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Emerging Environmental Liabilities: Identification, Management and Multi-jurisdictional Issues

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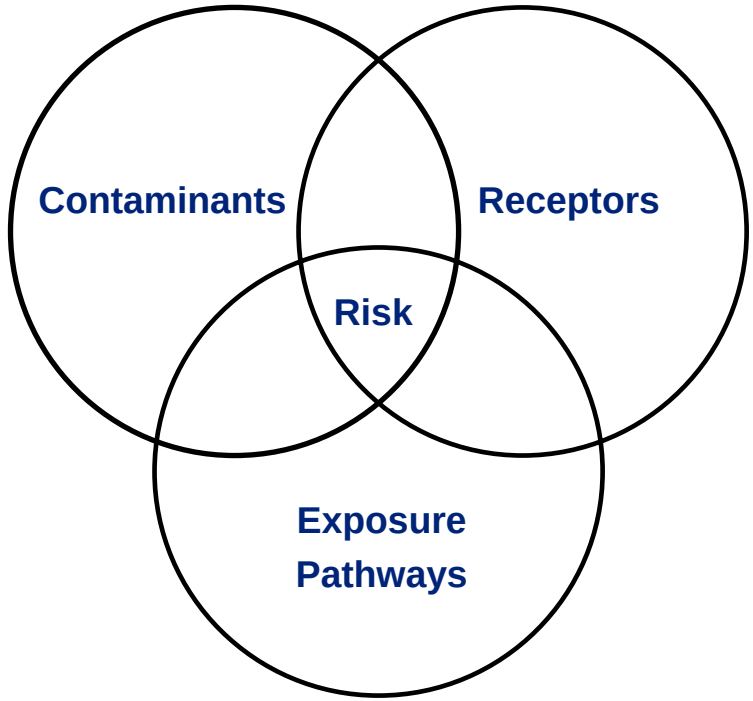
Overview

- General Introduction
- The Elements of Emerging Issues: Chemistry, Occurrence, Risk and Regulations
- Emerging Liabilities Case Study: MTBE
- Emerging Liabilities Case Study: Perchlorate
- Potential Implications
- Recommendations for Management

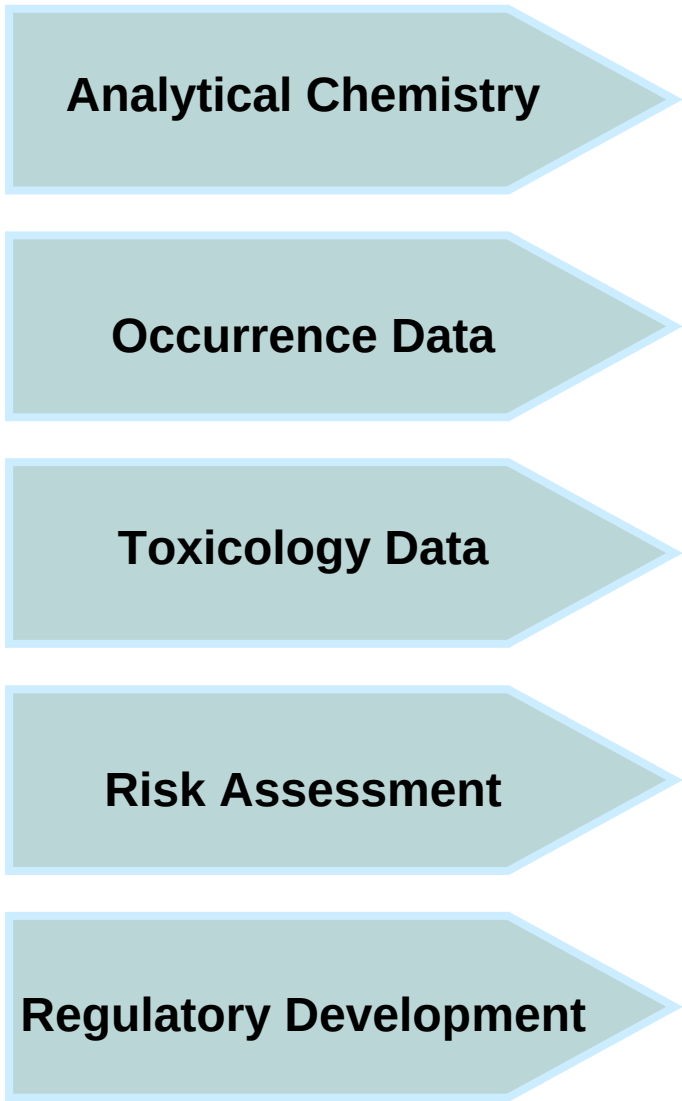
- Emerging Environmental Liabilities:
  - An environmental risk (either real or perceived) that was previously unknown to the general public, government bodies, and/or industry.

Risk Components

- General Public Perception – if chemical is present (at any concentration) then it will pose an adverse health effect.
- Perceived Risk = Scientific Risk + Outrage
- The public pays too little attention to scientific risk, while the experts pay absolutely no attention to outrage



Five Components of Emerging Issues



Method Development
Detections of new chemicals at some level
Interpretation of Data near detection limits
Matrix interferences

Which media
What locations – point source vs. non point source
What levels or concentrations
Localized vs. Population level exposures

Existing data available
New data required
Acute/Chronic exposures
Types of Effects
Sensitive subpopulations

Hazard, Pathway, Receptor
Public Health and Safety
Method development

Science
Stakeholders
Media of Concern
Economic Implications
Regulations and Enforcement

Emerging Contaminants - Who is Potentially at Risk?

- Industrial Producers
- Industrial Distributers
- Product End User
- Water Utilities (either public or private)
- General public
- Governments

What Makes a Significant Emerging Contaminant?

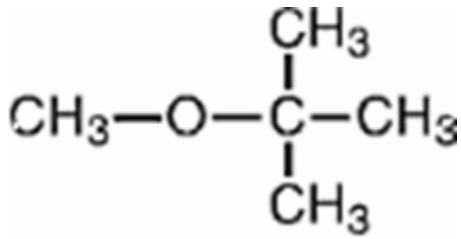
- New toxicological evidence
- Change in regulatory standard
- Change in analytical method (lower detection limit)
- New chemical or increase in production
- Heightened public awareness
- New legal theories

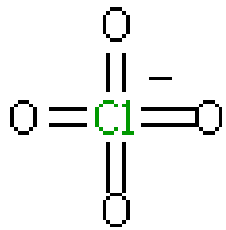
What Makes a Chemical of Significance?

