

Decision Support Tool- Giving transparency and justification in weathered hydrocarbon remediation



UNIVERSITY
OF ABERDEEN

Optimising Biopile processes for weathered hydrocarbons
within a risk management framework

Promise
Promise

The remediation market

- Remediation designs and practices are not commonly integrated with SI Companies
- Many Remediation companies have limited portfolio of techniques
- The market is conservative to technology
- Licence issues may be confusing
- Fit for purpose- says who?



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What would make on site ex situ bioremediation a more attractive option?

- Certainty
 - Can I meet target values?
- Informed assessment
 - Can I do something to increase the rate of degradation or the nature of the end-product
- Sustainable
 - Economic
 - Environmental
- Transparency for selection of technology
 - If I rank it against the competing technologies; is it the best?

Where is the market status at the moment?

- Test cases demonstrate success
- Cost benefit is unclear at the moment
- Few laboratories facilitate in decision making process
- Integrated thinking is absent-
 - from the Phase 1 through to the re-use of the materials

Predicting Success

- Physical
 - Structure, PSA, moisture holding capacity
- Biological
 - Microbial numbers and activity, performance of degraders, confirm habitat suitability
- Chemical
 - Total and bioavailable hydrocarbon, co-contaminants, nutrients

These features can be integrated with empirical testing

- At *Remedios* we developed a set of tests for predictive degradation
- These have been applied to 50 test sites with incredible success rates
- The key attributes are biological and chemical but these are then overseen in a physical and engineering context

$$\text{BF} = \left(\frac{\text{Resp}}{I \times [\text{TPH}]} \right) \times \left(\frac{[\text{TPH}]}{\log(\text{MPN})} \right) \times \text{Inhibition}$$

