

Advances in the Characterization and Remediation of LNAPL-Contaminated Sites:

Insights from a Collaborative Effort

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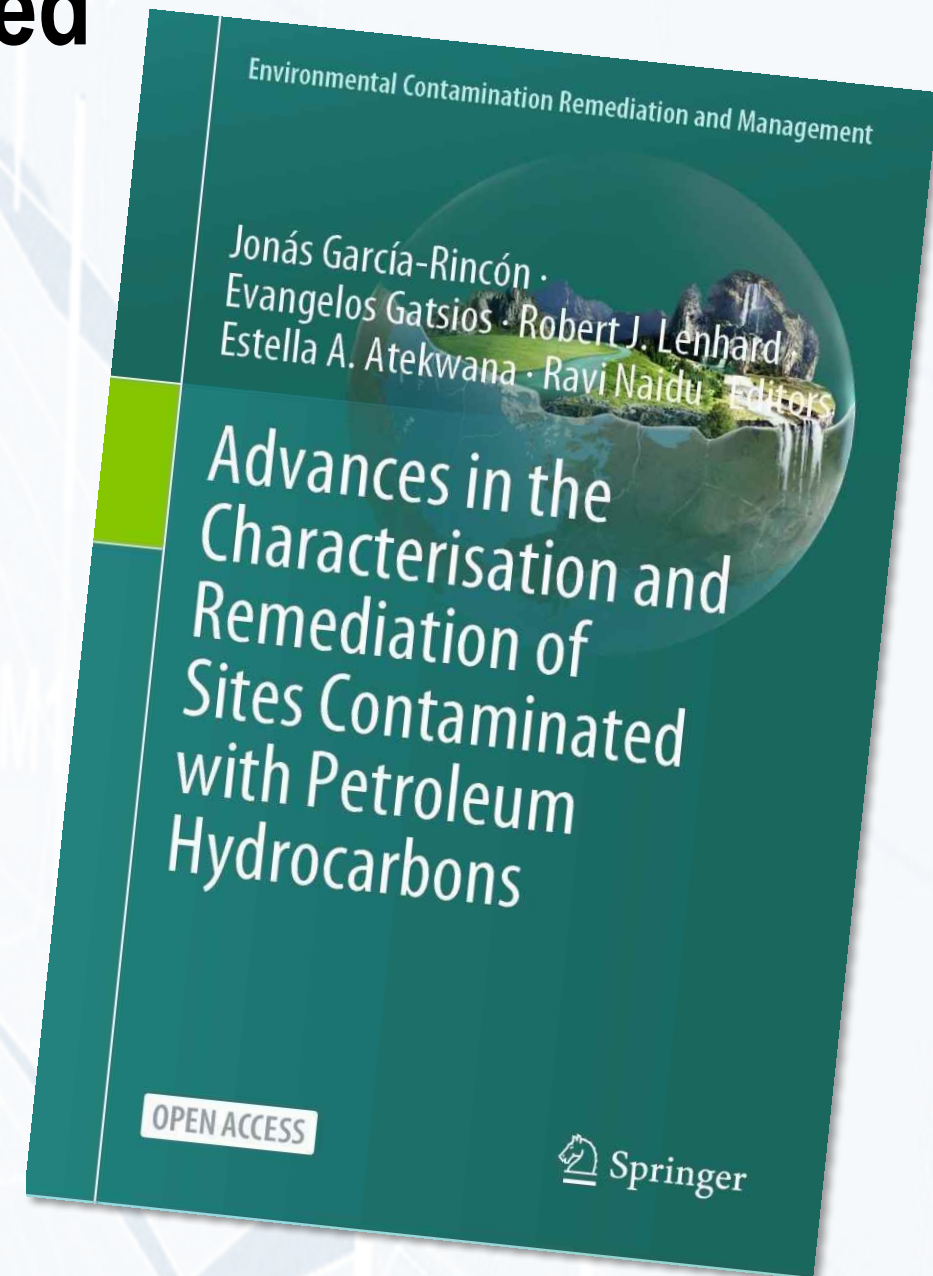


LEGION DRILLING

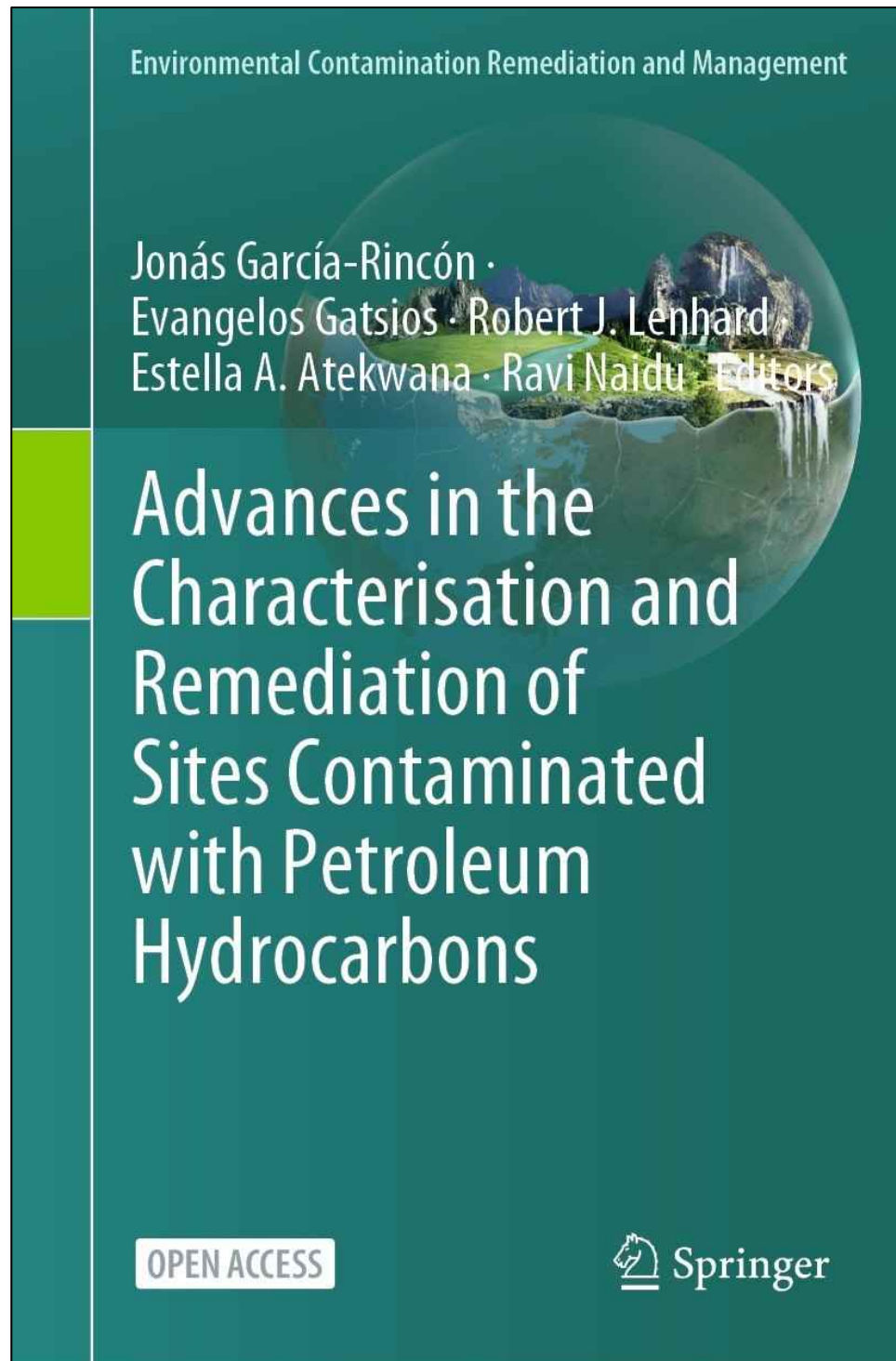
UCDAVIS
UNIVERSITY OF CALIFORNIA

 **INTERGEO**

 **CRC**
Care



The Book



- ✓ Contributed volume with 18 chapters, 677 pp.
- ✓ Peer reviewed
- ✓ Gives visibility to novel (and not so novel) concepts and methods
- ✓ Free download:



