

Hydrocarbon Spills into Water

Public Health Risk Assessment (PHRA)

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Hydrocarbon Spills into Water

Purpose

This document has been developed to support assessment of the potential health risks associated with large-scale contamination of drinking-water by petroleum products by Consultants in Public Health Medicine.

Rationale for Public Health Risk Assessment (PHRA)

- Inform ourselves and advise (as per statutory functions)
- Assess actual and potential health risks;
- Protect the public/consumers;
- Ensure accurate and timely communication with public/consumers; and
- Define criteria for lifting restrictions as early as possible.

Detection of an incident

Contamination of drinking water is usually detected in one of the following ways:

- Notification of a spill by the enterprise concerned or by another industry or public body (e.g. fisheries authorities or water service authorities);
- Triggering of a hydrocarbon alarm protecting the intake point on surface water supplies or alert from water treatment plant operators; and
- Complaints from the public re: taste/odour.

Initial Assessment

- Decisions may need to be made very quickly on whether to shut down water intake (with restriction of supply to consumers) before full information (chemical analysis) is available.
- The key information sought in the initial assessment is **whether the hydrocarbon has penetrated the water treatment process and to what extent.**
- This involves visual review and taste/odour assessment by the Irish Water (IW)/Local Authority (LA) staff of the source water and of the water at different stages of the water treatment process (from intake to final treated water) and hydrocarbon alarm information if available.
- In most cases, hydrocarbons are detectable by taste or odour at concentrations below those of concern for health, particularly with short-term exposure.
- Results of laboratory testing (as outlined in Table 1) may not be immediately available.

Table 1: tool for detection of hydrocarbon presence in water

METHOD		RATIONALE
Initial assessment	Taste or odour detection	The presence of tastes or odours in domestic water supplies serve to make the water unfit for consumption, even at sub-toxic levels of contamination.
	Hydrocarbon alarm	Hydrocarbon alarms linked to the water treatment plant SCADA system provide a rapid alert in the event that spills threaten extraction for water treatment or industrial purposes. They can also provide useful real-time confirmation of the absence or presence of detectable levels of hydrocarbons in an evolving situation, whilst awaiting confirmatory laboratory results.
Formal test results	Total petroleum hydrocarbon (TPH) concentration	TPH concentration can be conducted rapidly if laboratory capacity is available, but the results often vary depending on the analytical method used to measure it. However, this may be useful to monitor trends, e.g. to indicate that contamination is receding.
	Fractionated testing	Full fractionated testing is the gold standard in the assessment of health risks. Fractionated results (PRO-petrol range organics or DRO-diesel range organics) may be available in Irish laboratories without differentiation into relative concentrations of aliphatic and aromatic hydrocarbons, and this level of detection may be sufficient if hydrocarbon levels are very low, i.e. very close to background levels from control samples. However, the differentiated fractionation currently requires samples to be sent to a laboratory outside Ireland, and so results may not be available for approx. a week from the date of sampling. As time is of the essence, samples should be delivered to the laboratory by the quickest means available.
	Testing for specific substances	Specific testing may be required to detect and measure concentrations of substances such as PAH or benzene (WHO guideline value 10 µg/l). Again, because samples have to be sent to a specialised laboratory, results are not likely to be available as quickly as they are for TPH concentration.

Hydrocarbon Spill: PHRA Checklist

Please note that this list is not exhaustive, but provides a series of suggested questions/prompts for information.

		CONSIDERATIONS	
	INCIDENT DESCRIPTORS	Location	<ul style="list-style-type: none"> • Name, and address of site of incident; • Urban/rural setting – particularly interested in the density of population and residences around the incident; • Extent and type of water supply (i.e. surface- or ground-water) affected and it's interconnections; and also important to determine if ingress from hydrocarbons is in the raw water going into a water treatment plant or into filtered water after leaving the water treatment plant; • Proximity to public services (i.e. food premises, hotels, educational facilities, leisure centres, and hair salons); • Proximity to healthcare services (i.e. hospitals, long-term care facilities, dental surgeries, pharmacies, out of hours services, and general practice surgeries) • Local Authorities (LA) linked to incident; and • Network and infrastructure in environs (i.e. ease in access to site or exit if alternative water supply is required).
		Nature of incident	<ul style="list-style-type: none"> • Was the incident accidental or deliberate; • What hydrocarbons are involved and in what quantities? • How contained is the incident? • Are there any associated/related events? • Likely duration of incident? • How is the incident being managed?