BF = bioremediation function

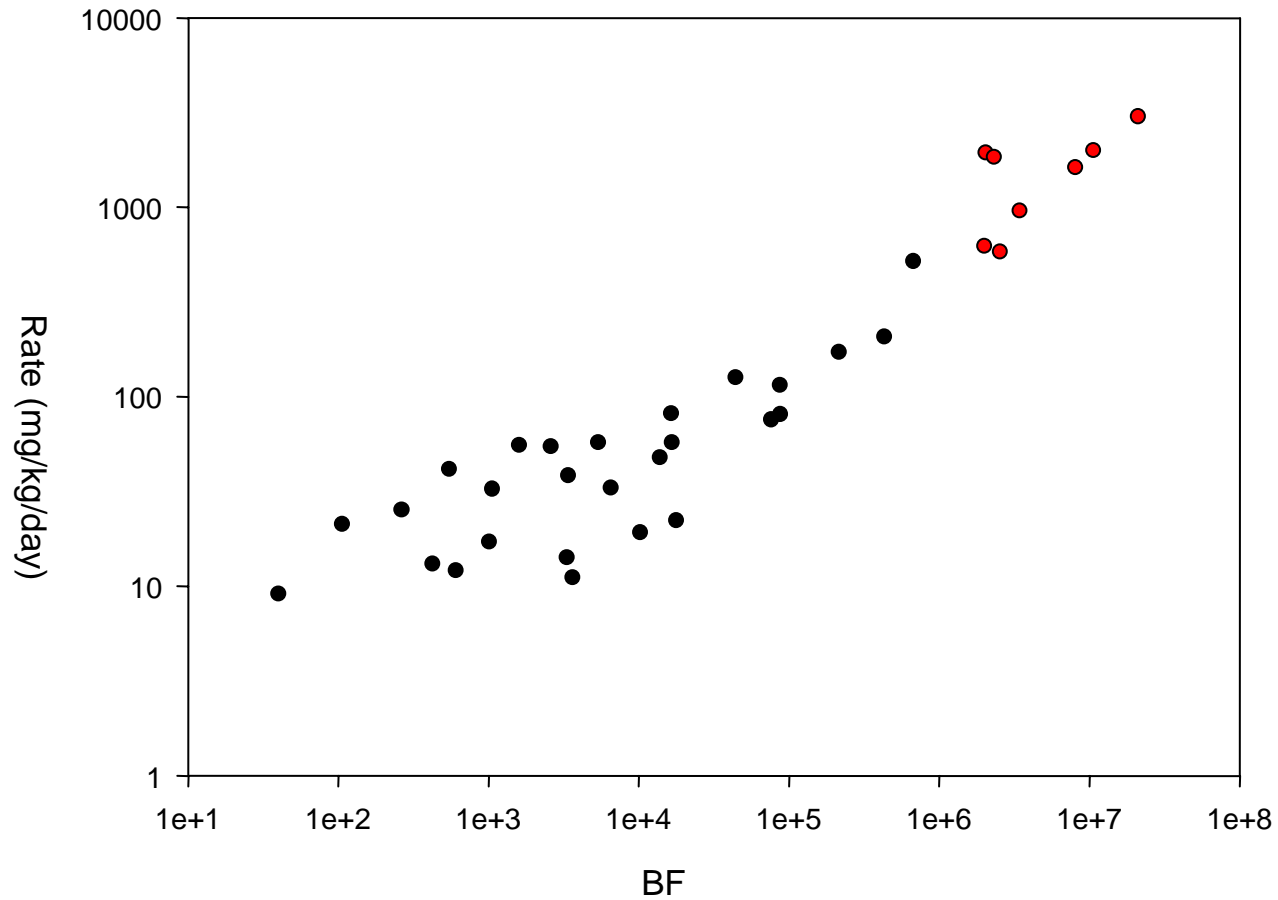
I = induction

[TPH] = TPH concentration

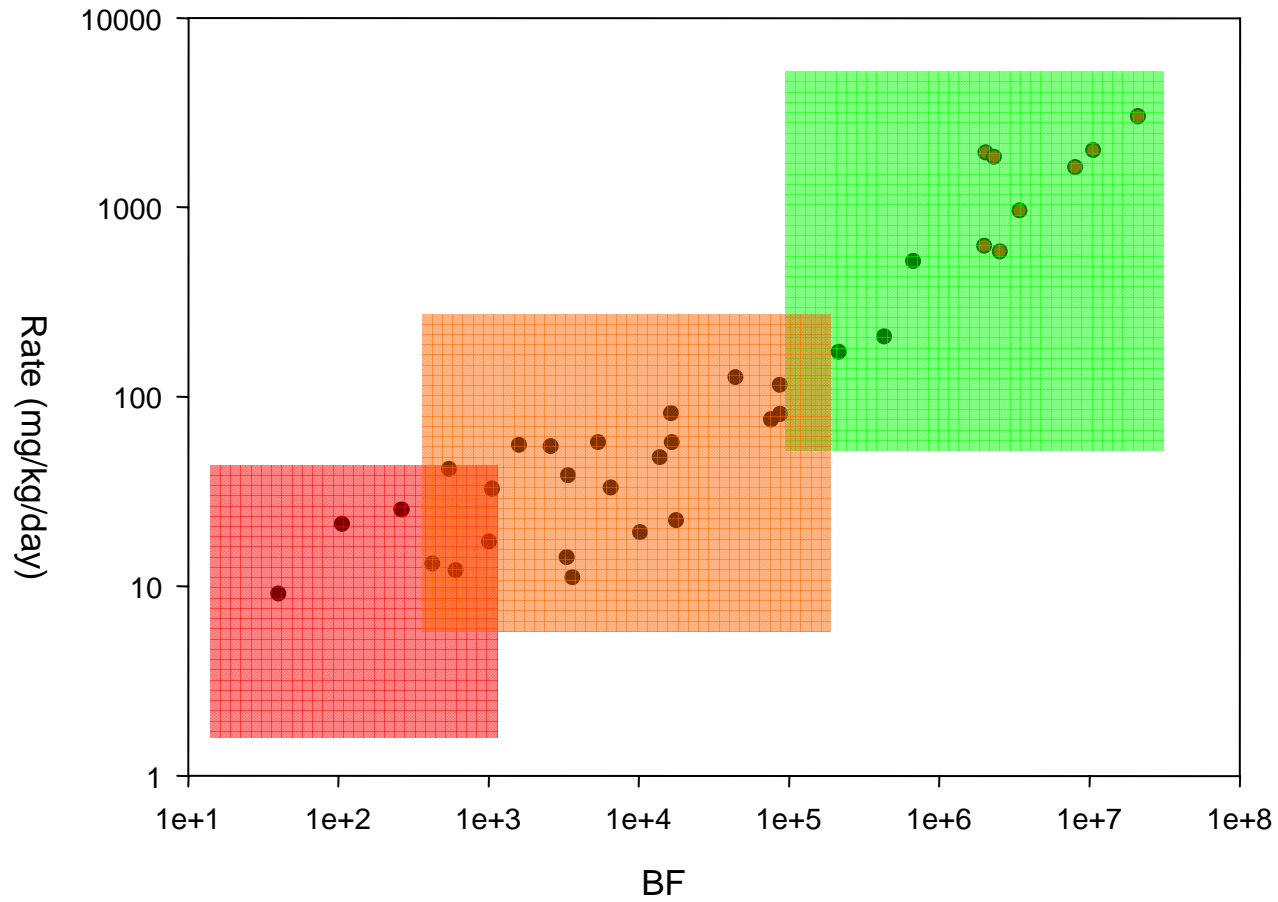
