UISCE ÉIREANN : IRISH WATER

Lead in Drinking Water Mitigation Plan

Safeguarding our water for our future

IW/FF/LDB/0115

Irish Water at a glance...

Irish Water was created in ***2013***

and serves

3.3 million people **producing over**

1.6 billion Litres

of drinking water every day and taking wastewater away for treatment before it is returned to our rivers and seas.

Thousands of assets are operated and maintained to provide these services, including more than:

900 ***water treatment plants***

which deliver water through an estimated

60,000 kilometres of pipelines

We treat wastewater in more than

1,000 wastewater treatment plants

and it is collected through an estimated

25,000 kilometres of pipelines

(This data is correct as of December 2016)

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Executive Summary

Introduction

The protection of public health is core to Irish Water's vision. In order to achieve this vision, substantial improvements to the water infrastructure are required which will require significant capital investment over many years.

In our Water Services Strategic Plan (WSSP, Irish Water, October 2015), Irish Water undertook to prepare and implement a Lead in Drinking Water Mitigation Plan (the Plan). The objective of this Lead in Drinking Water Mitigation Plan (the Plan) is to address the risk of failure to comply with the drinking water quality standard for lead for the infrastructure we are responsible for. While there are a number of actions which Irish Water can take within its area of responsibility, the emerging data reinforces the view of the Joint Environmental Protection Agency (EPA) / Health Service Executive (HSE) paper of 2013 that tackling this issue requires collective action, involving property owners, public bodies and water suppliers and this will be implemented through the Government's "National Strategy to Reduce Exposure to Lead in Drinking Water" (Department of Environment, Community and Local Government and Department of Health, June 2015). In May 2016 the Department of the Environment, Community & Local Government (DECLG) was renamed the Department of Housing, Planning, Community and Local Government (DHPCLG). For the purposes of this plan the new name has been adopted. The Plan is one element of the overall Government's National Lead Strategy.

The Plan has been prepared to comply with Irish Water's statutory obligations and forms the basis for broad public and stakeholder engagement. The Plan has been prepared in consultation with the EPA, HSE and other stakeholders. The Plan sets out the short, medium and longer term actions that Irish Water intends to undertake, subject to the approval of the economic regulator, the Commission for Energy Regulation (CER).

The establishment of Irish Water has provided new capacity and expertise to deal with a range of risks to the drinking water supply, through national and regional strategic planning, enhanced asset management capability and increased capital investment.

An initial public consultation to clarify the issues to be included in the Plan was held in the summer of 2015 and a public consultation on the draft Plan was held in the summer of 2016. The output of these consultations have informed this document. The Plan is subject to Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA). These documents have been published and are available at http://www.water.ie.

A glossary of technical terms and acronyms used throughout the Plan is included at the end of the document.

Lead in Drinking Water

Since December 2013, the European Union (Drinking Water) Regulations state that the maximum allowable limit for lead concentration in drinking water is 10 µg/l (micrograms per litre, also expressed as parts per billion).

The drinking water produced and distributed by Irish Water is free from lead and is compliant with the

European Union (Drinking Water) Regulations. Irish Water's records show there are no lead water mains in Ireland.

However, lead was used in water service connections and internal plumbing in many properties built up to and including the 1970s. Lead can be dissolved in low concentrations as water passes through these pipes or from pipe fittings that contain lead (such as brass).

Based on current available data, Irish Water estimates that lead pipework exists in up to 180,000 residential properties in Ireland as well as in many commercial and public buildings. In 2016, lead services were removed from the Irish Water network for approximately 3,000 residential properties. However, for the purposes of this plan the figure of 180,000 (combined individual and backyard service connections) will be used throughout the document as the baseline figure.

The challenge posed by the 2013 reduction in the allowable lead limit in drinking water has been recognised and highlighted since 1998. Successive annual EPA Drinking Water Reports identified the need to plan and implement measures to meet the limit. In the EPA's "Drinking Water in Ireland" report of 2004, the EPA encouraged the replacement of lead pipework and suggested that orthophosphate treatment should be considered to mitigate lead concentrations in drinking water.

It is currently estimated that 85% to 95% of properties meet the Lead Compliance Standards when sampled at the customer's tap. It is our goal to establish the current baseline compliance rate through a comprehensive national sampling programme and to increase this compliance rate to 98% by the end of 2021 and 99% by the end of 2027. This is subject to a technological alternative to lead replacement being deemed environmentally viable. The 2040 Irish Water target is for 99.5% of samples to meet with the 10 µg/l Drinking Water Regulations standard.

The World Health Organisation (WHO), EPA and HSE recommend lead pipe replacement (both lead service connections in the public supply, and lead supply pipes and internal plumbing in private properties) as the ultimate goal in reducing long-term exposure to lead. As recognised by the EPA and HSE this will inevitably take a considerable period of time.

Recognising that the removal of lead pipes is costly and will take decades, short to medium term proposals to mitigate the risk will be examined, such as pH adjustment and orthophosphate treatment to reduce plumbosolvency (ability of water to dissolve lead into water supplies from lead pipes).

Lead Mitigation Options

The Plan assesses a number of lead mitigation options available to Irish Water to reduce exposure to lead in drinking water, including:

1. Advice Only;
2. pH Adjustment;
3. Point of Use Filters;
4. Lining of Lead Services;
5. Lead Service Replacement;
6. Corrective Water Treatment for the protection of human health.

Environmental Assessment Processes

Where Plans and Programmes relating to water management can impact on the environment, they require an SEA to address environmental considerations at Plan level and, where relevant, an AA to address issues arising under the Habitats Directive, such as impacts on designated conservation areas. Irish Water has undertaken both SEA and AA processes in parallel with the preparation of the Plan because of the perceived risk of one of the proposed actions (corrective water treatment using orthophosphate) impacting on the environment.

This document, the SEA Report and Natura Impact Statement are available for download online at **http://www.water.ie**

The Plan

The Plan provides a detailed framework of measures to effectively address lead in drinking water. Irish Water's approach through the implementation of the Plan is to improve lead compliance nationally on a risk prioritisation basis.

The Plan will be monitored and adjusted as required to ensure it is effective in delivering the compliance target objectives.

The Plan consists of two primary elements which will run in parallel as follows:

1. **Risk Prioritisation:** Irish Water will identify and prioritise public water supply areas and properties nationally at risk of failing to meet the lead standards.
2. **Mitigation Identification and Implementation:** in order to achieve our targeted compliance levels Irish Water will implement the most appropriate actions in prioritised areas within our remit to reduce the potential danger to human health. Irish Water will apply the most economically advantageous method to reduce the risk for the greatest numbers of customers having due regard to prioritisation of high risk categories of the population.

The steps that Irish Water will follow to deliver these elements of the Plan are set out in the following sections.

Risk Prioritisation Steps

Irish Water is currently gathering relevant baseline information to inform the risk prioritisation, including the following:

- Water chemistry in the area given that some water types are more prone to plumbosolvency;
- Locations of properties with lead services from our metering programme, First Fix and mains rehabilitation programmes;
- Watermain type to determine properties with a higher likelihood of lead service connections;
- Central Statistics Office (CSO) small area property age maps to determine areas most at risk of having lead pipes.

The output, scheduled to be completed in 2017, will include mapped areas with lead services and a "Plumbosolvency Map" highlighting the areas at risk. These maps will be used to prioritise areas for action.

