Planning Treatment Trains and Concurrent Remedies

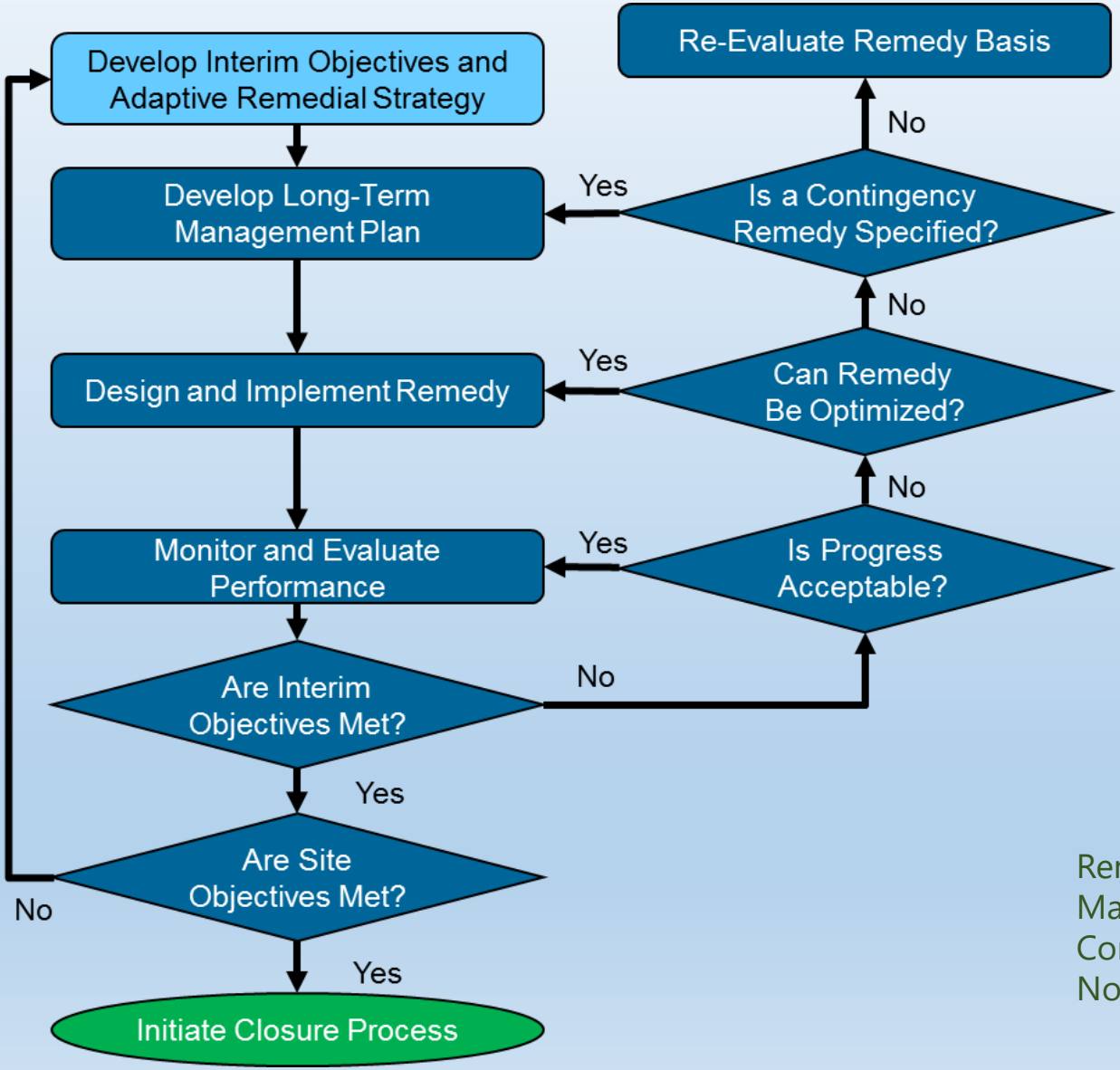
Failing to plan is…

planning to waste a lot of _____ (fill in the blank).

“CAP to Closure”

- What does this mean?
- How many states require one?
- Do you usually reach NFA in one try?
- Is the CAP ever updated?
  - How are modifications made?
  - How are costs reconciled?
- How do you judge remedial progress?

