Sustainable Land Contamination Risk Management in a Changing Climate

Paul Nathanail

LQM

Climate Change and Sustainability: Impacts and Innovation in Contaminated Land
20 - 21 October 2022, City Hall Conference Rooms, Bristol

LQM Activities

1997 – 2022: **25 Years of**
Sound Science Defensible Decisions

- Advisory
- Expert Witness
- Peer Review Services
- Contract Research
  - FP NanoRem, EuroDemo, EUGRIS,
  - H2020 SPRINT
- Consultancy
  - land contamination risk management
- Training
  - Short Courses
  - Bespoke courses
  - Live and DIY online
- Guidance
  - Asbestos in Soil
  - PFAS in soil and water
  - ISO18504
  - Soil screening levels
- Software tools
  - PAH Double ratio
  - Dose-response roadmaps
  - QGIS customisation
  - CSM software
- Environmental Data Analysis
  - Contaminated Land
  - Renewable Energy
  - Natural Capital
  - Land Use Planning
  - Utility route evaluation

Your speaker…

Professional geologist and contaminated land specialist with a career that combines University teaching & research with commercial consultancy and citizen science

- Director, LQM
- Research Fellow, British Geological Survey
- Director, CABERNET Brownfield Network
- Director, SILC Register Ltd
- Member, EU China Panel on Land and Soil
- Former Professor of Engineering Geology, University of Nottingham
- Glossop Medal, 2009; SCI Environment Medal, 2019

Paul Nathanail
CGeol, Euro Geol, SILC, SQP

Led writing of ISO 18504:2017
Lead author, UK guidance on asbestos in soil (2014)
Lead author, UK Soil Screening Levels (2015)
Lead author, Cyprus Soil Screening Levels (2020)
Author, UK guidance on bioavailability (2009)
Developed Dose-Response Roadmaps (2010)

(Selected) 2022 Writing Projects

- Climate change and contaminant chemistry
- CIRIA Guidance on PFAS in soil and water
- NICOLE PFAS Working group (Deputy Chair)
- Carbon Footprint of Remediation Technologies
- Geology of holes
- Groundwater forever – what's the PFAS?

BLOGS

https://www.lotsearch.com.au/blogs

SEP 2022 I've got a little list…

#TLDR Contaminated site registers differ in content and categories of land, reflecting the law in individual states and territories. Consistent historical land use and environmental information is needed by buyers and developers of sites affected by

https://www.landmark.co.uk/news-insights/blog/on-the-levelling-up/

SEP 2022 On the level…ling up?

#TLDR The Levelling-up and Regeneration Bill will change the financial and decision-making landscape to encourage brownfield redevelopment. Practitioners will need to reduce costs, accelerate development and innovate infrastructure delivery to make brownfield-first happen.

Key guidance

NPPF –indirect hints we ignore at our peril

2. Achieving sustainable development"

8. c) **an environmental objective** – to contribute to … **mitigating and adapting to climate change**, including moving to a low carbon economy.

14. Meeting the challenge of climate change, flooding and coastal change

150. New development should be planned for in ways that:

a) **avoid increased vulnerability to the range of impacts arising from climate change.** When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure;

LCRM – demands more than you might thing

"the likely commercial climate at the time remediation will start - especially if it's likely that there will be a long time before remediation can start"

Climate change

Adaptation:

Adjustments made to natural or human systems in response to the **actual or anticipated impacts of climate change,** to mitigate harm or exploit beneficial opportunities.

Mitigation:

Action to **reduce the impact of human activity on the climate** system, primarily through reducing greenhouse gas emissions.

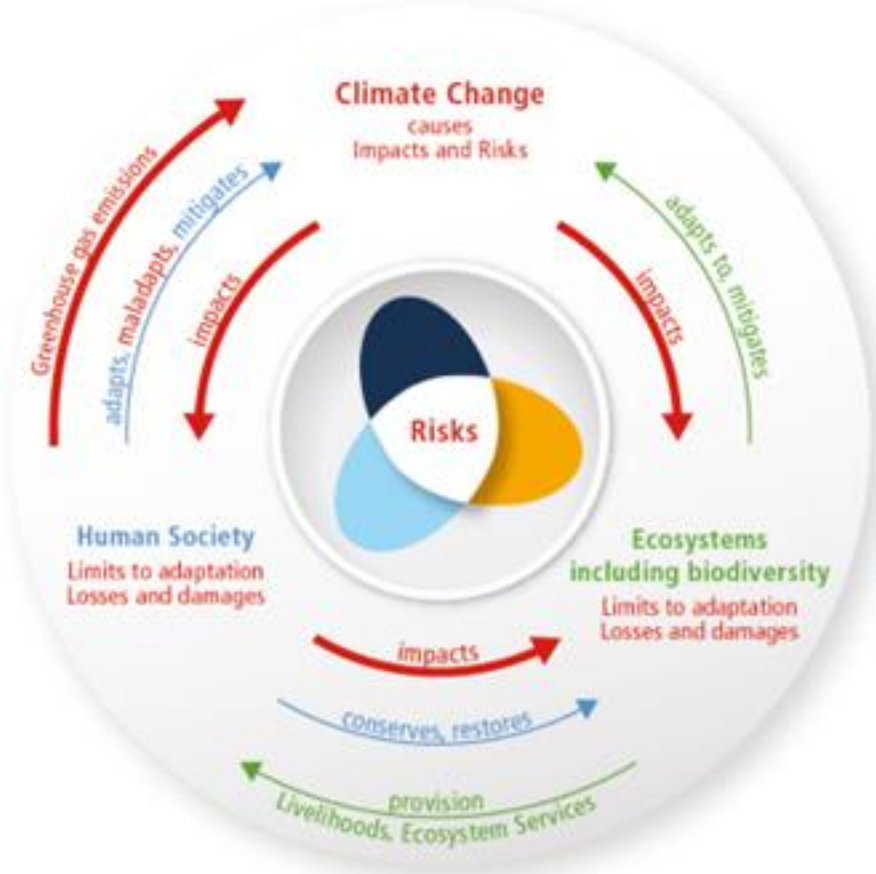
Big picture: IPCC Sixth Assessment Report (6AR)

Impacts, Adaptation and Vulnerability

- assesses **impacts** of climate change on ecosystems, biodiversity, and human communities at global and regional levels.
- reviews **vulnerabilities** and **capacities & limits** of natural world and human societies to **adapt** to climate change.