SOURCE	PATHWAY	RECEPTOR
High volume	Mobile	Toxic
Widespread use	Resistant to biodegradation	Other public health concern
Factual	Scientific	Medical Perception

Emerging Chemicals of Significance

- Fuel oxygenates – **MTBE***, TBA
- Rocket propellants – **perchlorate*,** NDMA
- Metals - hexavalent chromium and arsenic
- Radionuclide – radon
- Naphthenic acids (oilsands)



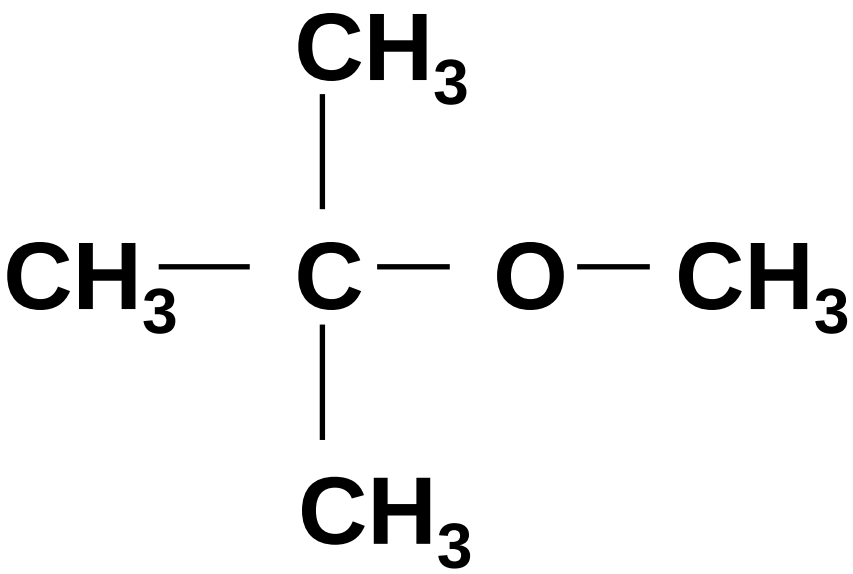


Emerging Contaminants of Significance

- Solvent Additives – 1,4-dioxane and 1,2,3 TCP
- Pesticides – 1,2,3 TCP
- Pharmaceuticals and other endocrine disruptors
- Biological agents – viruses and bacteria
- Polybrominated diphenyl ethers (PBDE)
- Fluoropolymers (Teflon) byproduct
- Ethoxylate Surfactants
- And ???

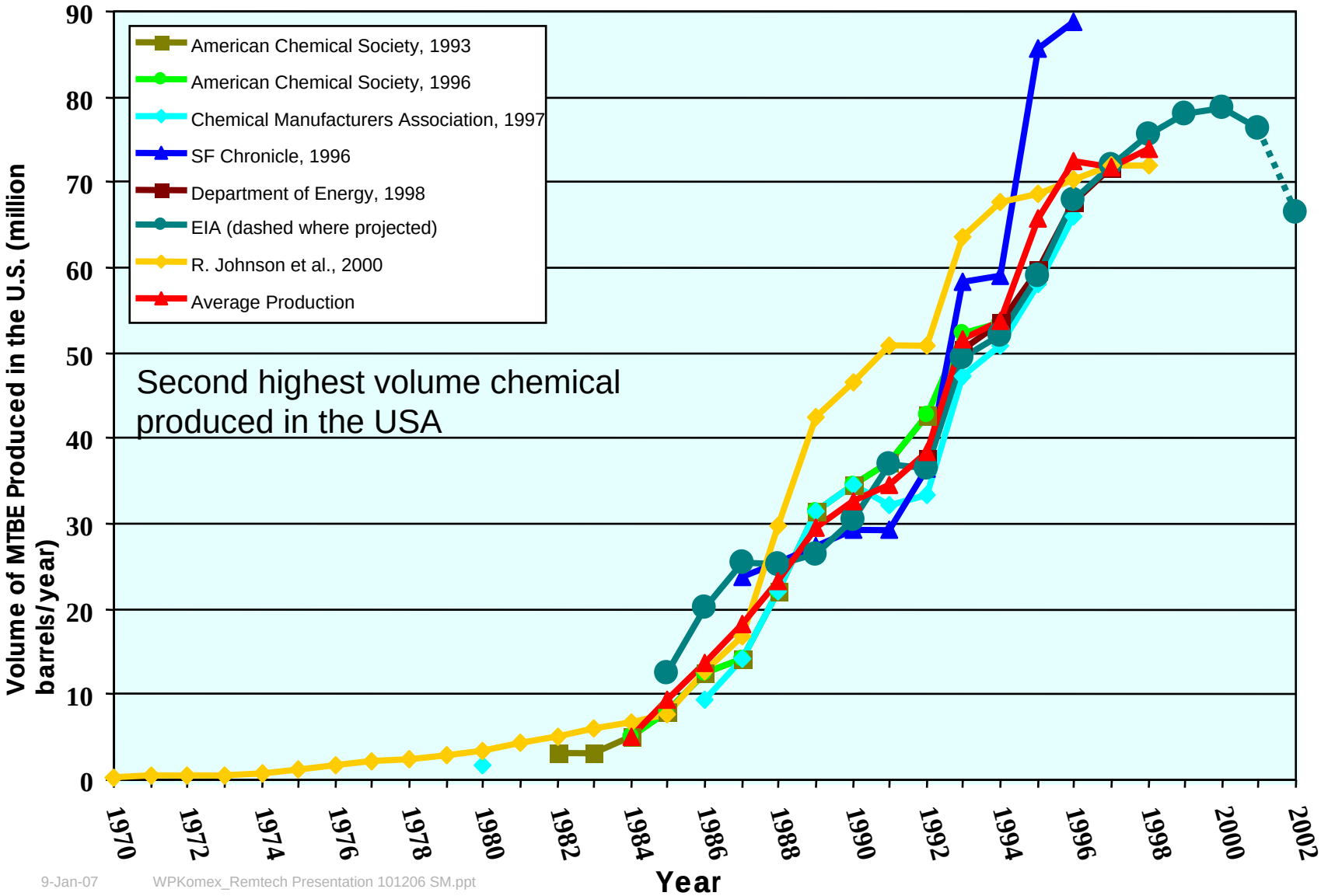
MTBE and Other Fuel Oxygenates

Methyl tertiary Butyl Ether (MTBE)