Adaptive Site Management



Remediation Management of Complex Sites (ITRC, November 2017)

21 Technology "Tools"

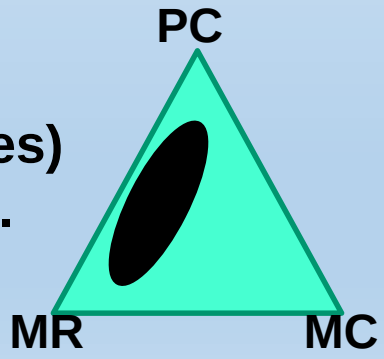
1. Excavation
2. Skimming
3. Vacuum enhanced skimming (LNAPL & vapor)
4. Total liquid extraction (LNAPL & water)
5. Multi-phase extraction (LNAPL, water, & vapor)
6. Water/hot water flooding
7. Surfactant-enhanced subsurface remediation
8. Cosolvent flushing
9. Steam injection
10. Electrical resistance heating
11. Air sparging/soil vapor extraction (AS/SVE)
12. In-situ chemical oxidation
13. Natural source zone depletion (NSZD)
14. Physical or hydraulic containment
15. In-situ soil mixing (stabilization)
16. Thermal conduction heating
17. In-situ smoldering
18. Biosparging/bioventing
19. Enhanced anaerobic biodegradation
20. Activated carbon
21. Phytotechnology

LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies (ITRC, March 2018)

LNAPL Remedial Technology Groups

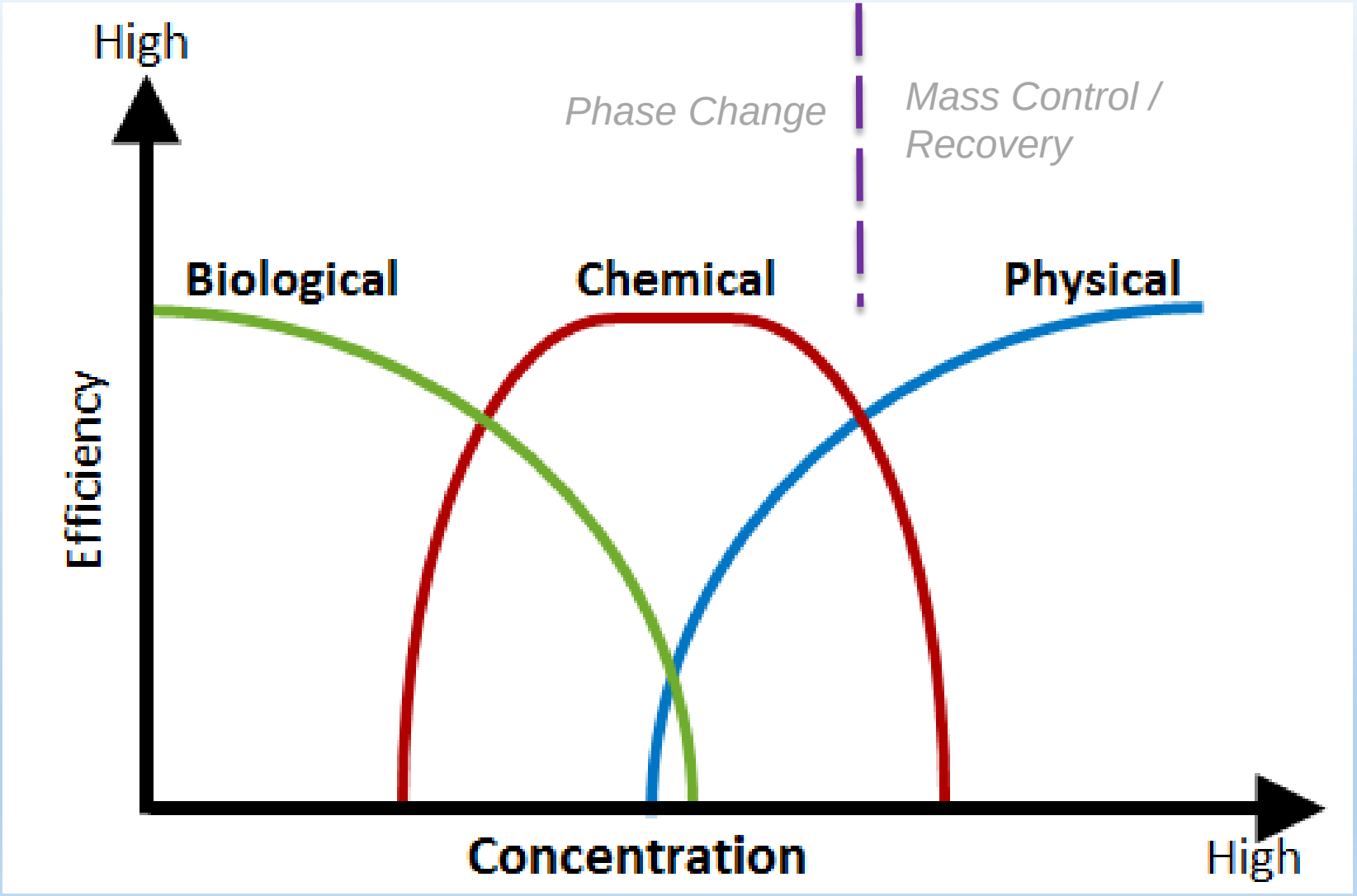
- **Mass Control** - Contain LNAPL at a defined boundary
- **Mass Recovery** - Remove LNAPL mass to limit migration
- **Phase Change** - Abate unacceptable COCs