- ✓ Accessed ~75,000 times (May 2024)

Some Participants



Guest editors:

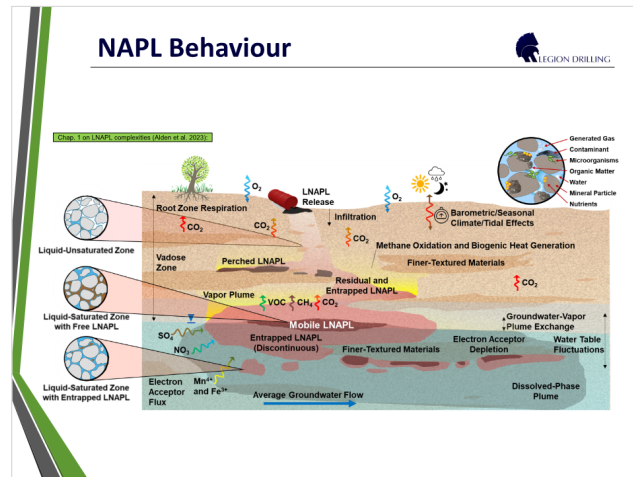


Some chapter contributors:

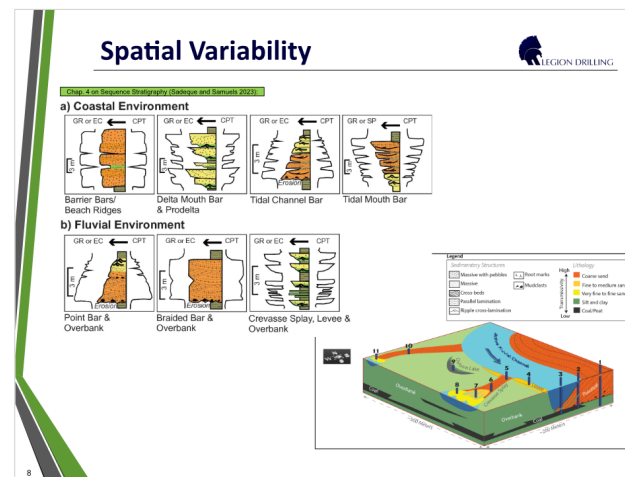


General Insights

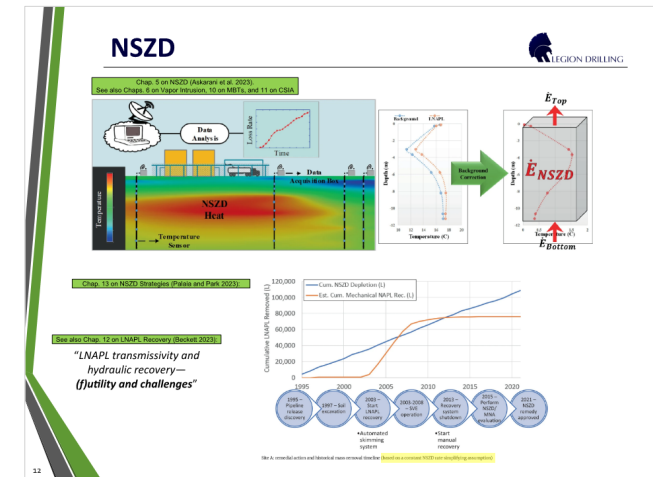
1. NAPL Behaviour



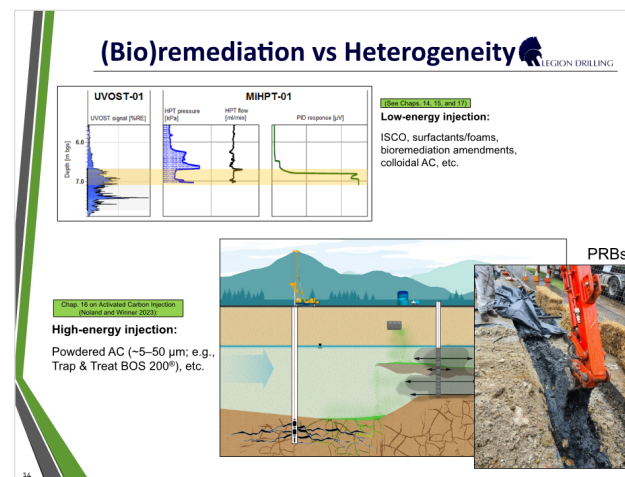
2. Spatial Variability



3. Biological Processes

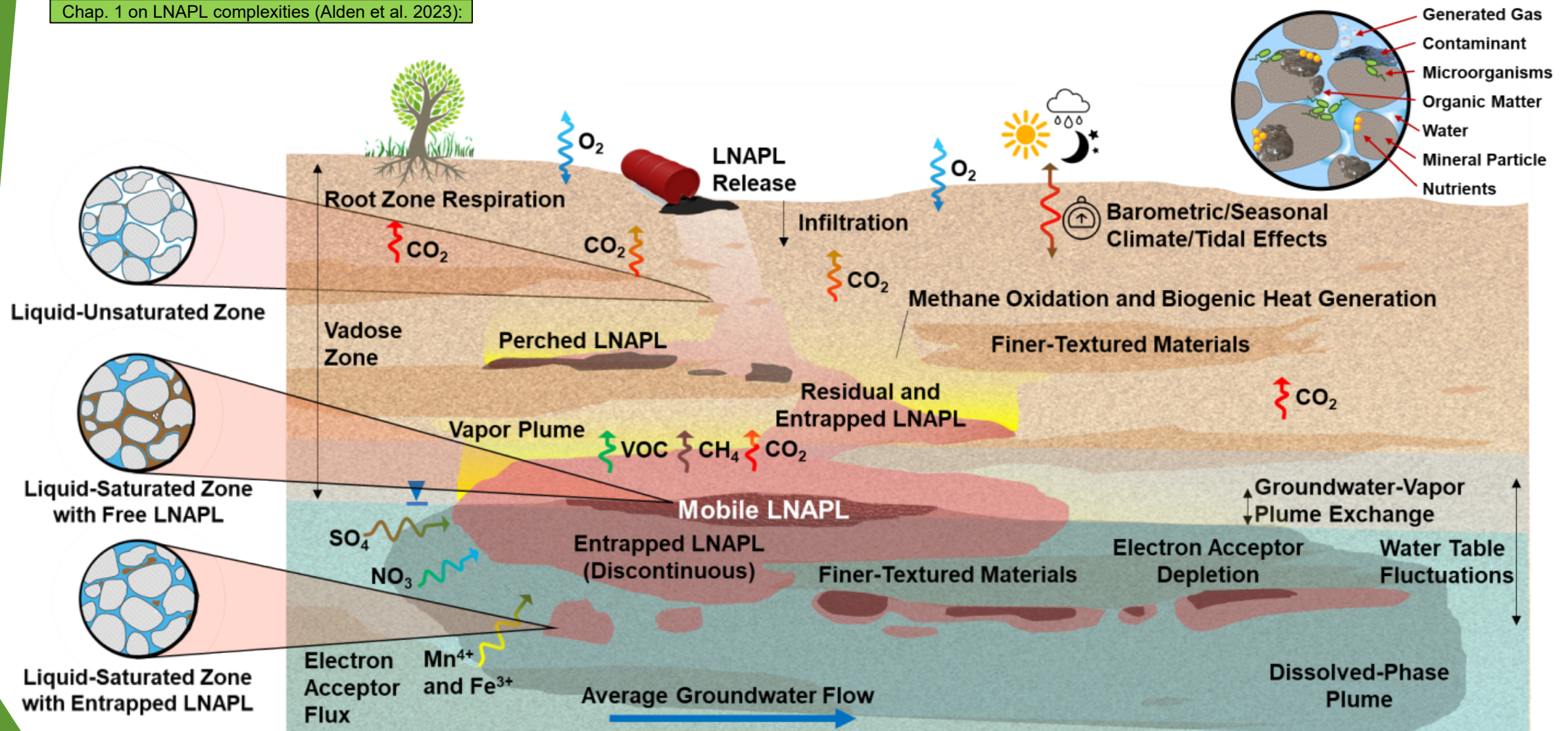


Site Management Strategies?