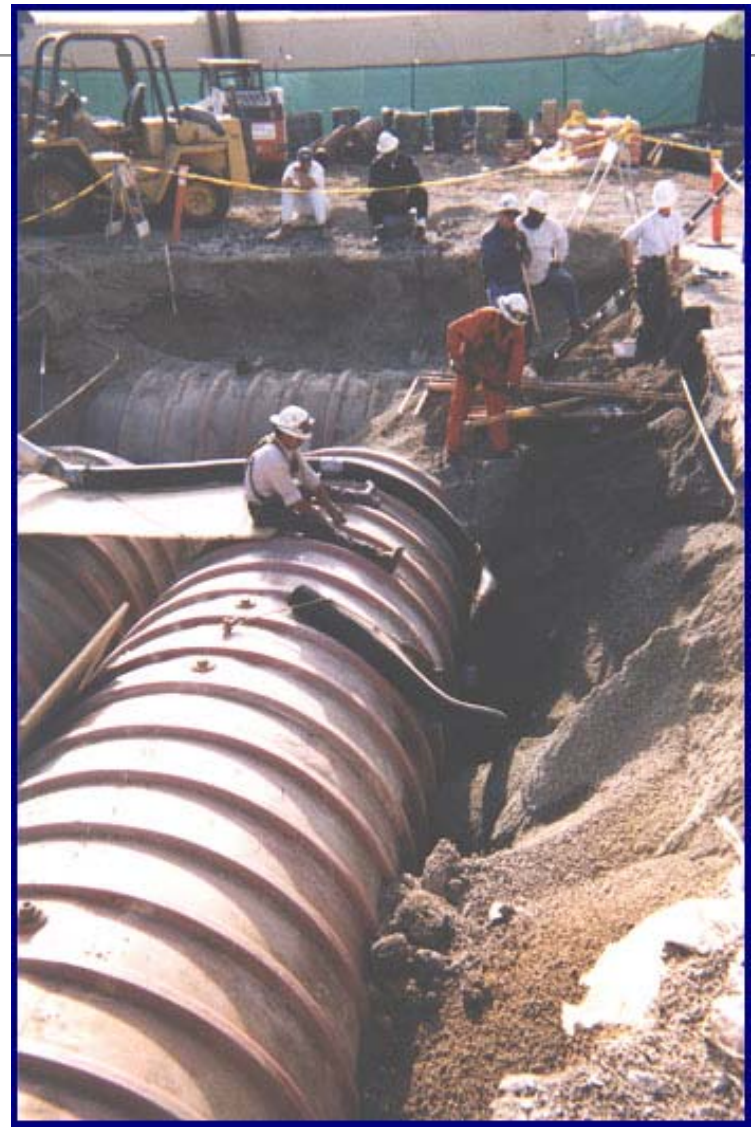
- Used since late 1970s as octane enhancer as part of lead phase-out
- Used since 1992 as an oxygenate in reformulated gasoline (11% to 15% vol./vol.)
- Adds oxygen (2+% by weight) to enhance combustion and reduce emissions

MTBE Production



Steel USTs

Fiberglass USTs



UST Removal

Impact to Drinking Water Supplies in United States

- Approximately 125,000 public wells nationwide
- Estimate 500 to 2,700 public wells to be contaminated with MTBE at 5 ppb or greater
- About 15,000,000 wells nationwide
- 50,000 - 500,000 private wells estimated to be contaminated by MTBE at 5 ppb or greater
- EPA reports 415,000 “confirmed releases (at USTs) … and about 150,000 UST sites remaining to be cleaned up”

The Cost to Address ($USD)

- Public wells – $1 to $33 billion
  - Santa Monica alone ~$350 million
- Private wells – $2 to $16 billion
- LUSTs - $28 to $92 billion
- Total - $30 to 142 billion
- Does not consider LUSTs closed without MTBE testing, bulk plants, terminals, pipelines, refineries, other sources.
- Does not consider non-technical costs (e.g. legal)

MTBE Litigation ($USD)

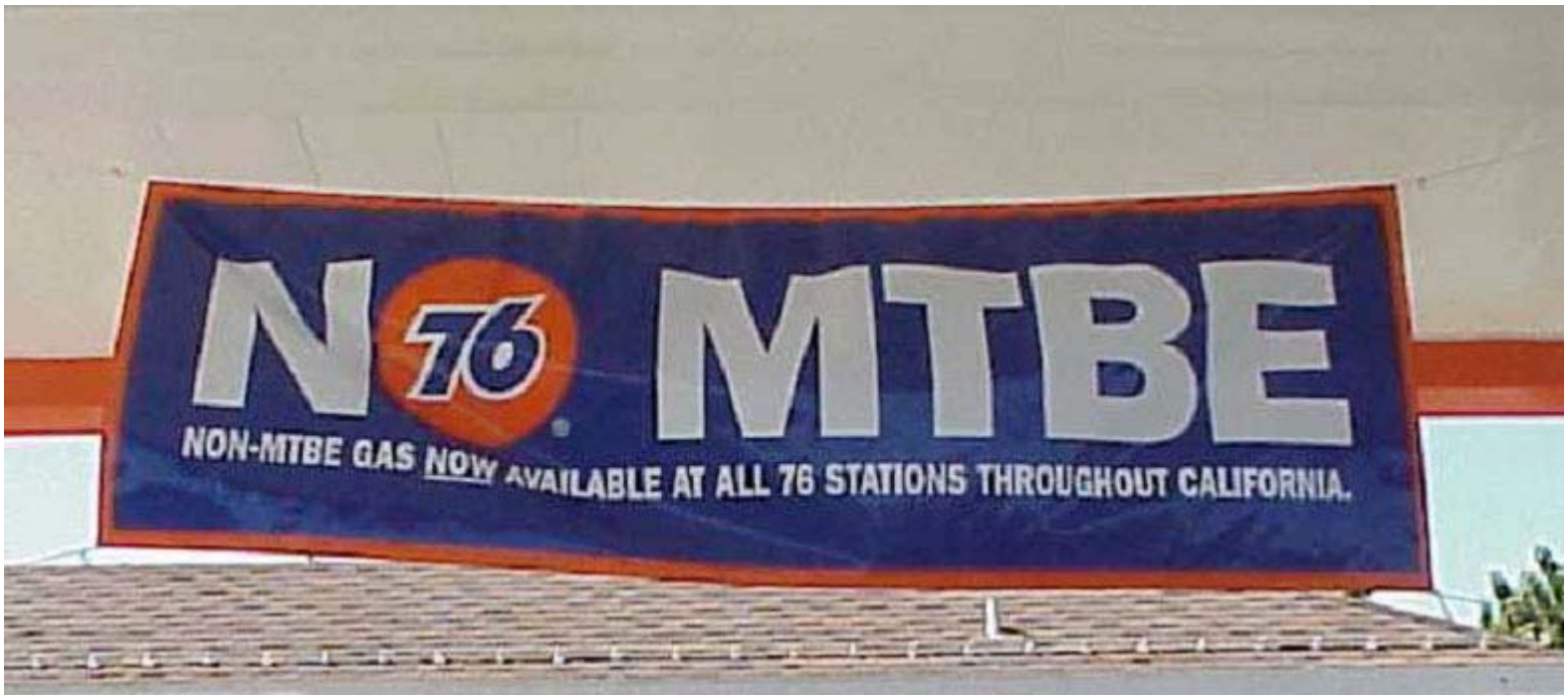
• Santa Monica, Charnock	$320,000,000
• Santa Monica, Arcadia	$30,000,000
• Tahoe	$69,000,000
• Orange County	$8,000,000
• Morro Bay	$3,000,000
• Cambria	$9,000,000
• Dinuba	$7,000,000