Technologies (i.e. processes) sometimes overlap groups.

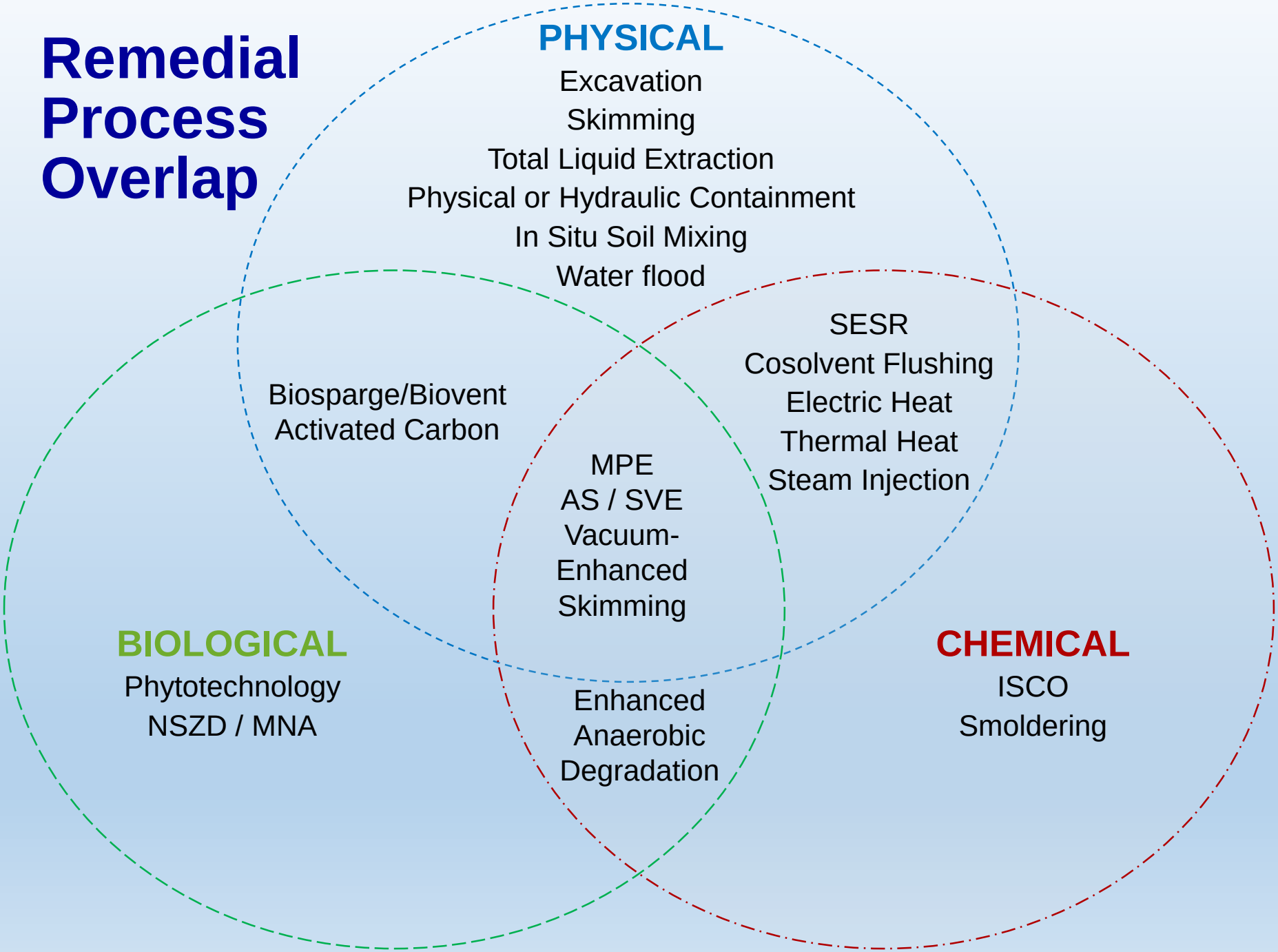


LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies (ITRC, March 2018)

Processes


High
Phase Change
Mass Control / Recovery
Biological
Chemical
Physical
Efficiency
Concentration
High

Remedial Process Overlap



Technically Achievable

Examples Include:

Remedial Mechanism	Technically Achievable Limit
1. LNAPL Recoverability	LNAPL Transmissivity (0.1 to 0.8 ft^2/day)
2. Volatilization • AS • SVE	Vapor Pressure (~1 kPa at 15^0 C) PID emissions stable, <xxx ppm
3. Injection • ISCO • Carbon	Soil texture limits delivery of oxidant/other media
4. Biodegradation • Biovent / Biosparge • NSZD/MNA	Rate of degradation won't achieve goal in timeframe

"Treatment Train"

(Consecutive Remedies)

- PLANNING to use multiple remedial technologies *in sequence* to achieve closure
- Sequence remedial technologies based on contaminant concerns and remedial objectives
  - Consider starting with a primary technology (excavation?) tailored for higher contaminant mass
  - Continue with a 2nd treatment technology (ISCO?) and possibly a tertiary polishing step (CBI?) to address remaining contaminant mass and to eliminate contaminant concerns

Treatment Trains

Bad

- Unplanned, lack SMART objectives, metrics for transition, milestones and endpoints uncertain
- “Throwing” more technologies at the problem

Good

- When planned with SMART objectives, metrics for transition, milestones and endpoints defined
- Orderly implementation

SMART?