From climate risk to climate resilient development: climate, ecosystems (including biodiversity) and human society as coupled systems

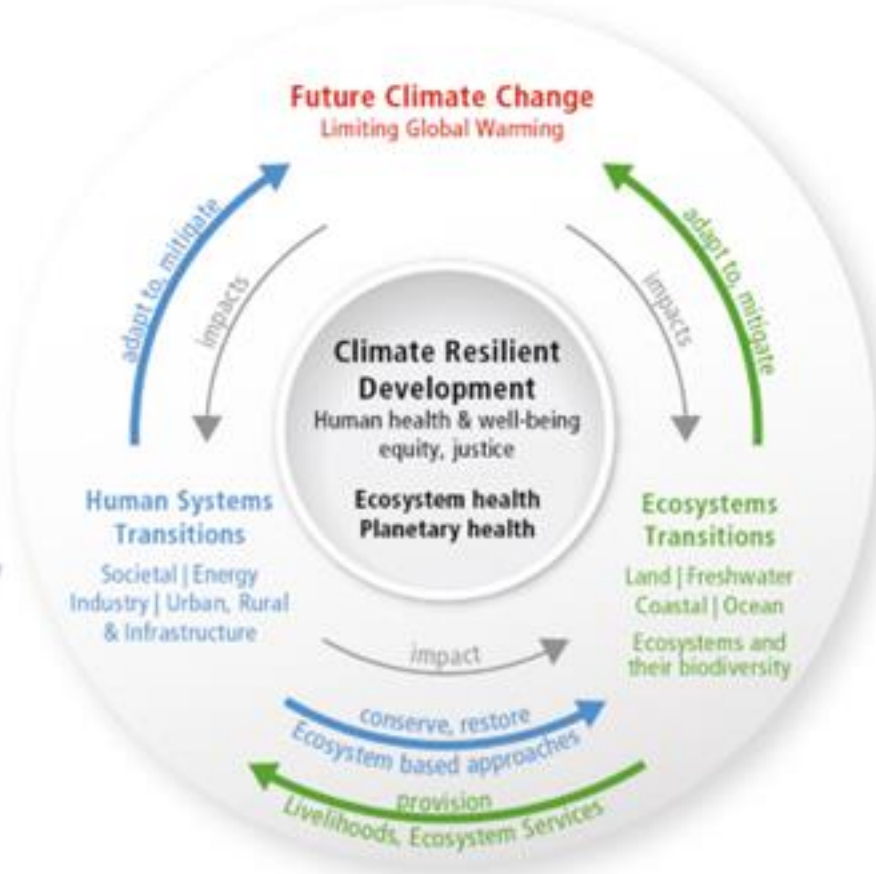
(a) Main interactions and trends



From urgent to timely action

Governance
Finance
Knowledge and capacity
Catalysing conditions
Technologies

(b) Options to reduce climate risks and establish resilience



The risk propeller shows that risk emerges from the overlap of:

Climate hazard(s) Vulnerability Exposure

...of human systems, ecosystems and their biodiversity

IPCC 6AR
Climate, Ecosystems and Human Society: Coupled Systems

(a) Observed impacts of climate change on ecosystems

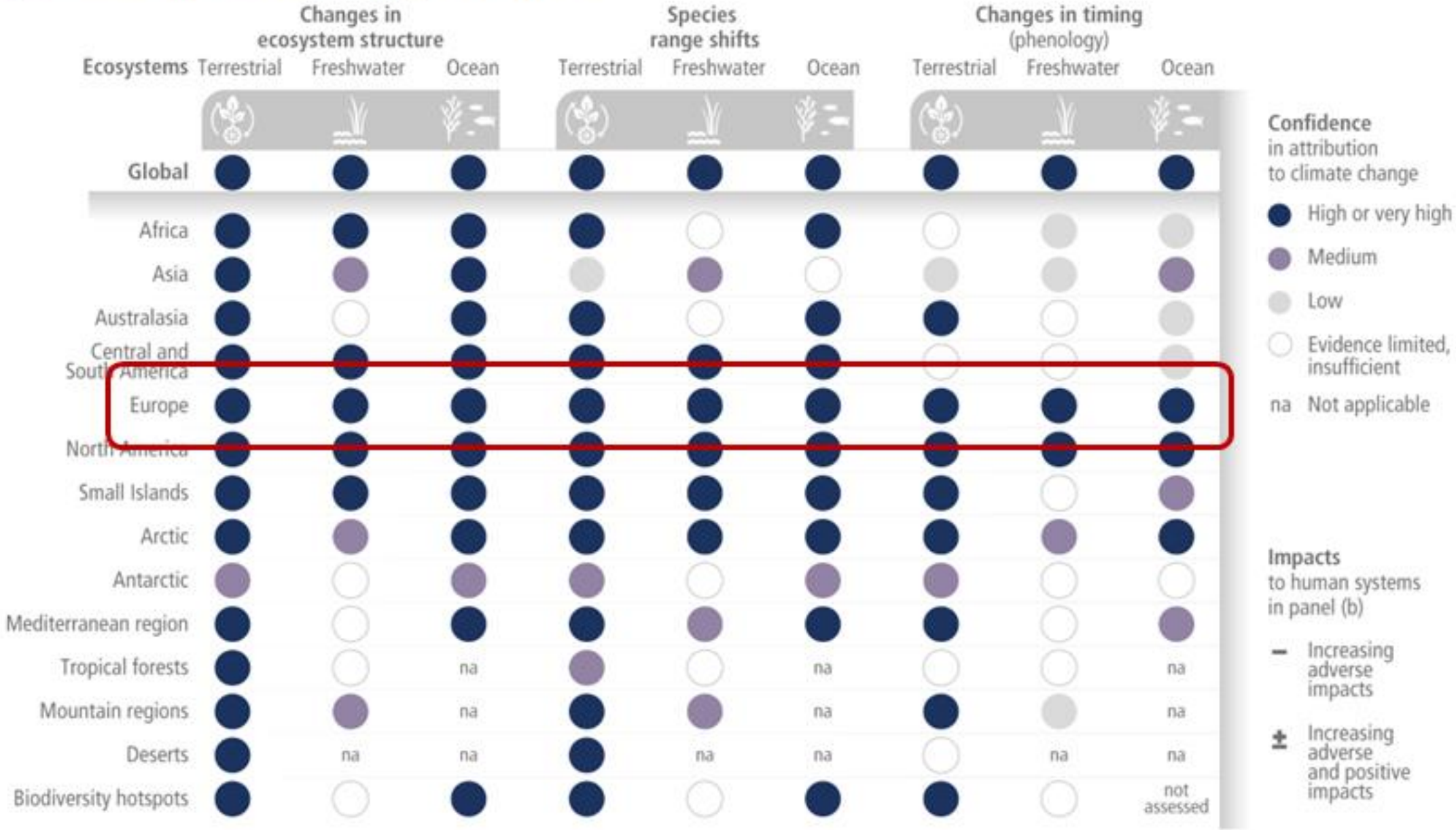
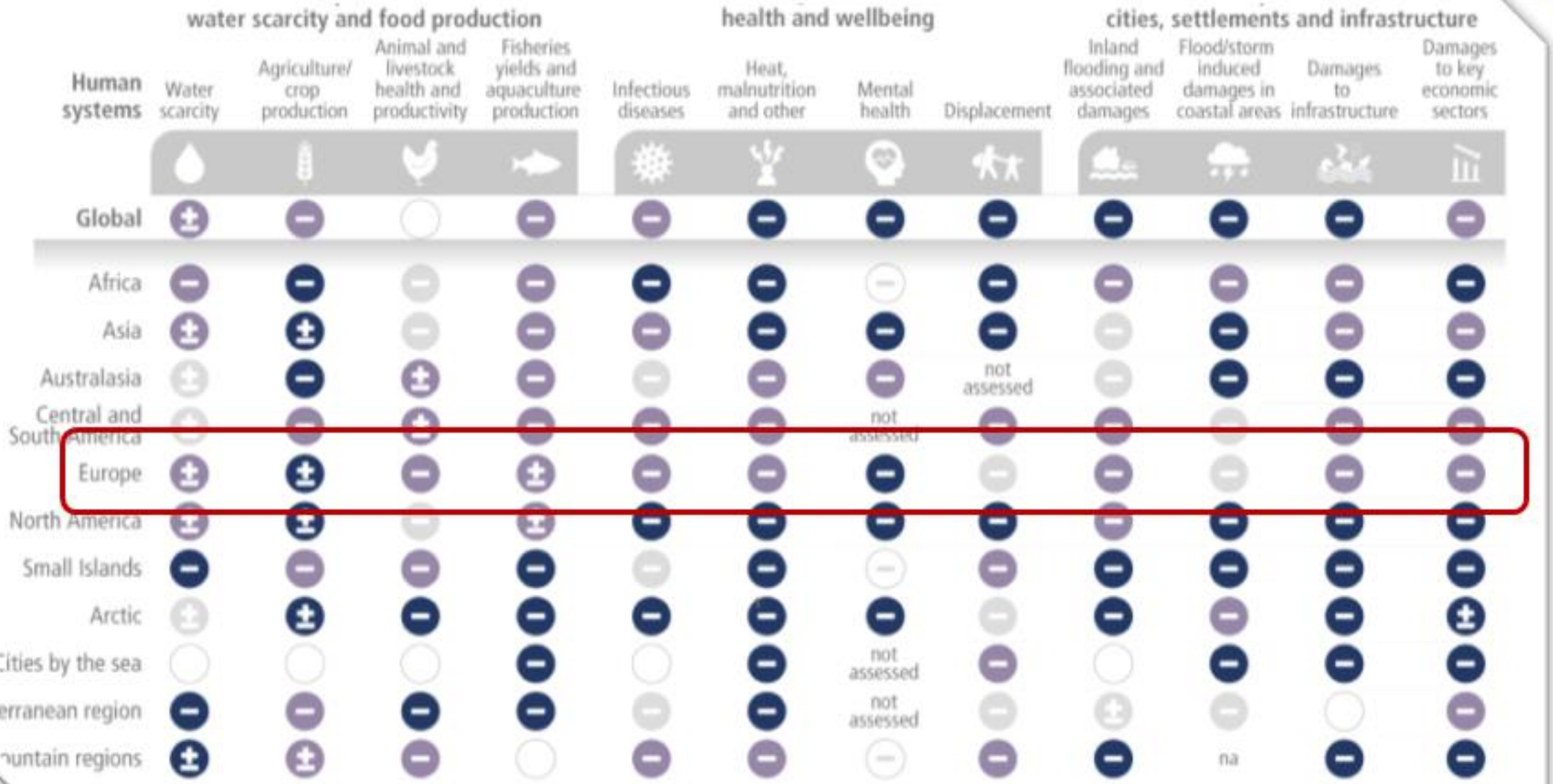
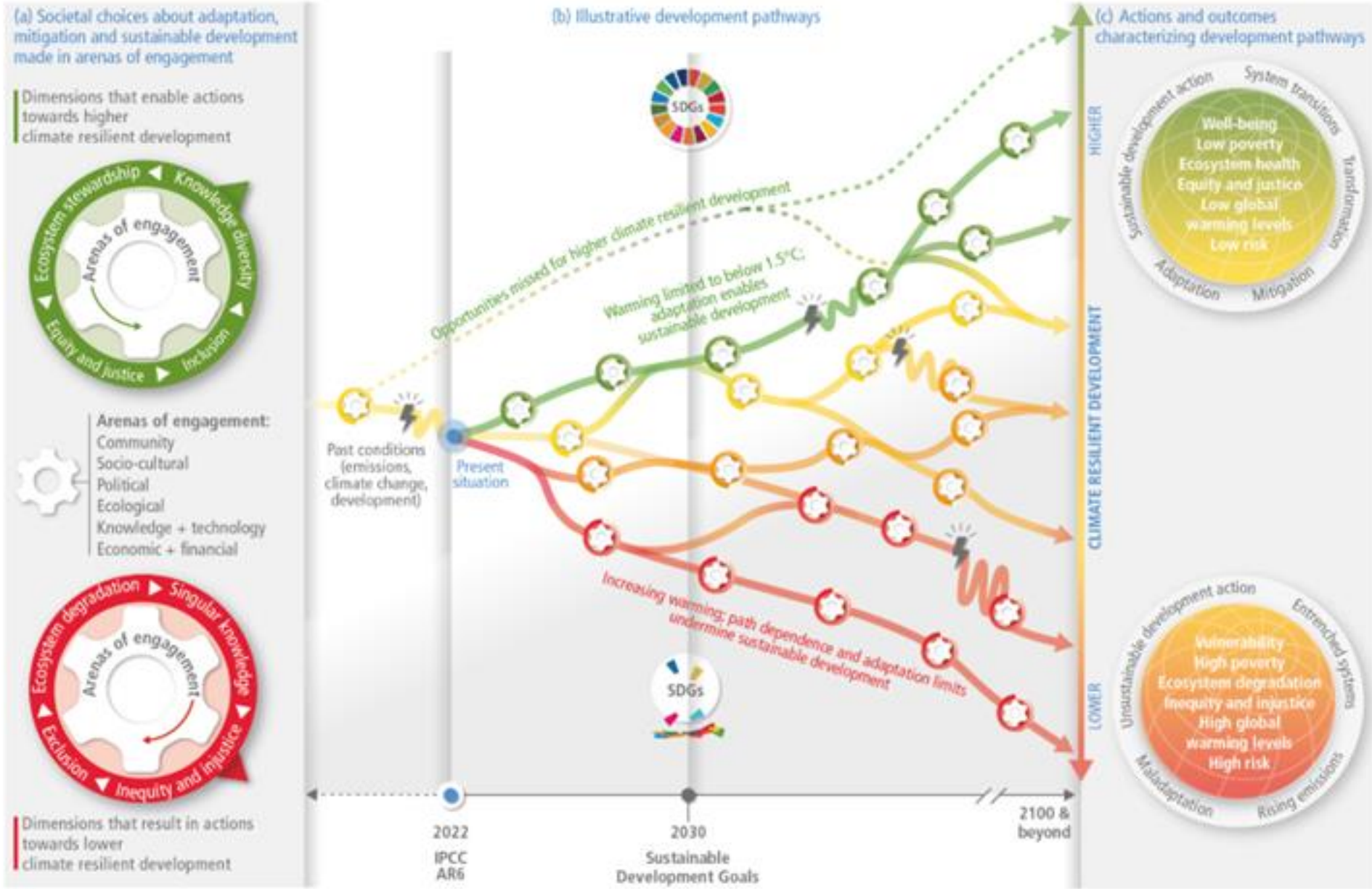


