

# NSZD – Moving Past the Perceptions

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# Abstract

The science supporting the effectiveness of natural processes to degrade and deplete petroleum non-aqueous phase liquid (NAPL) source zones (termed “natural source zone depletion [NSZD]”) is more than a decade old. As a synthesized remedial technology, it’s been referenced in peer-reviewed literature since 2006 and available in guidance since 2009 (U.S. Interstate Technology & Regulatory Council [ITRC]). One might think it would be fairly received since monitored natural attenuation (MNA), its predecessor, companion technology is one of the most commonly used remedial approaches for petroleum in groundwater. However, instead it has been met with a mixed response, demonstrating the on-going challenge with uptake of new science/technology and predisposition of natural processes as an inadequate approach. This presentation will directly address these issues and clearly explain that NSZD can be at least as effective, if not more than other remedial technology options.

This presentation will concisely cover the following key points:

- Current Perception of NSZD is Mixed - A poll summary to relate actual regulatory responses received from experience on >70 sites that have measured and included NSZD in remedy decision documents.
- NSZD is Significant- A database summary to demonstrate the effectiveness of NSZD as a knowledge-driven remedy as compared to other remedial technologies such as NAPL recovery and in situ aeration.
- There are Ample Precedents on Effective Use of NSZD as a Remedial Approach - Presentation of tangible examples where NSZD has been used as an effective risk management approach.

A poll of various practitioners was conducted to solicit real regulatory responses to help inform the current understanding of the practice and discern the cause for mixed responses. The information will be presented to initially establish the current state of the practice and regulatory receptiveness of using NSZD in North America.

Next, site-specific mass removal data can be used to directly compare NSZD to its peer technologies such as fluid recovery, aeration, and multiphase extraction. The Jacobs database shows that while some remedial technologies initially remove mass at a higher rate than NSZD, the mass removal efficiency of most declines relatively quickly to the point where the rate of NSZD outperforms them. This demonstrates that NSZD is significant.

Last, if the industry is to move forward with sustainable/resilient remediation and risk management, then NSZD must be considered at all petroleum sites. Through case study examples, this presentation will show exactly how NSZD can be used to satisfy regulatory requirements and cost-effectively manage risk at petroleum NAPL sites.

1. Impetus for this presentation
2. The current perception and state of the practice of NSZD
3. Ways in which NSZD is significant
4. Brief: Effective use of NSZD in the CSM and as a remedial approach
5. Closing thoughts



# Jacobs

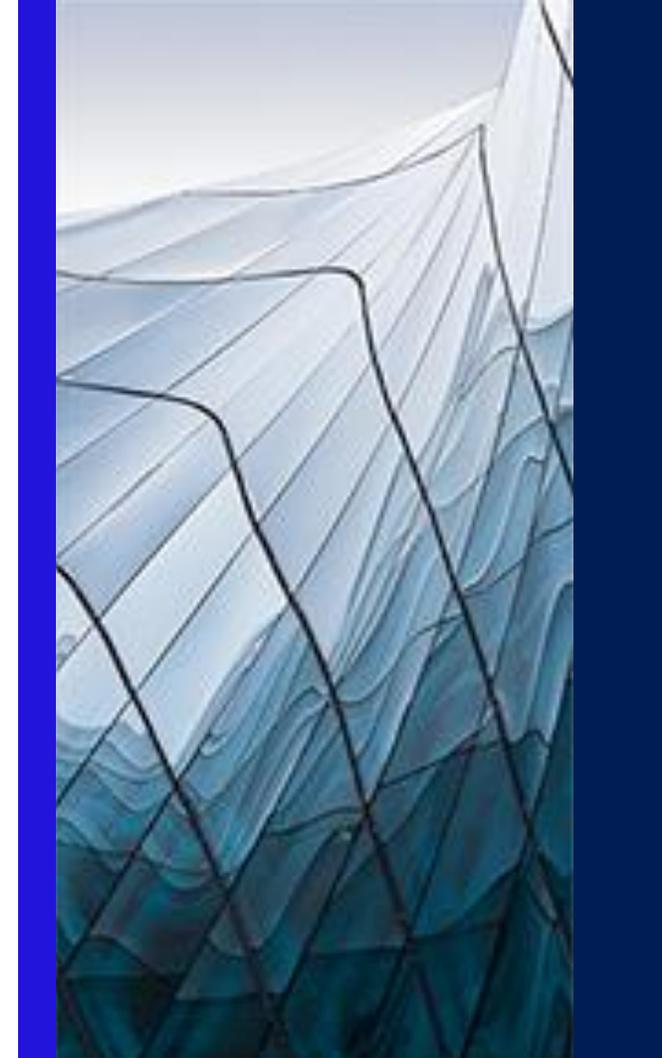
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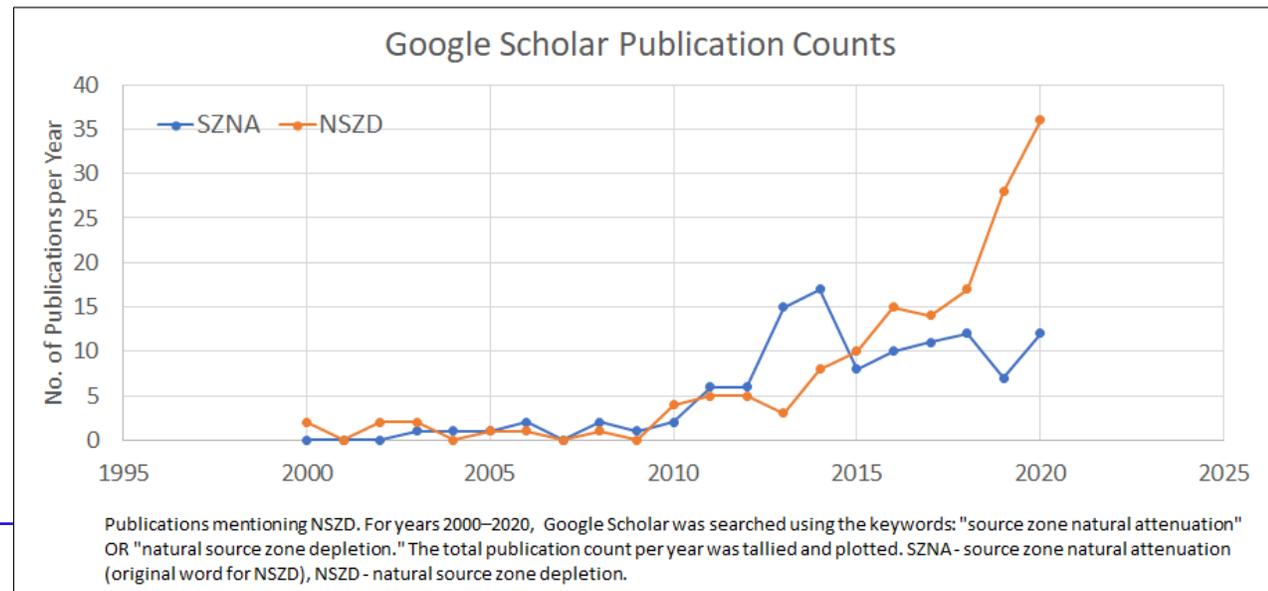
# Impetus for this presentation