MPN = most probable number

Resp = respiration

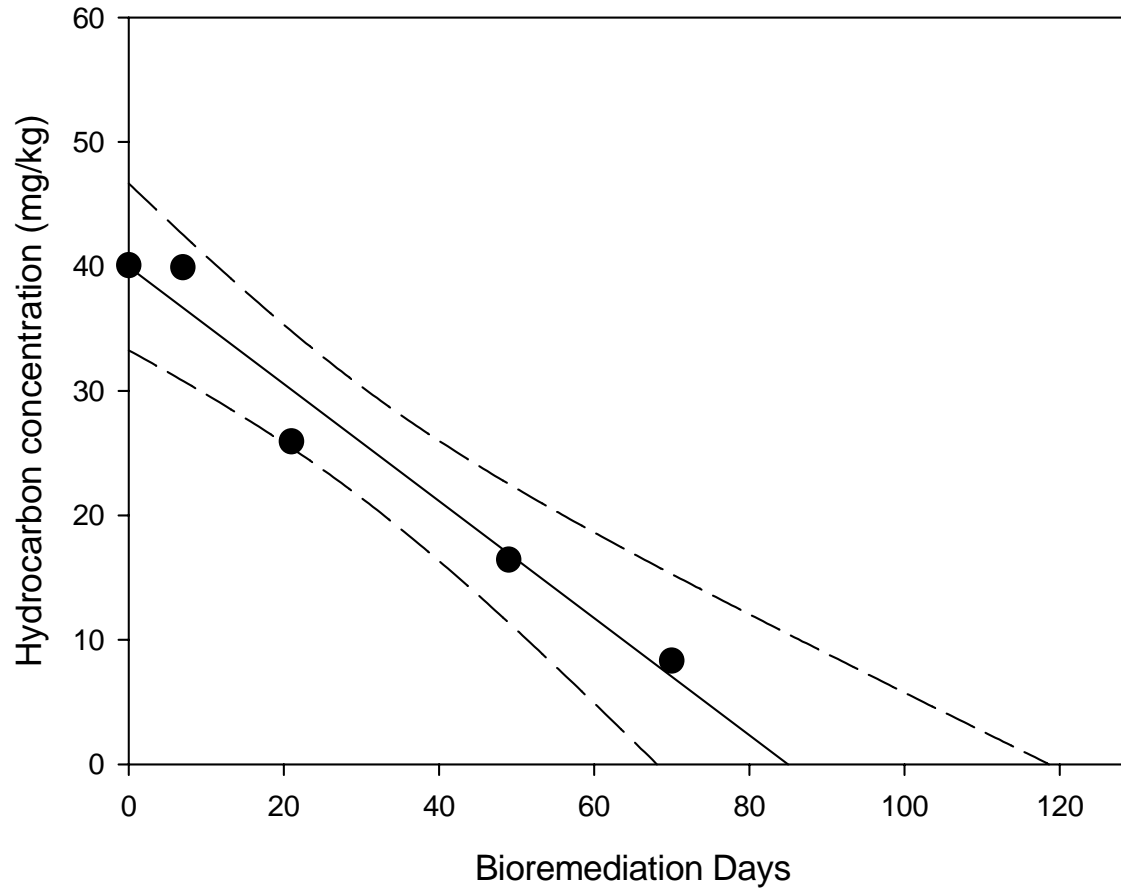
BF & Rate of Degradation



BF & Rate of Degradation