- >150 other lawsuits related to MTBE in the USA

Is MTBE a Significant Contaminant?

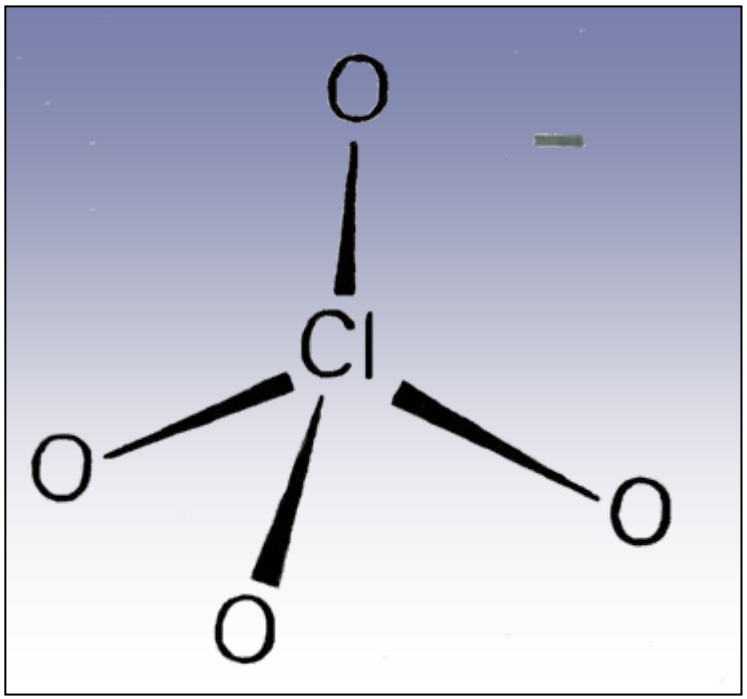
High volume ☑	Mobile ☑	Toxic ☑
Widespread use ☑	Resistant to biodegradation ☑	Other public health concern ☑
Factual	Scientific	Medical Perception

A Happy Ending
Or Too Little Too Late?



Perchlorate

Perchlorate Ion



- Perchlorate is a compound containing one chlorine atom and four oxygen atoms.
- Formed by dissociation of perchlorate salts in water

NaClO4 (s) ↔Na+ (aq) + ClO4- (aq)

Physical-Chemical Properties

- Very high solubility in aqueous solution (2.09 kg/L for NaClO4-) and is unaffected by pH or temperature.
- Low association with cations responsible for the extremely high solubilities of perchlorate salts.
- Very low potential for volatilization and has negligible vapour pressure.
- Perchlorate ion is abiotically stable in even very reducing environments (Eh < 200 mV).
- Thermal decomposition temperature ranging from 400 to 600 ºC.

Natural Sources

- Chilean fertilizer deposits
- New Mexican potash
- Canadian potash
- Californian hanksite
- Bolivian playa crusts

Anthropogenic Sources

- Rocket Fuel
- Fireworks
- High explosives
- Flares
- Herbicides
- Automobile airbags
- Tracer munitions
- Detergents ?

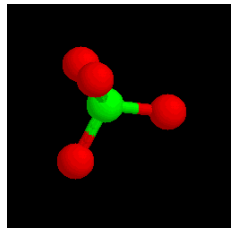
The typical perchlorate manufacturing process is as follows:

•NaCl (s) ↔ NaClO3 ↔ NaClO4 ↔NH4ClO4

PERCHLORATE USE

- Solid rocket propellant (50% AP)
- Explosive and Munitions
- Pyrotechnics, fireworks, munitions
- Air bag inflators/other charges
- Nuclear reactors/electronic tubes
- Additives in oils
- Laboratories: perchloric acid
- Chilean Nitrate Fertilizers
- Evaporite Deposits
- Others?