- Uptake of new science and technology is slow in our industry
  - Inefficient technology transfer to practitioners
  - Knowledge to practice is an evolution
  - Perception of barrier if regulator/stakeholder doesn't know/acknowledge it
  - Hesitancy, reluctance and need for more evidence
  - Distrust of results without more intimate knowledge
  - Complacency or perception that it is unnecessary, existing practice is already optimal
  - Too expensive
  
- Why the slow pace in uptake of NSZD?



# NSZD is a good case to study rate of new technology uptake

- One might think NSZD would be fairly, well received
  - Supporting science is more than a decade old (circa 2006) and born from various different universities/organizations (UBC, ASU, CSU, USGS, CSIRO, others)
  - There is ample existing practical guidance since 2009
    - From ITRC, CRC CARE, CL:AIRE, and ASTM coming soon
  - MNA, its predecessor, companion technology, is one of the most commonly used remedial approaches for petroleum in groundwater



## However, despite intentional outreach...

- 2/3<sup>rds</sup> of ITRC LNAPL Part-3 internet-based training series participants in past 4 years consistently have not used it



- Why the slow uptake of NSZD?

- Hypothesis:

- There is a predisposition to consider natural processes as an inadequate approach for petroleum remediation
- NSZD is perceived as a “do nothing” remediation strategy



# First, a poll to find out why the slow uptake

- A poll of various practitioners was conducted to get information from broader audience in North America
- Poll results provide data to help inform the current understanding of the practice and discern the cause for slow NSZD uptake

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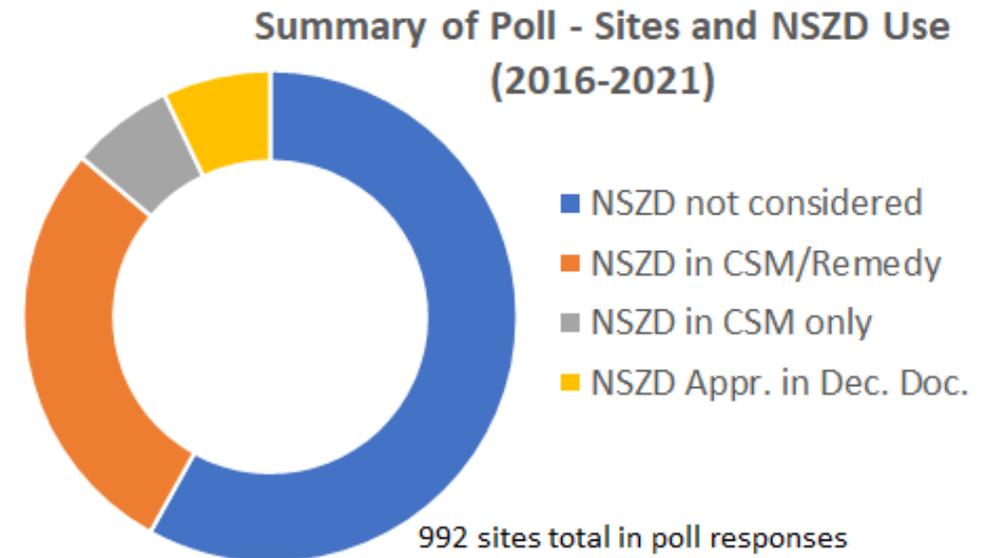
## Natural Source Zone Depletion (NSZD) - Crowd-sourcing State of Practice

### **A poll for petroleum hydrocarbon site managers.**

The intent of this poll is to solicit experience on the knowledge, use, and implementation of the NSZD remedial technology. The information provided will be kept confidential by the poll owner (Jacobs) and used for NSZD technology analytics only; analytics designed to identify impediments to NSZD use and design of future communications to address these impediments. Personal contact may be made for follow-up details on responses if an email address is provided. A condensed version of the poll results may be shared upon request.

