



ΚΤΗΚ



Sound science:  
Defensible decisions

Ενημερωτική ημερίδα απορρύπανσης εδαφών από πετρελαιοειδή

# Ρύπανση εδάφους, υπόγειων υδάτων και θαλάσσιων ιζημάτων με βαρέα μέταλλα και υδρογονάνθρακες και εκτίμηση κινδύνου

Pollution of soil, groundwater and marine sediments

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Land Quality Management Ltd, UK  
@LQMTweets





# Journey

## ΟΔΟΙΠΟΡΙΑ



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Defensible decisions

Desk study  
& walkover

Intrusive  
Investigation

Risk  
Assessment

# Journey

# ΟΔΟΠΟΡΙΑ

Master Plan

Characterise

Remediate

Redevelop



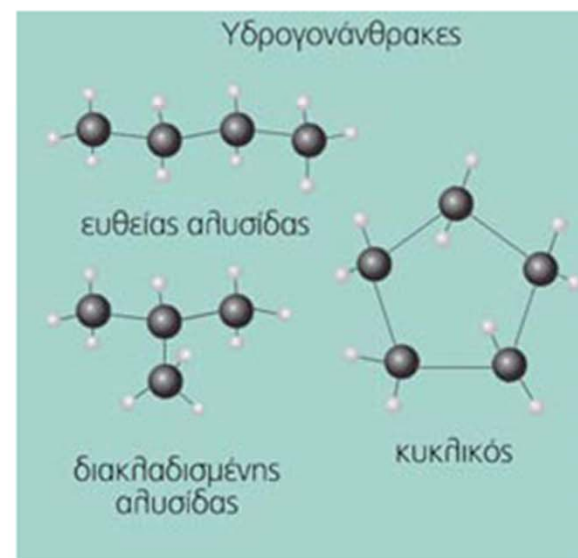
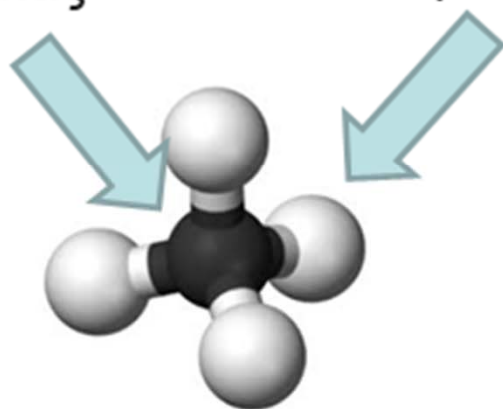
# υδρογονάνθρακες

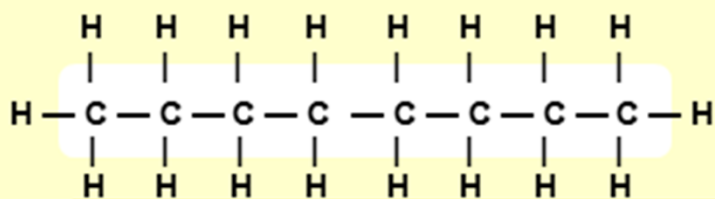
## Hydrocarbons



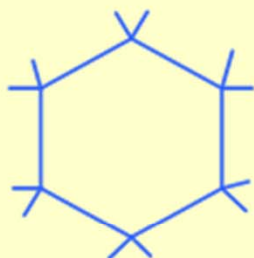
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άνθρακας υδρογόνο

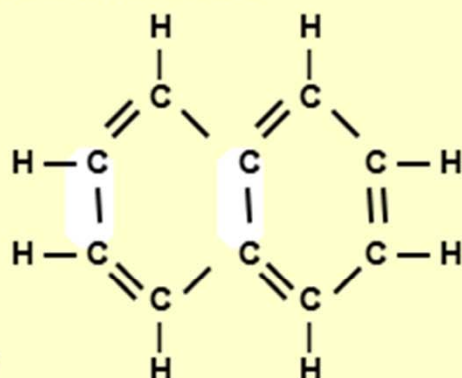




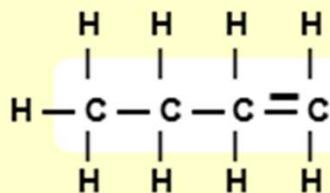
aliphatics/paraffins/alkanes



naphthenes/  
cycloalkanes



arenes/  
aromatics/ PAH



alkenes/  
olefins  
(not in crude)

Crude oils are highly complex mixtures of:



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Το αδιύλιστο πετρέλαιο είναι Μίγμα

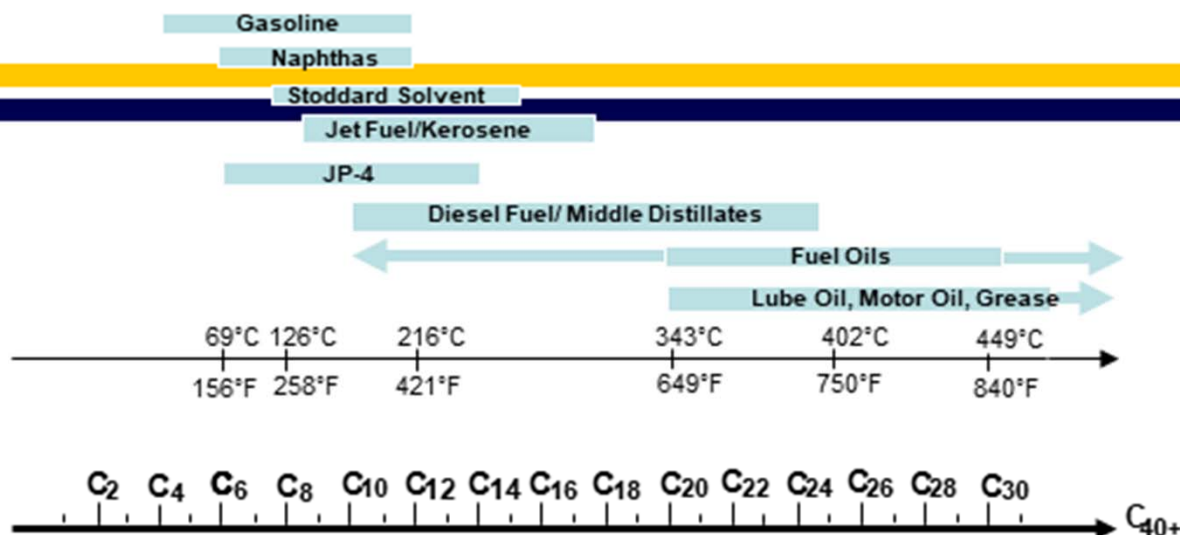
- Hydrocarbons
- Heteroatom compounds
  - - sulfur (sulfides, thiophenes)
  - - nitrogen (carbazoles)
  - oxygen (organic acids, phenols)
- Inorganic sediments
- Metals
- Water



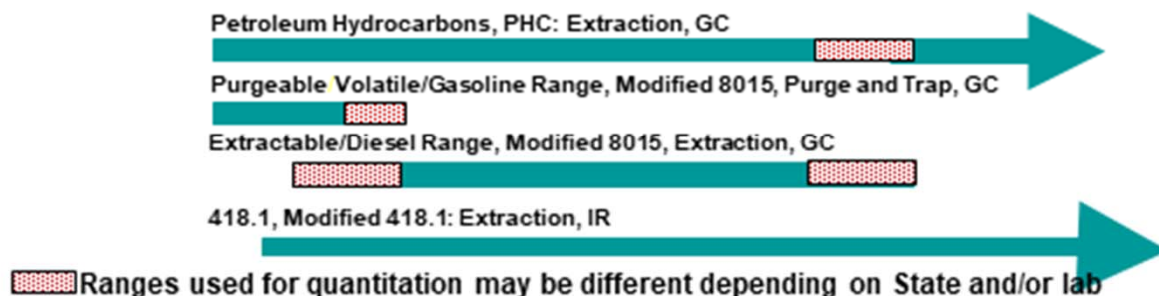
# Approximate Carbon and Boiling Ranges of Petroleum Products