NAPL Behaviour

Chap. 1 on LNAPL complexities (Alden et al. 2023):





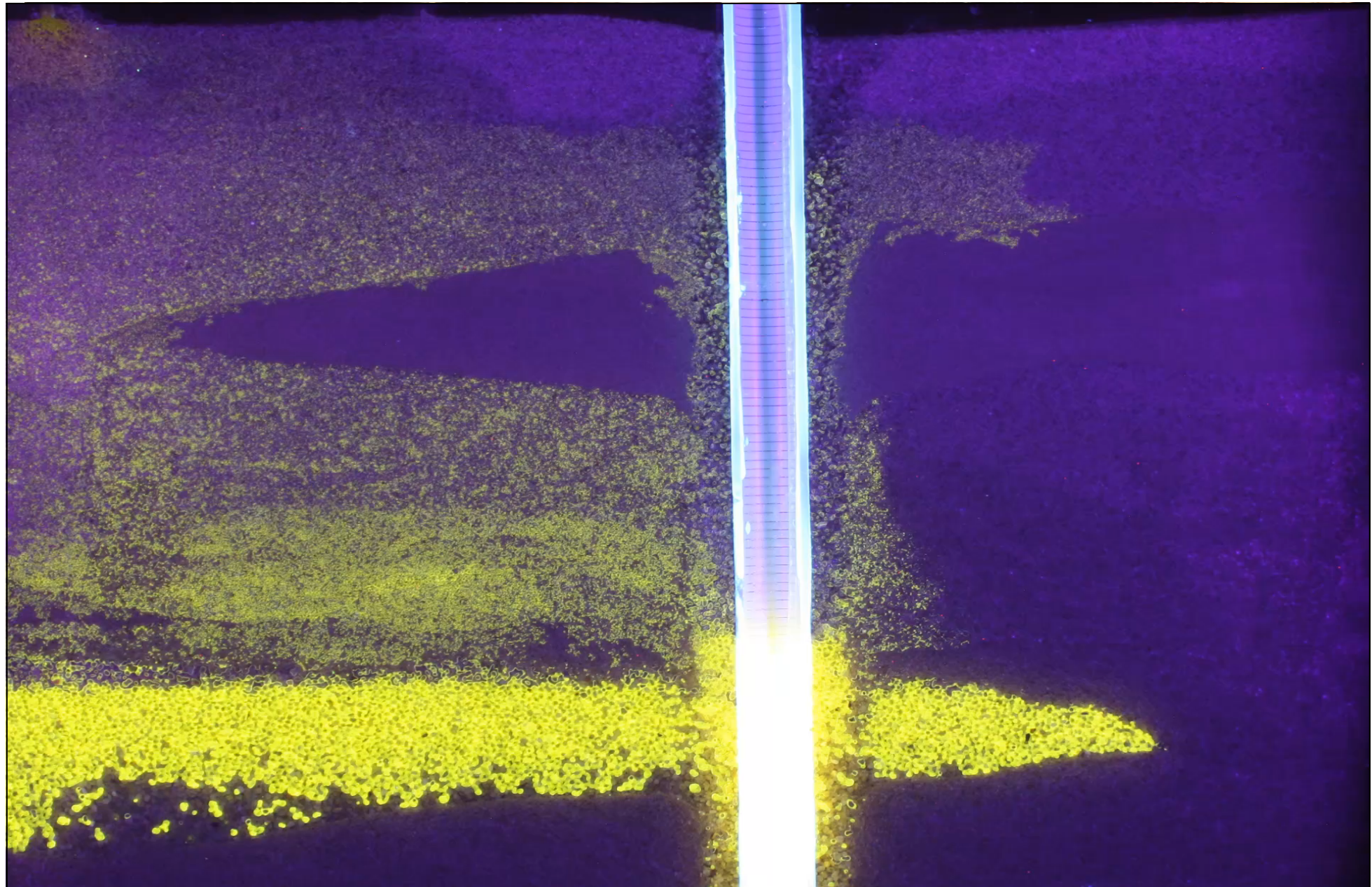
Liquid-Unsaturated Zone

**Liquid-Saturated Zone
with Free LNAPL**

**Liquid-Saturated Zone
with Entrapped LNAPL**

Residual & Entrapped NAPL

Chap. 1 on LNAPL complexities (Alden et al. 2023; video from Zimbron 2022):

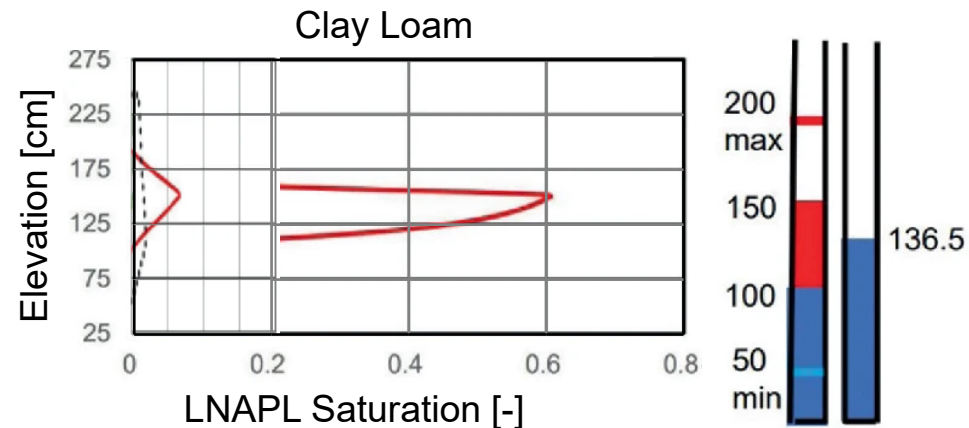


(Zimbron 2022)