This information will be validated through an enhanced lead monitoring regime to determine the levels of lead in the drinking water network and adjust the risk prioritisation score for each Water Supply Zone (WSZ) as required. Inventory sampling commenced in June 2016 and this involves an estimated 36,000 samples being carried out across WSZs to establish the full annual lead risk profile. Further sampling will be ongoing throughout the Plan period in order to assess the Plan's effectiveness.

Implementation Steps

Certain implementation steps are already underway including:

- General Public awareness communication following publication of our issues paper in June 2015.

- Direct customer communication and advice where lead services are identified.
- Replacement of public water service pipes in conjunction with mains rehabilitation projects.
- Inventory sampling to establish the full annual lead risk profile.
- Treated water quality analysis.
- Environmental assessments on WSZs for rollout of corrective water treatment

Full implementation of actions to increase compliance in a co-ordinated national approach will commence as soon as areas are prioritised and a tailored WSZ specific Plumbosolvency Control Plan developed to include a combination of the following:

- Ongoing communication with customers to provide advice and inform them directly where they are at risk.
- Corrective Water Treatment Options for the protection of human health; pH adjustment and orthophosphate treatment to reduce plumbosolvency risk over the short to medium term where permitted following Environmental Assessment
- An accelerated national programme of replacement of lead service pipes that are our responsibility in a phased manner. Higher risk properties will be prioritised.
- Ongoing provision of our "opt-in" scheme and other targeted communications to encourage property owners to remove privately owned lead pipework that is their responsibility.

The two main mitigation measures will proceed in parallel as illustrated below.

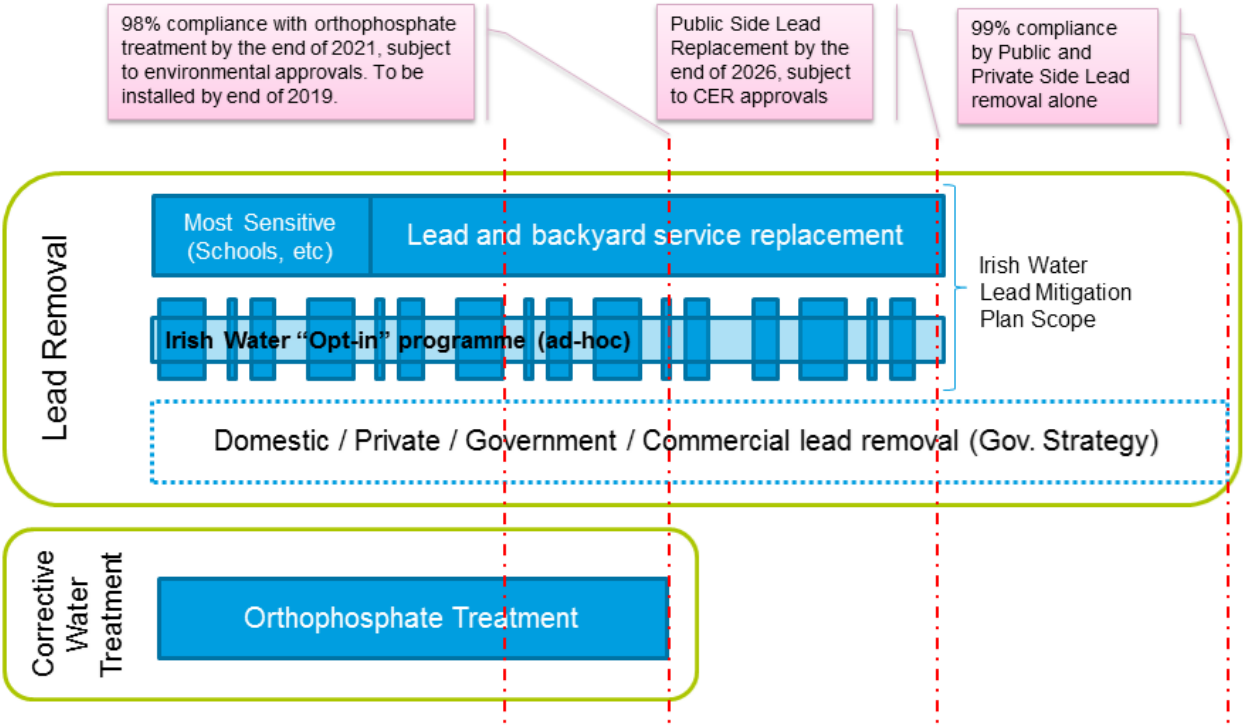


Figure 1: Proposed High Level Programme for Lead Service Removal and Corrective Water Treatment

Lead Service Replacement Programme – Long-Term Proposal

Irish Water recognises that the most effective long-term strategy is to remove all lead supply pipes. However, this is not feasible by Irish Water in isolation as the most significant portion of the lead pipework lies outside of Irish Water's ownership in private properties. Irish Water has no authority, unless granted express permission, to replace supply pipes on a customer's property. This Plan highlights the need for collective action, involving

property owners and a number of public and private stakeholders to reduce customers' exposure to lead in drinking water. Irish Water proposes to undertake an accelerated ten year programme to identify and replace public lead service pipes which are our responsibility in a phased and prioritised manner, subject to the Regulator's approval.

Recent studies indicate that unless both the public and private lead supply pipes are replaced, lead levels in the water will most likely remain higher than the Drinking Water Regulation limit. Replacing the public supply pipe or the private pipe in isolation does not resolve the problem.

The DHPCLG has a grant scheme available to homeowners to assist with the cost of replacing lead pipes in their property.

Irish Water actively encourages property owners to remove lead pipes within their ownership, and will continue offer a number of services for customers with lead pipework.

Corrective Water Treatment for the protection of human health – Short to Medium Term Proposal

Considering the constraints outlined above in achieving compliance targets, Irish Water propose to introduce corrective water treatment for the protection of human health as an interim mitigation measure at up to 400 Water Treatment Plants. This will be rolled out over an accelerated 3 year programme, subject to site-specific environmental assessments.

This corrective water treatment will include pH adjustment and orthophosphate treatment to reduce plumbosolvency risk over the short to medium term in high risk water supplies where it is technically, economically and environmentally viable to do so. This process creates a coating on lead and other metal pipes which minimises the lead dissolving into the water for the protection of public health. This practice is now the accepted method of lead mitigation in many countries (e.g. Great Britain and Northern Ireland) and has achieved very high levels of compliance for lead in relatively short timeframes.

Under the Habitats Directive, Irish Water is required to follow the statutory process of Appropriate Assessment before commencement of this corrective water treatment for the protection of human health. This EU statutory environmental process must be complied with before orthophosphate treatment can commence.

The introduction of pH adjustment and orthophosphate treatment, as a corrosion inhibitor, has the potential to reduce the risk of exposure to lead for properties that have lead pipework and fittings containing lead. This lead exposure presents a significant health risk, especially to infants, young children and pregnant women for which pH adjustment and orthophosphate treatment is the most practical short-term option as a water supply wide control measure.

The mitigation of lead in drinking water is recognised worldwide to be a very complex issue. Irish Water's Lead Mitigation Plan provides a detailed framework of measures to effectively address lead in drinking water. This will require significant capital investment over a number of investment cycles and proactive commitment of all stakeholders to effectively address the risk of failure, and comply with the drinking water quality standard for lead.