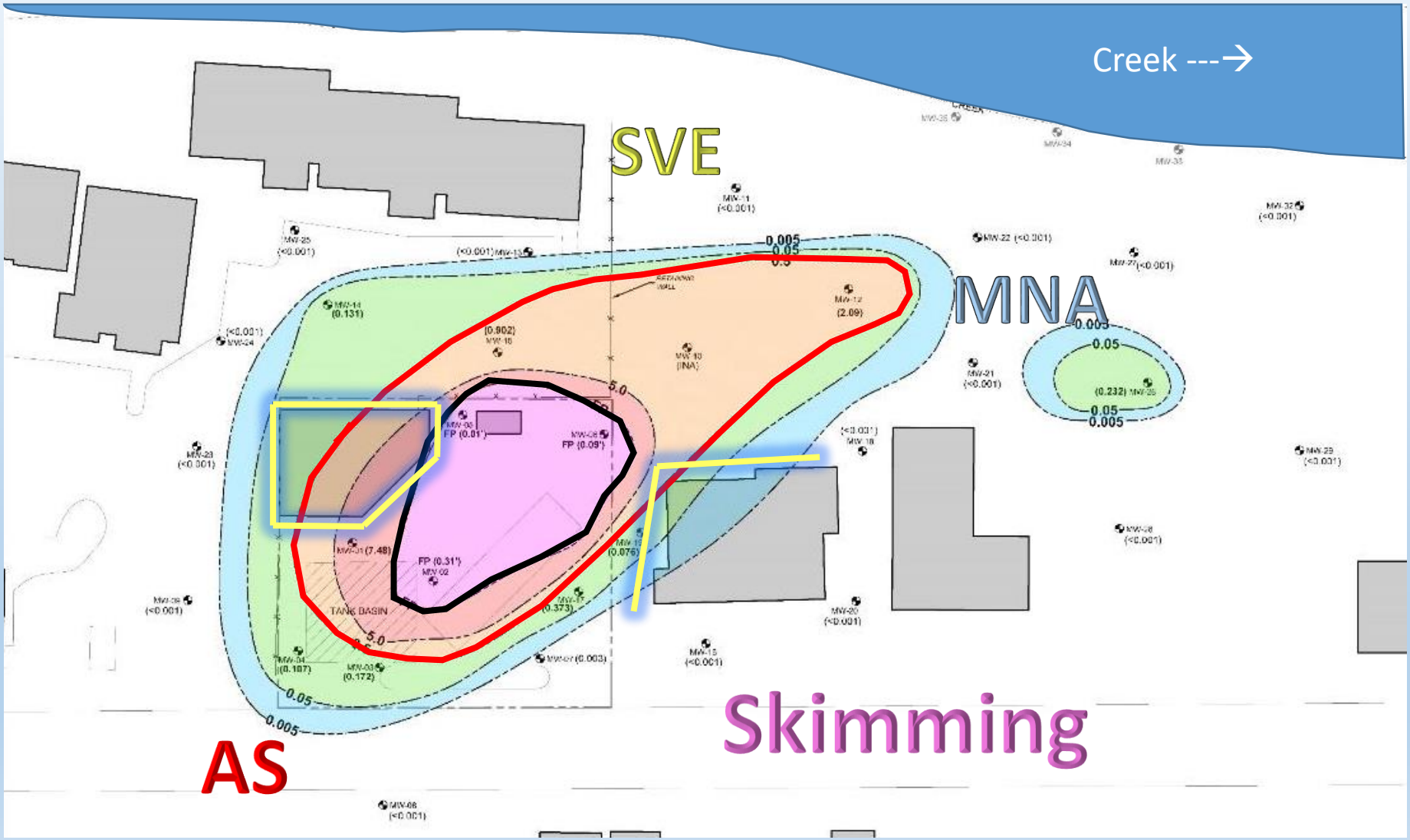
- **S**pecific - Targeted treatment area and technology-specific endpoints are clearly stated
- **M**easurable – Performance metrics that demonstrate progress towards the endpoint
- **A**greed Upon – Concerns, goals, objectives, treatment areas, metrics, endpoints
- **R**ealistic – Demonstrated ability to achieve objective
- **T**ime-Based – Target date of remedial endpoint being achieved

Achieving a remedial endpoint does not necessarily mean that all contaminant concerns have been eliminated