What does this mean?



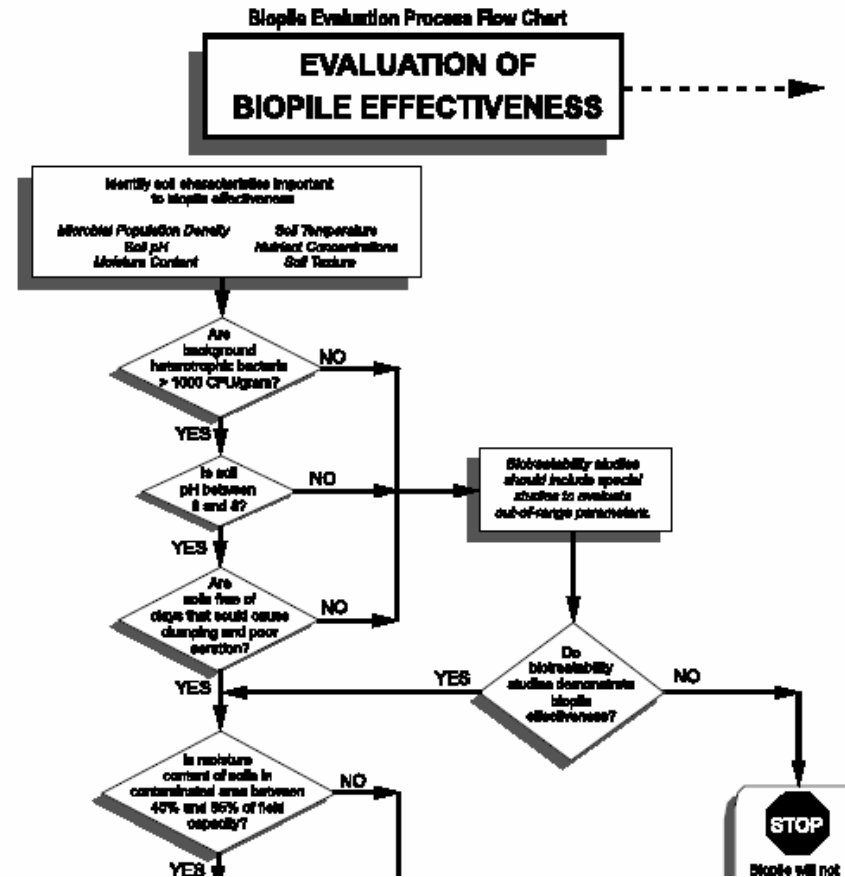
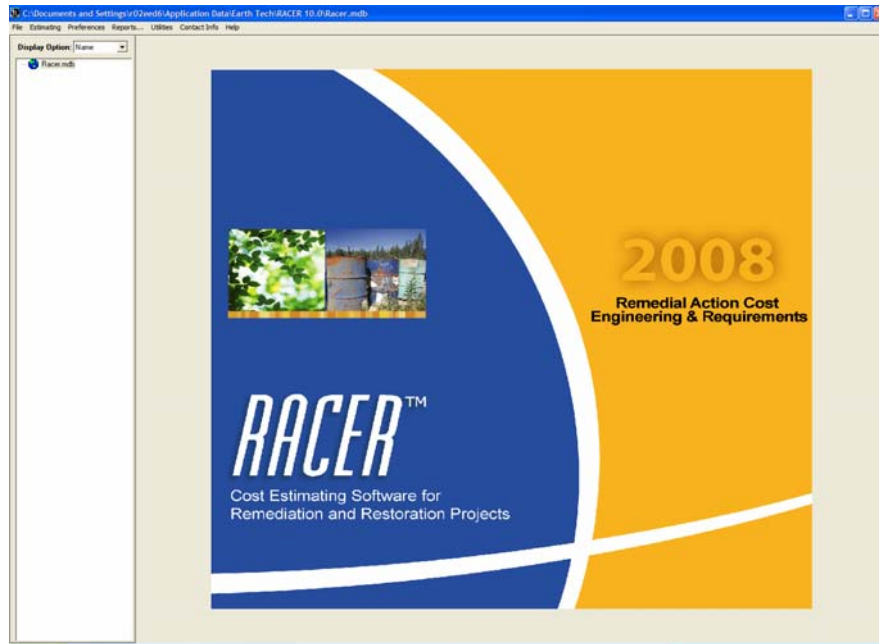
This is a single product.....