Figure: SPM.2b: Observed global and regional impacts on human systems attributed to climate change.



There is a rapidly narrowing window of opportunity to enable climate resilient development



1896
1964
1972
1997
2030
2100

NPPF "10. So that sustainable development is pursued in a positive way, at the heart of the Framework is a presumption in favour of sustainable development (paragraph 11)."

11. Plans and decisions should apply a presumption in favour of sustainable development.

For **plan-making** this means that:

a) all plans should promote a sustainable pattern of development that seeks to: meet the development needs of their area; align growth and infrastructure; improve the environment; **mitigate climate change** (including by making effective use of land in urban areas) and adapt to its effects;

b) strategic policies should, as a minimum, provide for objectively assessed needs for housing and other uses, as well as any needs that cannot be met within neighbouring areas6, unless:

i. the application of policies in this Framework that protect areas or assets of particular importance provides a strong reason for restricting the overall scale, type or distribution of development in the plan area7; or

ii. any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole.

For **decision-taking** this means:

c) approving development proposals that accord with an up-to-date development plan without delay; or

d) where there are no relevant development plan policies, or the policies which are most important for determining the application are out-of-date, granting permission unless:

i. the application of policies in this Framework that protect areas or assets of particular importance provides a clear reason for refusing the development proposed7; or

ii. any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole.

NPPF Strategic policies

20. Strategic policies should set out an overall strategy for the pattern, scale and design quality of places, and make **sufficient provision** for:

a) housing (including affordable housing), employment, retail, leisure and other commercial development;

b) infrastructure for transport, telecommunications, security, waste management, water supply, wastewater, flood risk and coastal change management, and the provision of minerals and energy (including heat);

c) community facilities (such as health, education and cultural infrastructure); and

d) conservation and enhancement of the natural, built and historic environment, including landscapes and green infrastructure, **and planning measures to address climate change mitigation and adaptation**.

NPPF Open space and recreation

98. Access to a network of high quality open spaces and opportunities for sport and physical activity is important for the health and well-being of communities, and can deliver wider benefits for nature and **support efforts to address climate change.** Planning policies should be based on robust and up-to-date assessments of the need for open space, sport and recreation facilities (including quantitative or qualitative deficits or surpluses) and opportunities for new provision. Information gained from the assessments should be used to determine what open space, sport and recreational provision is needed, which plans should then seek to accommodate.

NPPF 12. Achieving well-designed places

131. **Trees** make an important contribution to the character and quality of urban environments, and **can also help mitigate and adapt to climate change**. Planning policies and decisions should ensure that new streets are tree-lined, that opportunities are taken to incorporate trees elsewhere in developments (such as parks and community orchards), that appropriate measures are in place to secure the long-term maintenance of newly-planted trees, and that existing trees are retained wherever possible. Applicants and local planning authorities should work with highways officers and tree officers to ensure that the right trees are planted in the right places, and solutions are found that are compatible with highways standards and the needs of different users.

NPPF Planning for climate change

153. Plans should take a **proactive approach to mitigating and adapting to climate change**, taking into account the **long-term implications** for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures. Policies should support **appropriate measures to ensure the future resilience of communities and infrastructure** to climate change impacts, such as providing space for physical protection measures, or making provision for the possible future relocation of vulnerable development and infrastructure.

NPPF Planning for climate change

154. New development should be planned for in ways that:

a) **avoid increased vulnerability to the range of impacts arising from climate change**. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure; and

b) can help to reduce greenhouse gas emissions, such as through its location, orientation and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards.

NPPF Planning and flood risk

161. All plans should apply a sequential, risk-based approach to the location of development – taking into account all sources of flood risk and the **current and future impacts of climate change** – so as to avoid, where possible, flood risk to people and property. They should do this, and manage any residual risk, by:

a) applying the sequential test and then, if necessary, the exception test as set out below;

b) safeguarding land from development that is required, or likely to be required, for current or future flood management;

c) using opportunities provided by new development and improvements in green and other infrastructure to reduce the causes and impacts of flooding, (making as much use as possible of natural flood management techniques as part of an integrated approach to flood risk management); and

d) **where climate change is expected to increase flood risk** so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development, including housing, to more sustainable locations.