		Hydrocarbon spill considerations	<ul style="list-style-type: none"> • Volume of hydrocarbon lost/spilled? • Is this incident on-going or contained? • Date of the incident. • Protection of water treatment system from hydrocarbon contamination: hydrocarbon alarm above the abstraction point, activated carbon in the treatment process, etc. • Are there any visual or olfactory signs of hydrocarbons within water treatment system? • Has there been biochemical confirmation of hydrocarbons in water? • Has the hydrocarbon penetrated the water treatment process? <ul style="list-style-type: none"> A. No evidence; B. Has entered treatment system, but not in treated water; C. In treated water; or D. Awaiting results, either B. or C.
If there are gaps/omissions in this section, considerations should be given to holding an incident management team meeting	CHEMICAL PROPERTIES		<ul style="list-style-type: none"> • Chemical(s) properties and characteristics known and understood? (Include the UN/CAS number of substance(s) of concern) • Public Health concerns clear? • Quick dispersion likely?
	POPULATION		<ul style="list-style-type: none"> • Number of potentially exposed (including local population and first responders)? • Sensitive populations in the vicinity? • Considerations for consumers of water for human use: <ul style="list-style-type: none"> ○ Public water supply; ○ Group water supply; and ○ Vulnerable groups (if long-term restriction). • Considerations for consumers for industrial use: <ul style="list-style-type: none"> ○ Water of potable quality for use in food and pharmaceutical industries; and ○ Water of non-potable quality for other industrial uses.

	IMMEDIATE HEALTH & IMPACT ON HEALTH SERVICES		<ul style="list-style-type: none"> • Unusual symptoms reported to local/regional healthcare facilities, general practitioners (GPs) or National Poisons Information Centre? • Number actually exposed (including local population)? • Sufficient capacity at local Emergency Department?
	GENERAL PUBLIC HEALTH		<ul style="list-style-type: none"> • Initial PHRA and changes to the PHRA over time? • Individuals or populations at risk now/in future? • Public Health follow-up needed? Register of those exposed needed? • Close schools, businesses, other facilities? • Advice on if to use water or await an alternate supply? • Advice to wider community about the incident and try to include timeline if possible? • Advice to vulnerable groups within affected supply? • Advice to GPs and healthcare facilities? • Advice to media?
	ENVIRONMENTAL CONDITIONS		<ul style="list-style-type: none"> • Current and forecast weather conditions? (https://www.met.ie/).
	INCIDENT CONSIDERATIONS	Site issues	<ul style="list-style-type: none"> • Environmental/biological sampling and monitoring needed? • Personal protective equipment might be required. • Any historical facts about the incident site (e.g. illegal dumping)? Anything that could compromise the integrity of the water supply; and • Is the incident linked to a site licensed with LA/EPA? If so, are there records of materials/chemicals on-site?

ACTIONS

Immediate

- If there are significant Public Health risks, consider an escalated emergency response (*procedures in the Green Books – A Framework for Major Emergency Management can still be activated in the absence of a major emergency*);
- Link with HSE Environmental Health Service and water provider (Irish Water/LA);
- Contact person(s) and communications: Obtain the name, position, email and telephone number of person to contact / person-in-charge of co-ordinating the response; and
- Consider requesting a local incidence response team (if not already done) for the regular exchange of information and collected decision making (including and not exhaustive to Local Authority; Irish Water; Fire Brigade; An Garda Síochána; HSE Ambulance; HSE Public Health; HSE Environmental Health Service; Environmental Protection Agency; Civil Defence).

