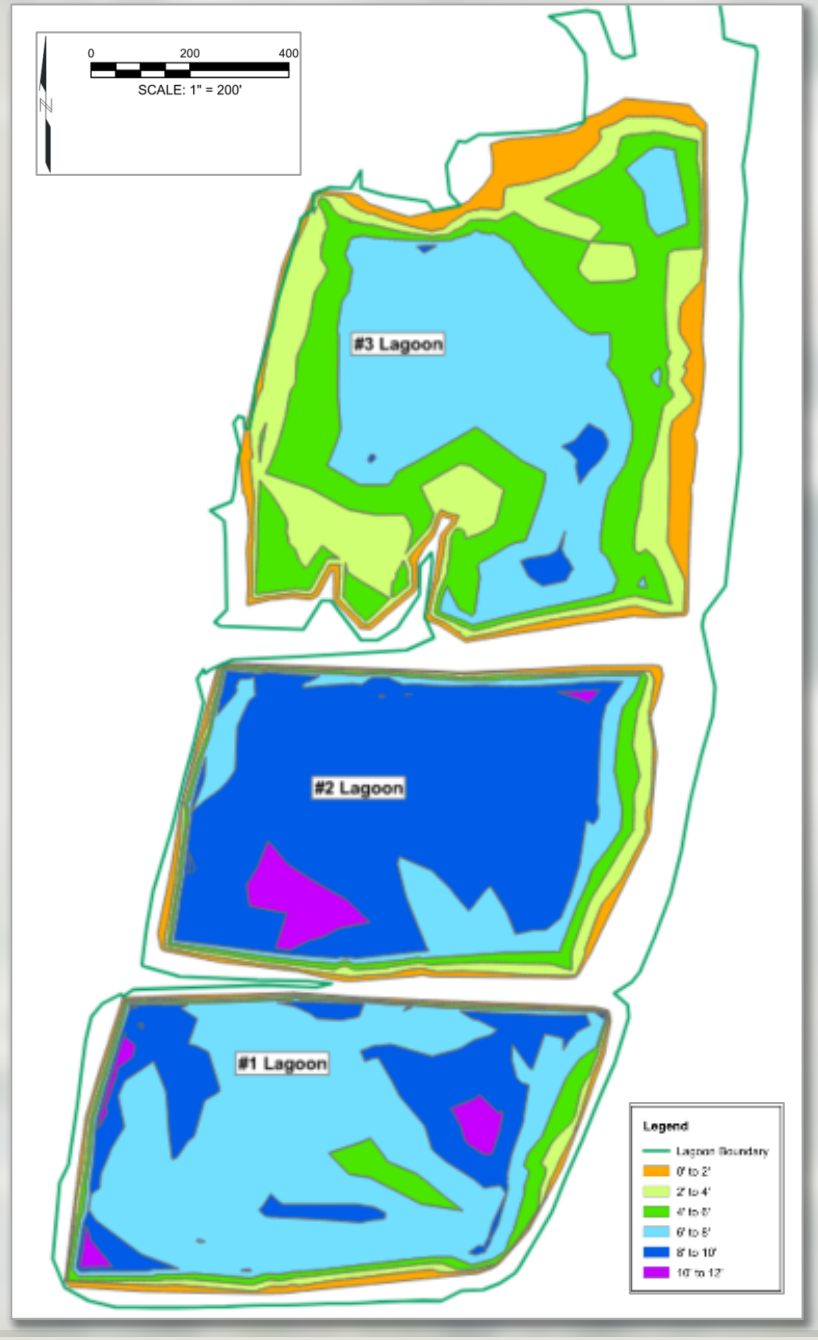
+

A source of NAPL

EBULLITION FACILITATED NAPL TRANSPORT (EFT)



- Large lagoons of approximately 40 acres
- **1950s** - lagoons created from borrow pits during construction of the adjacent river's flood control levee
- **1960s** – former petroleum site used lagoons for wastewater
- **1980s** - discharge to the lagoons ceased
- **To present** – Lagoons receive only flood and stormwater