Before you start

- **factor in climate change** to ensure site works and any long term remediation is **sustainably robust**

Stage 1 Risk Assessment

- Consider sustainability:
  - You can ***also*** consider **how climate change might impact your site**.
- Decide what information you need for GQRA
  - You may also need further information on other site conditions such as:
    - any previous investigation or remediation already done
  - **weather and natural patterns –** such as seasonal variations in water levels, tidal impacts and potential for or evidence of previous flooding, **climate change implications**
  - presence of structures and buried services

Land contamination risk management

Stage 2 options appraisal

Step 1: Identify feasible remediation options

Options appraisal management objectives

- Use management objectives to define the required remediation outcome. For example to:
  - consider and factor in any regulatory controls that you may need to meet…
  - achieve sustainable remediation **considering any reasonable climate change issues**

Sustainability

- You can use [Stage B of the SuRF-UK Framework or BS ISO 18504: Soil quality. Sustainable remediation] to differentiate the remediation options against environmental, social and economic indicators **taking into account any relevant climate change issues.**

Land contamination risk management

…/ Stage 2 options appraisal

…/ Step 1: Identify feasible remediation options

Durability

- Consider durability. This is the extent to which a remediation treatment is **likely to be effective** in reducing or controlling unacceptable risks to a defined level **over a period of time**.

Environmental impact

- Consider the effect that the remediation will have on the quality of the environment during and after it is complete.
- … Also **take climate change issues into account**.
- Consider if the technique will provide for a remediation strategy that delivers direct and indirect benefits.

Land contamination risk management

Stage 3 remediation & verification

- Sustainable remediation
  - The **remediation can also have adverse effects on climate change** if it is not done correctly.

Know the enemy

- Metals
- Asbestos
- Natural organics
  - Hydrocarbons – petroleum and coal
  - Methane
- Artificial organics
  - Chlorinated solvents
  - PFAS
  - Pharmaceuticals and personal care products

Minamata
Bangladesh
Hinkley CA
Libby Mountain
Buncefield
Deep Horizon
Bhopal
Loscoe explosion
Eastern Counties Leather
Dark waters

[BS AS] ISO 18504:18504 – Sustainable Remediation

Risk management: *"demonstrably breaking source-pathway-receptor linkages"*

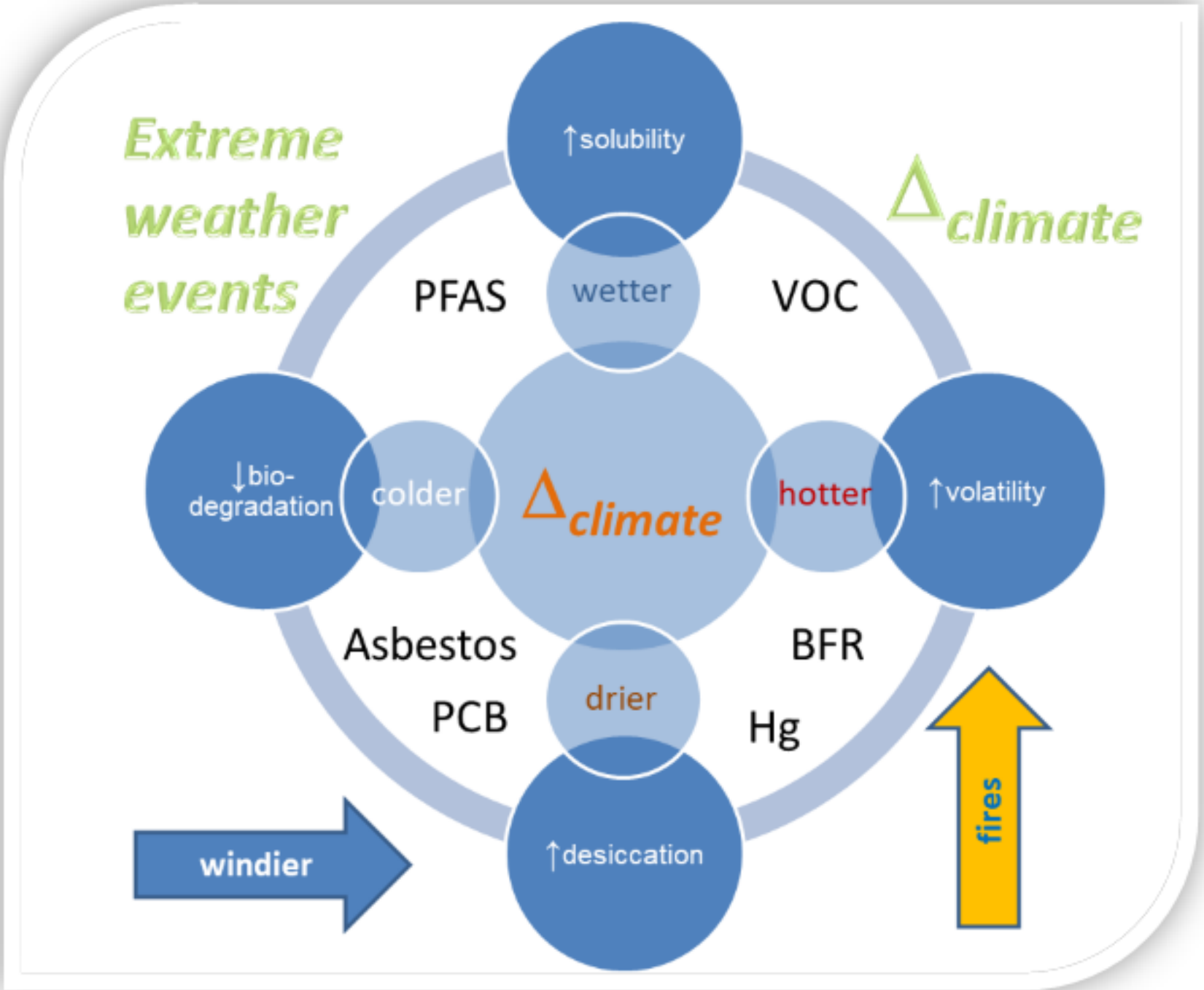
Sustainable Remediation: Elimination and/or control of unacceptable risks *in a safe and timely manner* ***whilst optimising the environmental, social and economic value of the work***