- The purpose of Promise was not to champion a single product
- And this *Remedios* algorithm is just a single step in the refinement of remediation success
- Require to assess the wider market and all the techniques available

So what is on the market to help us?

- Guidance documents
 - Lack specificity and flexibility
- The Battelle and USEPA books and documents
 - Been around a while and have not evolved
- A few software systems to support decision but these are very data heavy programmes
 - Racer is \$5k and requires enormous amount of data and doesn't help decision making

So what is on the market to help us?



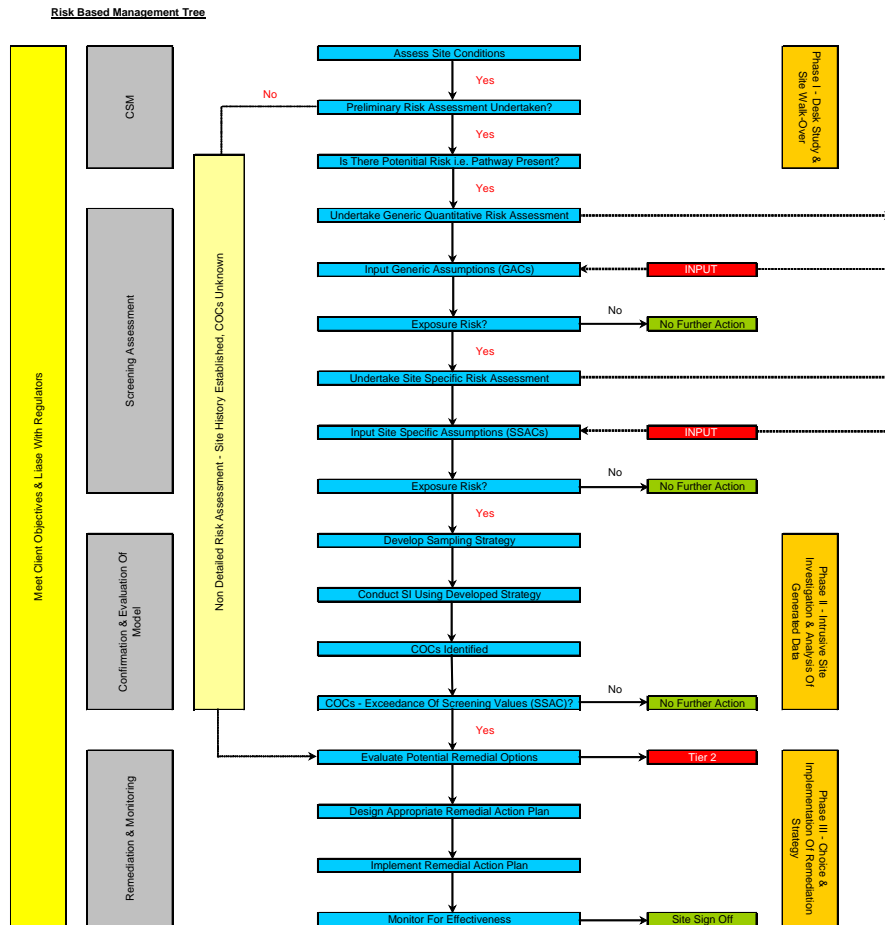
What do Regulators and Insurers Seek?