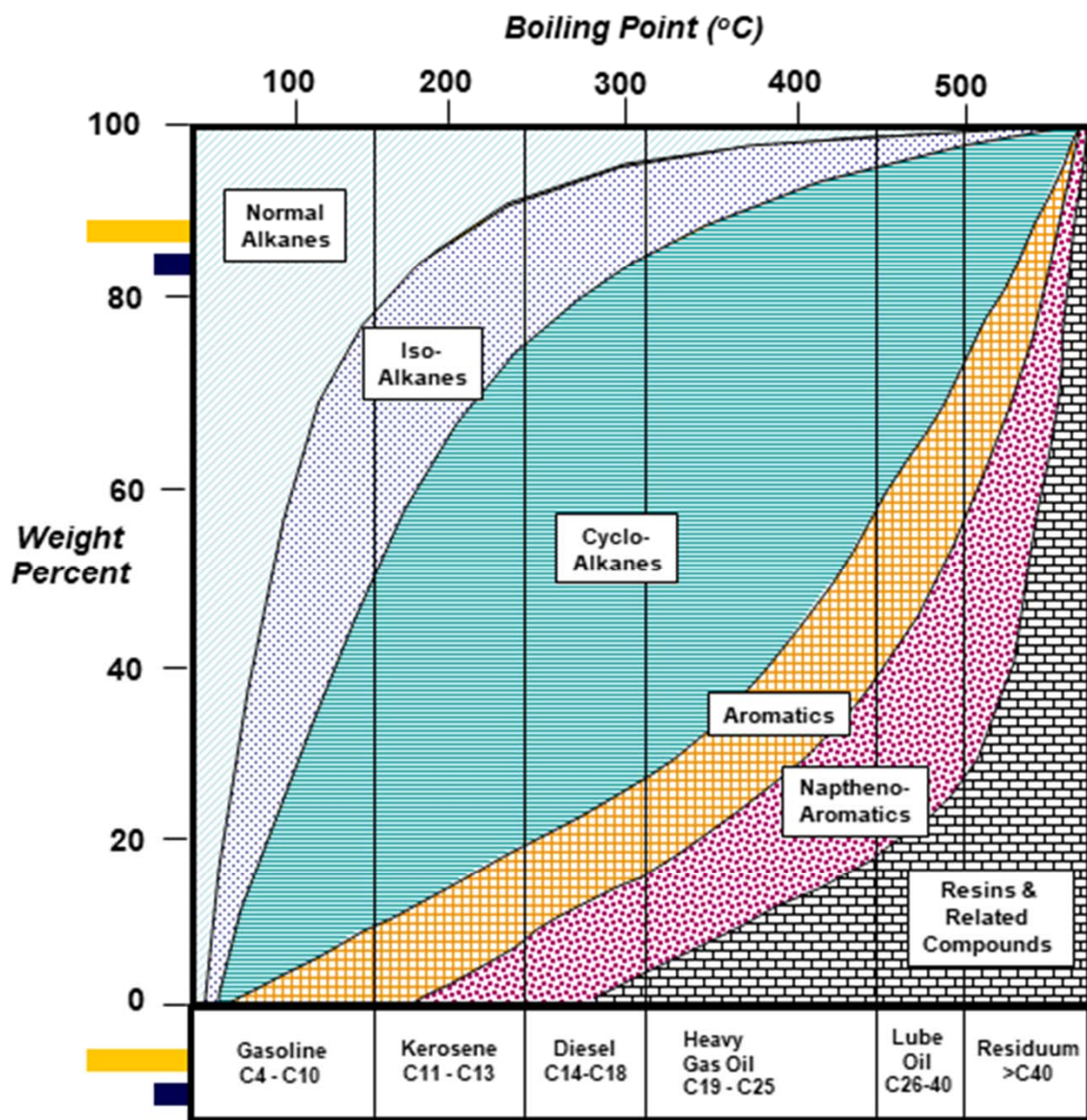
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## TPH Methods: Approximate Carbon Ranges







## Distribution of Hydrocarbon Type in Naphthenic Crude Oil

Relative abundance of Hydrocarbon Types (e.g., Aromatics) in a Refined Product (e.g., gasoline) can be estimated by Thickness of Corresponding Region in the Figure.

### Crude oil classifications

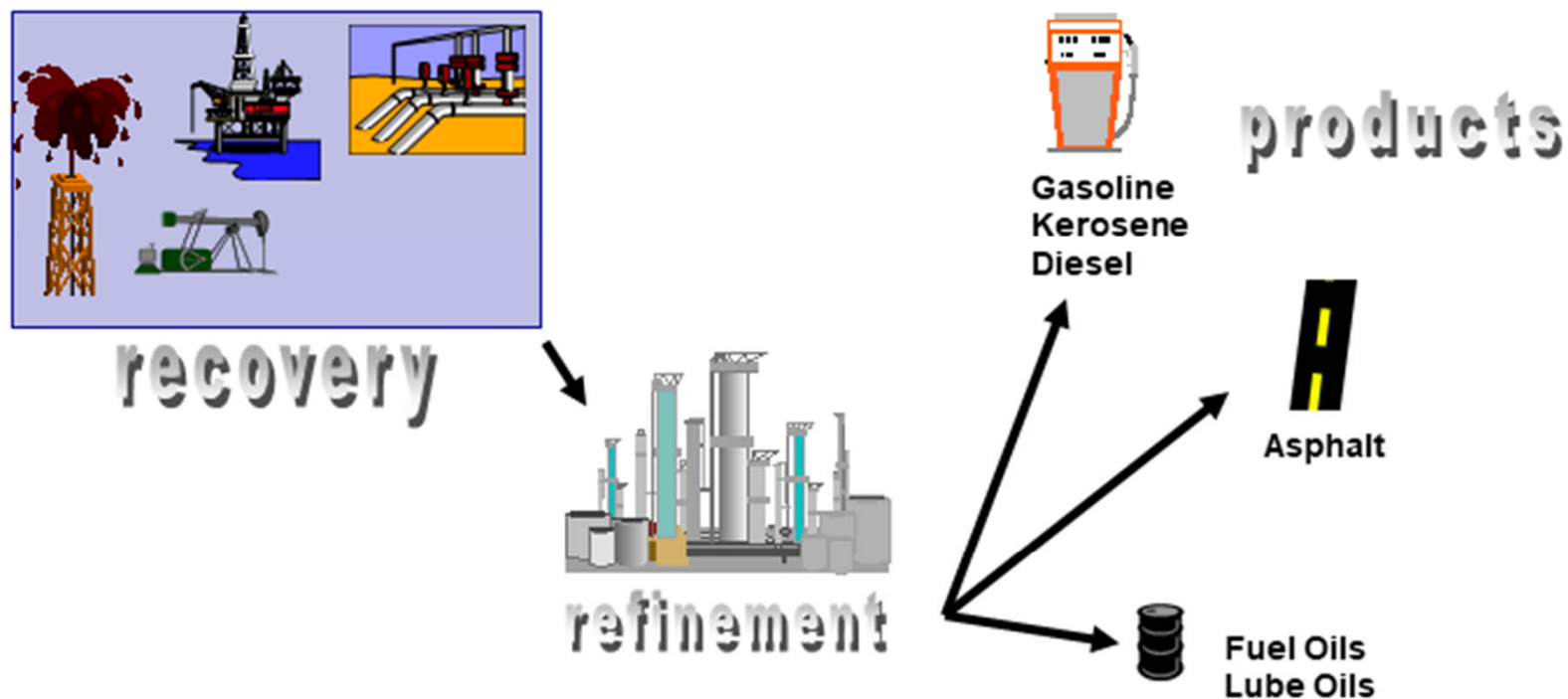
- Paraffinic (straight chain)
- Napthenic (cyclo-chain)
- Aromatic
- Mixed