ISO 18504 does:

- Provide standard methodology & terminology
- Advise on the assessment of the **relative sustainability** of alternative remediation strategies
- Promote consideration of SR throughout the planning design and implementation process

ISO 18504 does not

- Prescribe methods of assessment
- Prescribe indicators or their metrics
- Endorse or discuss "Green" or "Green and Sustainable" Remediation"

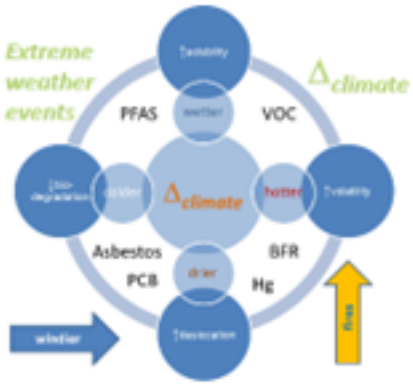


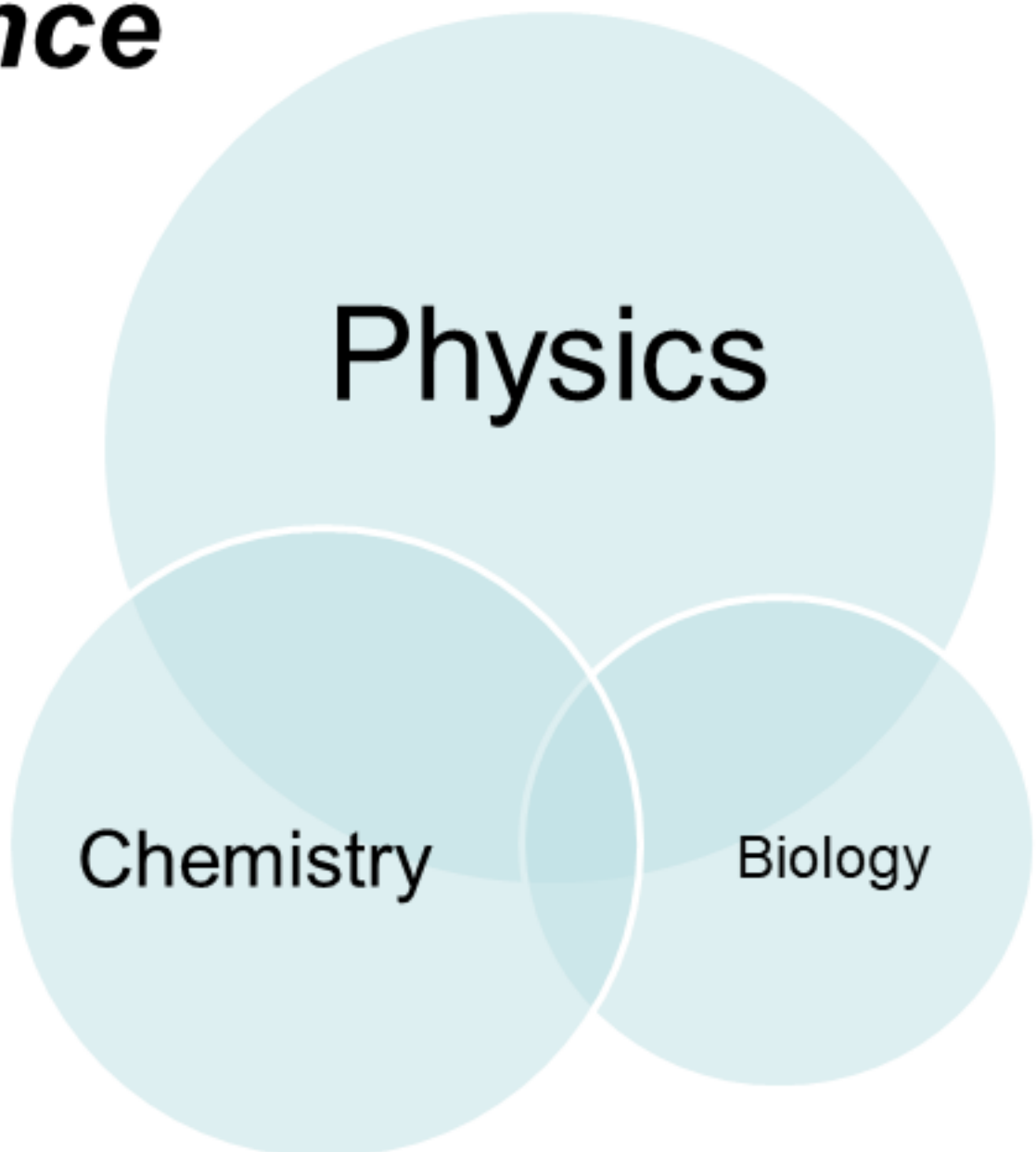
GRAPHICAL ABSTRACT

A reflection on the effects of climate change and extreme weather events on the behaviour of specific groups of contaminants and on remediation