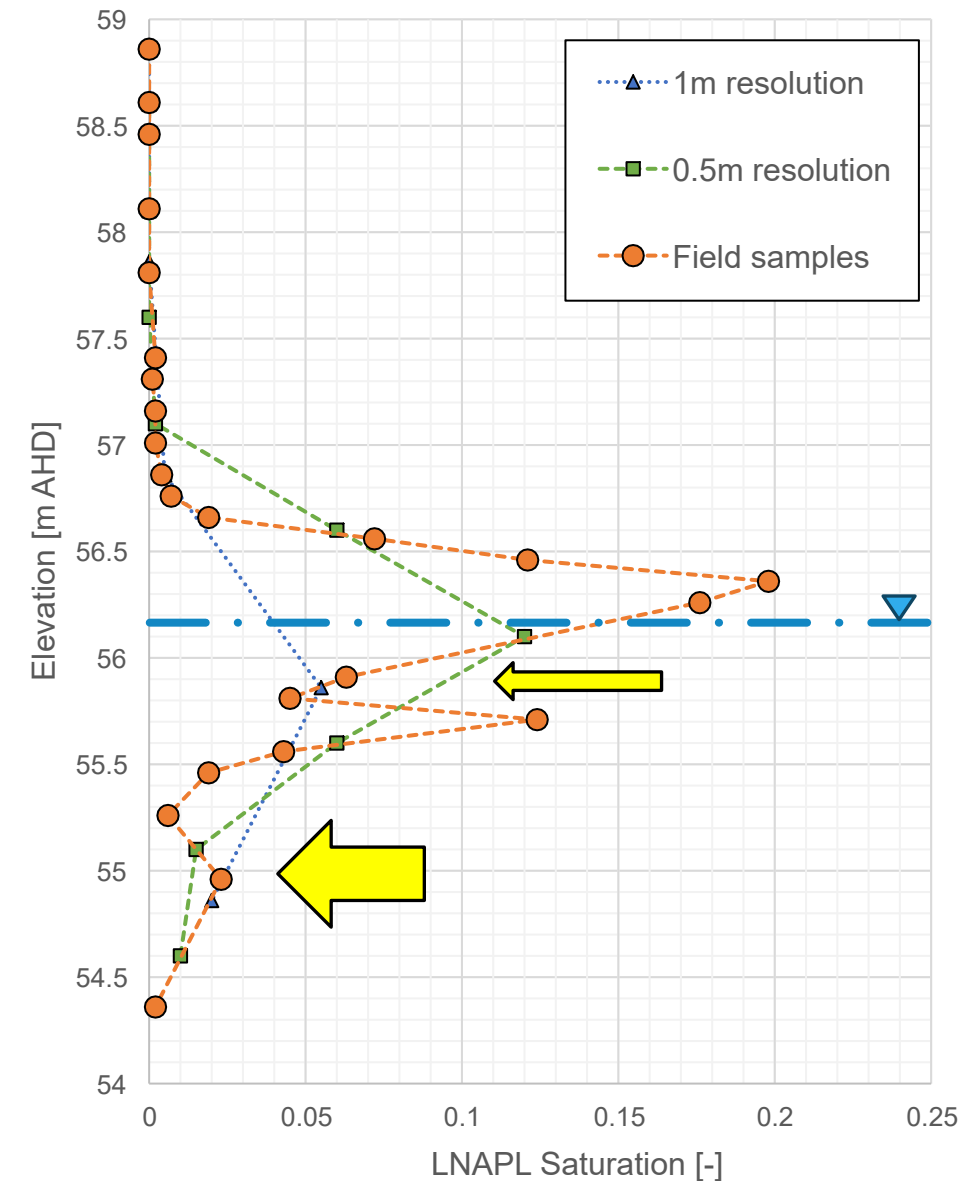
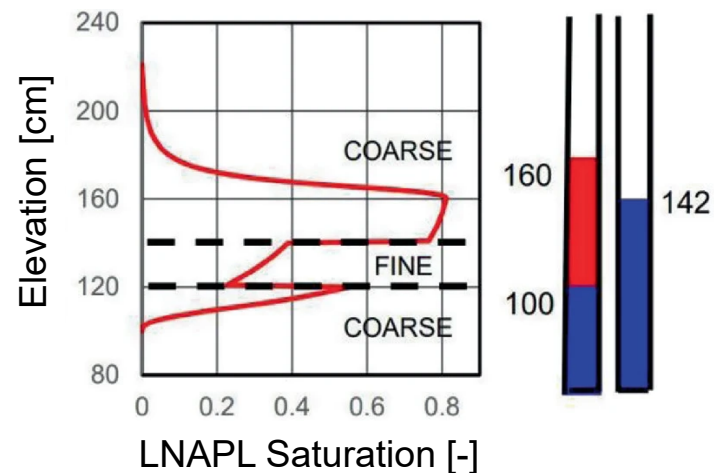
LEGION DRILLING

Field-Scale LNAPL Distribution

Chap. 2 on constitutive relations (Lenhard and García-Rincón, 2023).
See also Chap. 3 on Multimodal Distributions



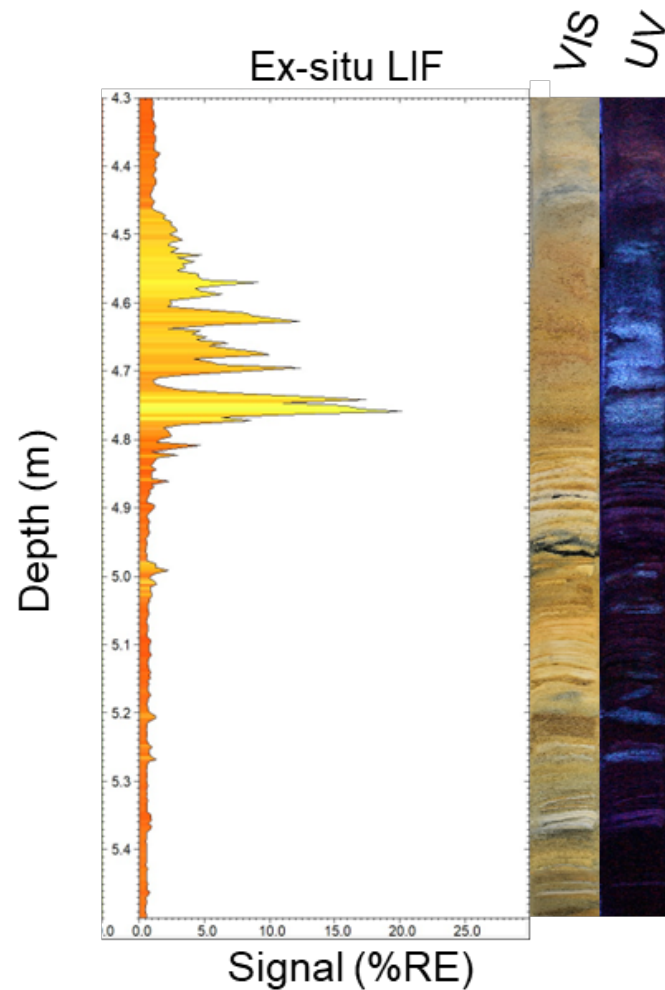
Layered conditions:



Low-resolution sampling
cannot adequately capture
fine-scale variability

NAPL Delineation with HRSC

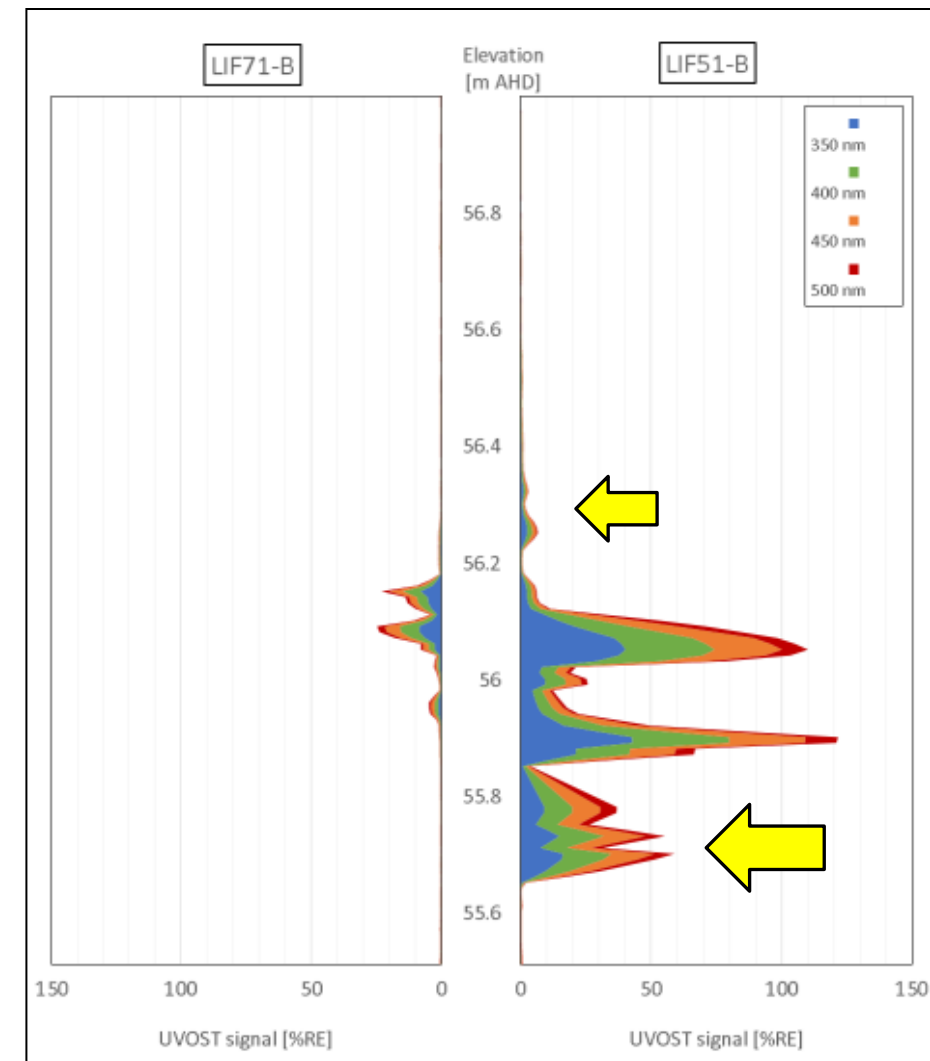
Chap. 8 on Laser-Induced Fluorescence
(St. Germain 2023):



Other methods: MiHPT, NMR,
conventional geophysics...