# Απο Μίγμα σε προϊόντα

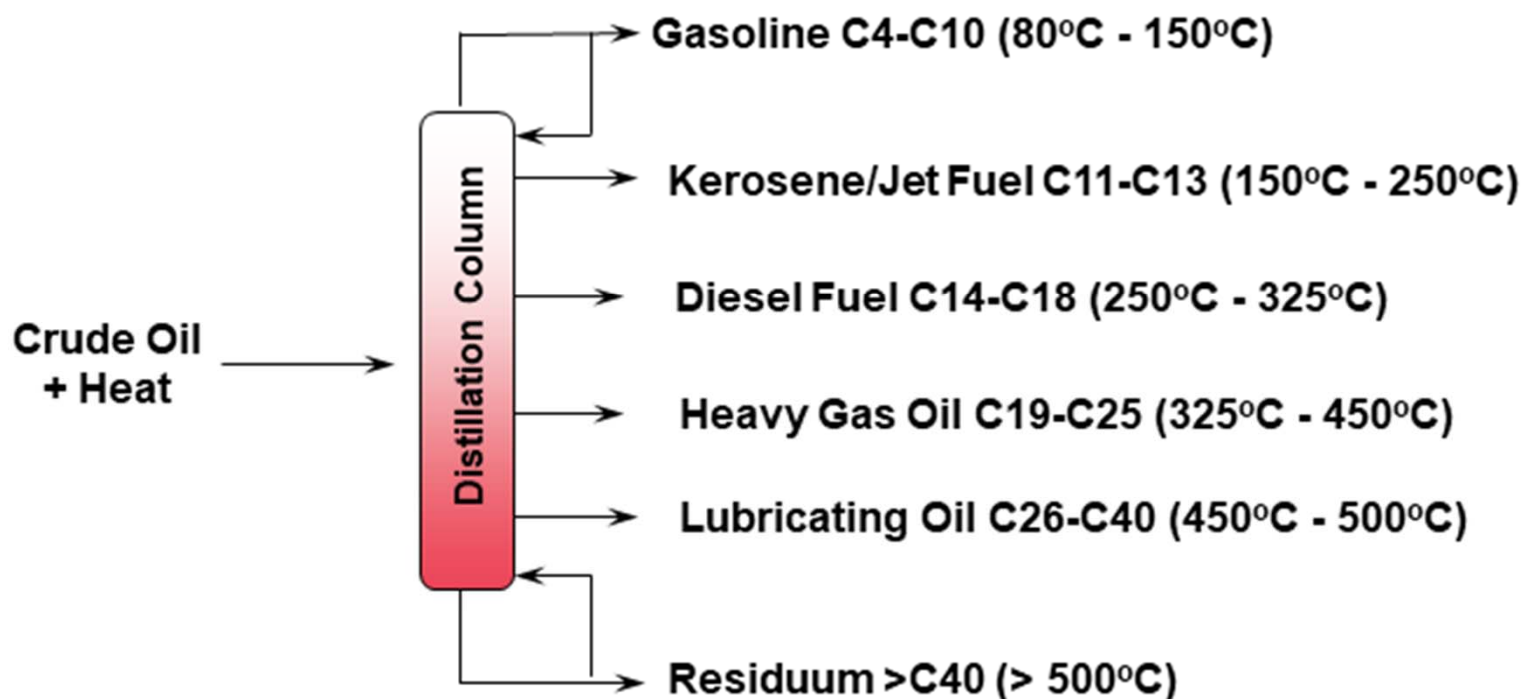
## Refining Process...



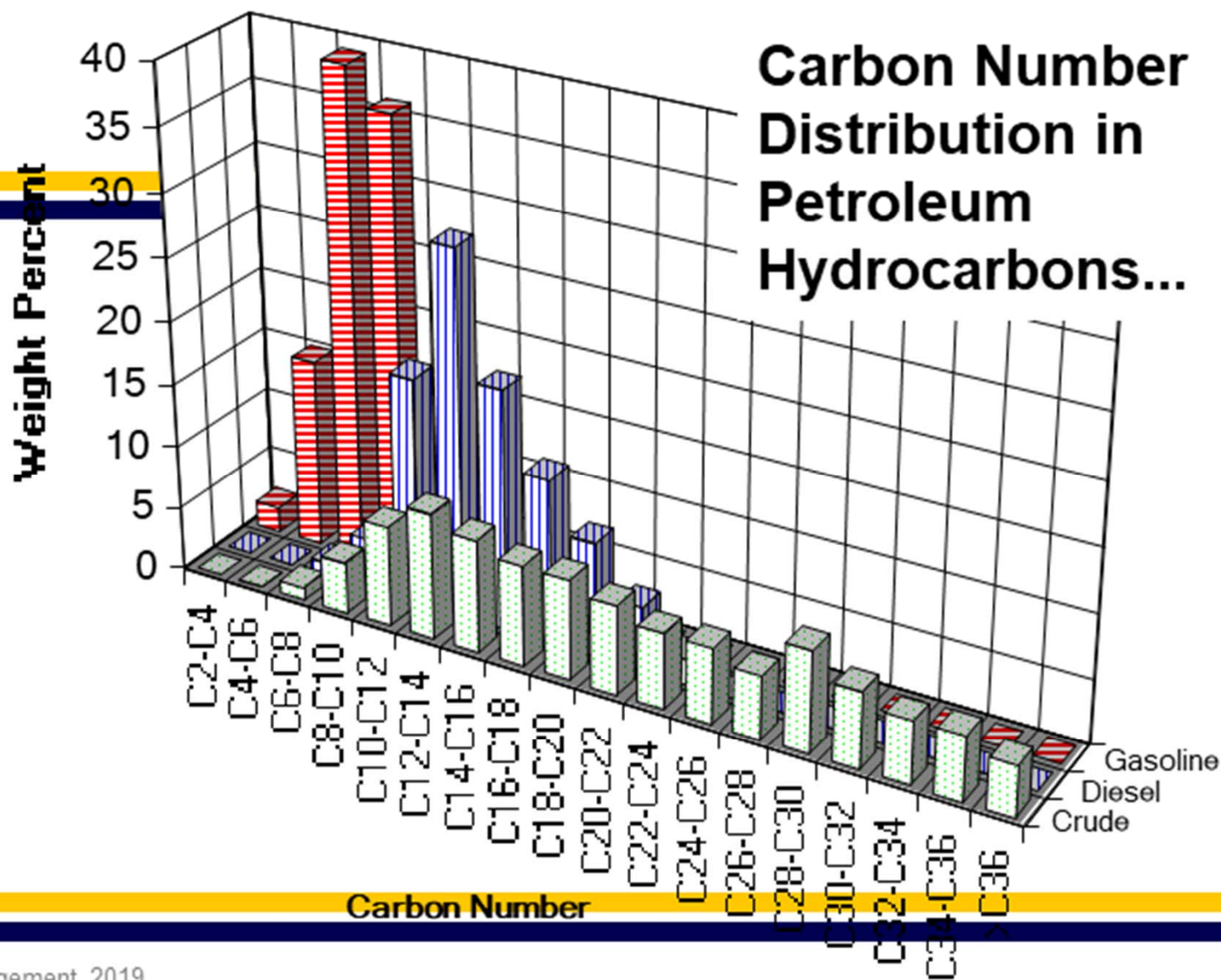
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# Distillation



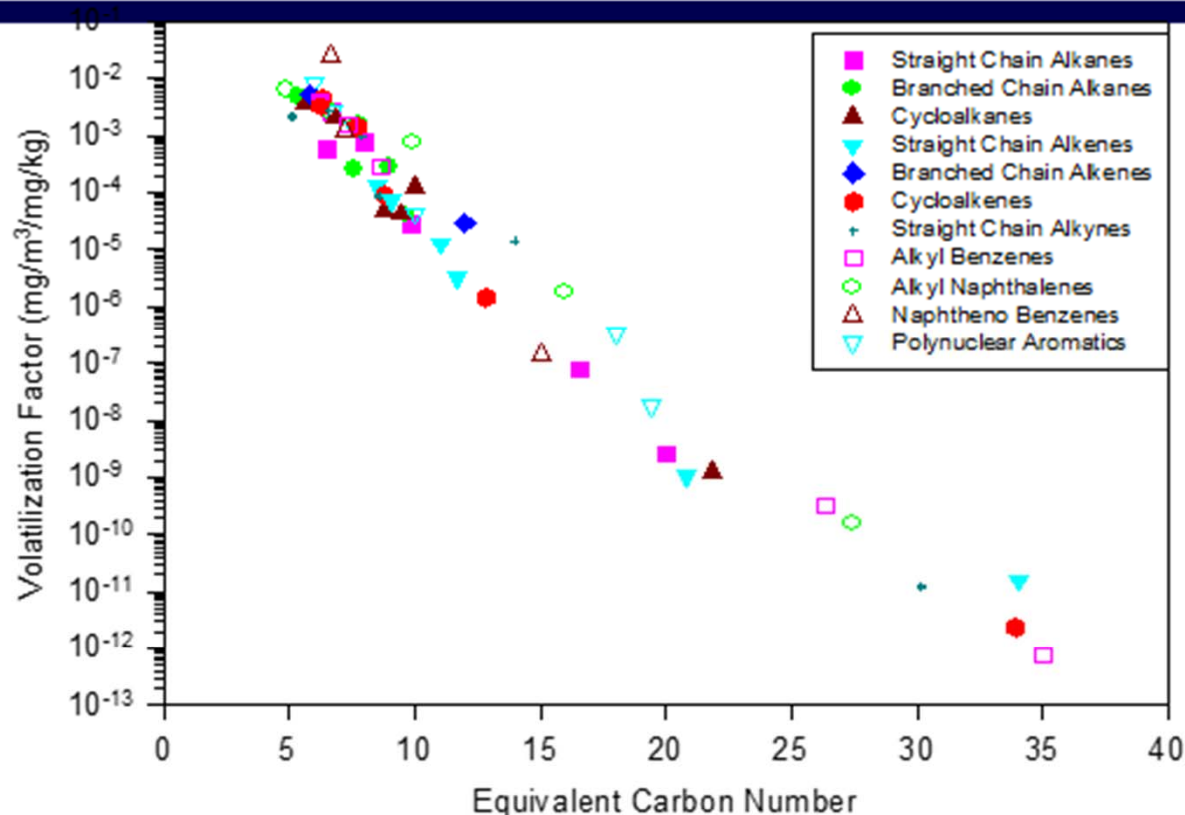
NB The various products are characterized by **different complex mixtures** of the hydrocarbons with differing boiling points, carbon numbers and compositions.