# NSZD state of the practice poll results – North America

- Poll responses represent ~1150 years and ~1000 sites total site management experience
  - 52 responses to ~20 question poll on work in past 5 years
- NSZD considered on ~420 sites
  - Consultants aware, but considered only on 42% sites
  - Only 14 respondents had not estimated it
- Limited life-cycle use thus far
  - Defined as carrying NSZD from CSM through to approved-remedy implementation
  - ~110 incorporated NSZD into dec. doc. (11%)
  - ~70 sites with NSZD dec. doc. approved (7%)



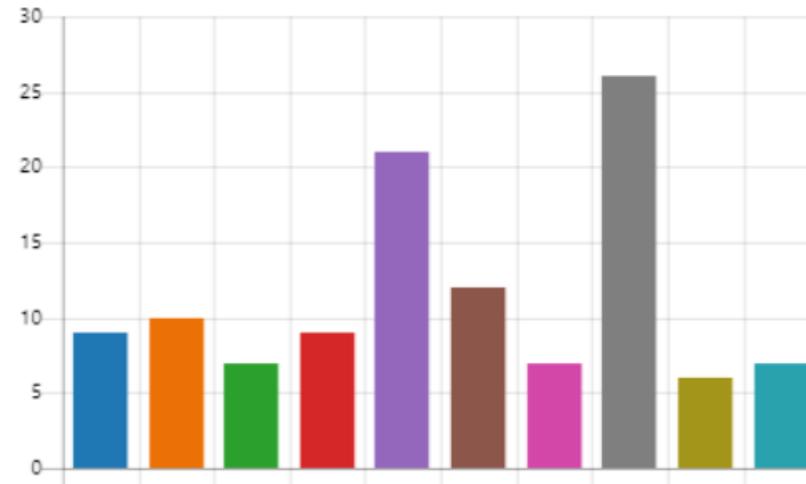
# Poll results – why is NSZD not considered on more sites?

## 10. Why wasn't NSZD considered?

[More Details](#)

● Not applicable - NSZD was co...	9
● Unfamiliar with approach/how...	10
● Uncertain with processes and ...	7
● Current remedy is effective	9
● Passive approach less accepta...	21
● Longer remedial time frame	12
● Human health/eco risk current...	7
● No regulatory pathway	26
● Budgetary constraints	6
● Other	7

No regulatory pathway, too passive/slow, unfamiliarity

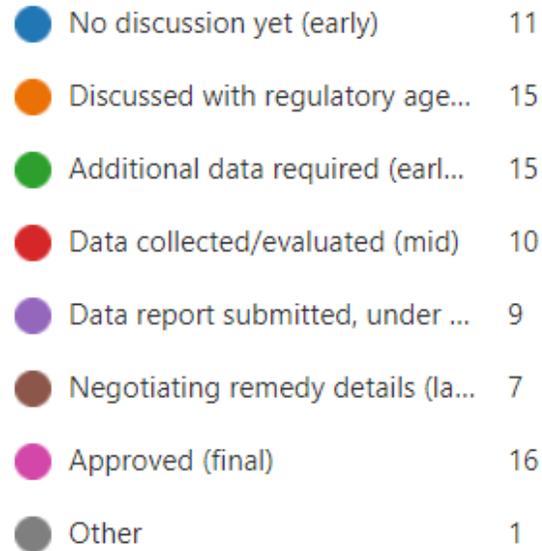


- Regulatory hurdles are present
- Perception of slow/passive, insufficient
- People still unfamiliar and needing more data (hands-on) before taking it further