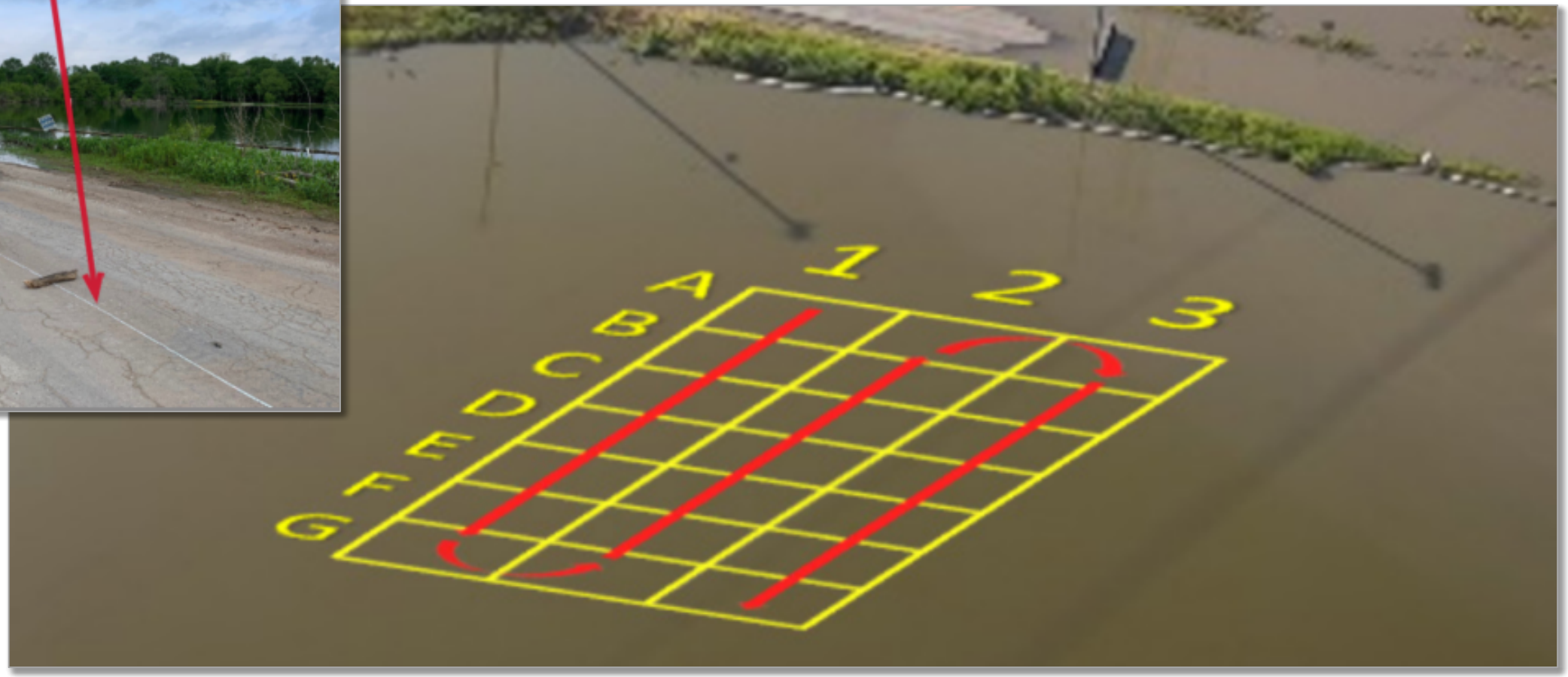


- **2019** – GEI planning further investigation and remediation approach
- **June 2019** – second highest flood on record

The Takeoff

Planning is critical to data quality.