Section 1 Introduction

Irish Water's Vision

Through responsible stewardship, efficient management and strong partnerships, Ireland has a world-class water infrastructure that ensures secure and sustainable water services, essential for our health, our communities, the economy and the environment.

The protection of public health is core to Irish Water's vision. In order to achieve this vision substantial improvements to the water infrastructure are required which will require significant capital investment over many years.

In our Water Services Strategic Plan (WSSP, Irish Water, October 2015), Irish Water undertook to prepare and implement a Lead in Drinking Water Mitigation Plan (the Plan). The overall objective of the Plan is to effectively address the risk of failure to comply with the drinking water quality standard for lead in as much as it is possible within Irish Water's areas of responsibility.

This Plan has been prepared in consultation with the Environmental Protection Agency (EPA), Health Service Executive (HSE) and other stakeholders. The Plan sets out the short, medium and longer term actions that Irish Water intends to undertake, subject to approval by the economic regulator, the Commission for Energy Regulation (CER).

The Plan provides a detailed framework of measures for implementation to effectively address lead in drinking water. The Plan is based on advice in the EPA Handbook (2010), EPA Advice Notes No. 1 and 2, and the International Water Association (IWA) Best Practice Guide on the Control of Lead in Drinking Water (2010). The approach to be taken by Irish Water through the implementation of the Plan is to improve lead compliance nationally on a risk prioritised basis.

This document is split into the following sections:

- Executive Summary
- Section 1: Introduction
- Section 2: Objectives
- Section 3: Consultation Process
- Section 4: Lead Mitigation Options
- Section 5: Environmental Assessment Processes
- Section 6: Proposed Plan
- Section 7: Ten Step Process
- Section 8: Public Information Campaign
- Section 9: Continuous Improvement, Data and Reporting

The Plan has been prepared to comply with our statutory obligation and form a basis for broad public and stakeholder engagement. An initial public consultation to clarify the issues to be included in the Plan was held in the summer of 2015 and a public consultation on the draft Plan was held in the summer of 2016. The output of these consultations have informed this document.

In tandem with the development of the Plan, Irish Water has prepared the environmental assessment reports required under Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA) legislation. The preparation of the environmental assessments has informed the development of the Plan. These documents were also available for the statutory consultation period required under SEA legislation. Following the evaluation of feedback from the statutory consultation, the Plan has been finalised and will be implemented subject to regulatory allowances made by the CER. The level of capital expenditure (Capex) for 2017 and 2018 has been approved by the CER, as part of its price control process, but Capex beyond 2018 is subject to available funding

and CER approval as part of future revenue control processes.

These documents have been published and are available at http://www.water.ie.

A glossary of technical terms and acronyms used throughout the Plan is included at the end of the document.

1.1 Government's National Lead Strategy

This Plan has been prepared in response to the recommendations in the "National Strategy to Reduce Exposure to Lead in Drinking Water" (Department of Housing, Planning, Community and Local Government and Department of Health, June 2015), hereafter referred to as the National Lead Strategy.

The National Lead Strategy highlights the need for collective action, involving property owners and a number of public and private stakeholders over many years to reduce exposure of the public to lead in drinking water.

The Strategy defines the roles and responsibilities of the various stakeholders including Irish Water. Refer to Figure 2 below.

Figure 2: National Lead Strategy Stakeholders

Where:

DHPCLG: Department of Housing, Planning, Community and Local Government
DoH: Department of Health
CER: Commission for Energy Regulation
NFGWS: National Federation of Group Water Schemes
HSE: Health Service Executive
EPA: Environmental Protection Agency
WSTG: Water Services Training Group

It defines the responsibility of Irish Water as having a "*statutory responsibility for all aspects of water services planning, delivery and operation at national, regional and local levels for public water schemes*". It goes on to state that legally, responsibility for the replacement of the water mains and public-side service connection pipes to the boundary of the property lies with Irish Water or the water supplier while responsibility for the maintenance and replacement of the supply pipe and internal plumbing pipes, tanks and fittings lies with the property owner. Refer to Figure 3 below.

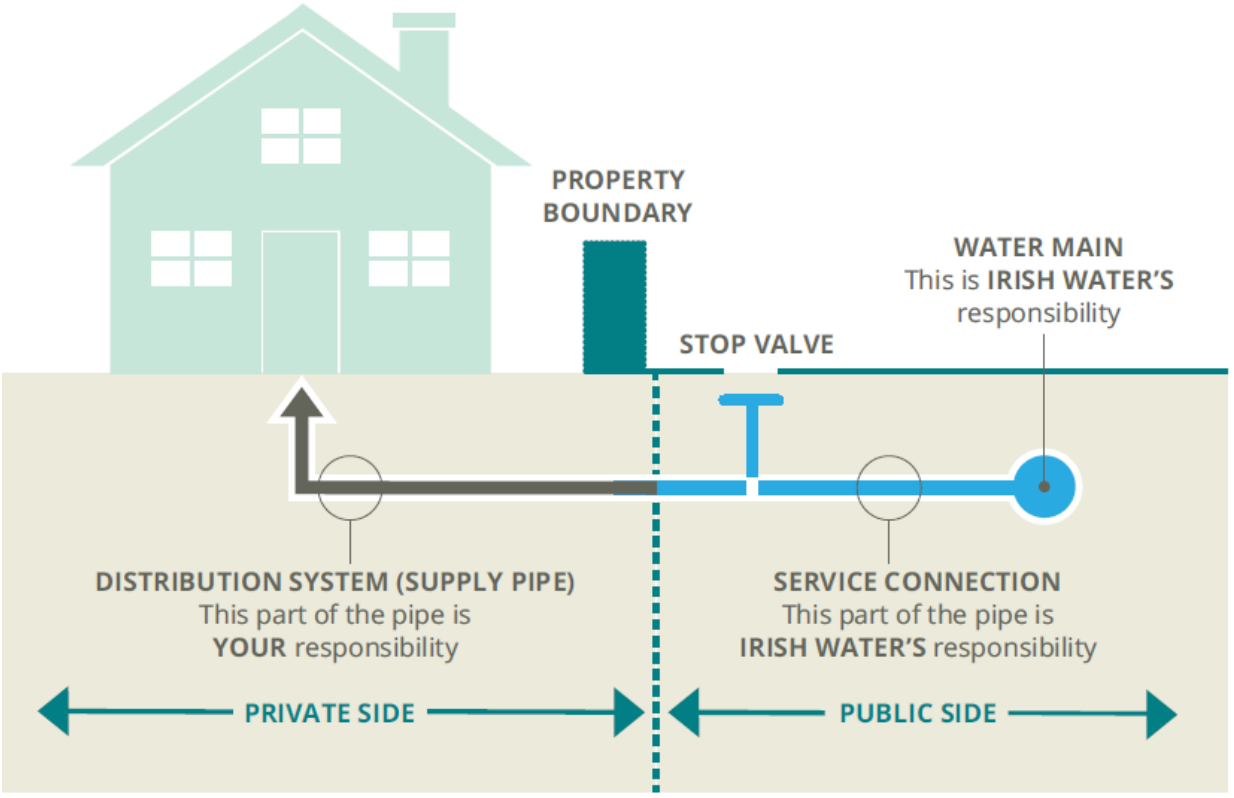


Figure 3: Extent of Responsibility for Household Connection Pipe (for the purposes of the Lead Mitigation Plan)

Responsibility for policy and legislation in relation to water quality issues rests with the Minister for Housing, Planning, Community and Local Government, taking account of any advice of the Minister for Health on matters pertaining to public health. The National Lead Strategy is being co-ordinated by these Departments.