- An explanation of how decisions were made
- Justification that the technique will meet the clean-up criteria
- Holistic assessment of the full process

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- Enables a transparent justification of the suitable technology from the outset of site works
- Gives focussed and streamlined support for targeting best options
- Interfaces with the web to enable continual updating as practices become established and lessons are learned

A multi-tier approach



- Tier 1- places in the context of a risk-based framework
- Tier 2- evaluates all the suitable comparative options
- Tier 3- aids the decision making for optimisation

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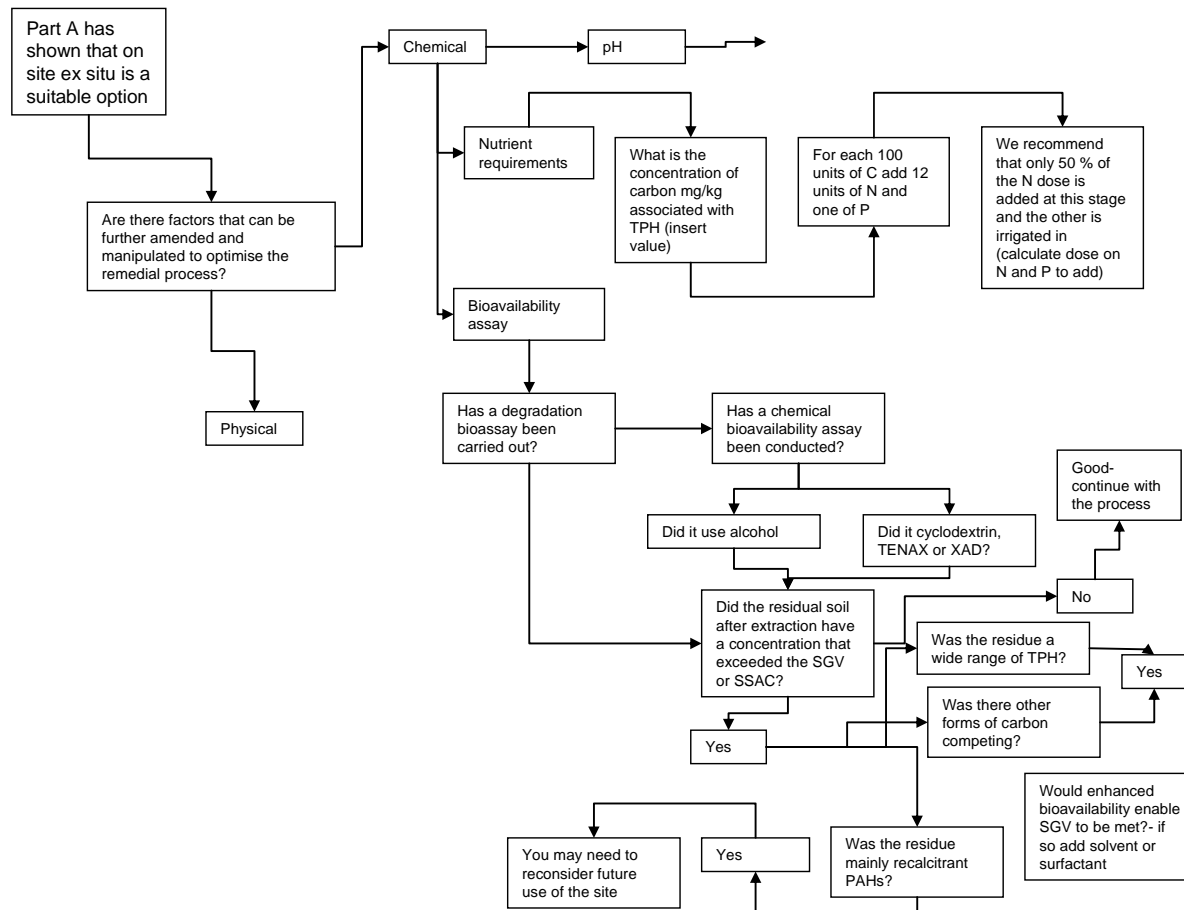
- Tier 2
- Permissibility and certainty
 - Applicability
 - Permissibility
 - Certainty
- Economic and duration
 - Capital
 - Operations and maintenance
 - Market constraints
 - Remediation duration
- Environmental credit