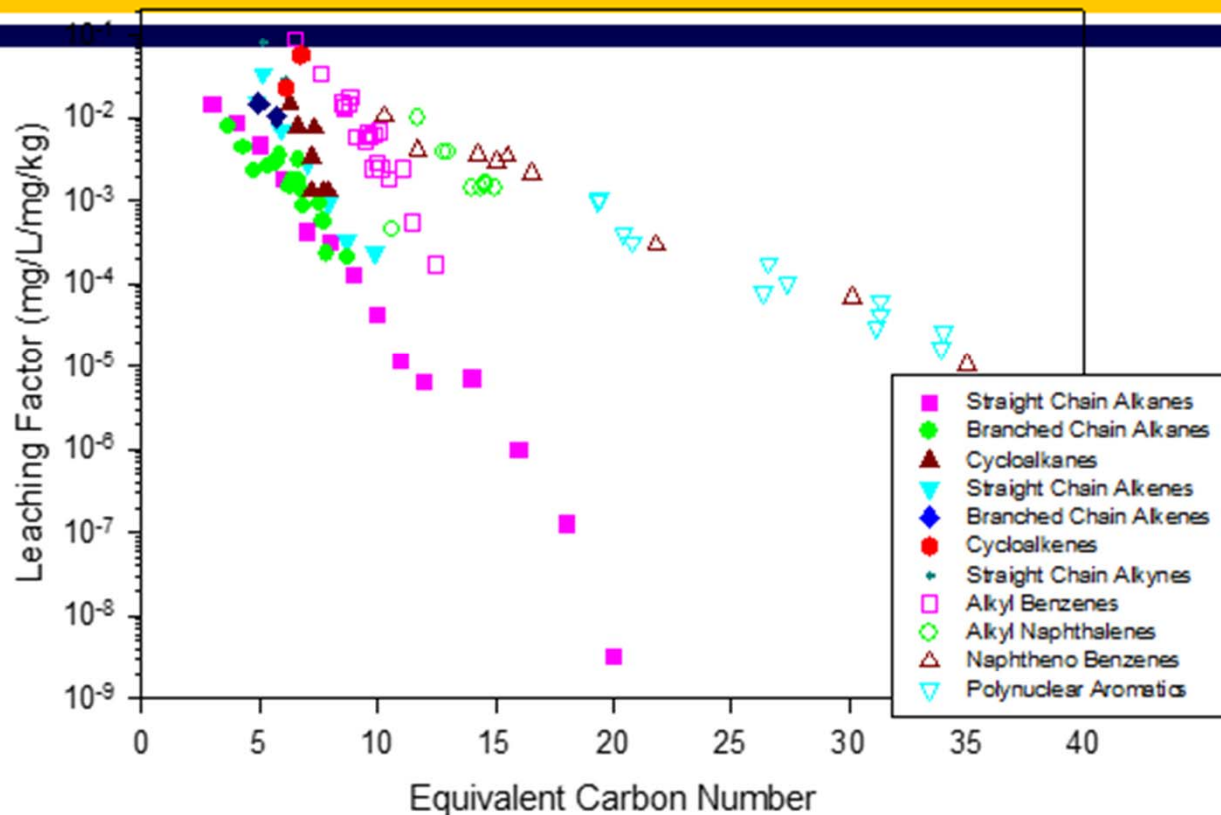
Carbon Number

Gasoline  
Diesel  
Crude

# Volatilization Factor by Homologous Series



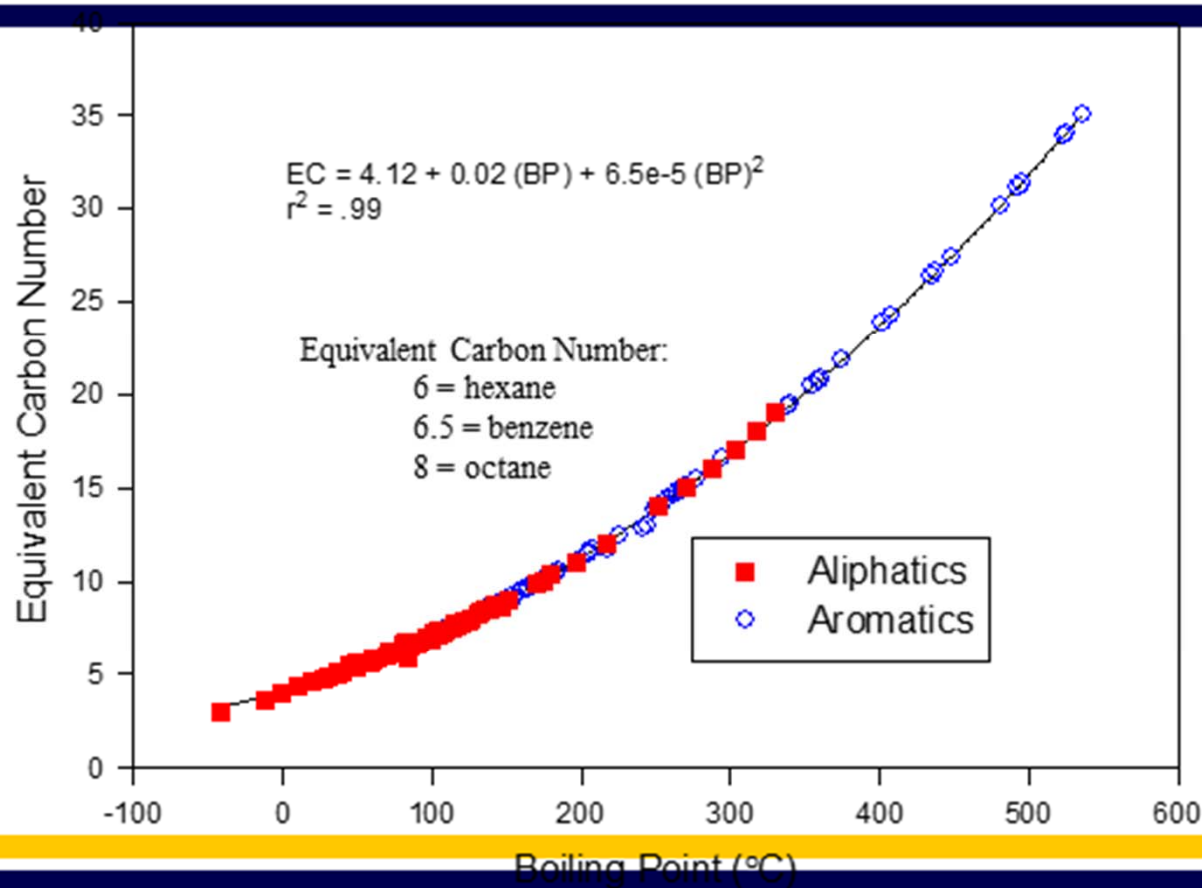
# Leaching Factor by Homologous Series



# Equivalent Carbon Number vs Boiling Point



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# 13 κλάσματα

## Hydrocarbon fraction

Carbon band range	Recommended petroleum hydrocarbon CoPC indicators and their EC values
Aliphatics EC5–EC6	n-hexane (6)
Aliphatics >EC6–EC8	n-heptane (7)
Aliphatics >EC8–EC10	n-octane (8) n-nonane (9)
Aliphatics >EC10–EC12	
Aliphatics >EC12–EC16	
Aliphatics >EC16–EC21	