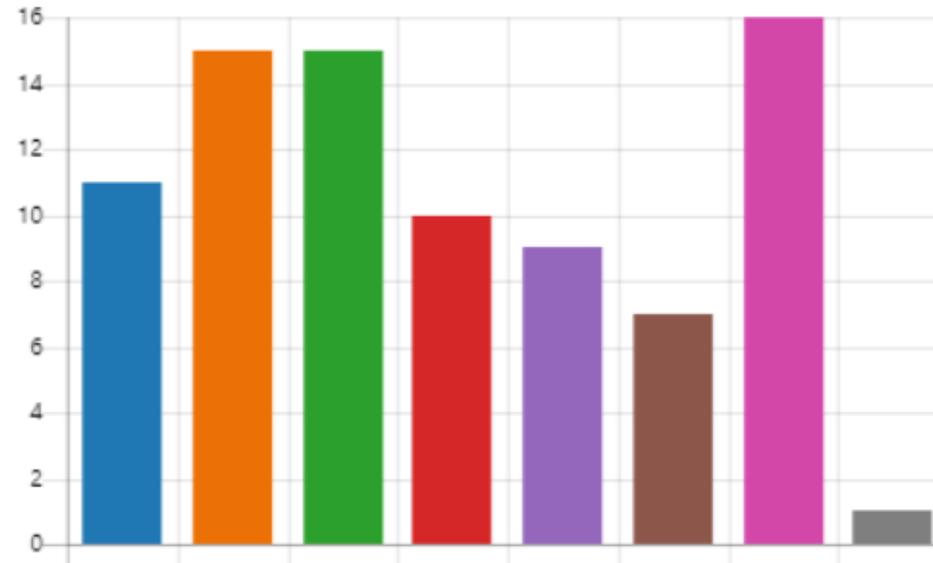
# Poll results – in which stage of regulatory approval are the NSZD sites?

22. In which of the following stages of approval are the NSZD remedy components?

[More Details](#)



Approved sites aside, most sites are in early stage or data collection



- There are a decent number of sites in the regulatory approval process
- NSZD is being discussed and more data being collected to increase familiarity and hands-on understanding needed to weave NSZD into remedial strategies

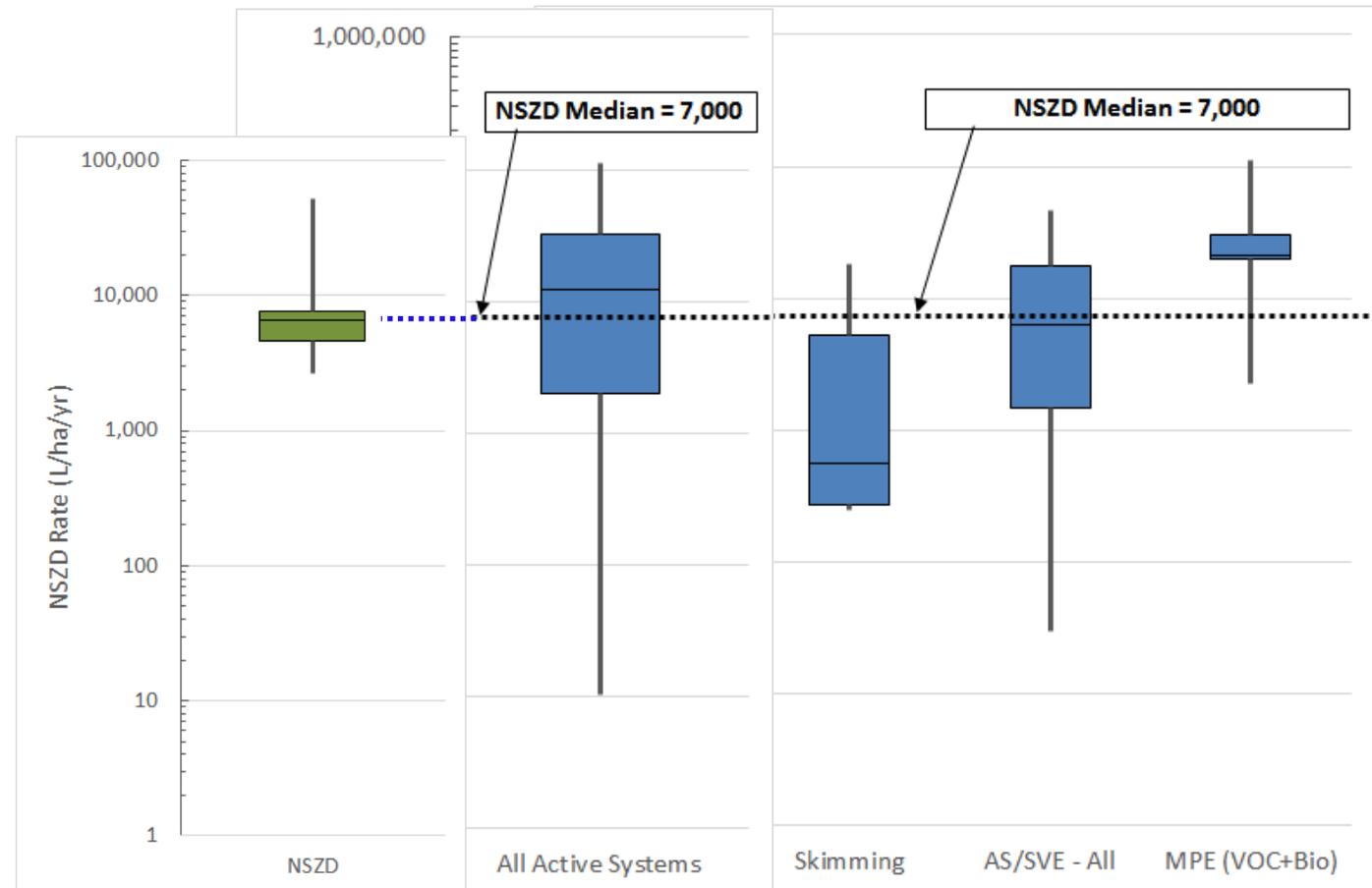
## With that, now what, where to?