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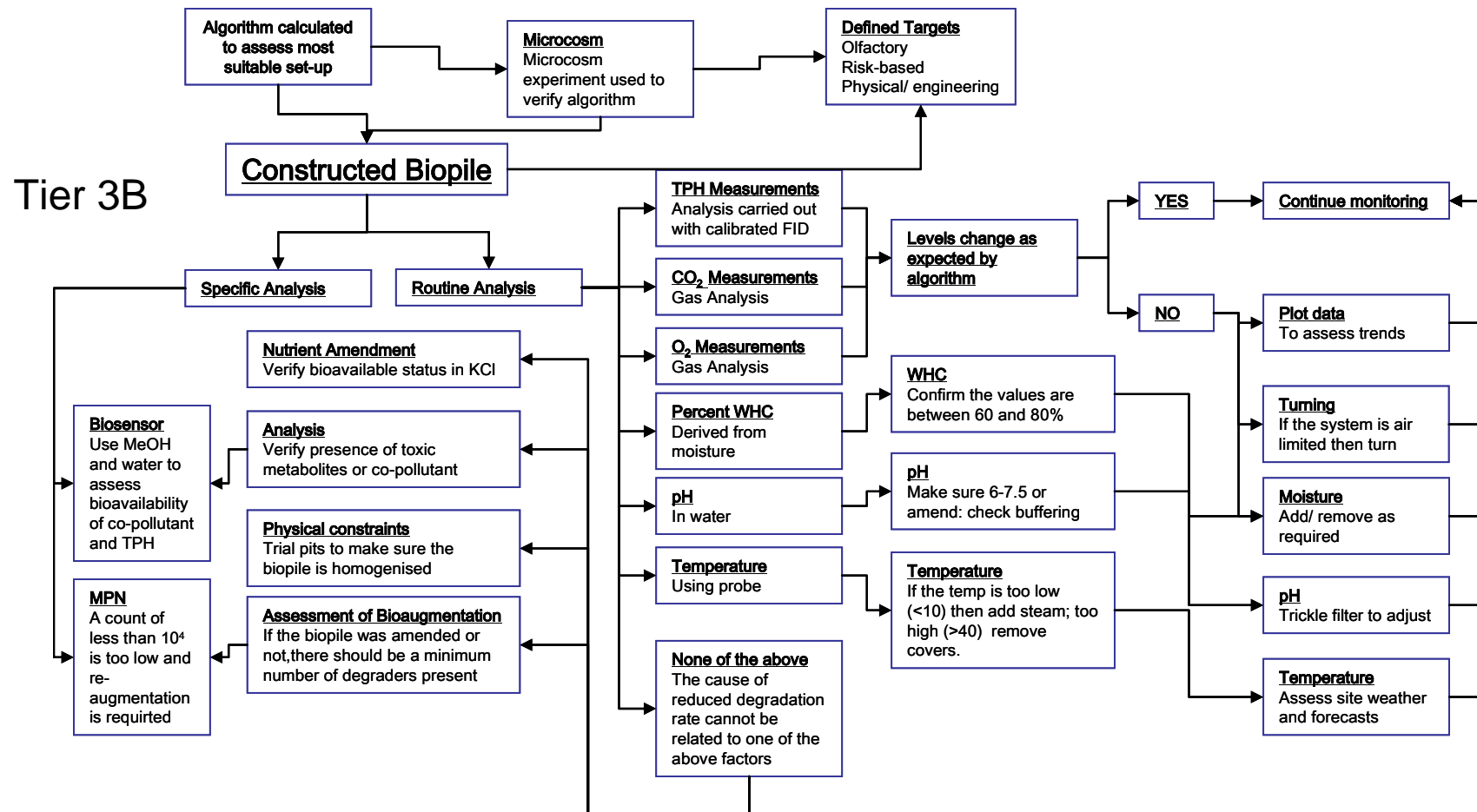
		Appropriateness (1-3) Site Size <1000	Feasibility (1-3) Site Size <1000	Legacy (1-3) Site Size <1000	Legacy (1-3) Site Size <1000			
Tonnage Of Contaminated Soil.....???? SML	Soil, Sediment, Bedrock and Sludge Treatment Technologies	Leave	Do Nothing Monitor	1 1	1 2	1 2	1 2	
		In Situ Biological	Bioventing Enhanced Bioremediation Phytoremediation	3 3 1	3 3 1	2 3 1	2 3 1	
		In Situ Physical/Chemical Treatment	Chemical Oxidation Electrochemical Processes Electrokinetics Soil Flushing Soil Vapor Extraction Surfactant-enhanced Remediation	3 3 2 2 3 3	3 3 3 3 3 3	3 2 1 2 3 3	3 2 1 2 3 3	
		In Situ Thermal Treatment	Thermal Treatment	2	3	2	1	
		Ex Situ Biological Treatment	Bioreactors Composting Landfarming Biosparging Deep-Draw Bioreactors Windrowing	3 3 3 3 3 3	3 3 3 3 3 3	2 2 2 2 2 2	2 2 2 2 2 2	
		Ex Situ Physical/Chemical Treatment (Assuming Excavation)	Chemical Oxidation Chemical Reduction/Redox Bioremediation Sparging Soil Flushing Soil Vapor Extraction	3 3 3 3 3 3	3 3 3 3 3 3	3 2 2 2 2 2	3 2 2 2 2 2	
		Ex Situ Thermal Treatment (assuming excavation)	Hot Oil Densification Incineration Deep Bed/Draw Incineration Sparging Thermal Desorption Landfill Cap Landfill Gas Collection/Flare/Recovery	3 3 3 3 3 3 3	3 3 3 3 3 3 3	2 2 1 1 1 1 1	2 2 1 1 1 1 1	
		Other Treatments	Excavation, Refractor, and CR-Site	1	3	3	1	
		Ground Water, Surface Water, and Leachate Treatment Technologies	Leave	Do Nothing Monitor	1 1	1 2	1 2	1 2