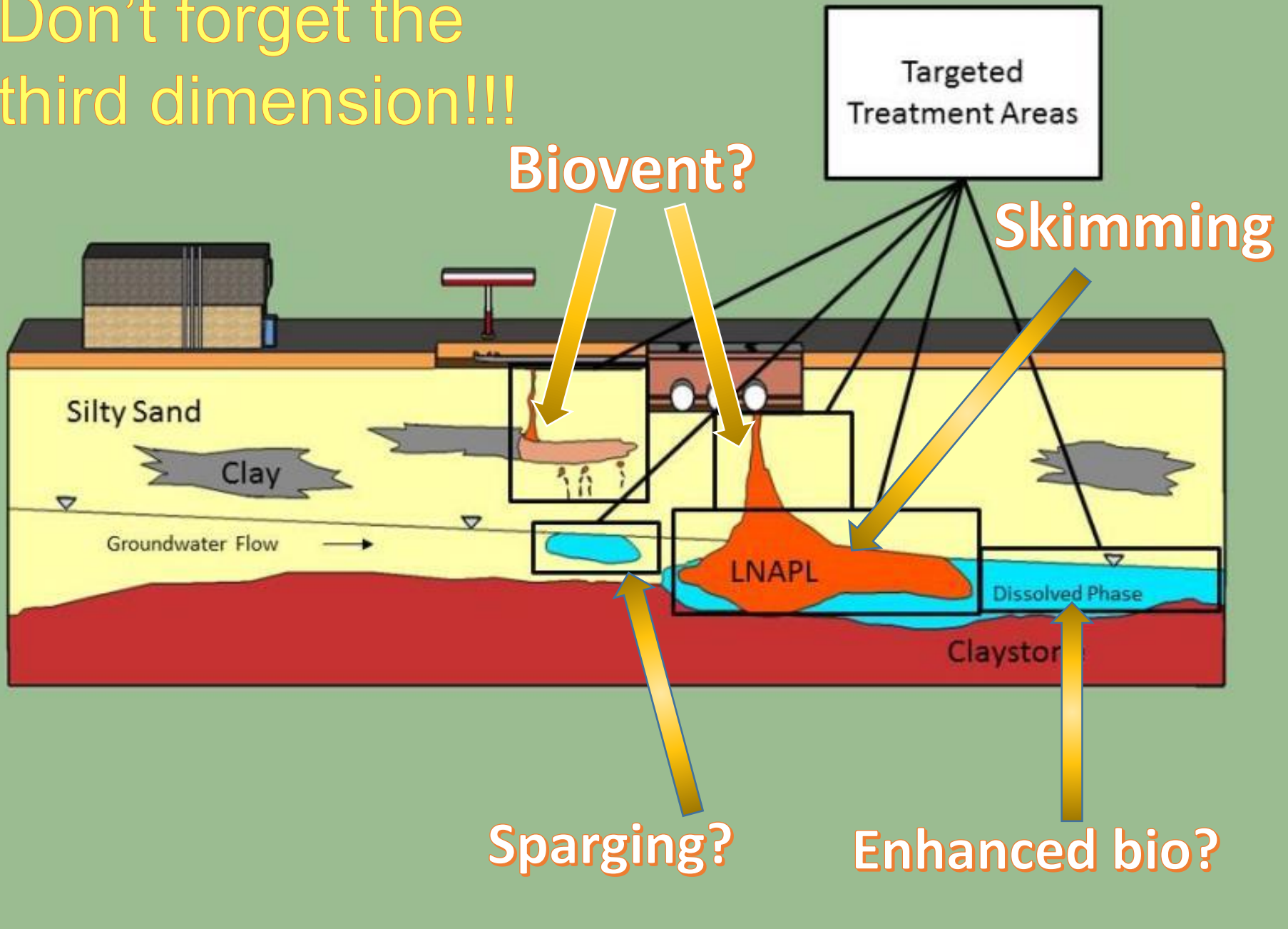
Concurrent Remedies

- Using multiple technologies on a site at the same time, in *different target zones* due to differing contaminant concentrations
  - Use primary technologies in the source area (e.g. excavation).
  - Use secondary or tertiary technologies on periphery of contaminated area, and in deeper zones.
- Still rely on SMART performance metrics to measure remedial progress

Example: Treatment Areas



Don’t forget the third dimension!!!



Performance Metrics

Measurable characteristics that track the progress of a selected technology to achieve a remedial objective and abate a contaminant concern

ASK: What conditions do you expect to change as you remediate the site? And how quickly?

Performance Metrics

- Technology-specific!
- Track progress toward endpoint
- Verify that remedy is being implemented effectively
- Allow for mid-course corrections
- Allow for CSM updates

Performance Metrics Examples
(What you measure)

- AS/SVE – Concentrations in emission samples (e.g. PID, benzene, CO_2, CH_4)
- ISCO - Data to evaluate distribution of an in-situ application (e.g. pH, ORP, DO, SO_4^{-2})
- SVE - Interim or final soil confirmation samples