Overall

- Contact Public Health England – Centre for Radiation, Chemical and Environmental Hazards (PHE-CRCE) for advice (*contracted by the 8 Public Health Departments for 24/7 advisory response*);
- Has the hydrocarbon spill been contained? (*managed by the Environmental section of Local authority*);
- Restriction of water usage (*various approaches need to be considered based upon the population at risk as identified above*);
- Minimisation of impact (*various approaches based upon target groups as identified above*);
- Provision of potable water from alternate sources (*i.e. tankers, diversion/reactivation of other supplies, replenishing of unaffected reservoirs with potable water from an alternate source, targeted arrangements for vulnerable groups, e.g. dialysis/palliative care patients*);
- Immediate local population may need different action/ advice than the surrounding general population about water usage;
- Sensitive populations (e.g. those that are more vulnerable like dialysis patients) may need different action/ advice than the affected population; and
- Consider contacting local hospitals & GP practices (*database of those with symptoms from ingestion of water, if unaware of not to use supply*).

Actions for consideration

(i.e. based on scenario encountered)

1. Abstraction may be halted temporarily until it is established that there is no on-going risk from the source water (scenario D in PHRA checklist).
2. If there is no evidence that hydrocarbon in source water has entered the treatment process (hydrocarbon alarm has not alerted and there is no visual, taste or odour evidence at any point in the treatment process), treated water supplies to consumers can continue during a period of assessment (scenario A).
3. If hydrocarbon has entered the treatment system, **but has not reached the treated water** then distribution to consumers of treated water supplies stored in the reservoir can continue during a short period of assessment/remediation of the treatment process. Conservation of stored potable water is essential at this stage. A full health risk assessment of hydrocarbon exposure is not required as the contaminated water has not reached consumers (scenario B).
4. If the scale of remediation required (e.g. application of activated carbon, rebuilding of filters, replacement of piping, etc.) will involve an extended period of restrictions to water supplies, Irish Water / Local Authority must decide whether it is feasible to provide alternative sources of water to consumers when the stored water has been exhausted. The decision depends on the logistics of each water supply (number and geographical dispersion of consumers; volume of treated water stored; heavy industrial use of the supply; availability and proximity of alternative supplies) (scenario C).
5. A health risk assessment may be required if multiple alternative supplies are activated during a remediation process (e.g. tankers, old reservoirs, inactive water supplies, etc.) or where Irish Water / Local Authority is forced to continue abstraction from the suspect source water because alternative supplies are insufficient.
6. Health risk assessment **is** required if hydrocarbon presence is confirmed in the treated water (water that has completed all treatment processes and is stored in the reservoir ready for supply to consumers) or has reached domestic taps (scenario C).

Incident Response Team (IRT)

1. In the event of a major spill, ensure that an incident response team (IRT) is formed by Irish Water/Local Authority as soon as possible.
2. Consider activating the Major Emergency Plan, depending on the scale of the incident.
3. The IRT may involve representatives from/consultation with:
 - Health Service Executive Department of Public Health
 - Health Service Executive Environmental Health Service
 - Irish Water
 - Environmental Protection Agency
 - Local authority environment section
 - Local authority emergency services
 - Civil Defence
4. IRT meetings and consultations may be convened on site.
5. The IRT will decide whether additional laboratory capacity needs to be contracted to conduct testing, and whether media communications function may be required.
6. The IRT must consider the following issues:
 - Preparation of a Drinking Water Incident Response Plan (DWIRP)
 - Containment of the spill
 - Need to restrict water usage
 - Minimisation of impact
 - Provision of potable water from alternative sources
 - Communication with public/consumers
7. Engineering solutions to contain a spill, minimise impact and to rebuild treatment and distribution systems will be coordinated by the local authority in consultation with Irish Water and the EPA.