Ebullition Survey

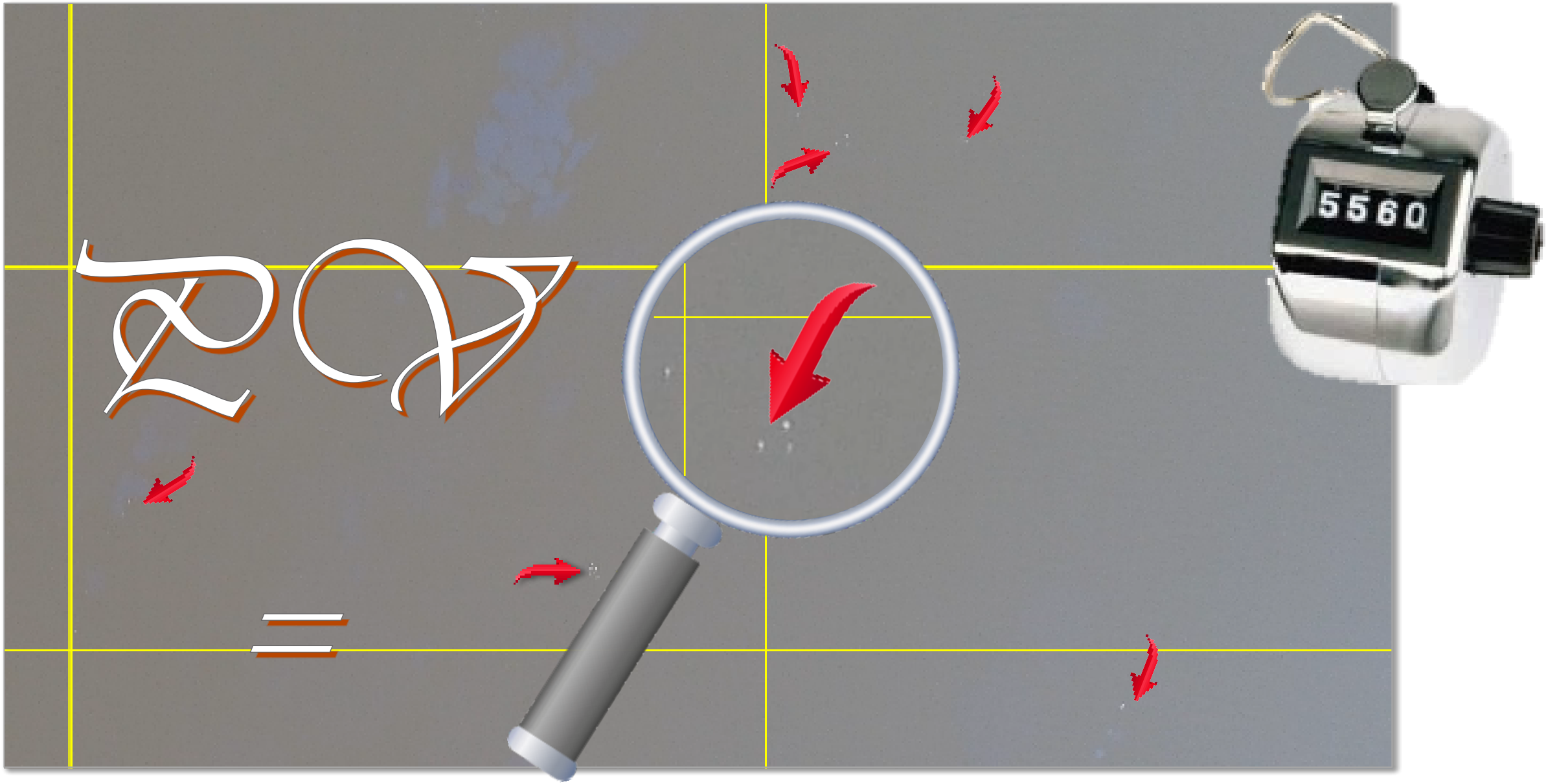


UAV Flights

Equipment & Planning

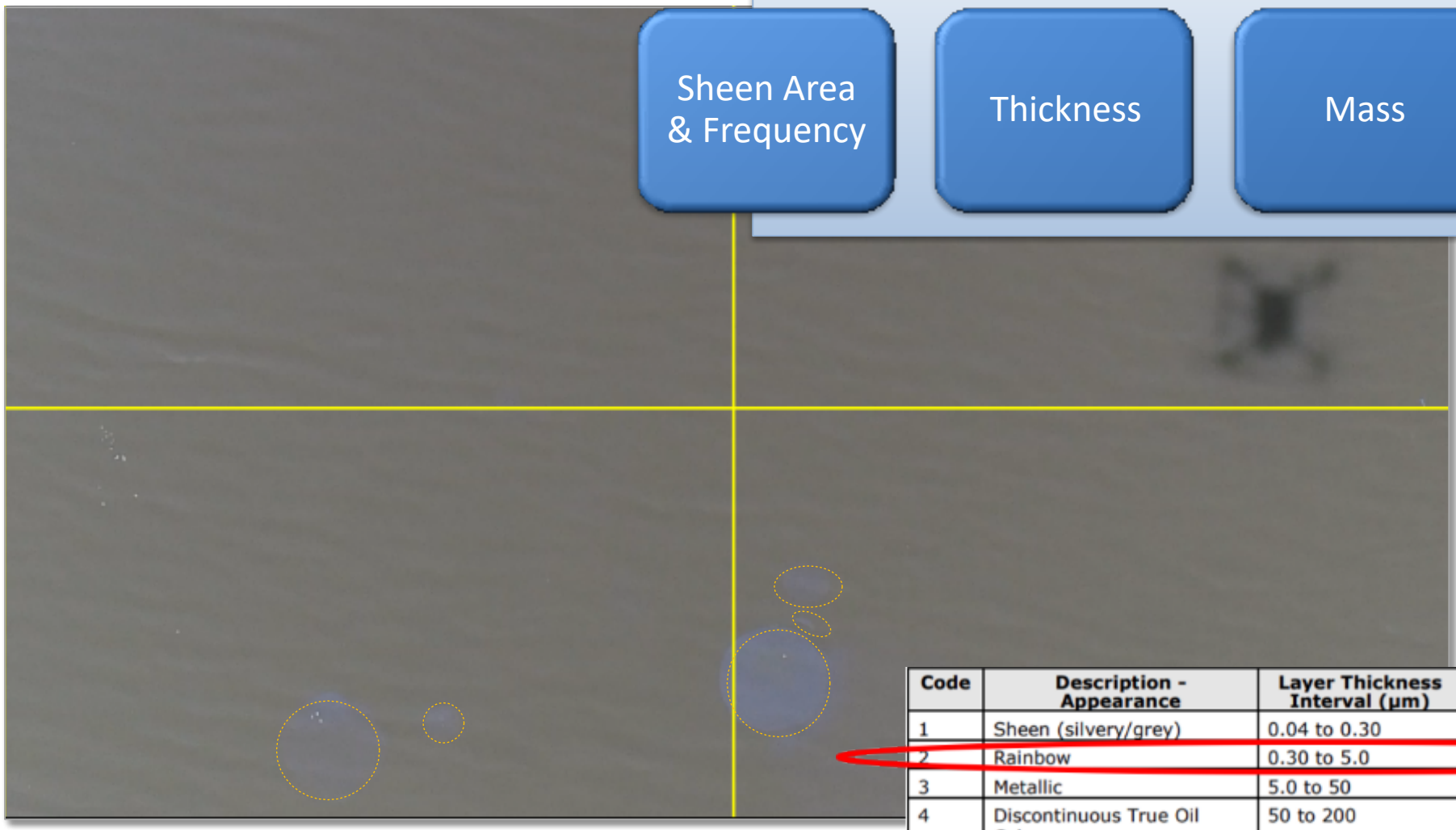
The Flight

UAVs are a viable option for quantitative estimates of EFT NAPL transport over a large area.



Ebullition Analysis

$$Mass_{sheen} = Area_{sheen} \times Thickness_{sheen} \times \rho_{water} \times S.G._{LNAPL}$$