- MNA – Organic/ inorganic/ biological samples

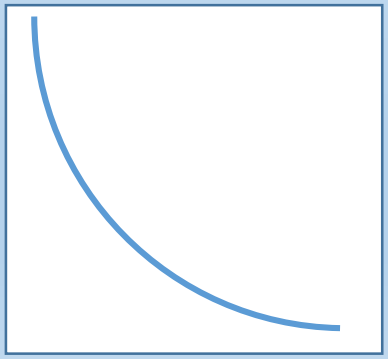
Remedial Milestones
(Interim Objectives)

Anticipated points to evaluate progress towards a remediation technology endpoint.

(a schedule)

Remedial Milestone Examples

- LNAPL reduction = 10% of volume estimate per quarter or /month
- Emissions decrease 25% per quarter or /month
- Dissolved phase concentrations remediated to 25%, 50%, 75% of endpoint (with timeframe)



Remember!

Declines are exponential, not linear

(90% of the result takes 10% of the time?)

Endpoints

- Also technology-specific!
- Defined as:
  1. LNAPL concern has been addressed, or
  2. Practicable limit of the technology reached

- If technology reaches its practicable limit before LNAPL concern is abated, then the endpoint marks the transition to the next technology in the treatment train

Endpoint Identification

- Predetermined value that describes when a technology has achieved the limits of beneficial application
- Should account for expectations of the selected remedial technology
- Does not necessarily eliminate all contaminant concerns described in the CSM

The endpoint may not be your site goal!