Comprehensive guidance on IRT is available in the HSE/Local Authority template (sections 5 & 6).¹

¹ Health Service Executive (HSE) 2008. **Drinking Water and Health. A Review and Guide for Population Health.** Available URL: <https://www.hse.ie/eng/services/publications/environmentalhealth/hse-drinking-water-and-health-review-and-guide-2008.pdf> (Accessed: 30th September 2019).

Decision to Restrict Water Use

- The World Health Organization (WHO) recommends that values used for assessing potential health risks only be used alongside sensory assessments of taste and odour which will make the water unfit for consumption.
- **If residents can smell an oil-like odour in their water, they should stop using it for drinking, cooking, bathing and showering.** Contaminated water can still be used for flushing toilets.
- Symptomatic individuals should cease using contaminated water altogether.
- If there is no smell or taste, then the indicative limits provided in Table 2 may inform the decision whether to restrict water usage.

Table 2: reference dose (RfD) for petroleum hydrocarbon fractions derived by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) and indicative concentration limits for water

Carbon number range	RfD (mg/kg body weight /day)	Indicative limits* (µg/l)
Aliphatic C5 – C8	5	3000
Aliphatic C8 – C16	0.1	65
Aliphatic C>16 – C35	2	1000
Aliphatic C>34	20	10,000
Aromatic C>5 – C8	0.2	130
Aromatic C>8 – C16	0.04	25
Aromatic C16 – C35	0.03	20

* In most cases, hydrocarbons are detectable by taste or odour at concentrations below those concentrations of concern for health, particularly with short-term exposure. In particular, substances such as ethylbenzene, trimethylbenzene and MTBE (methyl tertiary-butyl ether) have recorded taste and odour thresholds of a few micrograms per litre. For this reason, the World Health Organization does not consider it appropriate to set formal health-based guideline values for petroleum products in drinking-water. Nevertheless, in its 2005 guidelines, the WHO endorsed the use of criteria developed by the US-based Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG) to determine appropriate tolerable concentrations for a series of hydrocarbon fractions (Table 2) - this guidance may be of value in assessing health risk in situations where definite contamination of a source water has been confirmed by other methods.

Provision of Potable Water

(This is the primary responsibility of the water provider)

- If restrictions are enforced, distribution points for potable water will need to be provided in the community.
- Potable water may need to be provided from alternative sources to institutions such as schools and crèches; hospitals and nursing homes; GP premises and food premises.
- If restrictions are prolonged, targeted solutions including direct pumping of water into roof storage tanks may enable institutions to remain open. Leisure facilities (hotels and leisure centres) may provide hygiene facilities including showers for the able-bodied.
- Special provisions will be necessary for those who are not able-bodied (e.g. house-bound persons, terminally ill etc.); Civil Defence may provide special deliveries. Community Health Organisations (Public Health Nurses) & General Practitioners may provide information about vulnerable persons.

Criteria for Lifting Water Restrictions

1. *Consistent and satisfactory water quality results:*

- A sustained and secure return to background levels of the contaminant identified (according to the fractionation banding system, if available) and
- Microbiological clearance (in the event of extensive disruption / mixing of water supplies and variation in mains pressure or back siphonage which may have affected the integrity of the distribution system and chlorination levels).

2. *Confidence that additional measures in place to achieve these results are sustainable*

The sustained reduction/absence of hydrocarbon contamination of raw water and satisfactory completion of remediation/additional treatment.

Return of normal supplies may need to be made on a phased basis if prolonged restriction affecting the integrity of the distribution has been in place, as follows:

1. For toilet flushing
2. For all purposes other than consumption
3. Boil notice for consumption
4. Complete restoration of supply

Detailed records should be kept of key information gathered and decisions taken (see Table

3). This should be followed by agreed arrangements for the report of the incident.

