Environmental Management of Firefighting Foam

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Impact Mechanisms & Risks

- Foam characteristics & impact mechanisms
- Queensland awareness and risk review
- Fluorinated organic compound issues
- Regulatory considerations & decisions
- Health issues & worldwide concern
- Foam performance & certification
- Soil and water contamination issues
Fire fighting foam types

- **Class A Foam**
  - Penetrates & wets solids
  - Cool the fuel
  - Exclude oxygen
  - Suppress fuel vapor
  - Prevent (re)ignition

- **Class B Foam**
  - Layer on top of liquid fuels
  - Liquid fuel fires (hydrocarbons, solvents)
  - Fluorine-free foam
  - AFFF, FFFP, FP, etc
  - Fluoro-surfactants

**FOAMS**
- Cool the fuel
- Exclude oxygen
- Suppress fuel vapor
- Prevent (re)ignition

**CLASS A**
- Solids fires (3D)
- (timber, tyres, bushfires)
- Fluorine-free

**CLASS B**
- Liquid fuel fires
- (hydrocarbons, solvents)

**O₂**
- Heat
- Fuel

Fire fighting foam composition

- **FOAM CONCENTRATE**
  - **WATER** ~65%
  - **SURFACTANTS** ~17%
    - HC surfactants
    - Fluorosurfactants
    - Protein based, etc.
  - **MODIFIER** ~1-2%
    - Polysaccharide gum
    - Salts/oxides
    - Biocides, EDTA etc.
  - **SOLVENTS** ~16%
    - Glycol ethers
    - Alcohols
    - Carbitol, etc.

**CONCERNS**
- BIOTA (especially aquatic)*
- SOIL CONTAMINATION
- GROUNDWATER POLLUTION
- HEALTH

**IMPACT MECHANISMS**

**SHORT-TERM**
- BIOCHEMICAL O₂ DEMAND*
- ACUTE TOXICITY (short-term)

**LONG-TERM**
- PERSISTENCE
- BIOACCUMULATION
- CHRONIC TOXICITY (long-term)

**FIREFIGHTING IS HIGHLY DISPERSIVE**

Great state. Great opportunity.
Fluorinated Organic Compounds (FOCs)

- Persistence is extreme ("indefinite" – non-degradable)
- Bioaccumulative for many compounds
- Toxicity (acute and chronic effects, > for longer C-chains)
- Environmental and health concerns since ~2000
- PFOS of primary concern (but 100s of similar FOCs)
- No alternatives to FOCs for foam until ~2003-2006
- Fluorotelomers and short-chain FOCs are similar
Fluorinated organic compounds

Foam compositions
- Complex formulations (various mixes of C4 to C12 chain lengths)
- Do users know exactly what is in their particular stocks?
- Have foam types or different batches been mixed?

INCREASING CHAIN LENGTH

X:Y FLUOROTELOMERS

- Recognised as a risk by Queensland in 2011
- Review and clarification of issues (2012-13)
- Industry has not self-regulated effectively
- Regulatory Strategy model (around GED)
- Staged implementation needed

Environmental Management of Foam
- Recognised as a risk by Queensland in 2011
- Review and clarification of issues (2012-13)
- Industry has not self-regulated effectively
- Regulatory Strategy model (around GED)
- Staged implementation needed
The USER must take all necessary steps to prevent environmental harm (must be able to demonstrate current best practice) by:

- Determining all relevant factors.
- Assessing all the relevant risks.
- Obtaining all relevant information.

The user carries the risk and liability.
(The “Polluter Pays” principle)

BUT – Community/Government pay when the polluter can not pay (insolvent or legacy sites)

Regulatory position (the draft Qld Policy)

- Applies to ALL FOAMS (persistent & non-P).
- Existing environmental legislative coverage.
  (Foam → Acute & Chronic environmental harm)
- Extensive review of current state of technical knowledge & best practice.
- Clarification of standards & requirements for users to meet their obligations.
- Foam risks not well understood by users, very limited information available.
- Consideration of Ecologically Sustainable Development & the Precautionary Principle.
Regulatory position (the draft Qld Policy)

The *Precautionary Principle* (in decision making)

Triggered by:
- threat of serious or irreversible environmental damage; and
- scientific uncertainty as to the nature and scope of the threat of environmental damage.

Justice Preston (2006) stated:

"The function of the precautionary principle is, therefore, to *require the decision-maker to assume that there is, or will be, a serious or irreversible threat of environmental damage* and to take this into account, notwithstanding that there is a degree of scientific uncertainty about whether the threat really exists."