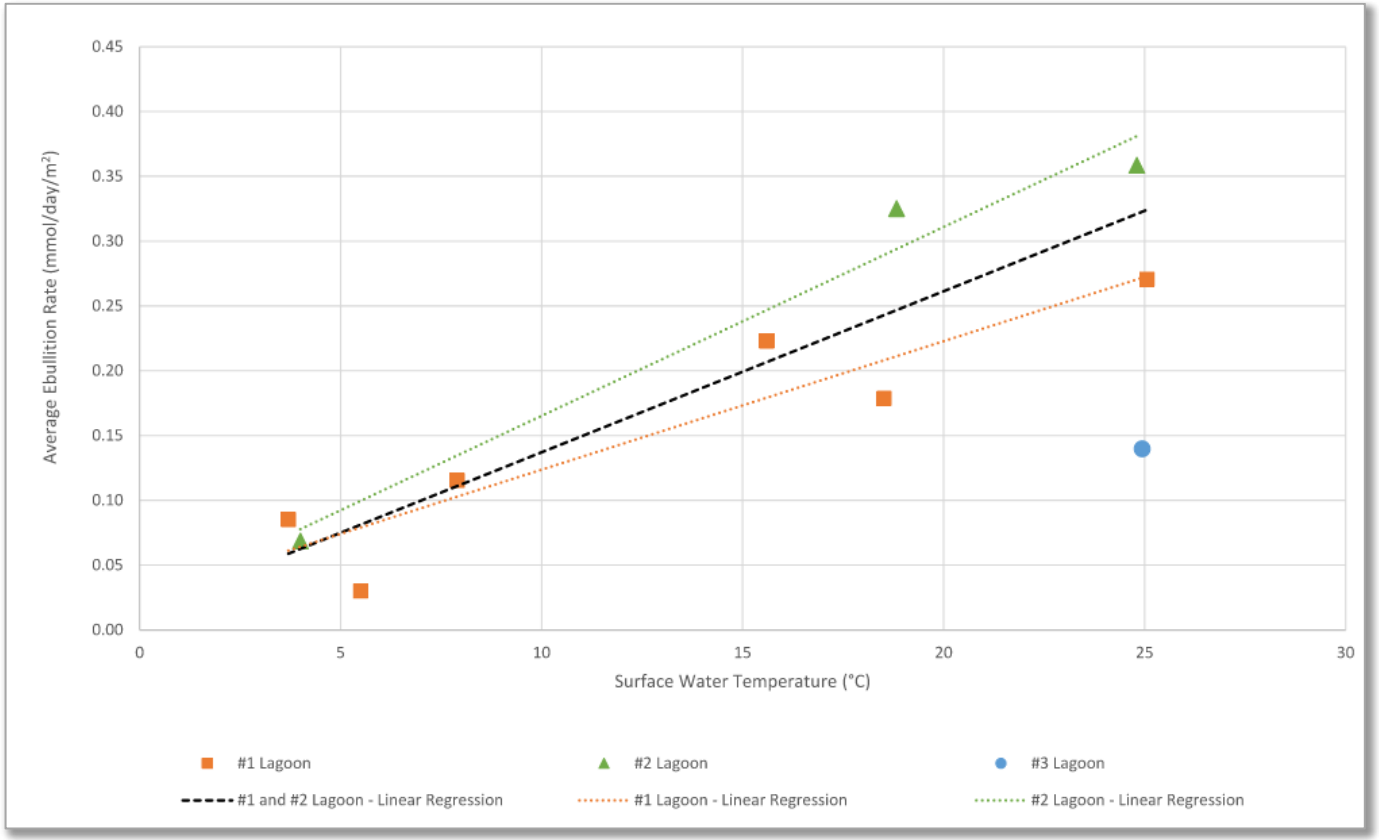
Sheen Area & Frequency → Thickness → Mass → NAPL Flux Rate