(see Chaps. 7, 8, and 9)

Distance: 2.7 m

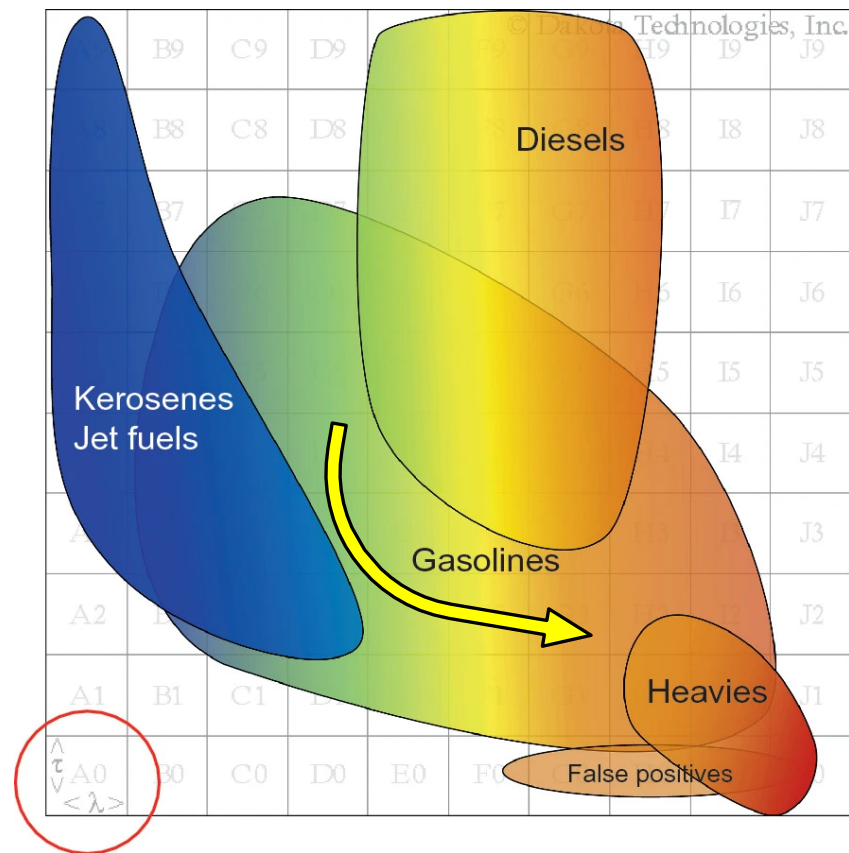


(García-Rincón et al. 2020)

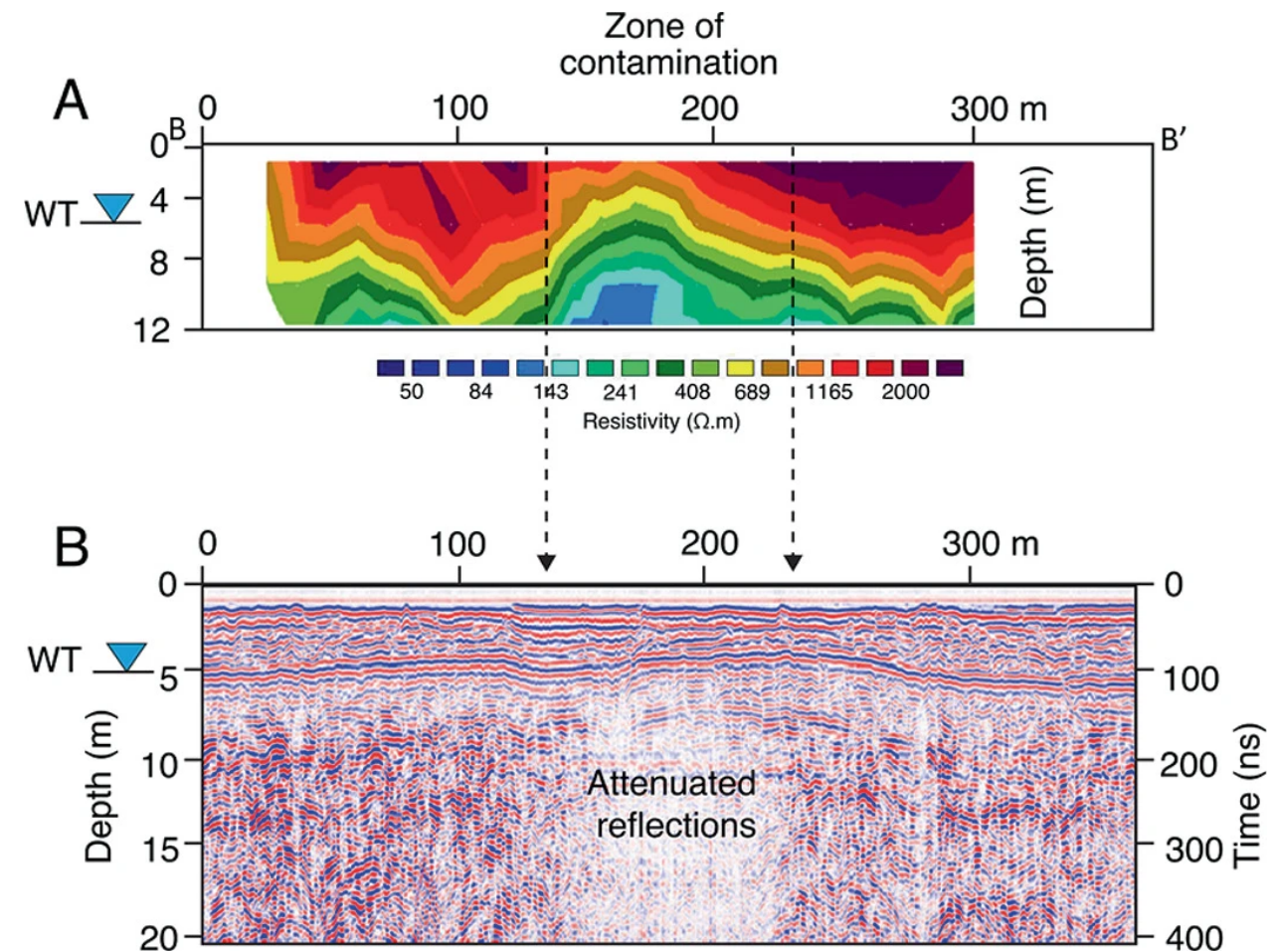
Entrapped LNAPL often
exists metres below the
potentiometric surface

Biological Effects on HRSC

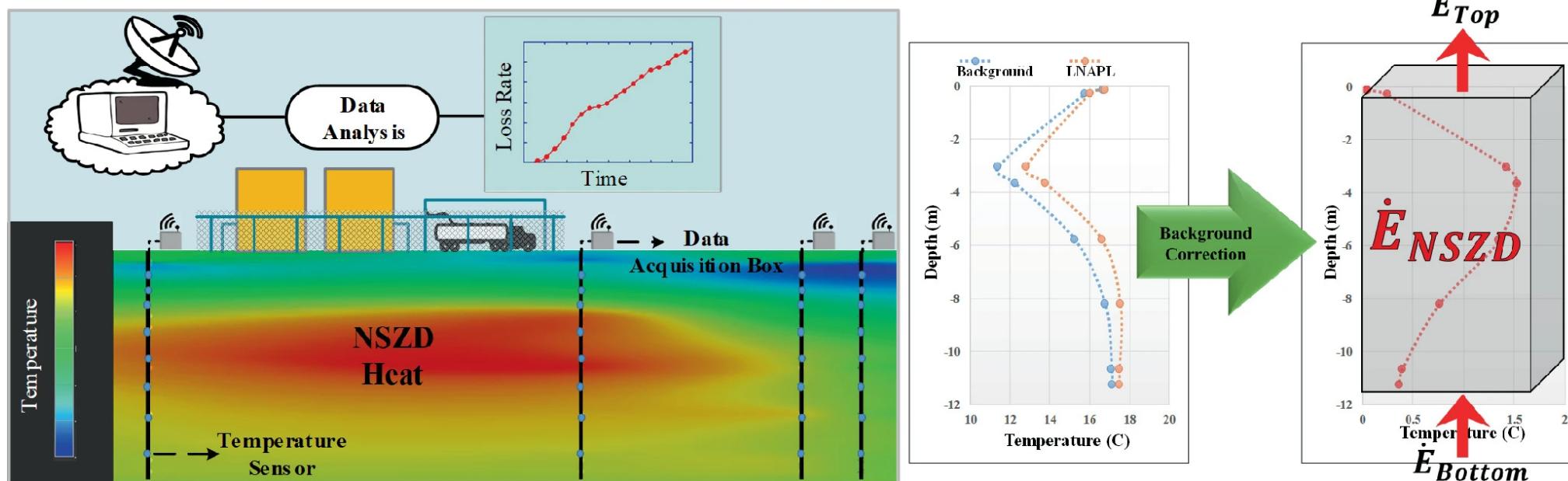
Chap. 8 on Laser-Induced Fluorescence (St. Germain 2023):