Aromatics EC5–EC7	benzene (6.5)
Aromatics >EC7–EC8	toluene (7.6)
Aromatics >EC8–EC10	xylenes (8.6–8.8) ethylbenzene (8.5) 1,2,4- trimethylbenzene (9.8)
Aromatics >EC10–EC12	naphthalene (11.7)
Aromatics >EC12–EC16	2-methylnaphthalene (12.8) acenaphthylene (15.1) acenaphthene (15.5)
Aromatics >EC16–EC21	fluorene (16.6), anthracene (19.4), phenanthrene (19.4), pyrene (20.8)
Aromatics >EC21–EC35	benzo[a]pyrene (31.3) benzo[b]fluoranthene (30.1) benzo[k]fluoranthene (30.1) benzo[ghi]perylene indeno[1,2,3 cd]pyrene (35.0)



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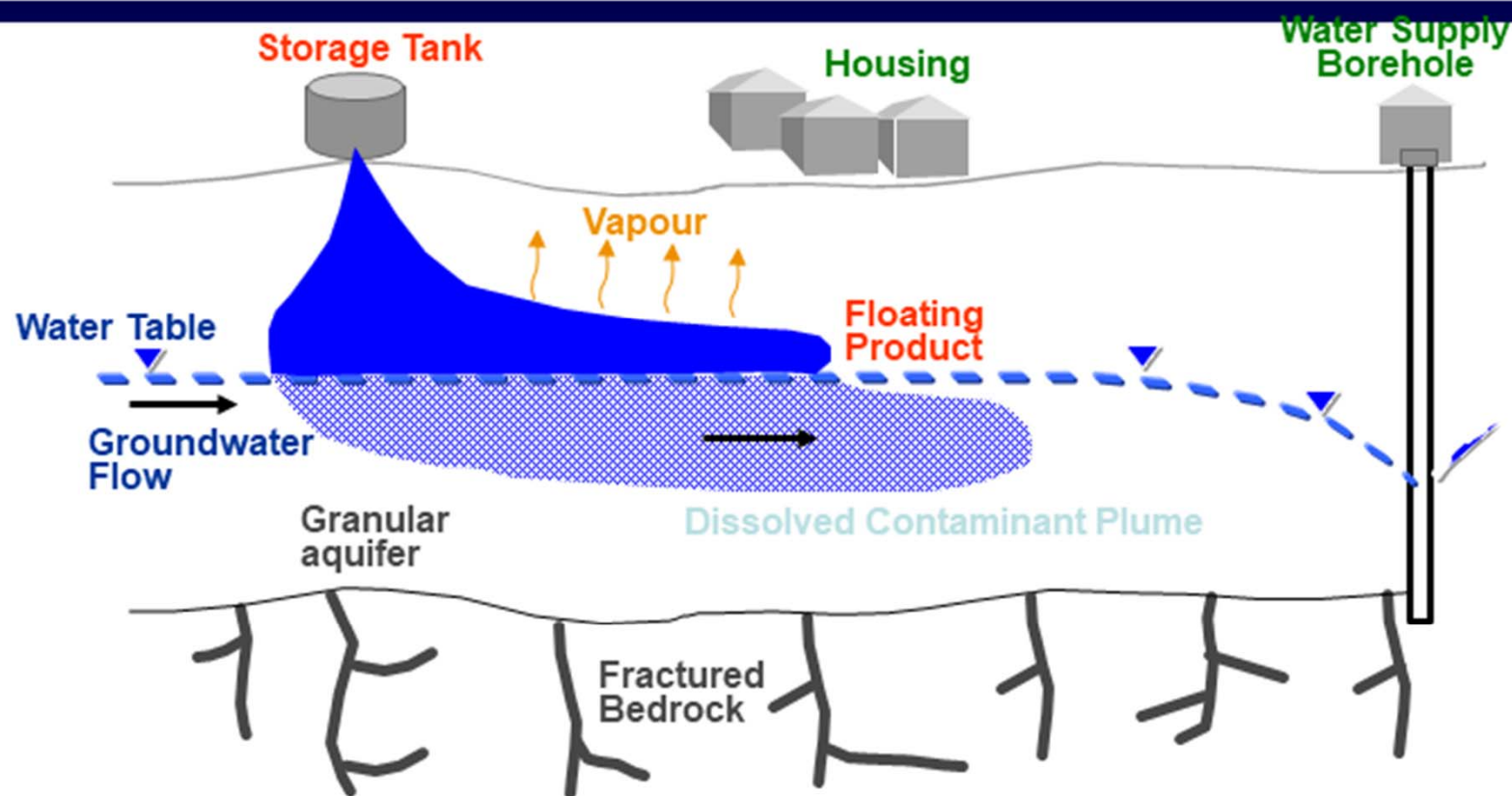


# Fate & Transport

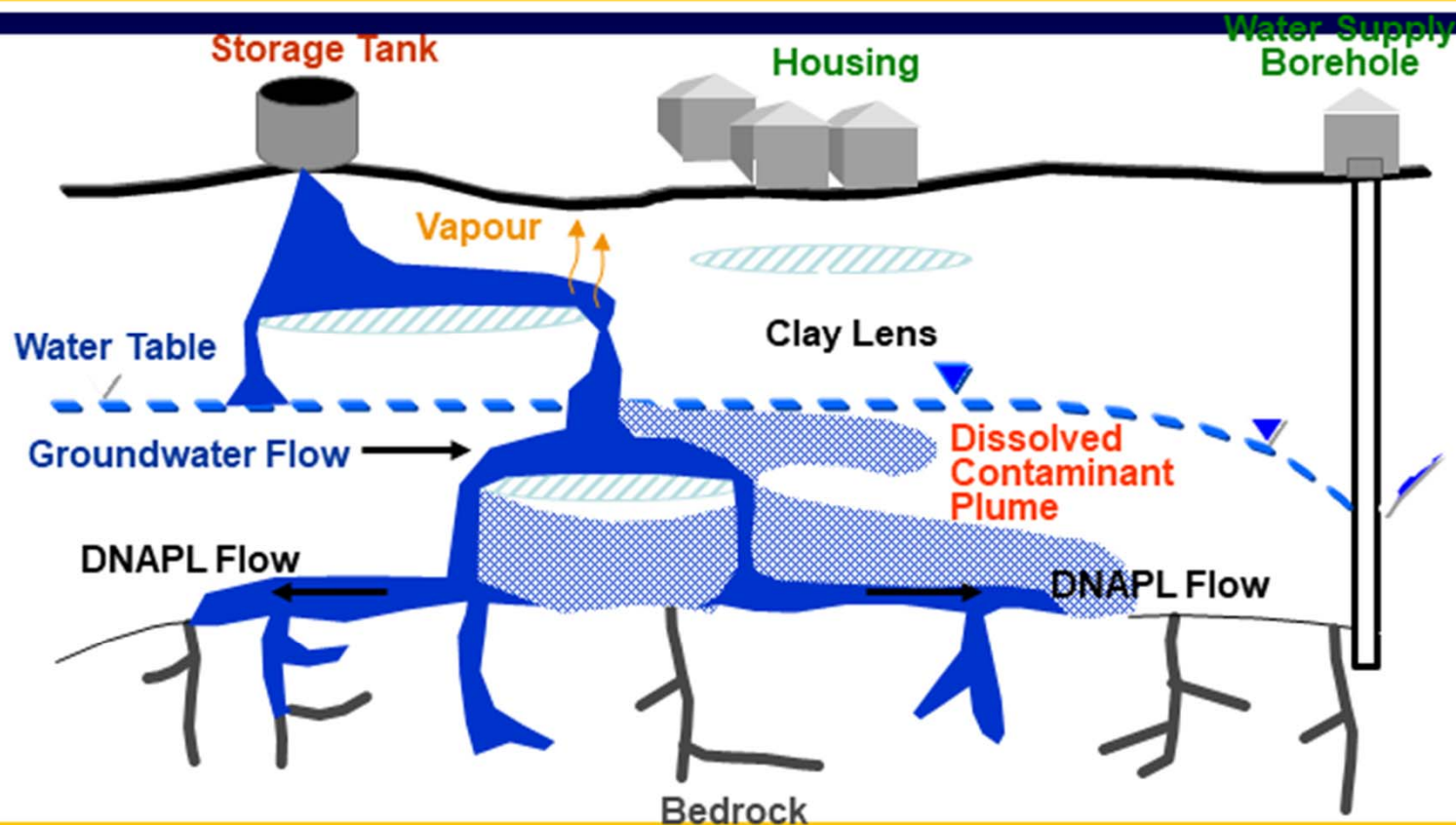
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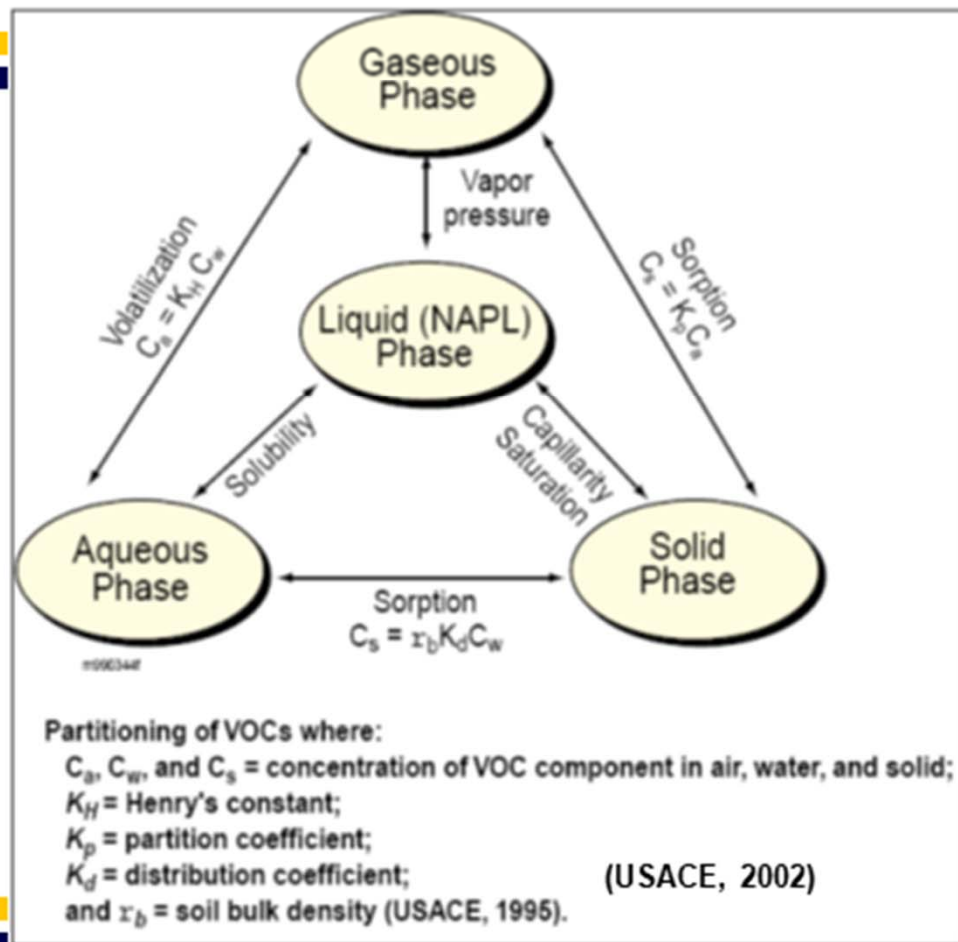
# Ελαφροί υδρογονάνθρακες LNAPL: Subsurface behaviour