- Regulatory hurdles – for another day. A second poll specifically for regulators in progress.
- For today, let's address the following poll finding issues:
  - #1 - Perception of NSZD as slow, passive, and insufficient
  - #2 – Unfamiliarity to practitioners
- To help expedite uptake here and now...



# NSZD is significant

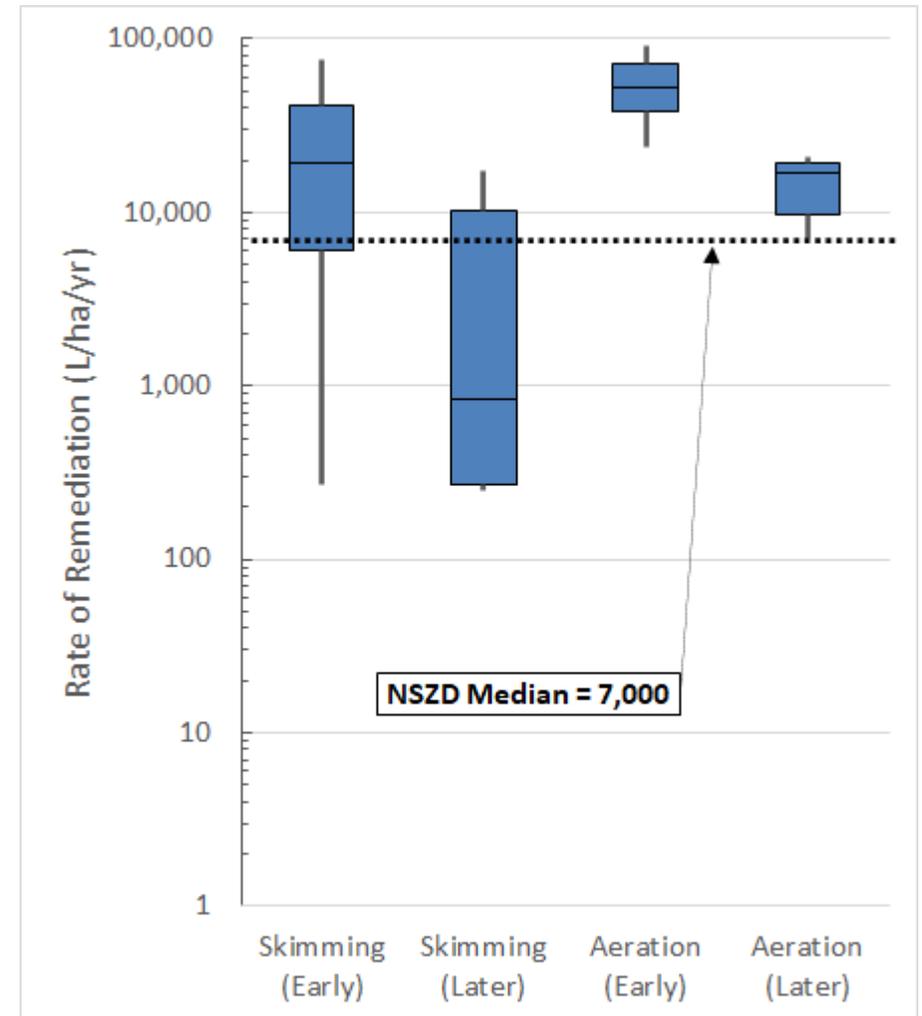
- Jacobs database created to demonstrate the effectiveness of NSZD as compared to mechanical means
- Database contains:
  - Sitewide NSZD rate estimates (13)
  - Site-specific mass removal data from mechanical remedial technologies (42)
- Mechanical remedial technology mass removal rates vary over three orders of magnitude
- NSZD is capable of high rates



Palaia, T. 2017. A Comparison of Natural Source Zone Depletion and Active Remediation Rates. Presented at the 7th International Contaminated Site Remediation Conference (CleanUp). 13 September.

## NSZD solo or as a transition remedy

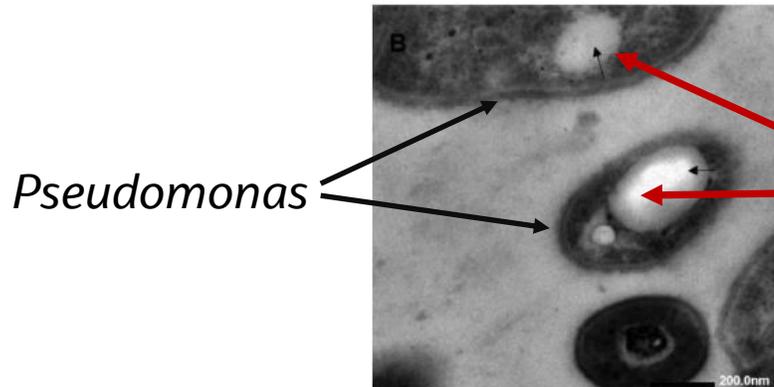
- Well designed mechanical remediation systems initially remove mass at a higher rate than NSZD
- As mass is depleted, however, the mass removal efficiency of the mechanical system declines to the point where the rate of NSZD can outperform it
- NSZD is sustained, degrades mass constantly
  - Not vulnerable to upset like mechanical systems
  - It is subject to seasonality
- It can play a significant mass removal role at most petroleum impacted sites