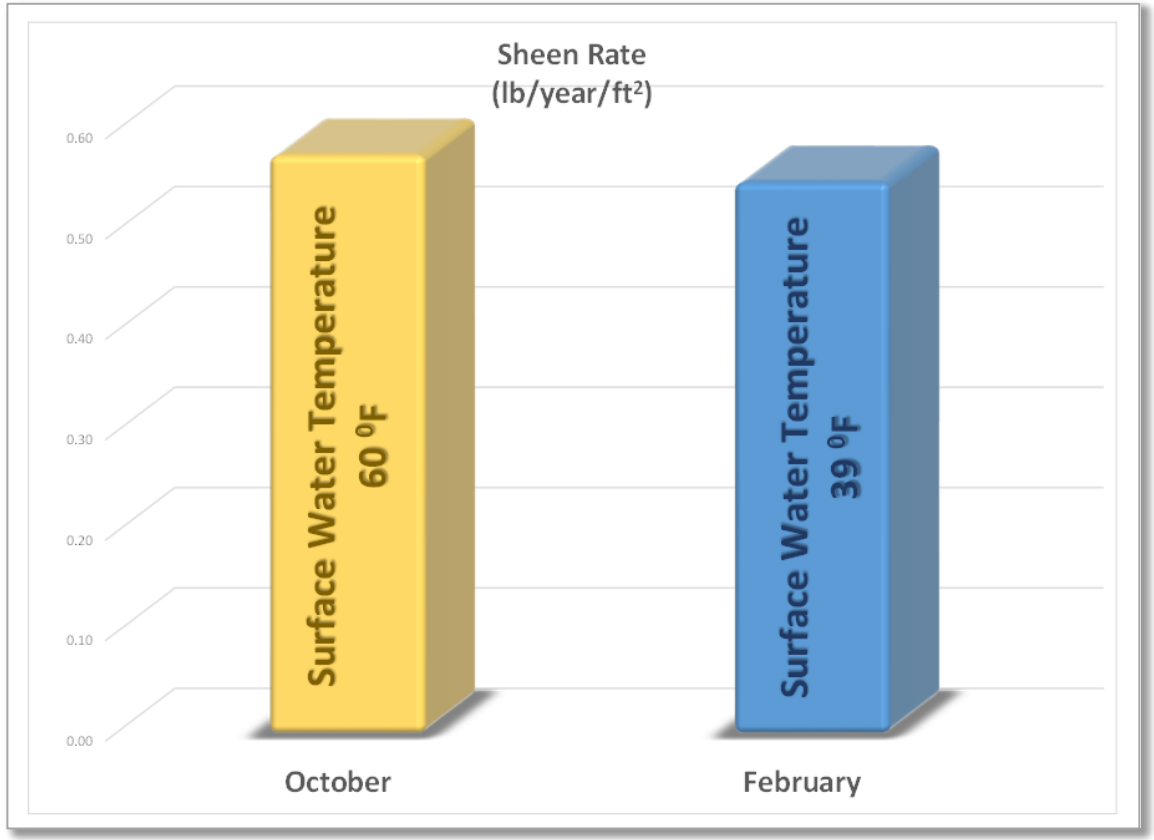
Code	Description - Appearance	Layer Thickness Interval (µm)	Litres per km^2
1	Sheen (silvery/grey)	0.04 to 0.30	40 – 300
2	Rainbow	0.30 to 5.0	300 – 5000
3	Metallic	5.0 to 50	5000 – 50,000
4	Discontinuous True Oil Colour	50 to 200	50,000 – 200,000
5	Continuous True Oil Colour	More than 200	More than 200,000

Bonn Agreement Aerial Operations Handbook, 2009

Sheen Analysis

Temperature Relationships





Temperature Relationships

The Landing

Ebullition and sheen rate data can be used to inform remedy design.

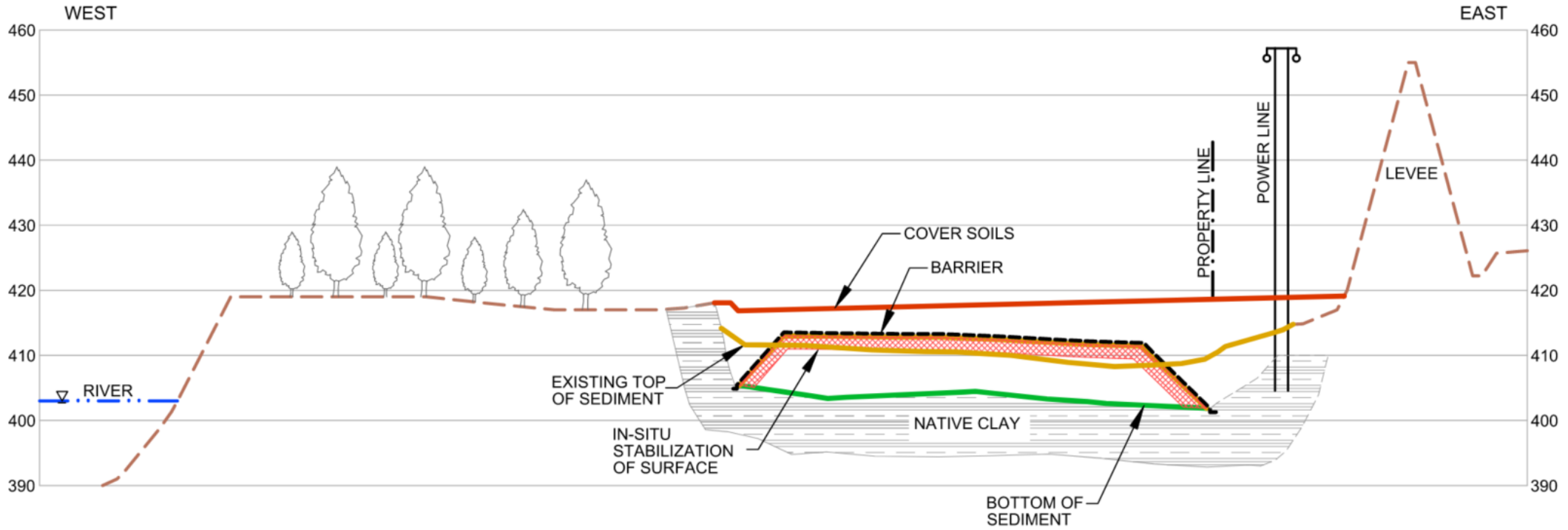
Reme	Feasibility	Limited Exposure Risk	Wildlife Habitat Improvement	Cost
No Action	✗	✗	✗	✓
Dredge and Dispose	✓	✗	✗	✗
Subaqueous Cap	✓	✓	✗	✗