HISTORY OF USE

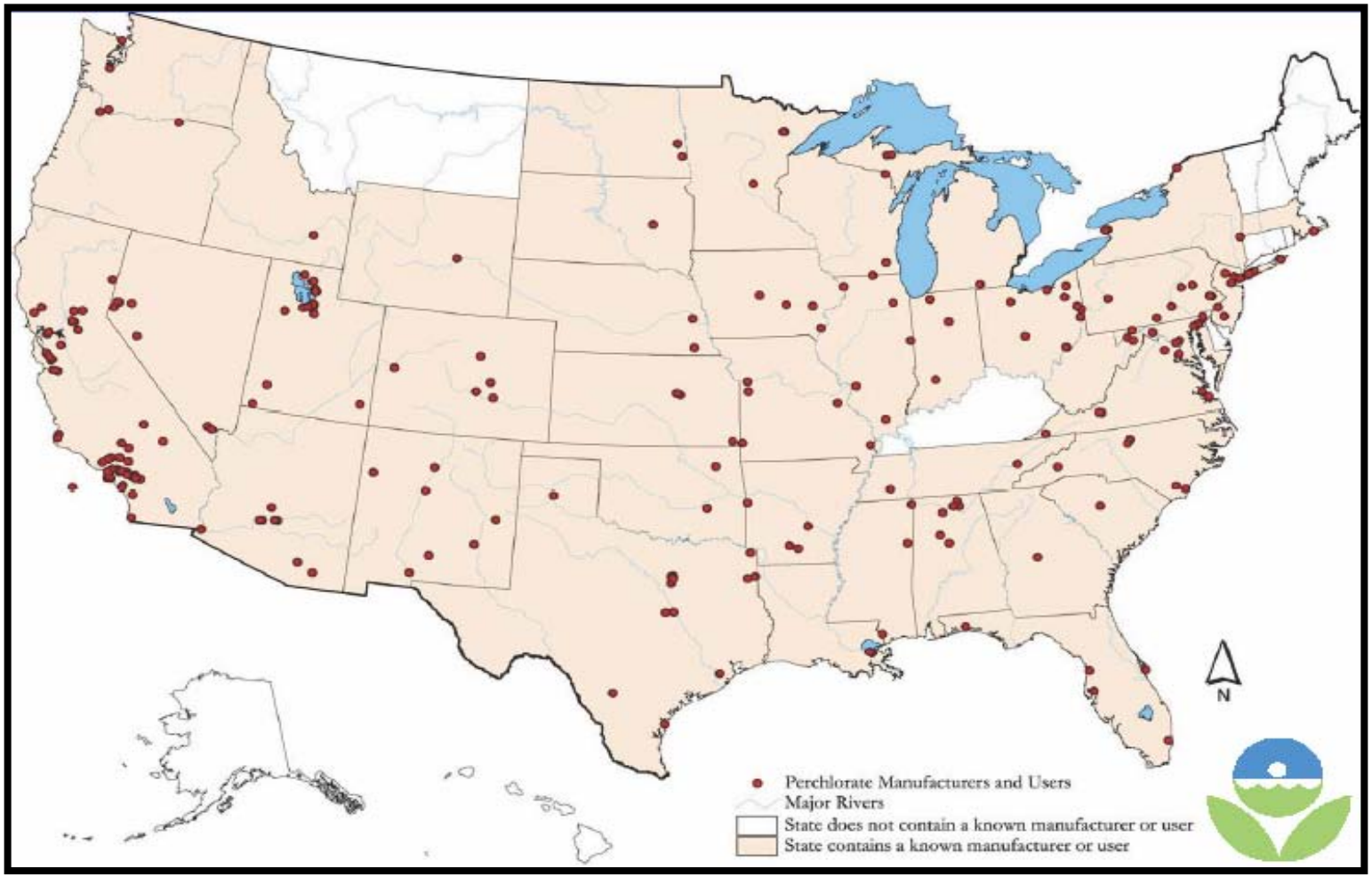


- 1908 1st manufacture
- WWII: significant advances in solid propellants
- 1948: Aerojet change from $KClO_4$ to AP
- 1950s –1990s Cold War/Space Races
- 1997: DHS DL 400 >> 4 ug/L
- 1999 - 2002: ~16.5 million lb/yr produced

Perchlorate Primer

- In 1985, perchlorate contamination discovered in monitoring wells at California Superfund Sites
- Contamination of Water sources in US at national scale not recognized until 1997
- > 11 million people have perchlorate in public water supplies at concentrations > 4 ug/L
- National DW standard does not exist in US or Canada
- Various Stakeholders are involved in developing standards
- National Academy of Sciences Review
- Potential Implications and Liabilities are excessive

SOURCES

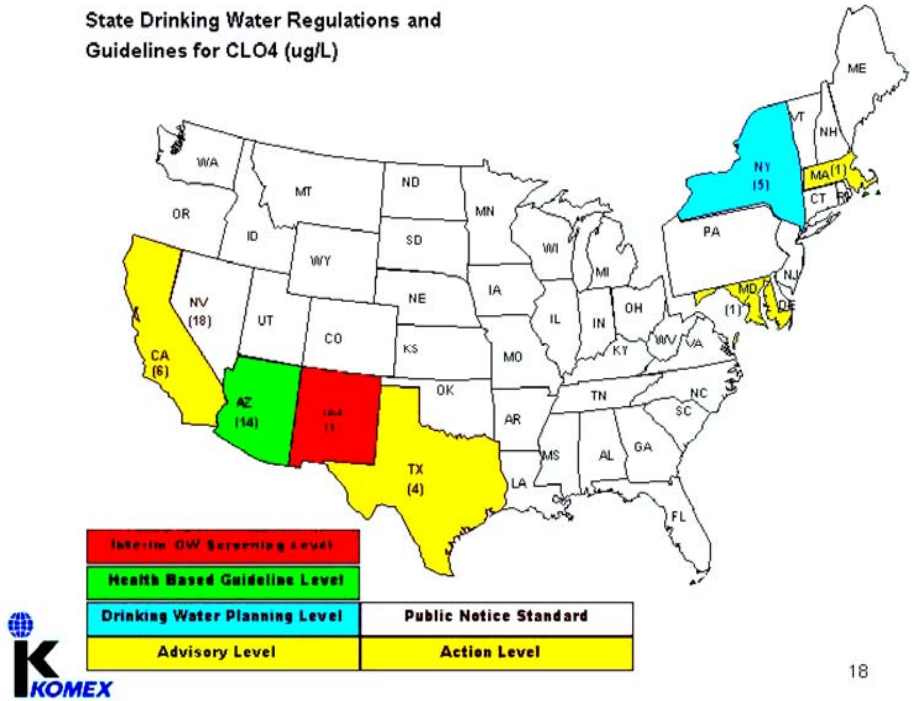

N
Perchlorate Manufacturers and Users
Major Rivers
State does not contain a known manufacturer or user
State contains a known manufacturer or user

Analytical Methods

- A key driver in development of ClO4- regulations
- Electrochemical methods, gravimetric methods used historically – many interferences and high MDLs
- EPA Method 314.0 – Introduced around 1997
  - Ion chromatography/conductivity detector
- MDLs – 1-2 ug/L using EPA 314.0

Regulations – United States

- Drinking Water Standards
  - National standard not established but USEPA examining need
  - State DW standards in eight states range from 1 to 18 ug/L
  - California – Public Health Goal of 6 ug/L for DW



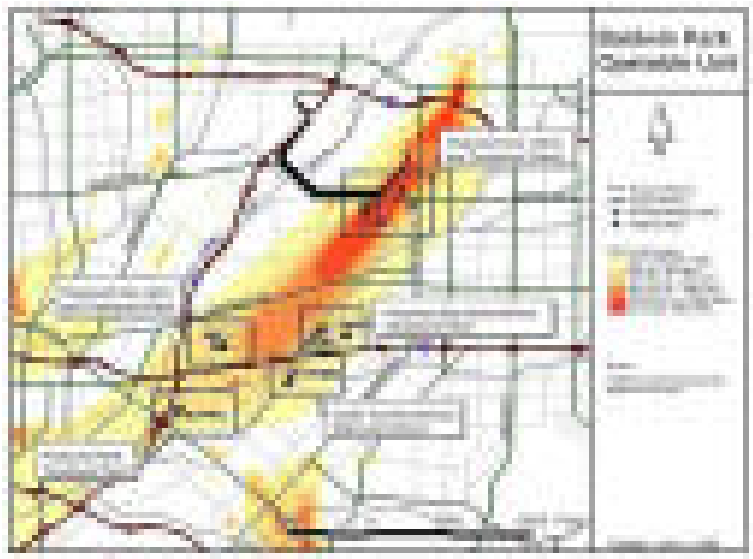
Regulations – United States

- Remediation Standards – National standards don't exist, set on site by site basis.
  - Preliminary clean up goal of 24.5 ug/L established in 2006
  - Final clean up determinations take site-specific information into consideration