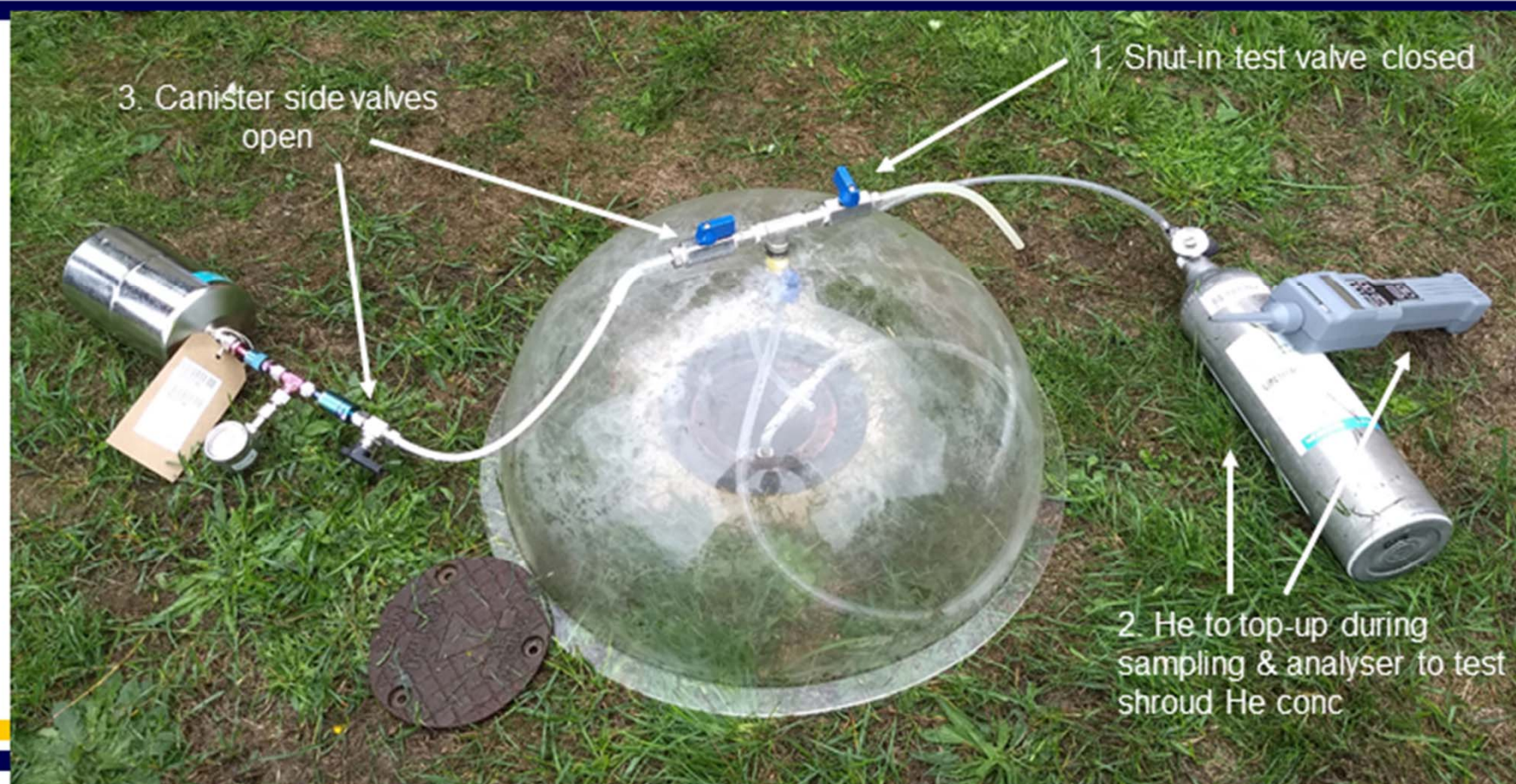
# Βαρυί υδρογονάνθρακες DNAPL: Subsurface behaviour