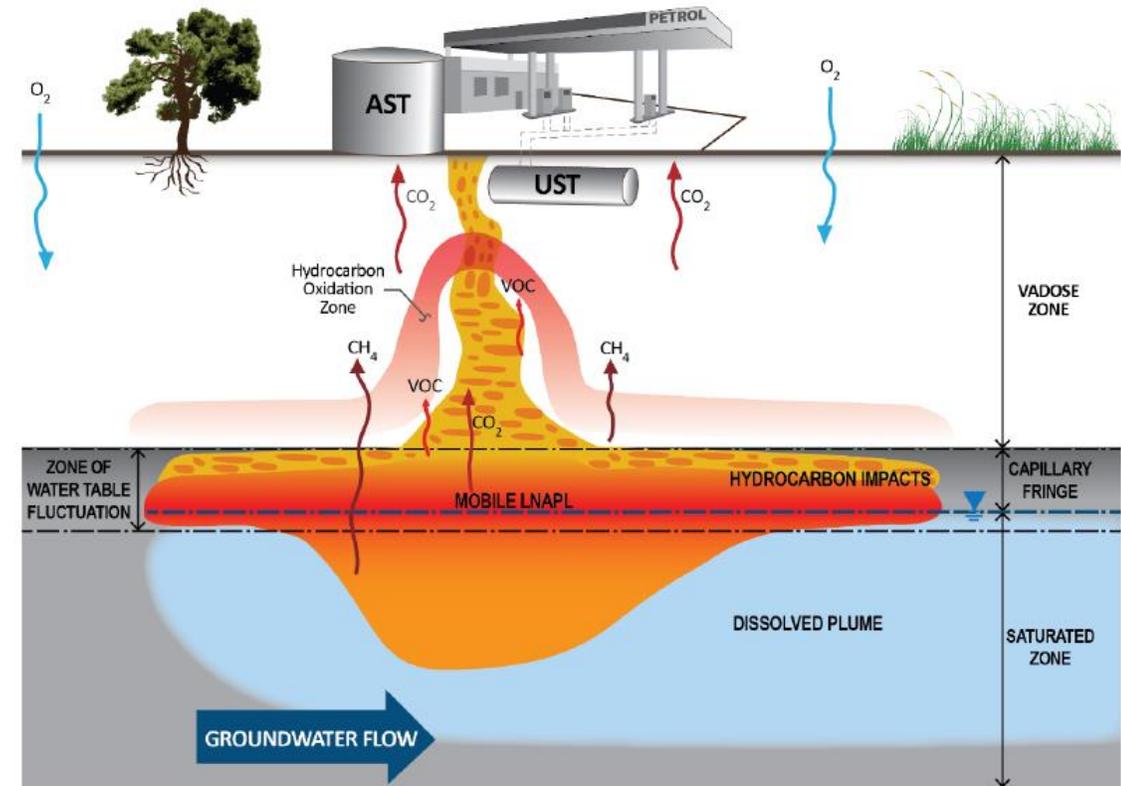
Palaia, T. 2017. A Comparison of Natural Source Zone Depletion and Active Remediation Rates. Presented at the 7th International Contaminated Site Remediation Conference (CleanUp). 13 September.

# NSZD is active, steady bioremediation

- Rates are measurable via biogas and groundwater monitoring
- Rates appear to be zero-order (constant)
- Direct biodegradation of petroleum NAPL
  - Oil-contact microbiology
  - Observing significant losses of longer chain compounds



(Transmission electron microscopy from Hua et. al., 2014)



(from CRCCARE, 2018, [https://www.crccare.com/files/dmfile/CRCCARETechnicalreport44\\_TechnicalmeasurementguidanceforLNAPLnaturalsourcezonedepletion.pdf](https://www.crccare.com/files/dmfile/CRCCARETechnicalreport44_TechnicalmeasurementguidanceforLNAPLnaturalsourcezonedepletion.pdf))