The National Lead Strategy has identified seven action themes to be delivered by specific stakeholders. Refer to Table 1 below.

Table 1: National Lead Strategy Action Themes

ACTION THEME	RESPONSIBLE BODIES
Raising awareness	Irish Water, Group Water Schemes, HSE, EPA, DHPCLG, National Federation of Group Water Schemes (NFGWS), Water Services Training Group (WSTG)
Water providers	Irish Water, Group Water Schemes
Removing lead from housing stock	DHPCLG, Local Authorities, Approved housing bodies, Property Owners
Education Sector – Priority lead pipe replacement	Department of Education and Skills with advice from HSE and EPA
Hospitals and Health Care facilities – priority lead pipe replacement	HSE
Other Public Bodies – complete risk assessment & replace lead piping in high risk areas	DHPCLG, all public bodies
Research and Monitoring	Department of Health, DHPCLG, Irish Water, HSE, EPA, NFGWS, LAs

The key actions to be undertaken by Irish Water are in line with the overall National Lead Strategy and include:

Table 2: Key Actions to be undertaken by Irish Water

Key Actions to be undertaken by Irish Water	Target
Provide specific consumer advice materials.	On-going
Liaise with Health Service Executive (HSE) and Environmental Protection Agency (EPA) on issues arising where exceedances found in line with regulations and EPA guidance or lead pipes are discovered through the Irish Water metering programme.	On-going
Conduct a more extensive water sampling programme to assess levels of lead and define priority areas through the use of other indicator data	On-going;
Conduct research on various aspects of the lead pipe issue, including trials of chemical lining systems and use of orthophosphate as corrosion treatment	On-going
Optimisation of the properties of the treated water to reduce the level of lead in the drinking water in the distribution network (e.g. control of pH and appropriate treatment techniques)	On-going

1.2 Role of the Public Stakeholders

As highlighted in Section 1.1, there are a number of public authorities who are important stakeholders in the consultation and delivery of the Lead in Drinking Water Mitigation Plan.

The **Department of Housing, Planning, Community and Local Government (DHPCLG)** is responsible for policy and legislation in relation to water quality issues taking account of any advice of the Minister for Health on matters pertaining to public health. Specific arrangements are in place to regulate and supervise the supply of drinking water. These arrangements reflect the fact that the majority of people in Ireland receive their drinking water through public supplies, with the remainder provided through group water schemes and private wells.

The **Commission for Energy Regulation (CER)** ensures that water services are provided by Irish Water in an economic and efficient manner. The capital expenditure needed to deliver this Plan must be approved by the CER.

The **Environmental Protection Agency (EPA**) regulates both environmental matters and drinking water quality standards. The EPA is the authority required to verify compliance of water intended for human consumption with the parametric limits specified in the Drinking Water Regulations.

The **Health Service Executive (HSE)** is responsible for the protection of public health and, under the Drinking Water Regulations, where Irish Water or a local authority (LA), in consultation with the Health Service Executive, considers that a supply of water intended for human consumption constitutes a potential danger to human health, Irish Water or the authority shall, subject to agreement with the Health Service Executive, ensure that the appropriate action is taken to protect human health.

The relevant stakeholders are presented in the graphic below.

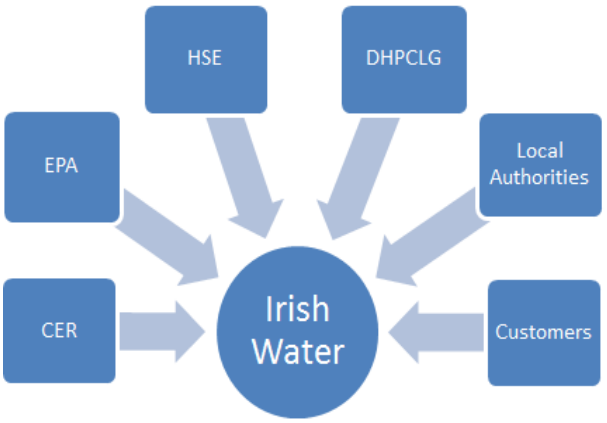


Figure 4: Lead Mitigation Plan - Relevant Stakeholders

1.3 Lead in Drinking Water

Drinking water as produced by Irish Water is free from lead and is compliant with the European Union (Drinking Water) Regulations. Irish Water's records currently show there are no lead water mains in Ireland. There are still some lead pipes in the public network. These are mostly in old shared connections or in the short pipes connecting the (public) water main to the (private) water supply pipes.

Lead can be dissolved in water as it travels through lead supply pipes and internal lead plumbing. Problems can also be caused by lead leaching from domestic plumbing components made of brass and from lead-containing solder. Recent international experience has shown that two out of three houses with lead pipes are now likely to exceed the new limit.

The use of lead pipes in water supplies has been documented in many countries from Roman times. Lead was used in the plumbing of houses and buildings built up to and including the 1970s. It was not generally used in the public distribution network, but was commonly used in shared backyard services serving groups of terraced houses, typically in older local authority built housing schemes.

Since December 2013, the acceptable limit for lead in drinking water as defined in the Drinking Water Regulations, was reduced to 10 micrograms per litre (µg/l). From 2003 to 2013, the limit was 25µg/l, which was a reduction of the previous limit (i.e. pre 2003) of 50µg/l.

The challenge posed by the 2013 lead limit reduction has been signalled since 1998 in Ireland. Successive annual EPA Drinking Water Reports identified the need for Water Services Authorities to plan and implement measures to meet the reducing limit. In the EPA's "Drinking Water in Ireland" report of 2004, the EPA encouraged the replacement of lead supply pipes and suggested that orthophosphate treatment should be considered to mitigate lead concentrations in drinking water: "Sanitary authorities must consider this problem in more detail if compliance with the standard of 10 µg/l is to be achieved by 2013. In particular some sanitary authorities may need to consider phosphate dosing to reduce the plumbosolvency of the water. This practice is widespread in the UK and in Europe but is currently not practiced in Ireland."

The relatively low levels of lead sampling required by the Drinking Water Regulations meant that the scale of potential non-compliance was not adequately reflected in published data. Over the past number of years the EPA has identified that the level of lead compliance would reduce once the 2013 limit came into force. Irish Water estimates that with intensified monitoring, the true level of compliance may be as low as 85-95%, lower than the current 98.7% (EPA 2015).

Recognising that the removal of lead pipes would be extremely costly and would take many decades, the UK Drinking Water Inspectorate (DWI) instructed UK water companies to add orthophosphate to drinking water supplies in 2001. The DWI required water companies in England and Wales to treat water with orthophosphate if more than 5% of RDT samples had exceeded 10µg/l. This treatment process creates a coating on lead and other metal pipes which minimises the lead dissolving into the water. This practice is now the accepted method of lead mitigation in many countries (e.g. Great Britain and Northern Ireland and has resulted in very high levels of compliance for lead (greater than 99%), in relatively short timeframes. Orthophosphate works as a corrosion inhibitor by forming a protective coating inside lead pipes. This coating helps reduce corrosion that can add lead to the water supply.