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**Precautionary Principle Considerations**

1. Spatial scale of the threat (local → global)
2. Magnitude of possible impacts (envir. & health)
3. Temporal scale of impacts (days → decades)
4. Manageability of possible impacts
5. Level of concern and supporting evidence
6. Reversibility of impacts
7. Difficulty and expense of remediation

“Burden of proof for evidence for safety rests on the proposers of a new technology”
The Precautionary Principle Assessment

<table>
<thead>
<tr>
<th>Assessment factors</th>
<th>Persistent compounds</th>
<th>Non-persistent compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Spatial scale of the threat</td>
<td>Local, regional, state-wide, national &amp; global</td>
<td>Localised impacts</td>
</tr>
<tr>
<td>2 Magnitude of possible impacts</td>
<td>Wider environment &amp; human health, chronic &amp; acute effects</td>
<td>Local aquatic environment – acute effects only.</td>
</tr>
<tr>
<td>3 Perceived value of the threatened environment</td>
<td>High perceived values for natural environment &amp; long-term local &amp; broader human health</td>
<td>High perceived value for natural environment</td>
</tr>
<tr>
<td>4 Temporal scale of possible impacts</td>
<td>Long-term – Decades to inter-generational presence</td>
<td>Short-term – weeks to months.</td>
</tr>
<tr>
<td>5 Manageability of possible impacts</td>
<td>Very poor post release Highly dispersive</td>
<td>Treatable or by natural recovery processes</td>
</tr>
<tr>
<td>6 Public concern &amp; scientific evidence</td>
<td>Established &amp; growing concerns with mounting evidence</td>
<td>Limited concern about harm based on established evidence</td>
</tr>
<tr>
<td>7 Reversibility of possible impacts</td>
<td>Not reversible or extremely long-term reduction</td>
<td>Reversible with remediation or natural recovery/decay</td>
</tr>
</tbody>
</table>

ADVERSE EFFECTS

UNKNOWN INDICATIONS SIGNIFICANT EVIDENCE CERTAINTY

Health effects of FOCs exposure

Possible health (& envir) effects:
- Reproductive impairment
- Chronic kidney disease
- Liver disease
- Endocrine disruption
- Developmental impairment
- Immune system depression
- Cholesterol elevation
- Vaccine interference
- Testicular & kidney cancer
- ADHD, &c.

Elimination in humans ($t_{1/2}$):
- C8, PFOS – 5.4 years
- C8, PFOA – 2.3 to 3.8 yrs
- C6, PFHxS – 8.5 years (≈C8)

(! x 5 half lives ↓ 15-40 years)

- Many similar compounds
- Information only emerging about the behaviour and effects of a few.
Environmental Management of Foam
Current International directions & concerns
• Emerging concerns on PFC adverse impacts (environment & health) e.g.:
  • Helsingør & Madrid Statements 2014
  • ECHA 2014 PFOA Restriction Proposal

>2,500 papers on PFAS from 2001-2011
Trojanowicz & Koc 2013

Significant increase in emerging information on fluorinated compounds in peer-reviewed scientific publications since 2008.
Grandjean & Clapp 2015

Industry knowledge (cancers) since 1997
US (Ohio) PFOA compensation trial evidence in 2015

REF 04 & 08
Great stats. Great opportunity.

Helsingør & Madrid Statements

Scientific community concerns:
• Widespread occurrence of fluorinateds
• Extreme persistence
• Lack of decline & increasing exposure
• Impacts of fluorinated alternatives
• Lack of info & testing for 100s of FOCs
• Lack of transparency by manufacturers
• Health & environmental impacts of FOCs
• Synergistic effects likely but unknown
• World-wide & tighter regulation needed
• Problematic & costly waste disposal
• Suggest cease use of all FOCs
• Develop non-toxic alternatives

REF 09 & 10
Great stats. Great opportunity.
Non-persistent foam performance (FFF)

- All foams are performance tested to the same standards according to the intended application.

- Certified for every major application including: LAST Fire (tanks), EN1568(1-4), DEF(Aust) 5706, ICAO Level B&C, AS5062, IMO (shipping) and reputedly US Mil Spec/UK Defence Specification.

- Tests are by carried out to strict standards by independent certifying agencies. (MPA Dresden, CAAi UK, FM Approvals, Underwriters Laboratories Inc., SP Technical, Resource Protection International, SP Sweden, DNV Norway, CSIRO Activfire, etc).

- Foams are specific to particular uses and must be used correctly to work as intended.