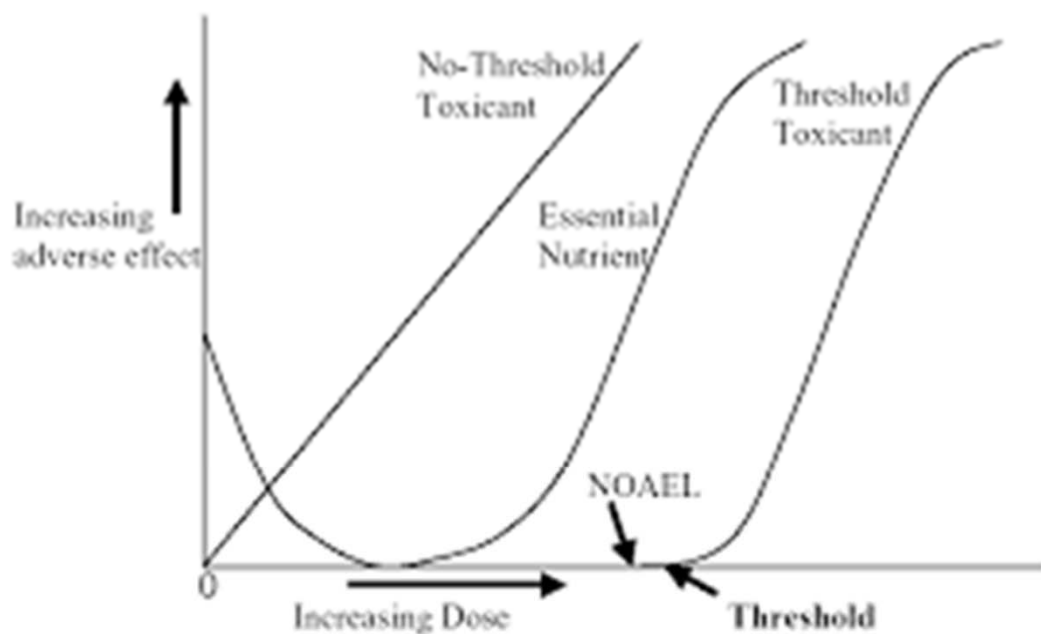
# διαμέριση Partitioning



# Vapour sampling



# Toxicology



# Fire fighting foams



## Class A



## Class B (class B fires—flammable liquids)

- Protein surfactants - biodegradable
- Synthetic surfactants – persistent
  - Alcohol-resistant Aqueous film-forming foams (AR-AFFF)
  - Aqueous film forming foams (AFFF)
    - Hydrocarbon-based surfactants (e.g. [sodium alkyl sulfate](#))
    - [fluorosurfactant](#) (PFAS e.g. [fluorotelomers](#), [perfluorooctanoic acid](#) (PFOA), or [perfluorooctanesulfonic acid](#)(PFOS))

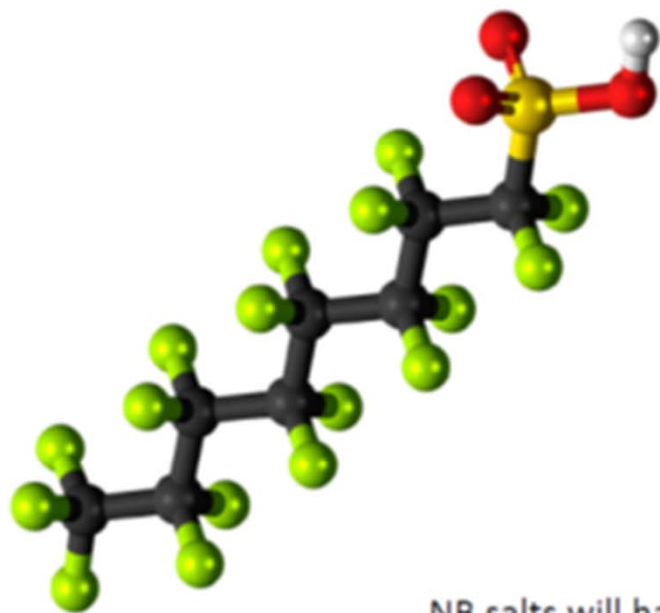
# Per- & Poly- fluoro alkyl substances persistent, bioaccumulative, toxic, soluble



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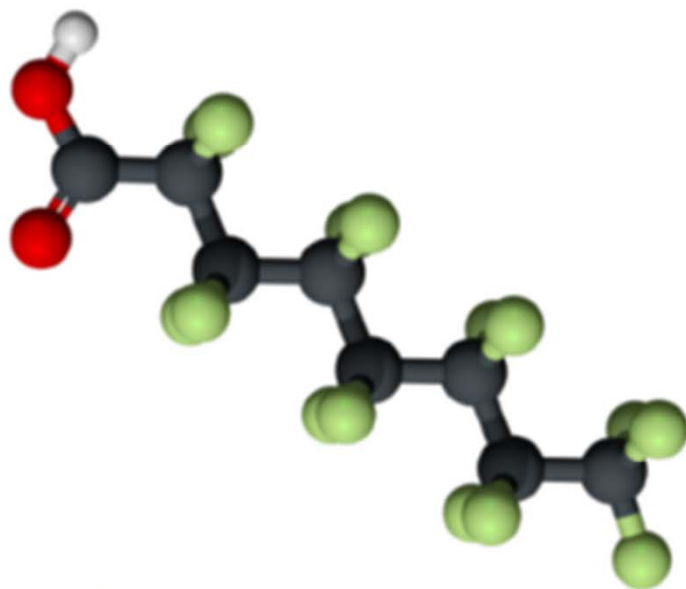
## PFOS

- CAS 1763-23-1



## PFOA

- CAS 335-67-1



NB salts will have different CAS numbers



# Pollution

- Leaky tanks
- Accidents from operation
- Corrosion/ defective joints in pipes

# Problem formulation

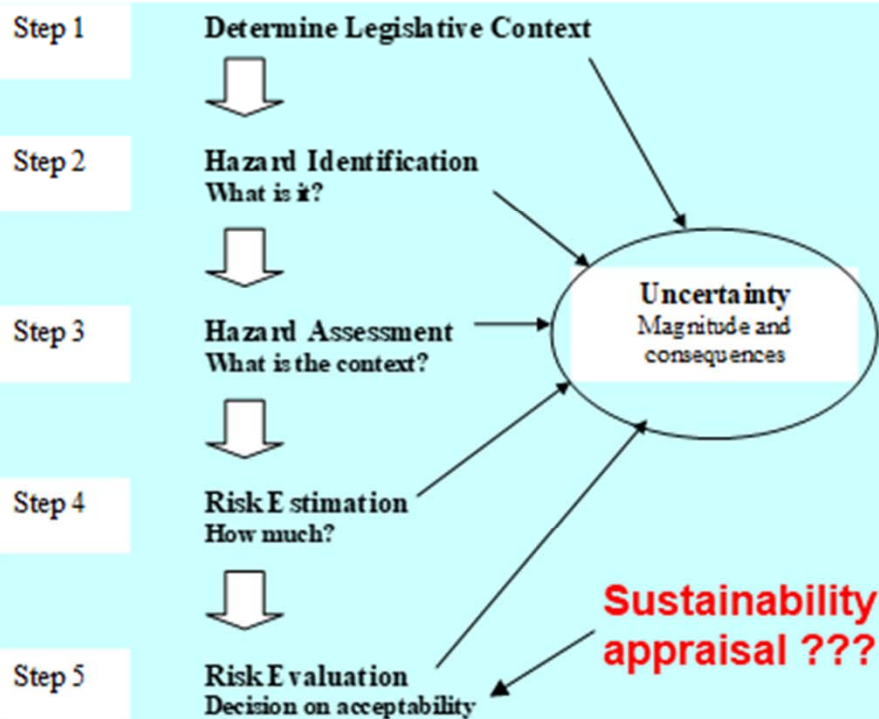
- Desk study
- Walkover
- Conceptual site model
- Preliminary risk assessment
- Design of intrusive investigation

# Risk based contaminated land management

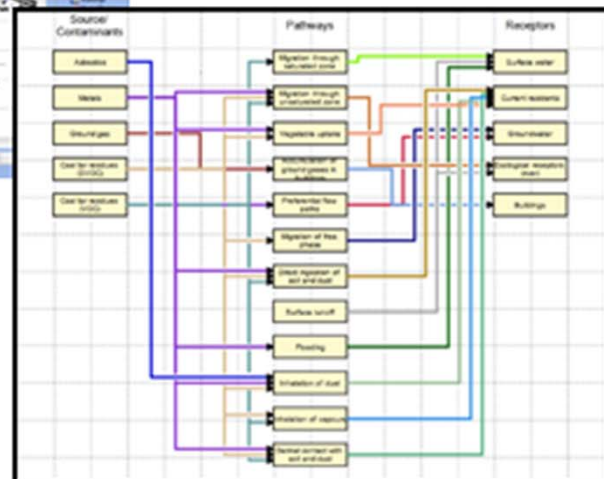
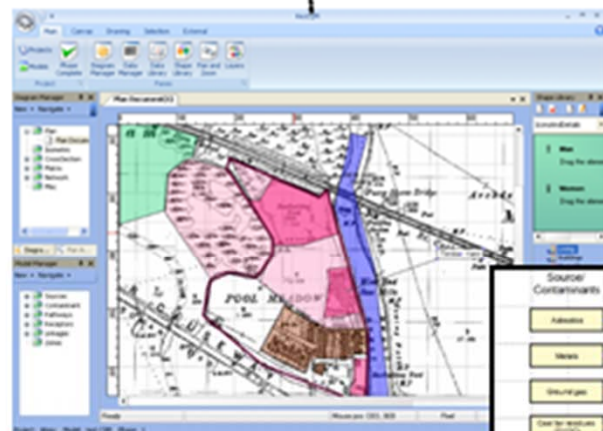