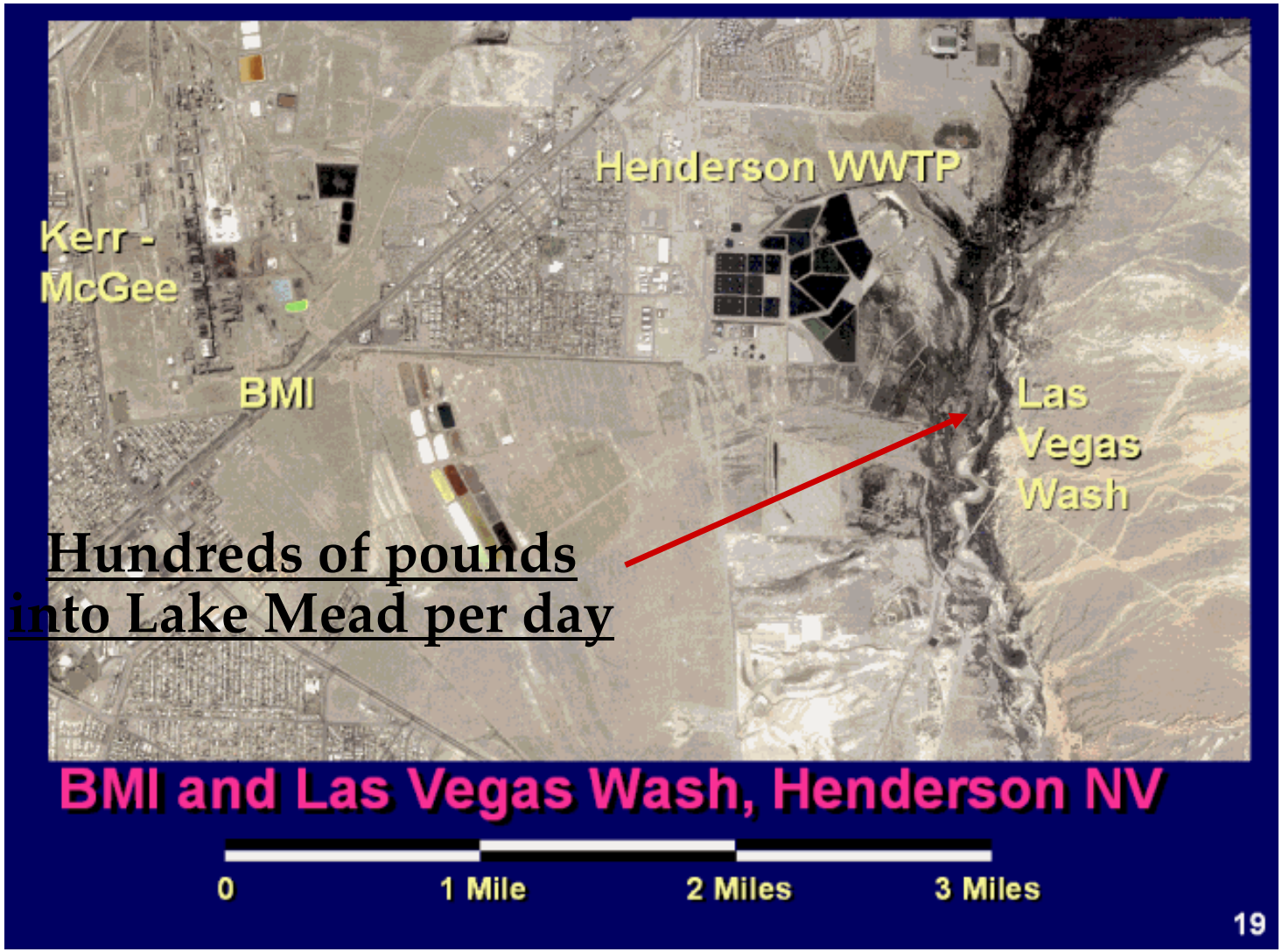
- Water Discharge Standards – National Pollutant Discharge Elimination System (NPDES)
  - ClO4- limits set for known producers

FATE AND TRANSPORT

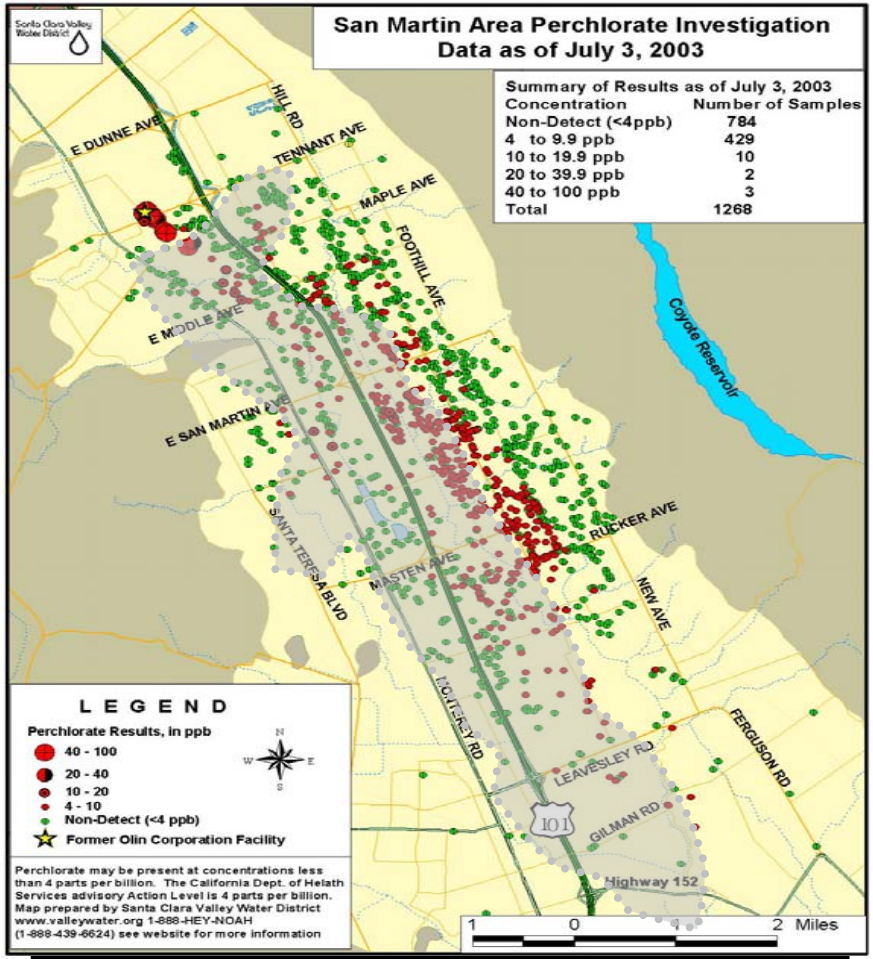
- Large source terms for ClO_4
  - ClO_4^-: Aerojet: ROD: 150,000,000 lbs in groundwater, Kerr McGee >2,500 lb/day removed
- High solubility
- Mobile in groundwater (salt)
- Low biodegradation potential