### Industry Application

<table>
<thead>
<tr>
<th>Industry Application</th>
<th>Australia/New Zealand</th>
<th>FFF meets required specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAST Terminal Facilities &amp; Refineries</td>
<td>LAST Fire Test &amp; EN1568</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>(some UL / FM for fixed systems)</td>
<td></td>
</tr>
<tr>
<td>Aviation</td>
<td>ICAO &amp; EN1568</td>
<td>Yes</td>
</tr>
<tr>
<td>Offshore</td>
<td>ICAO &amp; EN1568</td>
<td>Yes</td>
</tr>
<tr>
<td>Fire Services</td>
<td>ICAO &amp; EN1568</td>
<td>Yes</td>
</tr>
<tr>
<td>Defence (Army, Air Force, Navy)</td>
<td>DEF(Aust) 5706 / ICAO Level III</td>
<td>Yes</td>
</tr>
<tr>
<td>Royal Australian Navy</td>
<td>US Mil Spec / UK Defence Spec</td>
<td>Yes</td>
</tr>
<tr>
<td>Ports, Tugs and ships</td>
<td>EN1568 / DNV</td>
<td>Yes</td>
</tr>
<tr>
<td>Oil and Gas Industries</td>
<td>LAST Fire Test &amp; EN1568</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>(some UL / FM for fixed systems)</td>
<td></td>
</tr>
<tr>
<td>Mines</td>
<td>EN1568</td>
<td>Yes</td>
</tr>
<tr>
<td>General Industry</td>
<td>EN1568 &amp; LAST Fire Test</td>
<td>Yes</td>
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<tr>
<td></td>
<td>(some UL / FM for fixed systems)</td>
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<tr>
<td>Mining Heavy Vehicles</td>
<td>AS5062</td>
<td>Yes</td>
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<tr>
<td>Hand Held Extinguishers</td>
<td>AS1841 Provisional</td>
<td>Provisional</td>
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</table>

Note 2 – Legacy US MilSpec specific FOC content in addition to performance standards, changes being considered
Note 5 – Approved EU, under consideration in Australia
Non-persistent foam uptake

- Queensland Fire Service since 2003
- Most Queensland sea ports since 2014
- AirServices Australia since 2010
- Overseas airports ~90
- North sea offshore oil & gas platforms (~40)
- Fire brigades (5 Aust, 19 overseas)
- Petroleum producers ~20
- Other corporations ~47

Legacy issues & contaminated sites

- Multiple sites with legacy contamination of soils, waterways and groundwater.
- Need for investigation & clean-up standards.
- **CRC-CARE** project considering screening values for PFOS, PFOA & possibly fluorotelomers.
- *USEPA drinking water Provisional Health Advisory*
  - PFOS 0.2 µg/L
  - PFOA 0.4 µg/L.

*REF 11
CRC-CARE (Contamination Assessment & Remediation of the Environment)
Great state. Great opportunity.*
Legacy issues & contaminated sites

- Current engagement across agencies to determine appropriate and consistent contamination assessment standards.
- Australian soil screening criteria not established.
- Suggestion for Health Investigation Levels (HIL) for PFOS*:
  - Residential 4 mg/kg
  - Commercial 400 mg/kg
(However, may not take into account PFC mobility, e.g. Oakey)

*REF 11
Great stats. Great opportunity.

REFERENCES


REF11 - Australian Department of Defence, 2015. Army Aviation Centre Oakey Environmental Investigation Fact Sheet 3.

### PFOS Health Guidelines

<table>
<thead>
<tr>
<th></th>
<th>Drink water µg/L (ppb)</th>
<th>Soil Residential mg/kg (ppm)</th>
<th>Soil Commercial/Industrial mg/kg (ppm)</th>
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<tbody>
<tr>
<td>Australia</td>
<td>None yet</td>
<td>None yet</td>
<td>??</td>
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<tr>
<td>Germany</td>
<td>0.1</td>
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</tr>
<tr>
<td>USEPA</td>
<td>0.2</td>
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<tr>
<td>Minnesota Department of Health</td>
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<td>Minnesota Pollution Control Agency</td>
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<tr>
<td>Norway SFT</td>
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<tr>
<td>Canada</td>
<td>0.3</td>
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</tr>
<tr>
<td>UK</td>
<td>&gt;0.3</td>
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<tr>
<td>SFT</td>
<td>0.65 ng/L (ppt) fresh water</td>
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<tr>
<td>Minnesota Pollution Control Agency</td>
<td>1.1</td>
<td>14</td>
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Source – Summary by Dr Jimmy SEOW WA.

### PFOA Health Guidelines

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</thead>
<tbody>
<tr>
<td>Australia</td>
<td>None yet</td>
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<tr>
<td>New Jersey US</td>
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<tr>
<td>Germany</td>
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<tr>
<td>Minnesota Department Health</td>
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<td>2.1</td>
<td></td>
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<tr>
<td>Canada</td>
<td>0.3</td>
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<tr>
<td>USEPA</td>
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<td>16</td>
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<tr>
<td>West Virginia</td>
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<td>North Carolina</td>
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<td>UK</td>
<td>&gt;0.3</td>
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<tr>
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<td>14</td>
<td></td>
</tr>
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</table>

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Non-persistent foam used on tanker rollover into tidal mangrove area (Gladstone)