Table 3: Template for use, when criteria for lifting restrictions is met

CRITERIA FOR LIFTING RESTRICTIONS	DATE AGREED	DATE CRITERIA MET
<p>1) <i>Consistent and satisfactory water quality results: This will include :</i></p> <ul style="list-style-type: none"> • a sustained return to background levels of the contaminant identified (according to the fractionation banding system, if available) and • microbiological clearance in the event of extensive disruption / mixing of water supplies and variation in mains pressure or back siphonage which may have affected the integrity of the distribution system and chlorination levels. 	<p>Click here to enter a date.</p>	<p>Click here to enter a date.</p>
<p>2) <i>Confidence that the additional measures in place to achieve these results are sustainable,</i> i.e. Source of contamination eliminated, the sustained reduction/absence of hydrocarbon contamination of raw water and satisfactory completion of remediation/additional treatment incl. cleaning of activated carbon sludge from the tanks at the WTP.</p>	<p>Click here to enter a date.</p>	<p>Click here to enter a date.</p>

Background Information about Hydrocarbons

General Information

Because of their extensive and widespread storage, transportation and use, spills and leaks of petroleum products are relatively common.

This guidance document has been developed to fulfil the need for a sound basis for assessing the potential health risks associated with large-scale contamination of drinking-water by petroleum products.

Chemical Composition

Petroleum products occur as complex mixtures of chemicals, primarily hydrocarbons. Crude oil undergoes fractionation in order to produce petroleum products for particular uses. Their composition varies according to the type of use and depends on their source and fraction. There are, therefore, significant compositional differences between petroleum products such as petrol, diesel oil, aviation fuel and heating oil.

At a simple level, hydrocarbons may be divided into two families: aliphatics and aromatics. The aliphatics may be further subdivided into four groups: alkanes, alkenes, alkynes and cyclic alkanes. The petroleum industry uses equivalent carbon (EC) numbers to classify aliphatic and aromatic fractions on the basis of their boiling points, which tend to increase with increasing numbers of carbon atoms in the hydrocarbon molecules. For example, hexane consists of six carbon atoms, it has a boiling point of 69 °C, and its EC number is 6. Benzene also consists of six carbon atoms, but its boiling point is 80 °C, and its EC number is 6.5.

In general terms, alkanes have relatively low acute toxicity, but alkanes having carbon numbers in the range of EC5–EC12 have narcotic properties, particularly following inhalation exposure to high concentrations. Repeated exposure to high concentrations of *n*-hexane may lead to irreversible effects on the nervous system. Alkenes exhibit little toxicity other than weak anaesthetic properties. Most of the smaller aromatic compounds are of relatively low toxicity except for benzene, which is a known human carcinogen.

Most petroleum hydrocarbon mixtures contain very low concentrations of polycyclic aromatic hydrocarbons (PAH). Methyl tertiary-butyl ether (MTBE) may be used as an additive in the blending of some kinds of petrol.

Because hydrocarbons can often be detected by taste or smell at very low concentrations, long-term exposure is unlikely. Nevertheless, chemical analysis may be helpful in making the decision to intervene to protect the public from potential health hazards if it is possible that

contamination of a water supply has occurred. Because it is not practicable to analyse the content of a spill for each constituent, approaches involving surrogates may be applied, e.g. analysis by hydrocarbon fraction, as described below.

Environmental Fate

The variation in chemical and physical properties of individual petroleum hydrocarbons mean that they will behave differently in the environment. The main processes affecting environmental concentrations are volatilisation, biodegradation and dissolution in water.

The type of water source will also make a difference to the potential duration of contamination which will be more short-lived from a river source than from a lake or ground water source: weather also plays a part in defining the duration of contamination e.g. a spill will clear more quickly from a river in rainy weather when a river is flowing swiftly than in dry summer weather.

In the event of water contamination by petroleum hydrocarbons, the nature of the contaminants present will largely be a function of their solubility in water. In general, the lower-molecular-weight aromatic compounds are the most water-soluble components.

Apart from the immediate threat to contaminated water, hydrocarbons may be absorbed into plastic pipes, causing delayed contamination of the water they carry and possibly lasting for a prolonged period of time. In this event, the pipes may need to be replaced.