1.4 Health Issues

When lead is in contact with water, the metal can slowly dissolve. This process is known as plumbosolvency. The level at which lead can dissolve varies with the length of lead pipe, local water chemistry, temperature and the amount of water used at the property. Health studies in recent decades have identified risks to health from ingestion of lead. As a result, measures to reduce exposure to lead have been introduced in many countries worldwide, over the last 30 years. These measures included the removal of lead from petrol, paints, electronic goods and plumbing materials. It is widely recognised that the removal of existing lead pipes is a long term objective and in the meantime, alternative mitigation measures to reduce health impacts as adopted in other countries are required.

The continuous reduction in the allowable limits of lead in drinking water shows the increasing focus on minimising exposure to lead on health grounds in recent years.

The World Health Organisation (WHO), the EPA and HSE advise that pregnant women and young children are particularly vulnerable to the effects of lead. These organisations recommend that replacement of all lead pipework (public and private side) is the best long term solution to eliminate lead from drinking water. Current advice from the HSE and the EPA, based on WHO recommendations, is that no concentration of lead in drinking water is completely safe.

The WHO Guidelines recognise that lead is an exceptional issue, that most lead in drinking water arises from plumbing and that the ultimate remedial action consists principally of lead plumbing replacement. As this requires significant capital

investment, involves multiple stakeholders (including the property owner) and a long delivery time, it is recognised that not all drinking water will meet the guidelines immediately. In the meantime, all other practical measures to reduce exposure to lead, including corrective treatment should be implemented.

1.5 Legislative Background

The Directive Overview

The *Drinking Water Directive* (Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption) concerns the quality of water intended for human consumption. Its objective is to protect human health from adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean.

The Drinking Water Directive applies to:

- all distribution systems serving more than 50 people or supplying more than 10 cubic metre per day, but also distribution systems serving less than 50 people/supplying less than 10 cubic metre per day if the water is supplied as part of an economic activity;
- drinking water from tankers;
- water used in the food-processing industry, unless the competent national authorities are satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form.

The Directive sets out the essential quality standards at EU level. A total of 48 parameters covering microbiological, chemical and indicator categories must be monitored and tested regularly. In general, the *World Health Organization's* guidelines for drinking water and the opinion of the *Commission's Scientific Advisory Committee* are used as the scientific basis for the quality standards in the drinking water.

When transposing the Drinking Water Directive into their own national legislation, Member States of the *European Union* can include additional requirements e.g. regulate additional substances that are relevant within their territory or set higher standards. Member States are not allowed, nevertheless, to set lower standards as the level of protection of human health should be the same within the whole European Union.

Article 9 of the Drinking Water Directive *inter alia* requires Member States ensure that consumers are notified where remedial action is taken. In cases where a drinking water supply constitutes a potential danger to public health its use must be prohibited or restricted, or such other **action taken as necessary and consumers must be promptly informed** and given the necessary advice.

Drinking Water Regulations

In terms of statutory obligations with respect to lead in drinking water, Regulation 6 of the European Union (Drinking Water Regulations) S.I. 122 2014 sets out Irish Water's "Duties in relation to water on premises" (i.e. within households or public buildings).This states that:

> *Regulation 6(1) A water supplier* ***shall not be in breach of its obligations*** *under Regulation 4(1)* ***where non-compliance is due to the domestic distribution system in a premises****, or the maintenance thereof, and that distribution system is not in the charge or control of the water supplier in its capacity as a water supplier.*

Therefore, Irish Water is not legally responsible for water exceeding the lead concentration if this is due to lead pipework which it does not own or operate (i.e. within a property boundary). However, the Regulations further state that:

> *Regulation 6(3) Without prejudice to paragraph (4), where a non-compliance referred to in paragraph (1), or a risk of such non-compliance, is in a premises where water is supplied for human consumption as part of a commercial or public activity (including, but not limited to, schools, hospitals and restaurants) Irish*

Water or the relevant local authority shall ensure that appropriate action is taken promptly (whether by the owner of the premises or the water supplier, or both, as Irish Water or the relevant local authority may consider appropriate) to—

(a) immediately prevent, or restrict as Irish Water or the relevant local authority deems appropriate, the further supply of water for human consumption to the public through the domestic distribution system of the premises until the system is restored to such condition as to no longer be a cause or a risk of such non-compliance, and

(b) restore the domestic distribution system of the premises to a standard necessary for compliance with these Regulations, and Irish Water or the relevant local authority may issue such directions as it considers necessary for this purpose.

Therefore, if Irish Water is aware of a lead non-compliance with the Drinking Water Regulations in a commercial premises (i.e. where members of the public may be drinking water on the premises), it must ensure that appropriate action is taken, whether by the owner of the premises or by Irish Water (as Irish Water considers appropriate) to ensure that the drinking water on the premises is restricted and that the domestic distribution system at the premises is restored to a standard necessary to ensure compliance with the Drinking Water Regulations. Irish Water may issue directions as it considers necessary for this purpose.

Regulation 6(5) Where a non-compliance referred to in paragraph (1), or a risk of such non-compliance, is in a premises where water is supplied for human consumption but not as part of a commercial or public activity, Irish Water or the relevant local authority shall nevertheless ensure that—

(a) (i) appropriate measures are taken to ***reduce or eliminate the risk of non-compliance*** *with the parametric value,* ***including advising premises' owners*** *affected of any possible remedial action which could be taken by them, or*

(ii) other measures are taken, such as application of ***appropriate treatment techniques****, to change the nature or properties of the water before it is supplied so as to reduce or eliminate the risk of the water not complying with the parametric value after supply.*

Therefore, if Irish Water is aware of a lead non-compliance with the Drinking Water Regulations in a home (or non-commercial premises), it must ensure that advice is given on remedial and other measures to reduce the risk of non-compliance. Irish Water may as an alternative consider the application of appropriate treatment techniques to change the composition of the water before it is supplied so as reduce or eliminate the non-compliance with the parametric values as set out in the Drinking Water Regulations i.e. 10µg/L for lead.

One of the key challenges with this aspect of the regulations is that lead service connections were not recorded in the Irish Water/Local Authority Geographical Information System (GIS), and there are no records for lead in non-domestic connections. Records are being developed and improved through the Irish Water metering and watermain rehabilitation programmes. While this data gap exists, Irish Water must undertake national sampling programmes, continuous GIS updates and investigative studies to identify the cause of the lead contamination.

The Point of Compliance

Irish Water's point of compliance is defined as the "the point within a premises at which it emerges from the tap or taps that are normally used for the provision of water for human consumption".

Pipe Responsibility

As illustrated in Figure 3, Irish Water pursuant to the lead replacement scheme only will be responsible for the replacement of pipes under the road or paths to the outer edge of the boundary of the property. Typically 75-90% of the pipe length from the water mains to the customer's tap can be within the property boundary, and is the responsibility of the homeowner.