CIRIA (Joanne Kwan, Claire Dickinson, Paul Nathanail) for the Environment Agency

The *science*



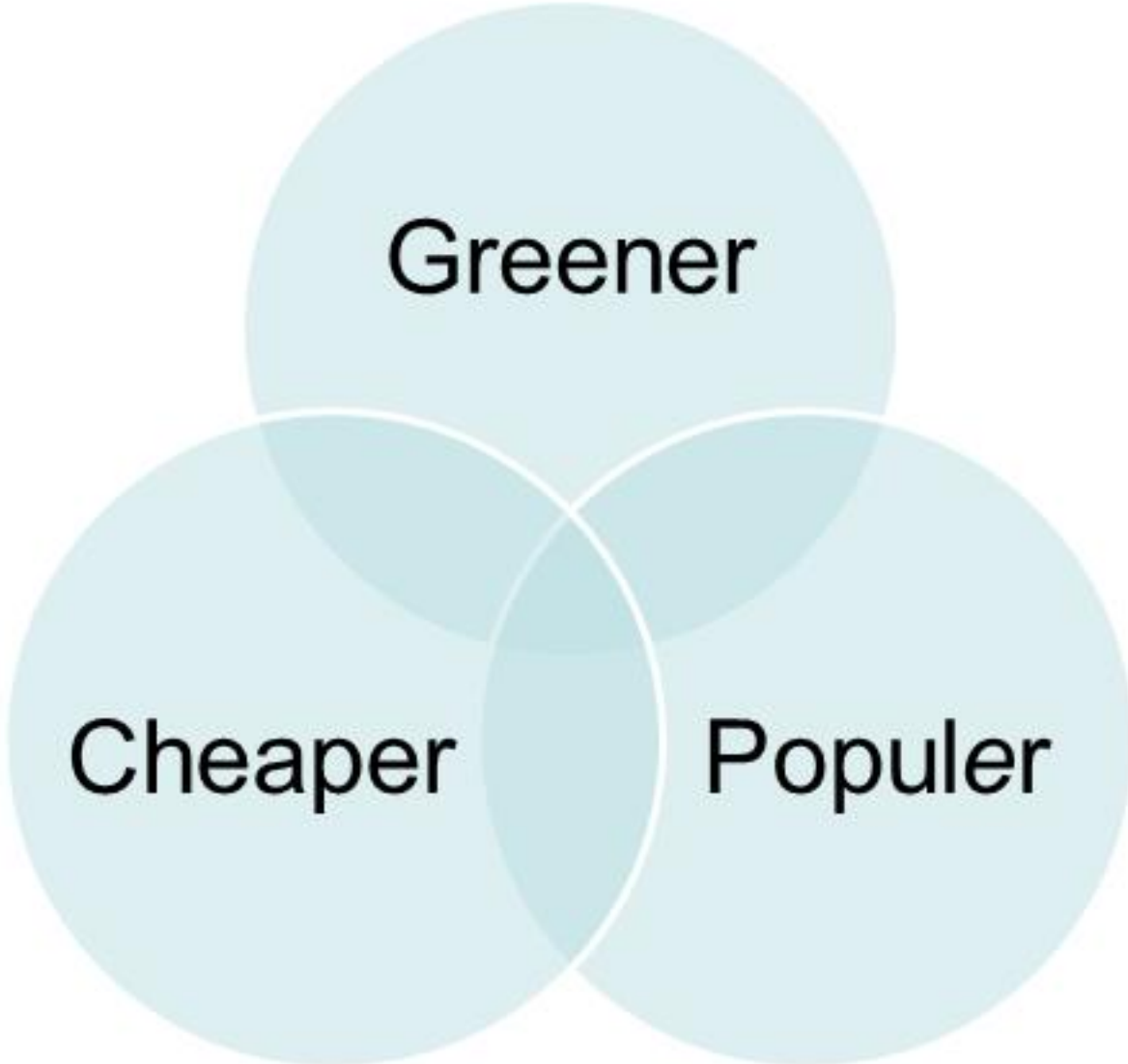


ENERGY
Water
Wind

BEHAVIOUR
Solubility
Volatility

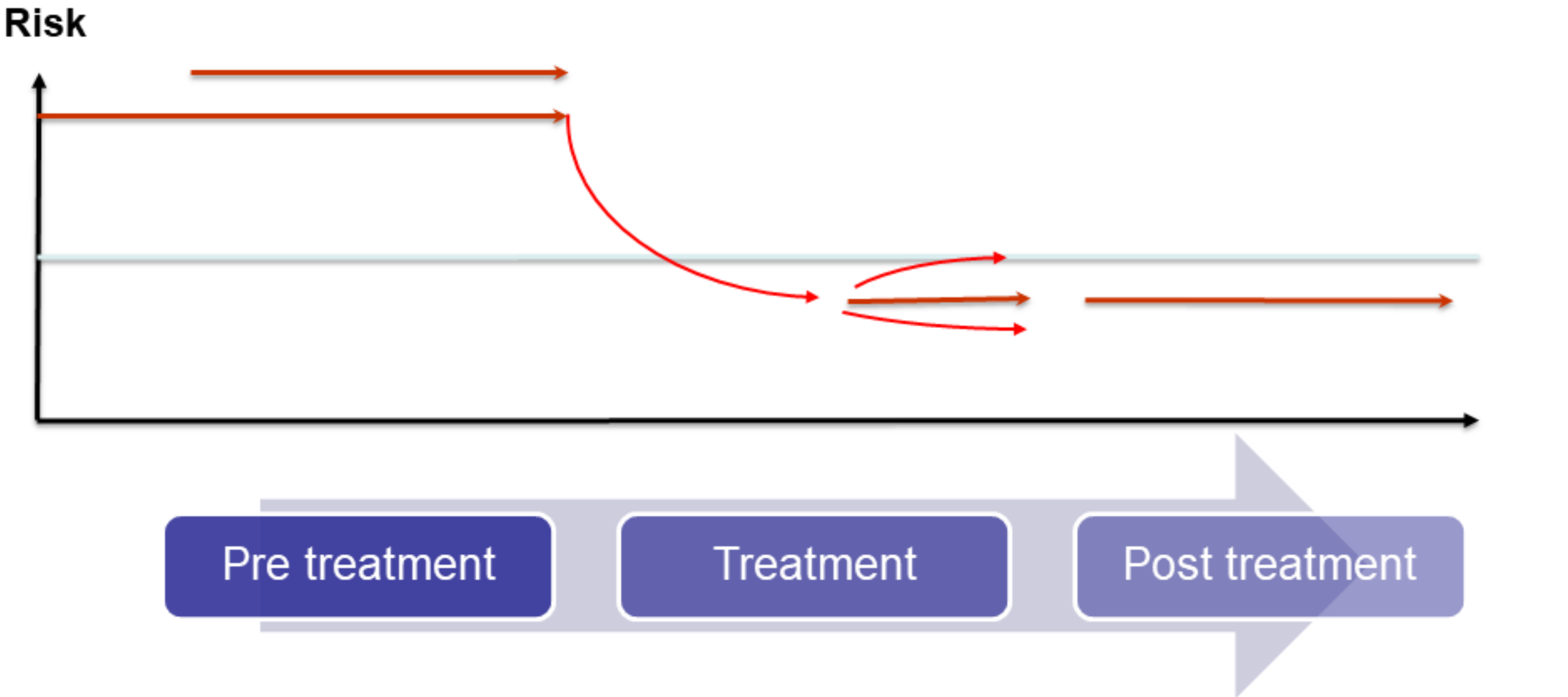
METABOLIC RATE
Optimal temperature
Optimal moisture