Perchlorate in Colorado River

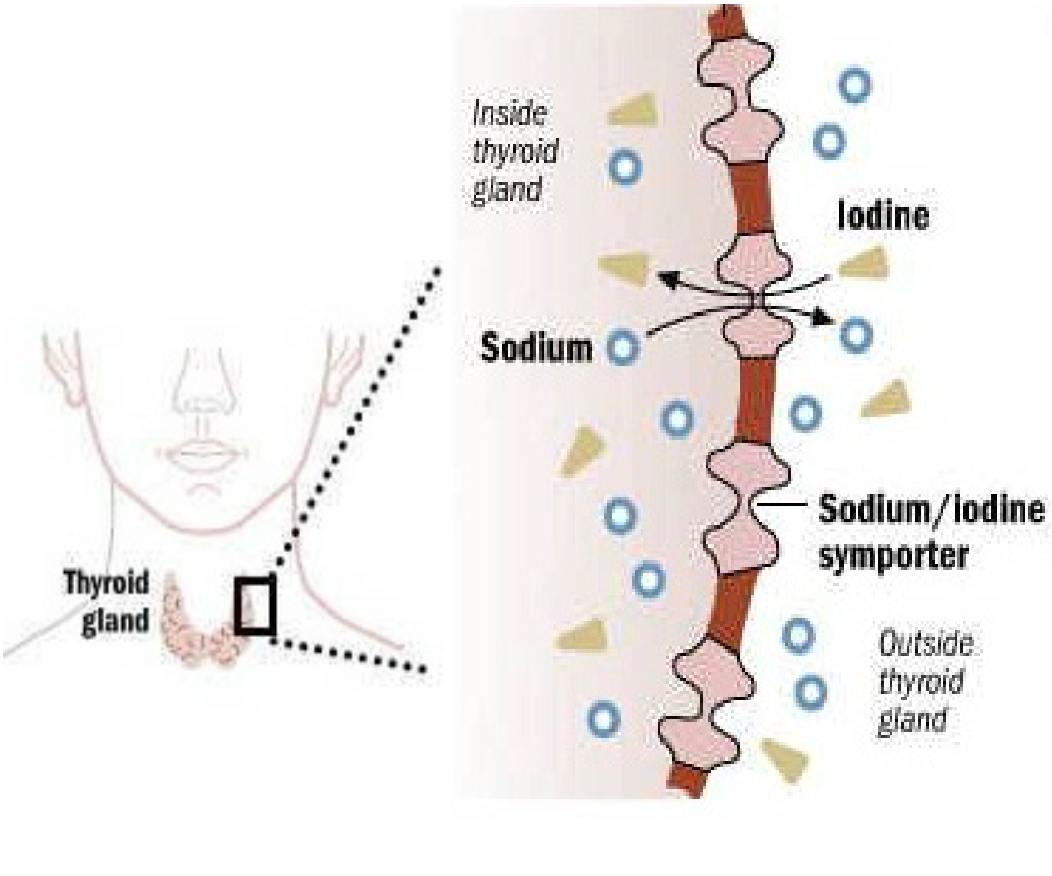


LOCAL ISSUES

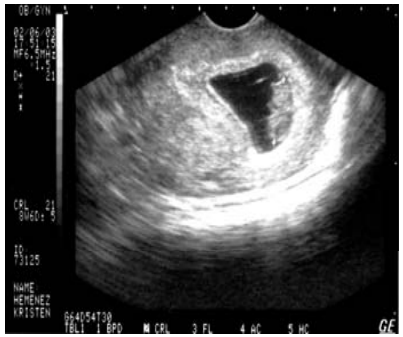


ClO_4^-: 23 wells > 6 ug/L

>400 private wells


Thyroid gland
Inside thyroid gland
Iodine
Sodium
Sodium/iodine symporter
Outside thyroid gland
Perchlorate

POTENTIAL PERCHLORATE TOXICITY



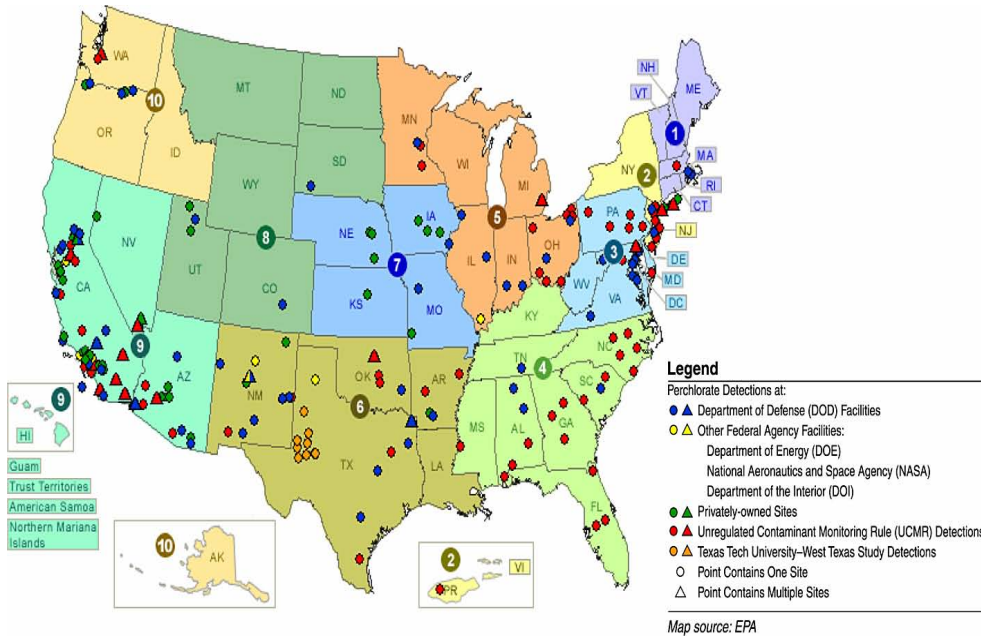
- Low doses may affect child development
- Causes developmental problems in sensitive ecological receptors
- Taken up by plants and stored in leaves – ingested by foragers
- Ecological health effects relatively unknown

Is Perchlorate a Significant Contaminant?