The water pipe which joins the water main to the outer edge of the boundary to the curtilage of the property is called the 'service connection'. Inside the boundary to the curtilage of the property is the distribution system. Service connection pipes can be either separate (one pipe per property), or shared (two or more properties fed by a single common service pipe). Irish Water is not responsible for either separate or shared supply service connections unless they have been taken-in-charge. There are some lead pipes in the public network that cross through private property. Irish Water is responsible for these pipes at the rear of older terraced housing where the water is supplied by a looped shared service pipe, connected to the public supply at both ends.

Depending on the age of a property, public-side service connection pipes (either separate or shared) may be of lead or materials containing lead. Local authority housing pre-1950's was typically built in terraces and the supply (usually small diameter and often lead or gun-barrel (containing lead) pipe was laid in the backyards of properties. Pipes looped at both ends was a low cost approach to servicing housing stock, enabling shorter runs of smaller diameter pipe to be used with shorter connections to the kitchen tap. There are multiple pipe configurations associated with backyard services. Backyard services will need to be examined on a case-by-case basis to determine pipe ownership.

Irish Water's pipe maintenance responsibility Figures 5,6 and 7 below (Irish Water, 2014) demonstrate the maintenance responsibility of water supply and wastewater pipes between the property owner and Irish Water for a number of scenarios. For more details view the following link: *www.water.ie/piperesponsibility*