The Sustainable remediation *triathlon*



Sustainability is not [detailed] enough

Our tool box



Principles of remediation – **source removal**

- Physical – extract, separate
- Chemical – destroy molecule; change speciation
- Biological – degrade molecule
- Thermal – destroy or mobilise
- [Trans boundary shipment]

Remediation hierarchy

- **Simple, cheap, low intensity**
- **Complex, costly, high intensity**
- **Sophisticated, costly, energy intensive**

Principles of remediation – **pathway interruption**

- Physical – containment, sparging, vapour extraction, foam fractionation, Permeable Reactive barrier
- Stabilisation/ solidification – mix & lock – using local clays
- Off site disposal
- [Trans boundary shipment]

Remediation hierarchy

- **Simple, cheap, low intensity**
- **Complex, costly, high intensity**
- **Sophisticated, costly, energy intensive**

Climate change and EWE

Source destruction

- The ~~witch~~ source is dead!
- Done and dusted

Pathway interruption

- Time… matters
- There is ***no*** away

NB chemical transformations or physical relocations are not [necessarily] permanent solutions

Conclusions

- Some consider land contamination works are already being impacted by climate change
- Industry is considering climate change primarily in a qualitative manner
- Low levels of consistency in practice and regulation
- Contaminant behaviour will change
- Environmental changes will affect contaminant fate & transport
- Pathway interruption requires consideration of long term climate unlike source removal
- Decarbonisation of [some forms of] remediation is possible

Recommendations

LCRM expects climate change to be considered so that site works and any long-term remediation are sustainably robust.

- LCRM could signpost:
  - detailed guidance on how to consider EWE impacts on the conceptual site model during the risk assessment, options appraisal and remediation stages.
  - guidance on sensitivity analysis to constrain the impacts on remediation design of different rates of infiltration, fluctuating groundwater levels, predicted groundwater temperatures in shallow aquifers – all over periods relevant to the anticipated lifespan of the remediation approach being designed.
  - specific reference to mercury and PFAS in the options appraisal spreadsheet

Recommendations

- Monitor effects of year-on-year climate change by harvesting, curating and making available already collected environmental data
- Establish the long-term resilience of cover systems
- Understand the current range of shallow aquifer temperatures and what would be reasonable future predictions.
- Encourage development of tools that incorporate the effects of climate change on land contamination projects.
- Encourage empirical and theoretical research on the effects of rainfall intensity on susceptible remediation approaches such as capping and stabilisation.

Recommendations to plug substance specific gaps in knowledge

PCBs:

- Effect of warmer and wetter weather on fate and transport of PCBs in the presence of small amounts of non-polar solvents

BFR:

- We need to understand how different behaviours of five groups of BFR compounds in the environment could limit potential degradation options

PFAS:

- chemical and physical properties of all types of PFAS
- influence of climate change and EWE in soil and groundwater chemistry and how this affects the forms, fate and transport of the PFAS
- exposure pathways of soil, plants, animals and groundwater
- long-term performance of pathway interruption techniques including capping and stabilisation

Recommendations to plug substance specific gaps in knowledge

VOC:

- how lag time and level of temperature change in shallow soils during extreme heat or cold
- effects of changes in soil moisture in the vicinity of the top of the saturated/base of the unsaturated zones on natural biochemical processes of VOCs

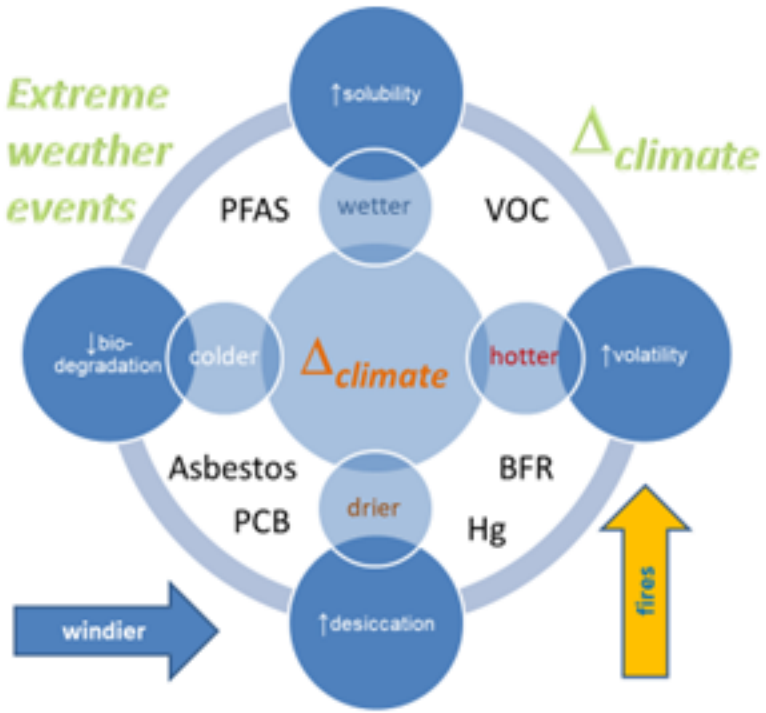
Mercury:

- effects of changing soil chemistry (e.g. acidification, loss of organic matter, desiccation) due to EWE on the form of mercury
- effects of changes in soil moisture in the vicinity of the top of the saturated/base of the unsaturated zones on natural biochemical processes are poorly constrained and rarely studied as part of a site investigation

Asbestos:

- more good UK data on background asbestos in air

Sustainable Land Contamination Risk Management in a Changing Climate



The effects of climate change on land contamination and selected contaminants

DON'T

- Don't assume
- Don't bury your head in the sand
- Don't ignore or turn a blind eye

DO

- *Read* the guidance (NPPF, LCRM, …)
- *Follow* the guidance
- It's all about the… uncertainty
  - Measure if you can; model if you must
  - Qualitative & Quantitative scenario models
  - Use Probabilistic modelling

Thank you!

Feel free to email me

paul@lqm.co.uk

For a copy of my slides please fill in the form at:

https://forms.gle/XyeDoeWByU1dwXH3A