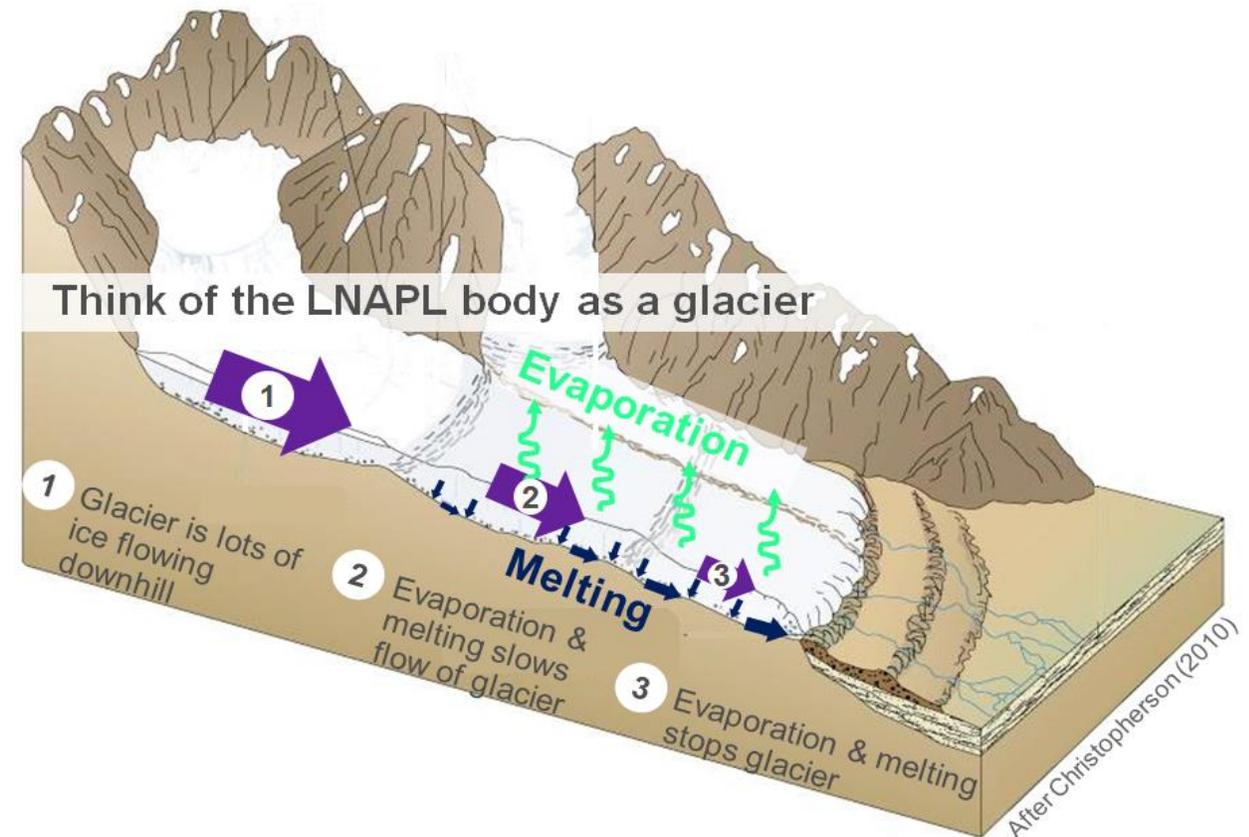
## Addressing the 2<sup>nd</sup> NSZD uptake issue – unfamiliarity

- Understand – it takes time to adopt new technology...
- Plethora of existing practical guidance/training on theory, measurements, and use of NSZD
  - Written by ITRC, CRC CARE, CL:AIRE
  - Bibliography at the end of this presentation file
- Requires practitioner creativity, outreach, and continuing education
- Let's cover a couple of the key aspects of how to use NSZD on your sites now...



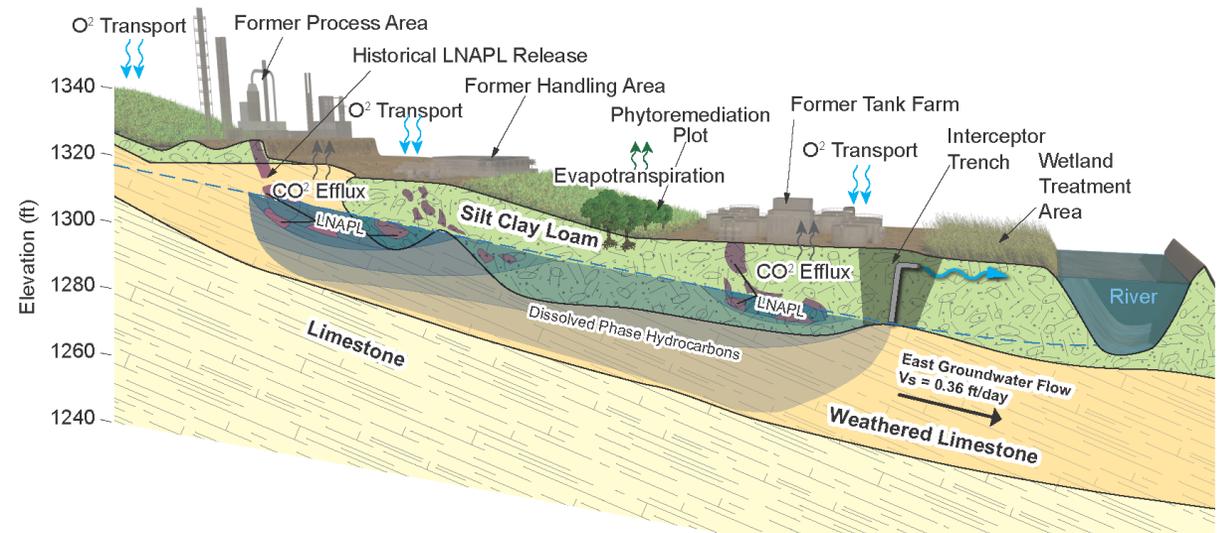
# Here's how to use NSZD as a component of the CSM

- Estimate it for your site using literature values, existing data, or field measurements
- Incorporate the NSZD mass reduction process into the CSM and compare it to observed changes in in-well NAPL extent and dissolved [COC] trends
- Compare its magnitude against past and on-going remedial efforts
- Evaluate its significance in terms of site cleanup rate
- You can leave NSZD right here as a component of the CSM, or if its mass reduction rate is significant enough, take it to the next level