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## The process



## The method: conceptual site model



[www.lqcom.com](http://www.lqcom.com)

# Risk assessment

- Risk estimation =  $\frac{\text{Exposure}}{\text{Toxicology}}$
- Risk evaluation

# Exposure

- Soil
- Oral inhalation dermal

# Soil screening values/ target values

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- Dose – reponse relationship
- TPH CWG
- UK S4ULs

# The LQM/CIEH S4ULs



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## The LQM/CIEH S4ULs for Human Health Risk Assessment



Land Quality Management Ltd  
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- Generic Assessment Criteria for use in human health risk assessment
- Result of collaborative working
  - LQM & Chartered Institute of Environmental Health (CIEH)
  - Face-to-face workshop
  - On-line workshop
  - Local authorities, consultants & others (approx 50 people)

# S4ULs published for ...



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- Metals

- Arsenic
- Beryllium
- Boron
- Cadmium
- Chromium (III & VI)
- Copper
- Mercury
- Nickel
- Selenium
- Vanadium
- zinc

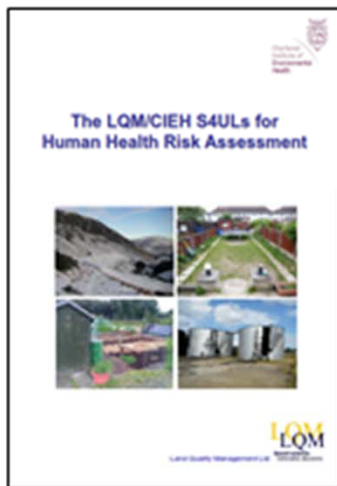
- Petroleum Hydrocarbons

- 16 fractions



- Polyaromatic Hydrocarbons

- USEPA 16





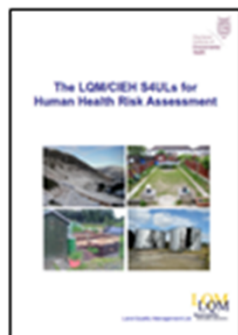
# S4ULs published for ...



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- Chloroalkanes & alkenes

- 1,2-Dichloroethane
- 1,1,1-Trichloroethane
- 1,1,2,2- and 1,1,1,2- Tetrachloroethanes
- Tetrachloromethane
- Trichloroethene
- Trichloromethane
- Chloroethene



- Explosives

- 2,4,6-Trinitrotoluene
- RDX & HMX



- Pesticides

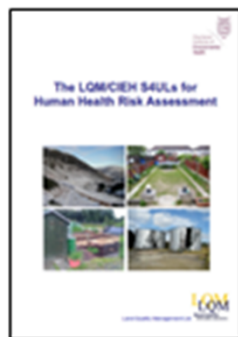
- Aldrin & Dieldrin
- Atrazine
- Dichlorovos
- Endosulfans
- Hexachlorocyclohexanes

# S4ULs published for ...



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- Chlorobenzenes
  - Chlorobenzene
  - Dichlorobenzenes (3)
  - Trichlorobenzenes (3)
  - Tetrachlorobenzenes (3)
  - Pentachlorobenzenes
  - Hexachlorobenzene
- Phenol & Chlorophenols
  - Phenol
  - Chlorophenols (4)
  - Pentachlorophenol
- Other
  - Carbon disulphide
  - Hexachlorobutadiene



# Sustainable remediation



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The screenshot shows a web browser window displaying the ISO website. The browser's address bar shows the URL: <https://www.iso.org/standard/62688.html>. The page header features the ISO logo and the text "International Organization for Standardization" and "When the world agrees". Below the header, there are navigation links for "Standards", "All about ISO", "Taking part", and "Store". A search bar is also present. The main content area displays the title "ISO 18504:2017" with a "Preview" button and the subtitle "Soil quality -- Sustainable remediation". A description of the standard is provided, followed by a "Buy this standard" section with options for "Format" (PDF + ePub, Paper) and "Language" (English). The price is listed as CHF 118 with a "Buy" button. The Windows taskbar is visible at the bottom of the browser window.

ISO 18504:2017 provides procedures on sustainable remediation. In particular, it provides:

- standard methodology, terminology and information about the key components and aspects of sustainable remediation assessment;
- informative advice on the assessment of the relative sustainability of alternative remediation strategies.

ISO 18504:2017 is intended to inform practitioners about contemporary understanding of sustainable remediation. It is not intended to prescribe which methods of assessment, indicators or weights to use. Rather, it is intended to inform consideration of the concept of

Buy this standard

Format	Language
<input checked="" type="checkbox"/> PDF + ePub	English
<input type="checkbox"/> Paper	English

CHF 118 Buy

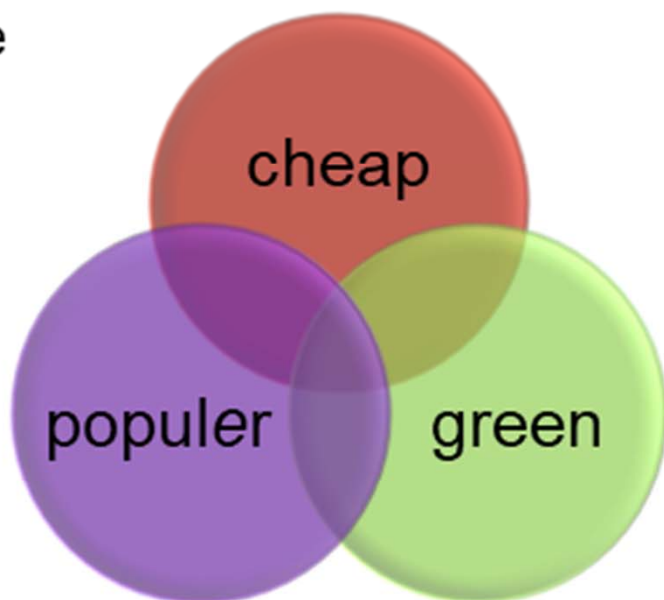
# Sustainable Remediation



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## Essential

- Breaks the linkage
- On time
- On budget
- Bells
- whistles



## Desirable

- As (cheap, green, populer) as possible

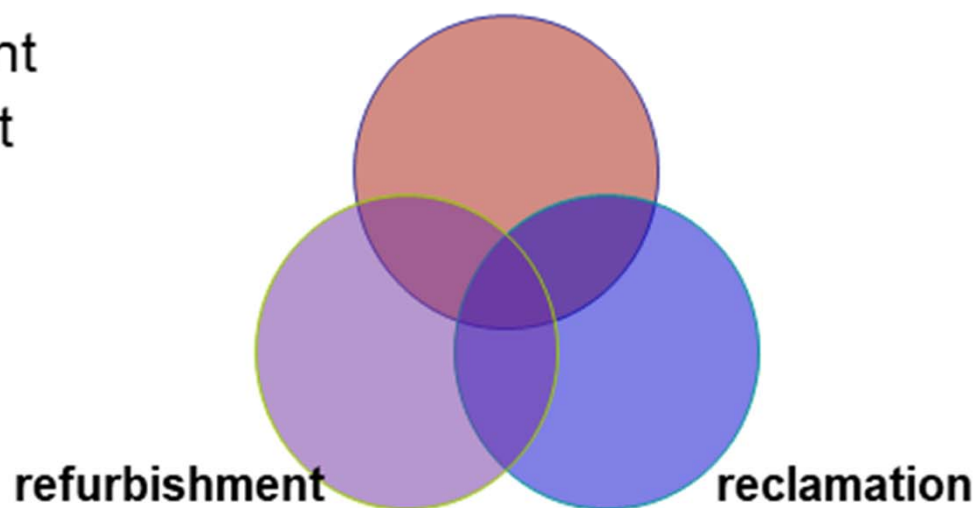
# Remediation is not enough



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- Remediation
- Reclamation
- Recycle
- Redevelopment
- Refurbishment
- Reuse
- Redeploy
- Regenerate
- Revitalise
- **RENEW**

The sum must be greater  
than the parts  
**remediation**



καλή επιτυχία!



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