Chap. 9 on Biogeophysics (Atekwana et al. 2023):



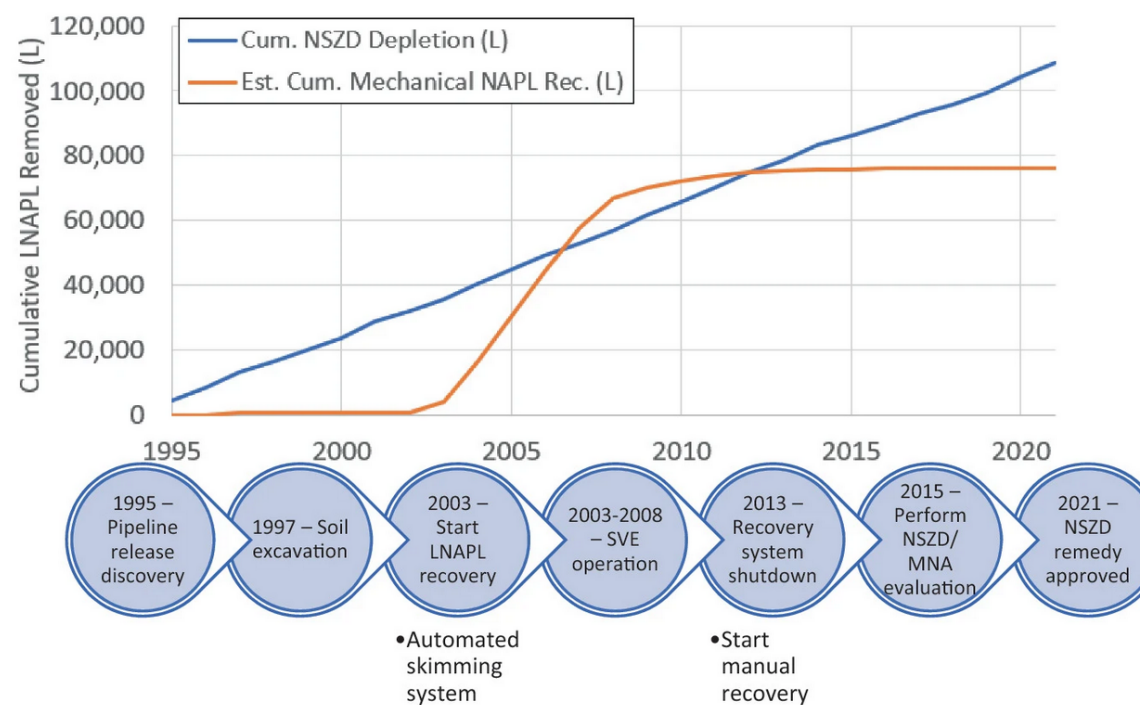
Chap. 5 on NSZD (Askarani et al. 2023).
See also Chaps. 6 on Vapor Intrusion, 10 on MBTs, and 11 on CSIA



Chap. 13 on NSZD Strategies (Palaia and Park 2023):

See also Chap. 12 on LNAPL Recovery (Beckett 2023):

*“LNAPL transmissivity and hydraulic recovery—
(f)utility and challenges”*



Site A: remedial action and historical mass removal timeline (based on a constant NSZD rate simplifying assumption)

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journal homepage: www.elsevier.com/locate/jconhyd

Tracking NSZD mass removal rates over decades: Site-wide and local scale assessment of mass removal at a legacy petroleum site

G.B. Davis^{a,*}, J.L. Rayner^a, M.J. Donn^a, C.D. Johnston^a, R. Lukateli^b, A. King^c, T.P. Bastow^a, E. Bekele^a

^a CSIRO Land and Water, 147 Underwood Avenue Floreat, Western Australia 6014, Australia
^b Consultant, Baldivis, Western Australia, Australia
^c Remediation Management, BP Australia Pty Ltd, Melbourne, Victoria, Australia

Highlights:

- ☐ Gasoline NSZD rates 21 years ago predict zero mass in 2020, but 11 kg/m² remained.
- ☐ Diesel NSZD rates estimates were 3–6 times lower after 14 years.
- ☐ Single point-in-time NSZD rate estimates are at odds with LNAPL longevity measures.

Groundwater

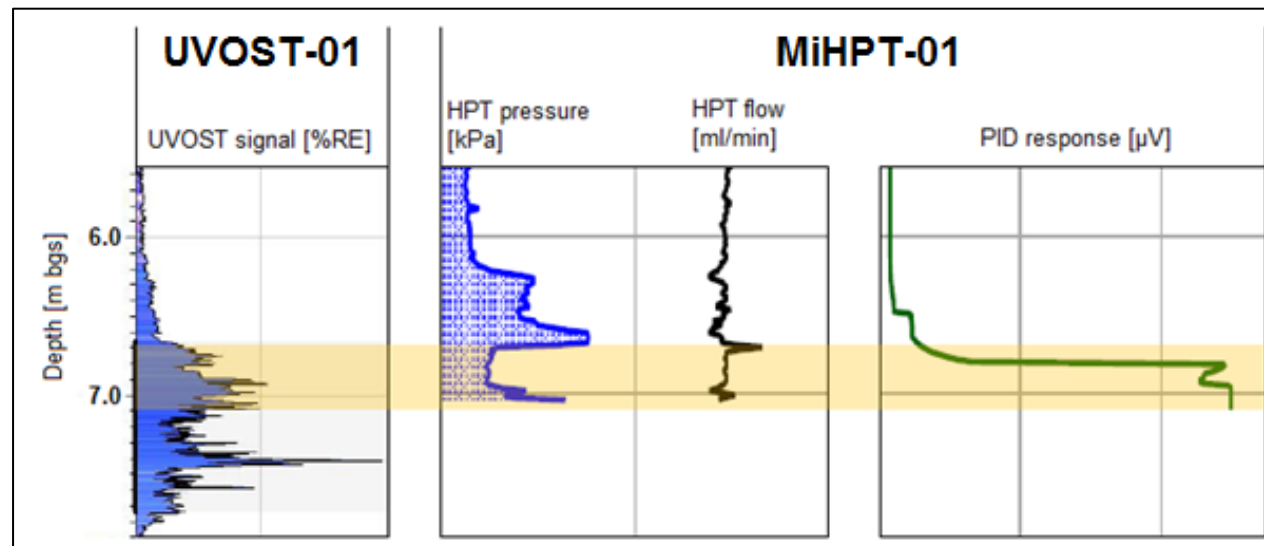
Weathering of Oil in a Surficial Aquifer

by Mary Jo Baedeker¹, Robert P. Eganhouse², Haiping Qi², Isabelle M. Cozzarelli², Jared J. Trost³, and Barbara A. Bekins⁴

“We already know everything about LNAPLs and natural attenuation”

-Anonymous Professor, Spain,
15 years ago.