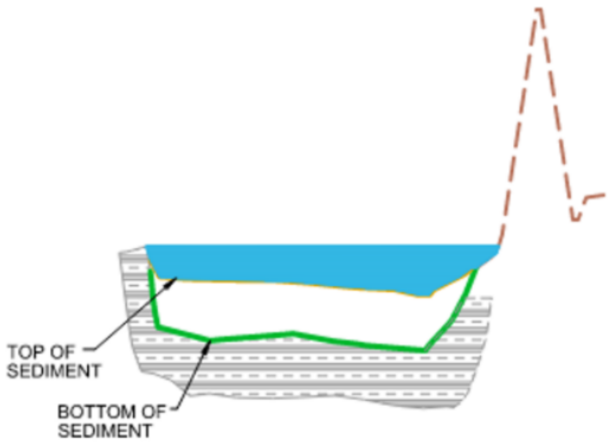
Remedy Design

Remedy	Feasibility	Limited Exposure Risk	Wildlife Habitat Improvement	Cost
No Action	✗	✗	✗	✓
Dredge and Dispose	✓	✗	✗	✗
Subaqueous Cap		✓	✗	
Cap and Cover	✓	✓	✓	✓

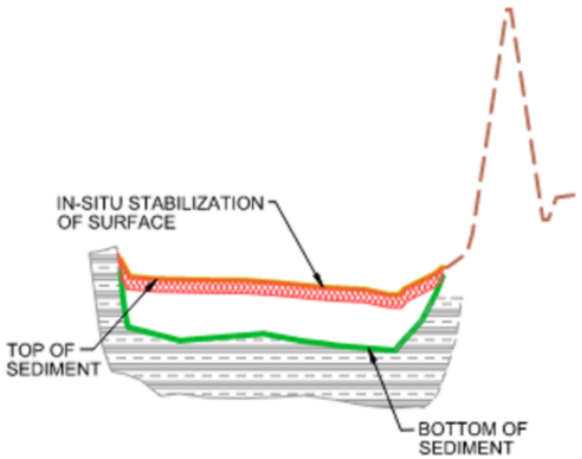
Remedy Design



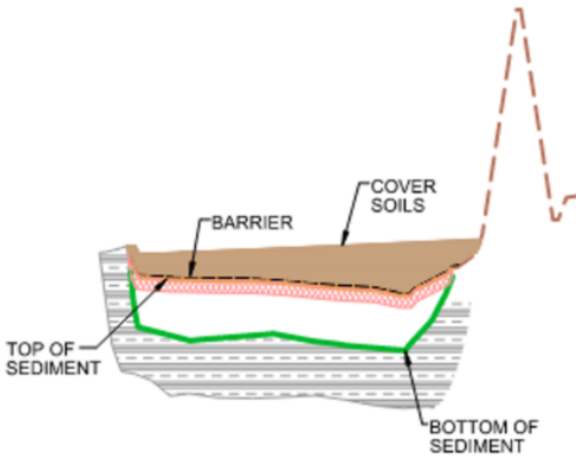




DEWATER



STABILIZE



COVER

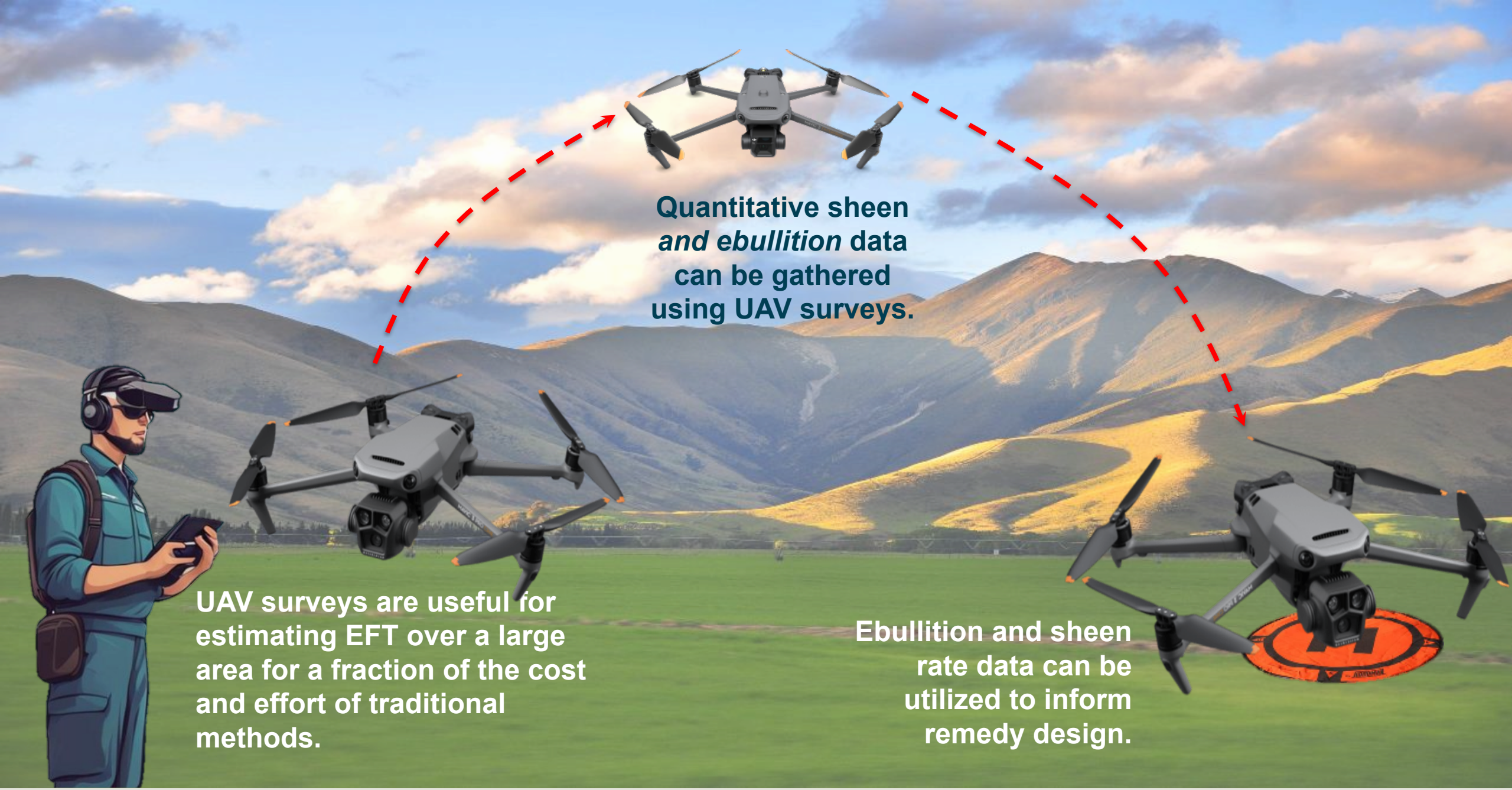
10:55 AM - 11:20 AM

Ebullition-Facilitated NAPL Transport: Case Studies where Screening Evaluations Changed the Remedial Path

Part of session: ***D9. LNAPL Sites: Understanding and Managing Risks (Platform)***

D9. LNAPL Sites: Understanding and Managing Risks (Platform) Platform

D Sessions (Mile High Ballroom, Room 2a)


Quantitative sheen *and ebullition* data can be gathered using UAV surveys.
UAV surveys are useful for estimating EFT over a large area for a fraction of the cost and effort of traditional methods.
Ebullition and sheen rate data can be utilized to inform remedy design.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