# Generally, here's where to use NSZD as an effective remedy

- There are ample precedents on effective use of NSZD as a regulatory acceptable remedial approach
  - Demonstrated in the poll results - 20% of total sites for which NSZD was considered have remedies in-place approved with NSZD
- NSZD is suitable for sites with the following conditions:
  - Risk/concern from the petroleum LNAPL presence is acceptable – stable plumes
  - Mechanical remediation hits a practical limit short of guidelines
  - Institutional and/or engineering controls are in-place to restrict exposure
  - Extended remedial timeframes are acceptable



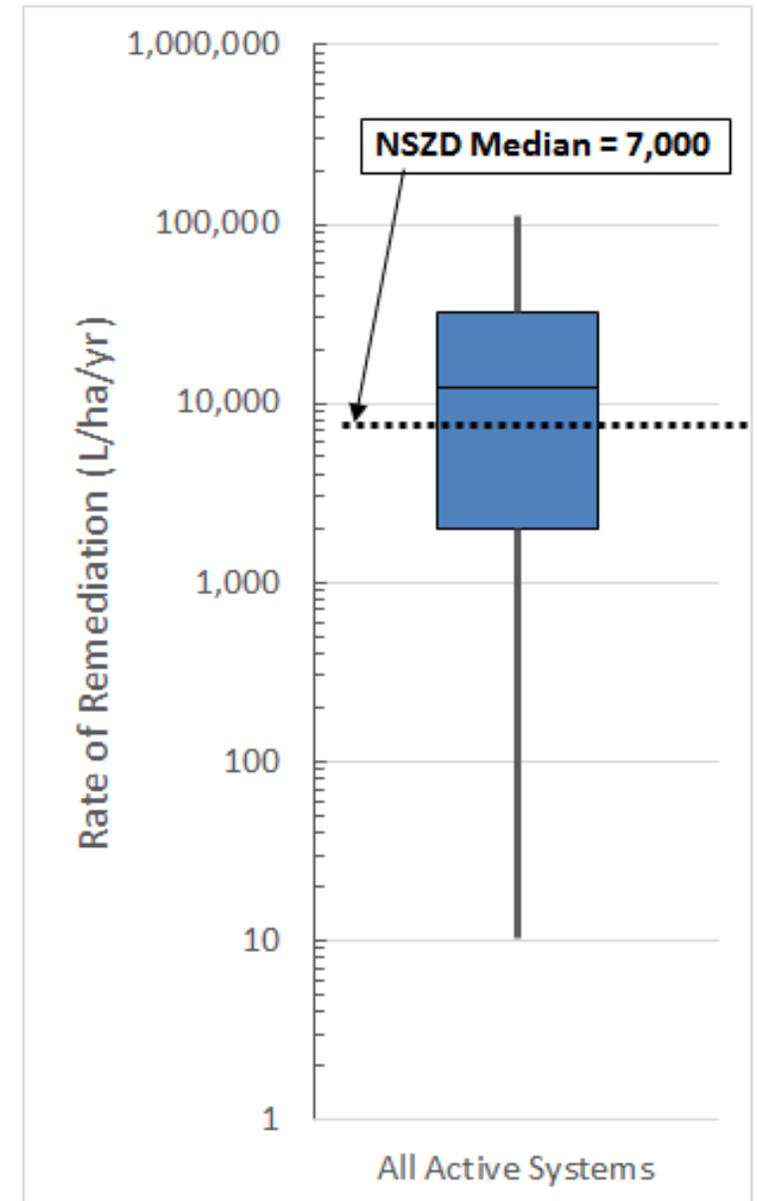
## Closing thoughts

- There is room for improvement in our uptake of new science/technology
  - Embrace the learning curve, together
- Let's address the issues with slow uptake of NSZD technology
  - Principal are regulatory barriers, perception of slow/insufficient, and unfamiliarity
- If our industry is to move forward with sustainable/resilient remediation, then NSZD must be considered at all petroleum sites



# Food for thought

- Take another look at your sites
  - How does the remedy compare to literature values of NSZD?
  - How much of the mass reduction is actually from NSZD rather than the mechanical system?



# Bibliography of existing practical NSZD guidance

- Multipart series on NSZD for LNAPL sites. ITRC.
  - 2009. Evaluating Natural Source Zone Depletion at Sites with LNAPL, ITRC, April.  
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  - 2020. Australian case studies of LNAPL NSZD rates compared with conventional active recovery efforts. March.  
[https://www.crccare.com/files/dmfile/CRCCARETechnicalReport47\\_AustcasestudiesofLNAPLNSZDrates.pdf](https://www.crccare.com/files/dmfile/CRCCARETechnicalReport47_AustcasestudiesofLNAPLNSZDrates.pdf)
- CL:AIRE - An Introduction to Natural Source Zone Depletion at LNAPL Sites. June 2019.  
<https://www.claire.co.uk/home/news/1176-nszd-bulletin>
- ASTM – pending new Standard Guide for Estimating Natural Attenuation Rates for LNAPLs in the Subsurface.



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# Thank you!

The NSZD poll is still open 😊