			In Situ Biological Treatment	Enhanced Bioremediation Managed Natural Attenuation Phytoremediation	3 3 3	3 3 1	2 2 1	1 1 1
In Situ Physical/Chemical Treatment	Air Stripping Bioreactors Chemical Oxidation Chemical Reduction Dissolved Air Flotation Dual Phase Extraction In Situ Thermal Hydroxyl Radicals Enhancement In-Well Air Stripping Pretreat/Reactor Treatment Units		3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3	2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2		
Ex Situ Biological Treatment	Bioreactors Constructed Wetlands		3 3	3 3	3 2	2 2		
Ex Situ Physical/Chemical Treatment (Assuming Pumping)	Absorption/Adsorption Advanced Oxidation Processes Air Stripping Compressed Aqueous Phase (CAP) Leachate Phase Carbon Adsorption Ground Water Circulation and Heat Extraction Precipitation/Coprecipitation Processes Sparging Sprinkle Irrigation		3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3	2 2 2 2 2 2 2 2 2	1 1 1 1 1 1 1 1 1		
Containment	Physical Barriers Deep Well Injection		3 3	3 3	3 2	3 1		
Air Emissions/Off-Gas Treatment	Bioreactors High Volume Destruction Membrane Separation Adsorption Scrubbing Variable Phase Carbon Adsorption		3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3		

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Tier 3A



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- Technology and techniques are supported by web information
- Profile enables ease of updating
- Initial focus on bioremediation being progressed
- Transparent support of screened materials on the web
- Test validation performed
- www.abdn.ac.uk/remediation-dst