High volume ☑	Mobile ☑	Toxic ☑
Widespread use ☐	Resistant to biodegradation ☑	Other public health concern ☑
Factual	Scientific	Medical Perception**

Unregulated Contaminant Monitoring Rule (UCMR)

- Established in 1999 under the Safe DWA
- 3-tiered system for unregulated contaminants based upon analytical methods and contaminant properties
- Candidate Contaminant Lists (CCL) Established in 1998
- Perchlorate detections occurred in areas without a known source
- Largest contiguous ClO4- plume in US discovered with UCMR sampling (>50,0000 km2) in West Texas

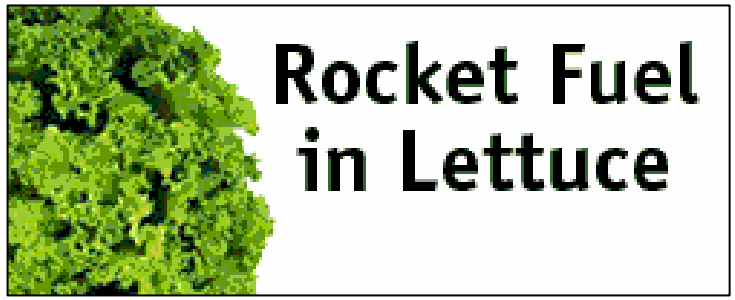


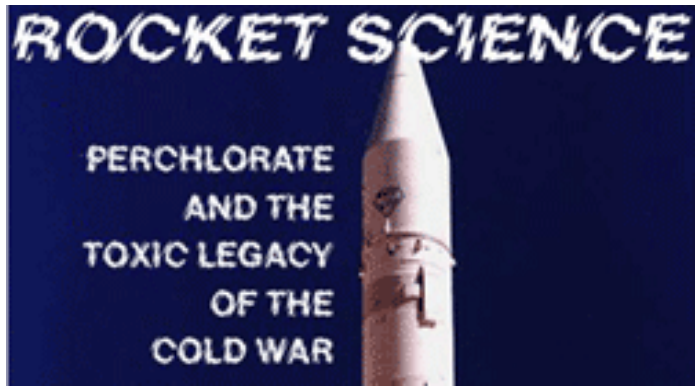
National Academy of Science Review (Jan 2005)

- Reviewed USEPA 2002 Perchlorate Risk Characterization
- Reviewed current state of science regarding thyroid function and perchlorate exposure
- Perchlorate does not appear to be as hazardous as USEPA scientists estimated but is more harmful than industry contends.
- USEPA adopted NRD RfD which would correspond to a MCL of 24 ug/L
- USEPA has not set a MCL in drinking water

Risk: Recent Scientific Research (2005-2006)

- Recent studies have identified perchlorate in foods, milk and forage
- Perchlorate in dairy milk collected from supermarkets in Texas
- Studies identified ppm levels of perchlorate in wheat and alfalfa samples
- Additional inputs of perchlorate from foods will have implications on the levels that be allowed in drinking waters
- 62 urine samples contained ClO4- concentrations above trace concentrations in Atlanta water





Current status with Perchlorate

- Perchlorate – state of science is still advancing
- Sources of perchlorate (both natural and anthropogenic) are still being evaluated.
- Occurrence data is expanding
- Massachusetts adopted first DW standard (2 ug/L) in August 06.
- Remediation liability currently unknown

Canadian Perspective

- Difficult to determine
- To date, significant MTBE contamination has not been observed (in most cases)
- Most MTBE produced was distributed and used in US
- To date, significant perchlorate contamination has not been observed.

- ***However, these chemicals may not be included in all investigations***

Canadian Perspective

- Drinking Water Standards:
  - MTBE is not regulated in drinking water supplies
  - Perchlorate is not regulated in drinking water supplies
- Remediation Standards - BC Contaminated Sites Regulation (CSR)
  - MTBE (soil) – Schedule 10
  - MTBE (groundwater) – Schedule 6
  - Perchlorate soil remedial standards for all land uses and groundwater remedial standard (for DW supply)
- Water discharge standards – specific discharge standards for perchlorate and MTBE don't exist

LESSONS LEARNED

- **All contaminant releases may pose risk and liabilities –**
  - *some can be tolerated, some can be managed, and some have to be mitigated; however, like beauty,* ***risk is in the eye of the beholder.***
- **Understand the chemical properties of the contaminants and the hydrogeologic setting into which they are released –**
  - *Chemistry and hydrogeology are the keys to effective protection, investigation and remediation.*
- **No aquitard is impenetrable –**
  - given enough mass, space and time, contamination will find its way to deeper aquifers.

LESSONS LEARNED

- **Early action is essential –**
  - If an emerging contaminant is detected, take immediate action.
- **Treatment technologies can effectively remove emerging contaminants from water –**
  - although these options may be more expensive to implement than for other contaminants.
- **Don't rely on Federal or Provincial regulators –**
  - Only the respective industries can look after their own best interests.

HOW CAN INDUSTRY PROTECT ITSELF

Be informed and proactive, evaluate your own facilities and operations.
Evaluate emerging contaminants of concern within effluents and products
Understand potential implications associated with emerging chemicals of concern – to industry, clients, shareholders.
Establish relationships with regulatory agencies
Understand the regulatory process in different jurisdictions
Keep abreast of scientific data
Take lead on establishing standards, guidelines etc

Summary

- Emerging contaminants of concern can pose potentially significant liabilities to stakeholders
- Significant time can pass between analytical detection to regulatory development
- Use lessons learnt from previous emerging contaminants to better manage emerging contaminants in the future

Closure

– ***"Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know."***

Donald Rumsfeld

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Questions?