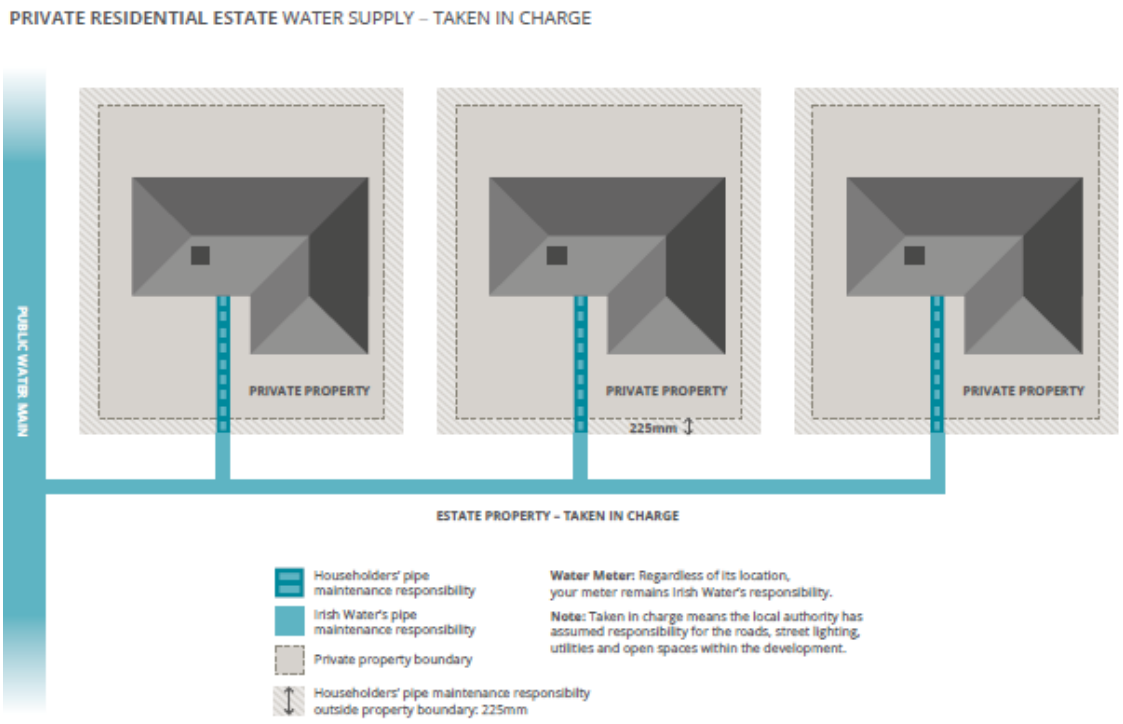


Figure 5: Pipe Responsibility - Taken in charge

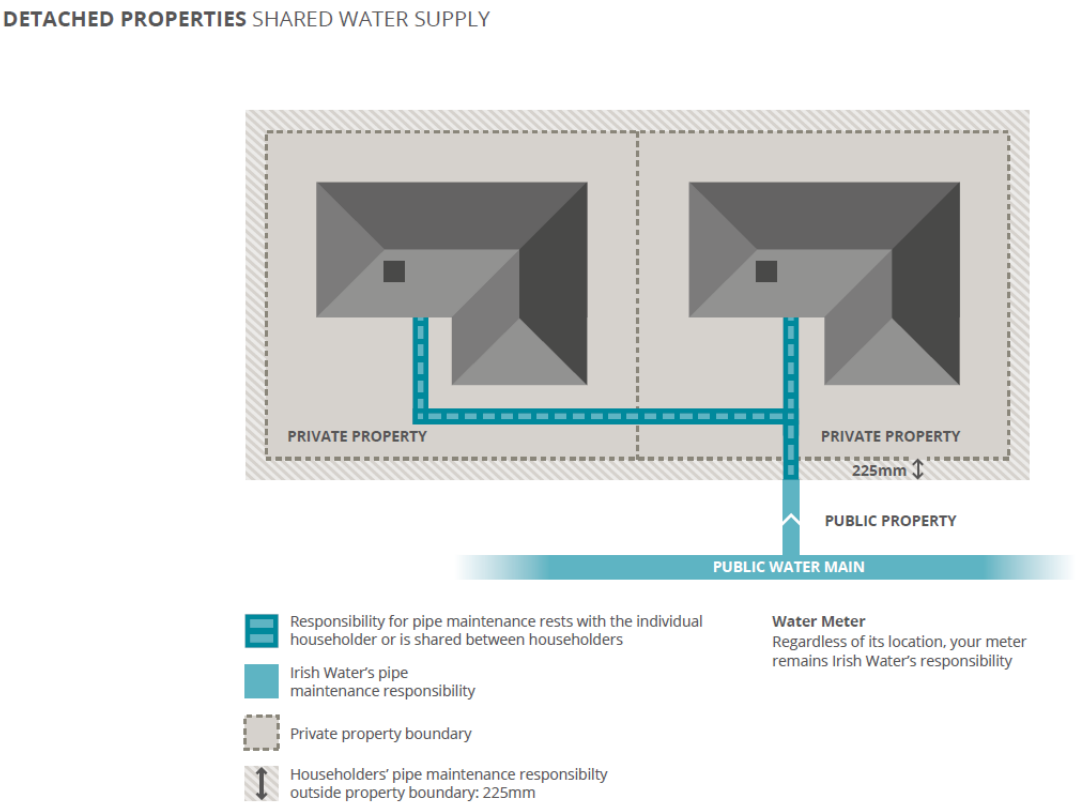


Figure 6: Pipe responsibility - Detached Properties Shared Water Supply

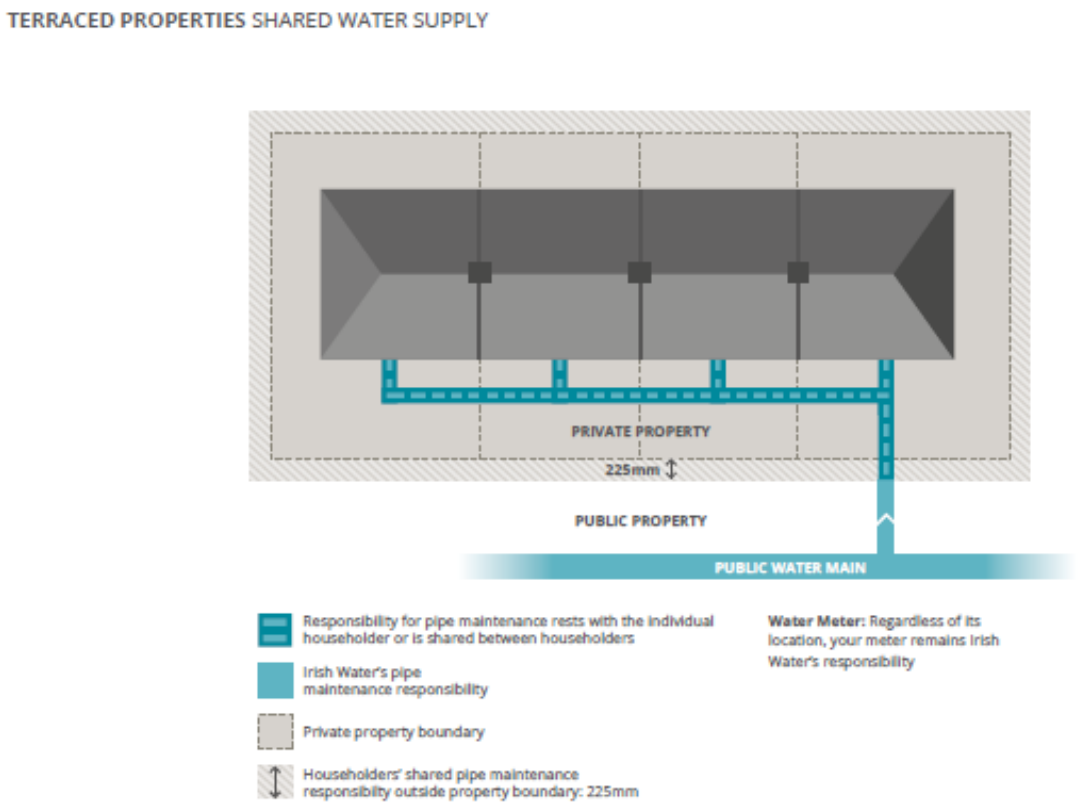


Figure 7: Pipe responsibility - Terraced Properties Shared Water Supply

1.6 Summary of Actions Taken to Date

Irish Water was established in 2013 and took over responsibility for public water services in Ireland from January, 2014. It immediately identified lead in drinking water as a very significant issue. The Irish Water Capital Investment Plan (CIP 2014-2016) committed to quantifying the lead problem and to developing a Lead in Drinking Water Mitigation Plan. The actions taken by Irish Water to date in quantifying and addressing the lead problem are discussed in the following paragraphs.

More extensive sampling by Irish Water has identified levels of lead at customer properties multiples greater than the new lead limit. Where exceedances have been confirmed, they have been notified to the EPA, HSE and the affected customers. This in turn has given rise to a much greater public awareness of lead pipes as an issue for drinking water quality. Moreover, it has become clear that the problem is nationwide and that the presence of lead piping is an indicator of lead in drinking water. A national approach is required to resolve the lead issue involving Irish Water and other stakeholders including the EPA, HSE, CER and the DHPCLG.

Irish Water has examined international experience in dealing with lead in drinking water and made its initial assessment of the scale of lead in the system as a basis for developing the Issues Paper and in the preparation of a Lead in Drinking Water Mitigation Plan. In preparing this Plan, Irish Water has liaised extensively with the DHPCLG, the EPA and the HSE. Due to the scale of the problem and the cost implications of replacing lead pipework Irish Water propose a long term integrated approach, which considers all available measures in the mitigation of health risks to the public.

Irish Water is collating data from the Local Authorities (LAs), the water metering programme and Central Statistics Office (CSO) small area property age maps. This data is being uploaded onto a Geographical Information System (GIS) to identify locations of properties likely to have lead pipes and which may exceed the drinking water limit.

Irish Water advising customers where lead pipes have been identified through the national metering programme. Our website provides advice to customers on lead in drinking water and includes the HSE and the EPA Joint Position Paper on Lead in Drinking Water (December 2013), which is available at the following links:

http://www.water.ie/help-centre/questions-and-answers/lead-pipes-information-for-customers/

http://www.epa.ie/pubs/advice/drinkingwater/7523epaDrinkingWaterReportWeb.pdf

http://hse.ie/eng/health/hl/water/drinkingwater/lead/

To date over 36,000 letters have been sent to houses where lead service connections were identified during meter installation works.

The potential solutions being considered by Irish Water are detailed in Section 4 of this Plan.

These include:

- Advice to customers in properties that may be at risk;
- Actions that can be taken to reduce lead concentrations at a property; and,
- Irish Water's long term goal for full removal of all public side lead pipework (This will only be effective, if property owners replace their lead pipework in the same timeframe).

For the past 20 years, there has been a significant investment in water conservation and service improvement programmes that have focussed on water main replacement in areas with backyard services due to high levels of leakage. Prior to investment, customers in these properties generally experienced very poor levels of services in terms of pressure and interruptions due to leakage and bursts. Backyard services have often been built/extended over by property owners and consequently cannot be exposed for repair. Years of incremental leakage and bursts have gone unrepaired, with the only practical solution being to lay new water mains in public roads at the front of the property. These programmes have been a priority since the 1990's.

Irish Water has continued to remove lead service connections and backyard services and improve customer service levels as part of our water conservation and water main rehabilitation programmes under the Capital Investment Plan 2014-2016. We will continue to do so under the next Investment Plan (2017-2021), which outlines removal targets.

Irish Water has established lead pipe replacement "opt-in" scheme, where Irish Water will also replace the pipework between the water main and the outer edge of the property boundary, if a property owner replaces the lead pipework on their property.

Section 2 Objectives

2.1 Drinking Water Safety Plan

The objective of this Plan is to improve lead compliance nationally on a risk prioritised basis.

Irish Water has adopted the World Health Organisation (WHO) Drinking Water Safety Plan (DWSP) approach to identify, reduce and manage risk to drinking water supplies. The DWSP will be prepared and implemented for all Water Supply Zones (WSZs).

The WHO considers a Drinking Water Safety Plan (DWSP) as '*the most effective means of consistently ensuring the safety of a drinking water supply through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer*'.

The primary objectives of a DWSP are to:

- Ensure that drinking water supplies are safe and secure;
- Increase levels of compliance and reduce the number of incidents through a more proactive and risk based approach to water safety;
- Identify and reduce risk in a more systematic and consistent way;
- Inform strategic and investment decisions and provide a more consistent method of targeting, prioritisation and justification for capital investment;
- Provide a more standardised and consistent set of operating procedures and Standard Operating Procedures (SOPs), across the organisation; and
- Identify gaps in staffing, training, and knowledge base.

DWSPs are to be developed specifically for each WSZ within a risk management process to ensure the continuous supply of safe water. The key components of a DWSP approach to identify the various risks in a water supply are illustrated in the figure below.

Figure 8: Key components of a DWSP

In Ireland, the EPA and the DHPCLG have been promoting the preparation of DWSPs since 2009. The EPA issued Advice Note 8 (Developing Drinking Water Safety Plans) in 2011 to assist LAs with the preparation of plans.