(Bio)remediation vs Heterogeneity



(See Chaps. 14, 15, and 17)

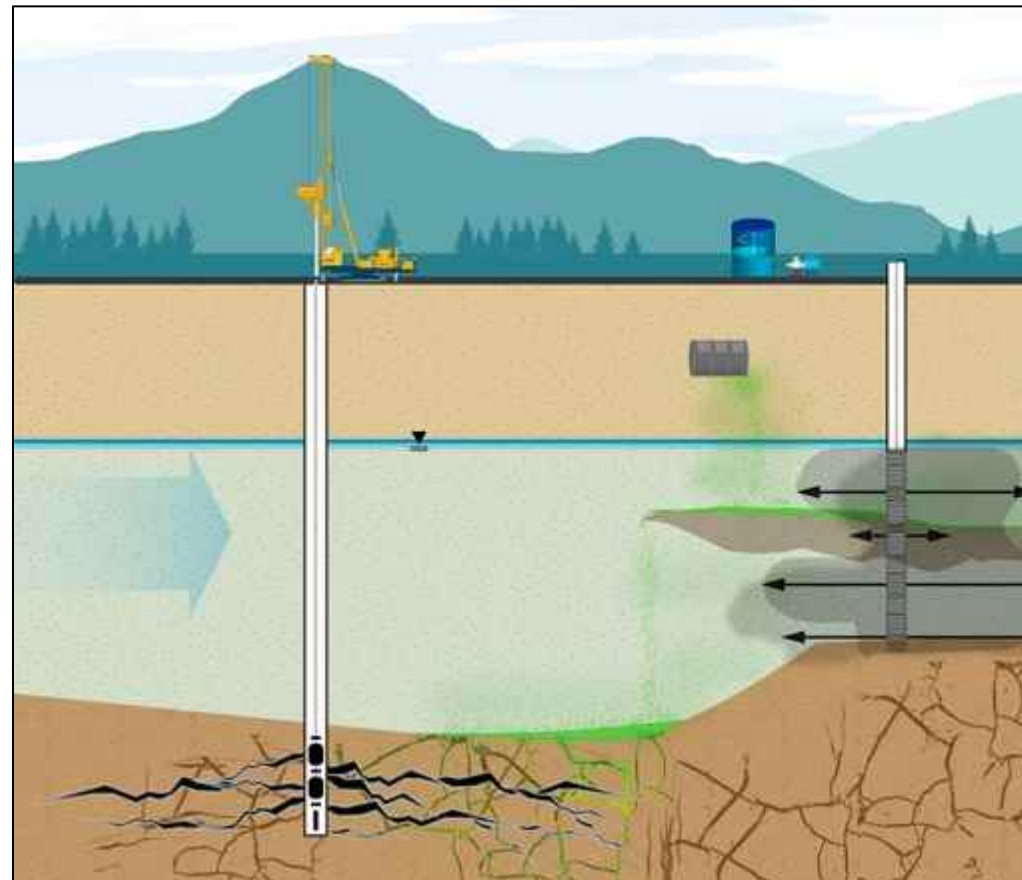
Low-energy injection:

ISCO, surfactants/foams, bioremediation amendments, colloidal AC, etc.

Chap. 16 on Activated Carbon Injection
(Noland and Winner 2023):

High-energy injection:

Powdered AC (~5–50 µm; e.g.,
Trap & Treat BOS 200®), etc.



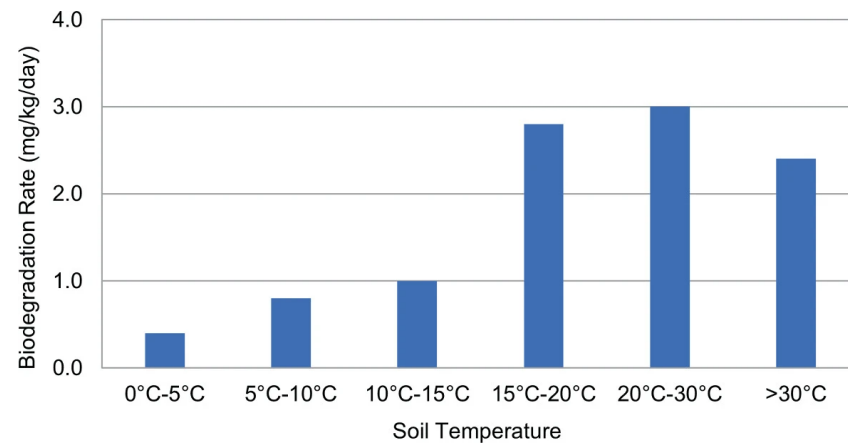
PRBs:



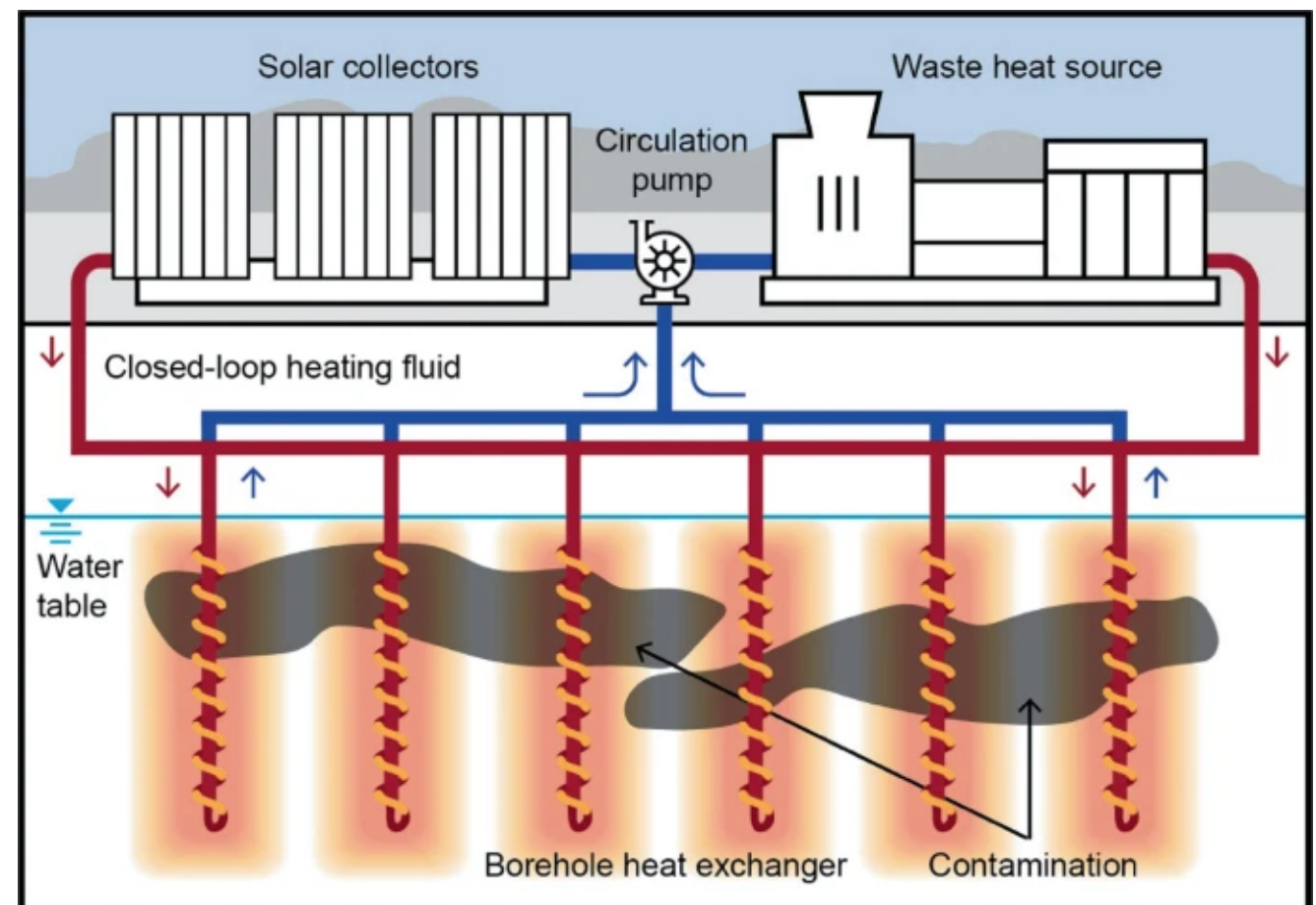
(Bio)remediation vs Heterogeneity

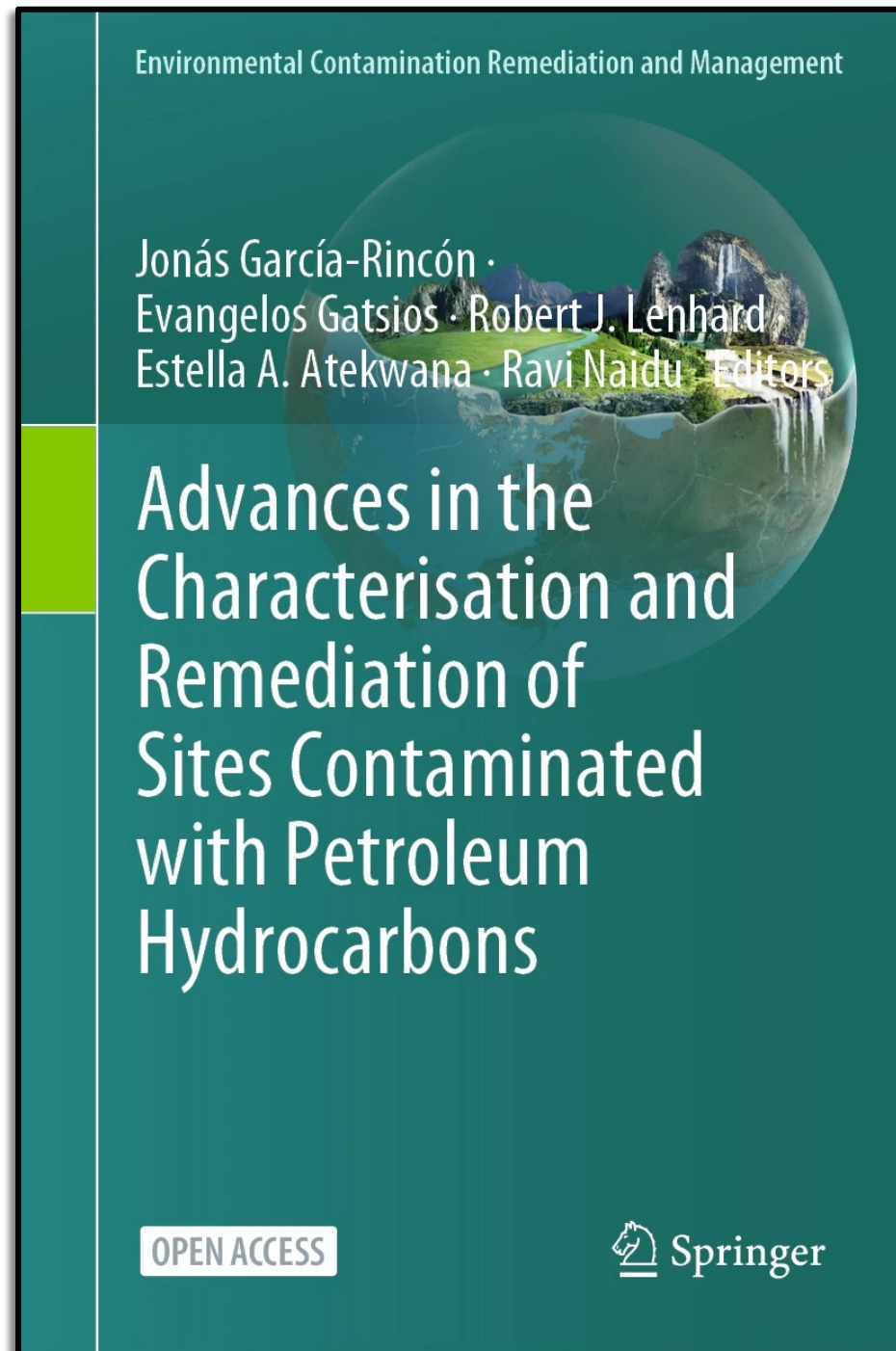


Thermal-enhanced SZD:



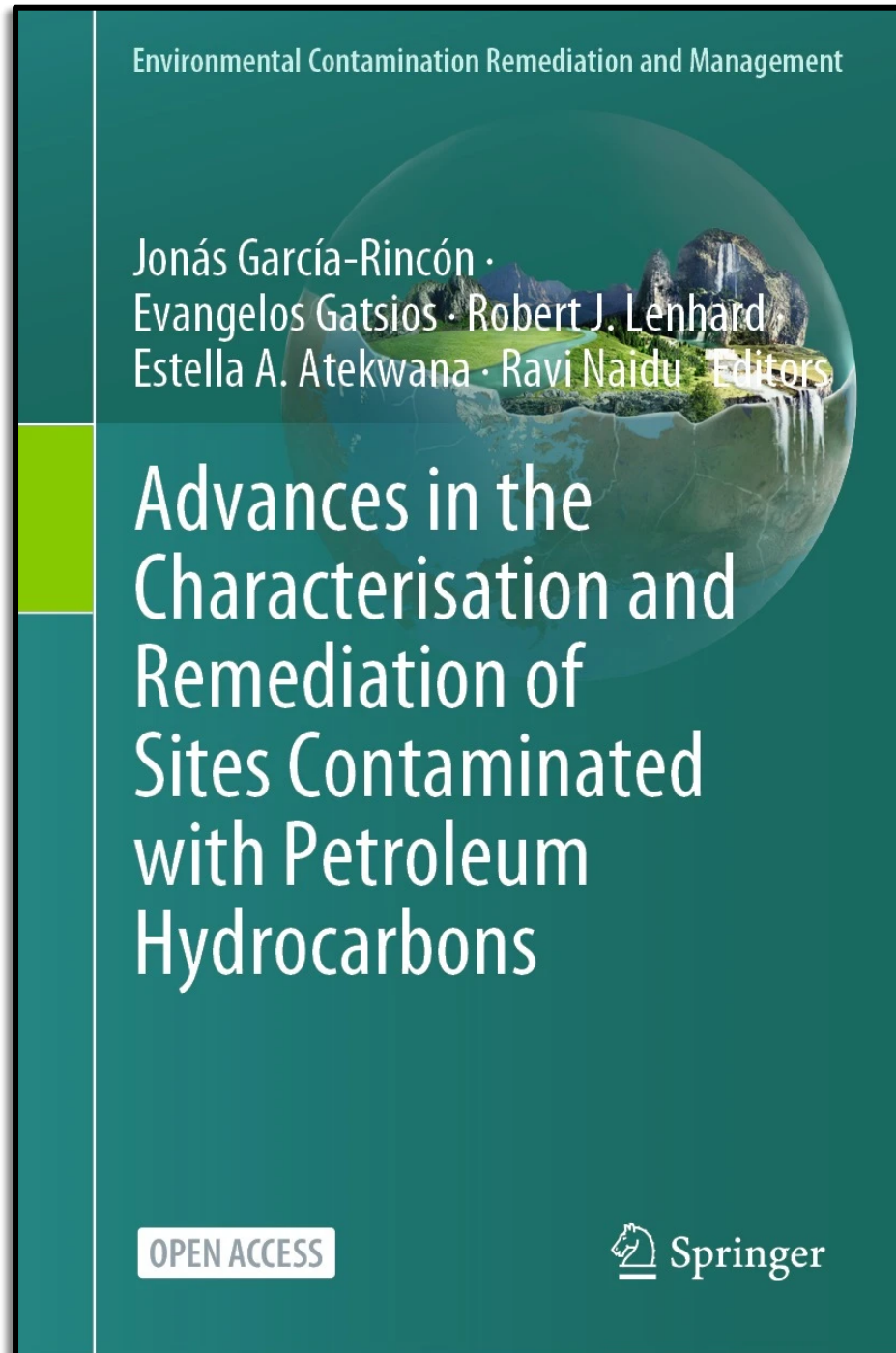
Chap. 16 on Thermal Remediation
(Munholland et al. 2023):





- Most methods presented in the book deal with heterogeneity and/or take advantage of biodegradation
- Improved concepts and technologies still not broadly adopted internationally. Why?
- Many open questions and room for improvement for more efficient and sustainable management

Thank You!



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download:



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