The following three DWSP risks are related to lead in drinking water.

Table 3: Drinking Water Safety Plan Hazards related to Lead

DWSP Ref. No.	DWSP Hazard Related to Lead
DN150	Presence of lead mains in the ownership of the Water Supplier causing contamination
DN160	Presence of lead communication pipes (lead service connections) in the ownership of the Water Supplier causing contamination
DN170	Leaching and pipe work corrosion causing entry of corrosion by-products into water supply

Irish Water's analysis from lead compliance monitoring data, metering survey data, metering installation records, watermain type and property age data, indicates that there are likely to be 180,000 domestic customer properties (combined individual and backyard service) affected by lead service connections. The approach to be taken by Irish Water through the Plan is to improve lead compliance nationally on a risk prioritised basis.

Following the elimination of all known lead water mains (with the exclusion of looped shared and backyard services for which GIS records have yet to be developed as part of the lead programme), risk Reference Number DN150 is currently not applicable. Risk Reference Number DN160 is considered to apply to every water supply zone on the basis that there are pre-1980 houses present in the majority of them. Lead pipes may have been used in water service connections and internal plumbing in properties built up to and including the 1970s. Risk Reference Number DN 170 is also applicable as it applies to not only lead, but copper and other metals that were commonly used in water mains, service connections and distribution systems.

The following tables set out the risk assessment methodology in accordance with the Drinking Water Safety Plan outlined in EPA Advice Note 8 i.e. Risk Classification = Severity of Consequence X Likelihood.

All water is sufficiently plumbosolvent to cause a breach of the 10 µg/l limit, therefore it is considered that any property with a lead service pipe and/or distribution system is "likely" to happen again (Score = 4) as shown below in Table 4.

Table 4: Likelihood Descriptors

Level	Descriptor	Description
1	Most unlikely	Has not happened in the past and is highly improbable that it will happen in the future
2	Unlikely	Has happened in the past, is possible and cannot be ruled out completely
3	Foreseeable	Has happened in the past, is possible and under certain circumstances could happen again
4	Likely	Has occurred in the past more than once, is likely to happen again
5	Almost certain	Has occurred in the past, is an ongoing problem, and is very likely to happen again

Lead in drinking water is recognised as a health concern. The limit for lead in drinking water has been reducing over time and is now at a very low level (10 µg/l or 10 micrograms per litre). Exposure to lead is well established as a "major" long term health risk (Score=4) as shown below in Table 5.

Table 5: Severity/Impact of Consequence Descriptors

Level	Descriptor	Description(s)
1	Insignificant	Wholesome water, no public health impact
2	Minor	Short term or localised, aesthetic or not health related. Treatment compromised. No regulatory failure
3	Moderate	Long term non-compliance, widespread aesthetic issues or not health related. Treatment compromised. Regulatory failure but no health risk
4	Major	Potential long term health effects (e.g. lead, THM's, nitrate). Treatment compromised. Regulatory failure. Disruption to consumers in the supply
5	Catastrophic	Presence of micro-organisms, parasites or substances that are an imminent danger to public health (e.g. E.coli, Cryptosporidium). Treatment compromised. Regulatory failure. Disruption to consumers in the supply

Based on a severity score of 4 and likelihood score of 4 in Tables 4 and 5 above, any lead connections in a water supply zone has a risk score of 16 (4 x 4 = 16) and a risk classification of 'very high' as shown below in Tables 6 and 7. In accordance with DWSP planning, a very high score requires urgent action to mitigate the hazard in the short term. The mitigation of lead in drinking water issue is a complex challenge. Section 4 below discusses mitigation options available to Irish Water to achieve the objectives of the Plan.

Table 6: Risk Assessment Matrix

			Severity/Impact of Consequence				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
Likelihood	Almost certain	5	5 (L)	10 (M)	15 (H)	20 (VH)	25 (VH)
	Likely	4	4 (L)	8 (M)	12 (H)	16 (VH)	20 (VH)
	Foreseeable	3	3 (L)	6 (M)	9 (M)	12 (H)	15 (H)
	Unlikely	2	2 (L)	4 (L)	6 (M)	8 (M)	10 (M)
	Most unlikely	1	1 (L)	2 (L)	3 (L)	4 (L)	5 (L)

Low 1 – 5, Medium 6 – 10, High 12 – 15, Very High 16 – 25

Table 7: Action to be taken following risk assessment

Risk Classification	Action
Low	Manage using routine procedures, keep under review
Medium	Action required, plan and prepare
High	Priority action required to mitigate hazard in short term
Very High	Urgent action required to prevent hazard (e.g. shut down supply/ boil notice or water restriction), action required to mitigate hazard in short term

Section 3 Consultation

3.1 Introduction

In order to successfully prepare and implement the Plan it is not only important to comply with the relevant legislation but also to ensure the confidence of the numerous stakeholders.

3.2 Stakeholders / Consultees

A list of statutory and other interested parties to be consulted was prepared at an early stage prior to publication of the Lead in Drinking Water Mitigation Plan - Issues Paper in June 2015. A non-statutory public consultation was held on the Issues Paper from 3rd June to 15th July 2015 to invite feedback from the public, statutory bodies and all interested individuals and organisations. Newspaper ads were also placed to generate awareness of the Issues Paper and information was uploaded to the Irish Water website.

The draft Lead in Drinking Water Mitigation Plan was prepared in consultation with the EPA, HSE, CER and other stakeholders as applicable and was published for public consultation on 27th July 2016. A National media and communications campaign was run by Irish Water to inform the public and any other interested parties of the development of the LDWMP, SEA and NIS and to invite feedback. The campaign included newspaper and radio advertisements, both nationally and locally, and also National and local media appearances.

The Irish Water Website was updated with information on the Plan and the draft LDWMP and associated environmental reports were made available for download. A copy of the Draft LDWMP and associated environmental reports was also sent to each Local Authority with a request to make the documents available at planning counters.

3.3 Public Information Strategy

The four phases to the public information strategy for the LDWMP were as follows:-

1. Non-statutory public consultation on the Lead in Drinking Water Mitigation Plan – Issues Paper;
2. SEA Scoping Report published following consultation with statutory consultees;
3. Statutory consultation on the Draft LDWMP, SEA and AA and;
4. Publication of the finalised LDWMP and SEA Statement.

A project roadmap was prepared to provide a synopsis of the project activity, what it involves and how and when the public can participate. A copy of this is included in Figure 9.

Submissions from the consultation on the Issues Paper and at the SEA Scoping stage were reviewed and taken into account in the development of the draft LDWMP, final Plan and the associated environmental reports.

Submissions on the draft LDWMP and associated environmental reports have been taken into account, in the preparation of the final documents.

3.4 Public Consultation Feedback Report

An eight-week public consultation period for the draft LDWMP, SEA and NIS commenced on 27th July 2016 and finished on 21st September 2016. Submissions on the published documents were received from eighteen stakeholders and interested parties.

All feedback received as part of this consultation was reviewed by the project team and the issues raised were published in the Lead in Drinking Water Mitigation Plan Consultation Report. This report is available on the website *www.water.ie/lead*.

Submissions from individuals are reported anonymously in the Consultation Report, while feedback from organisations is attributed to them. All feedback from all the public and statutory

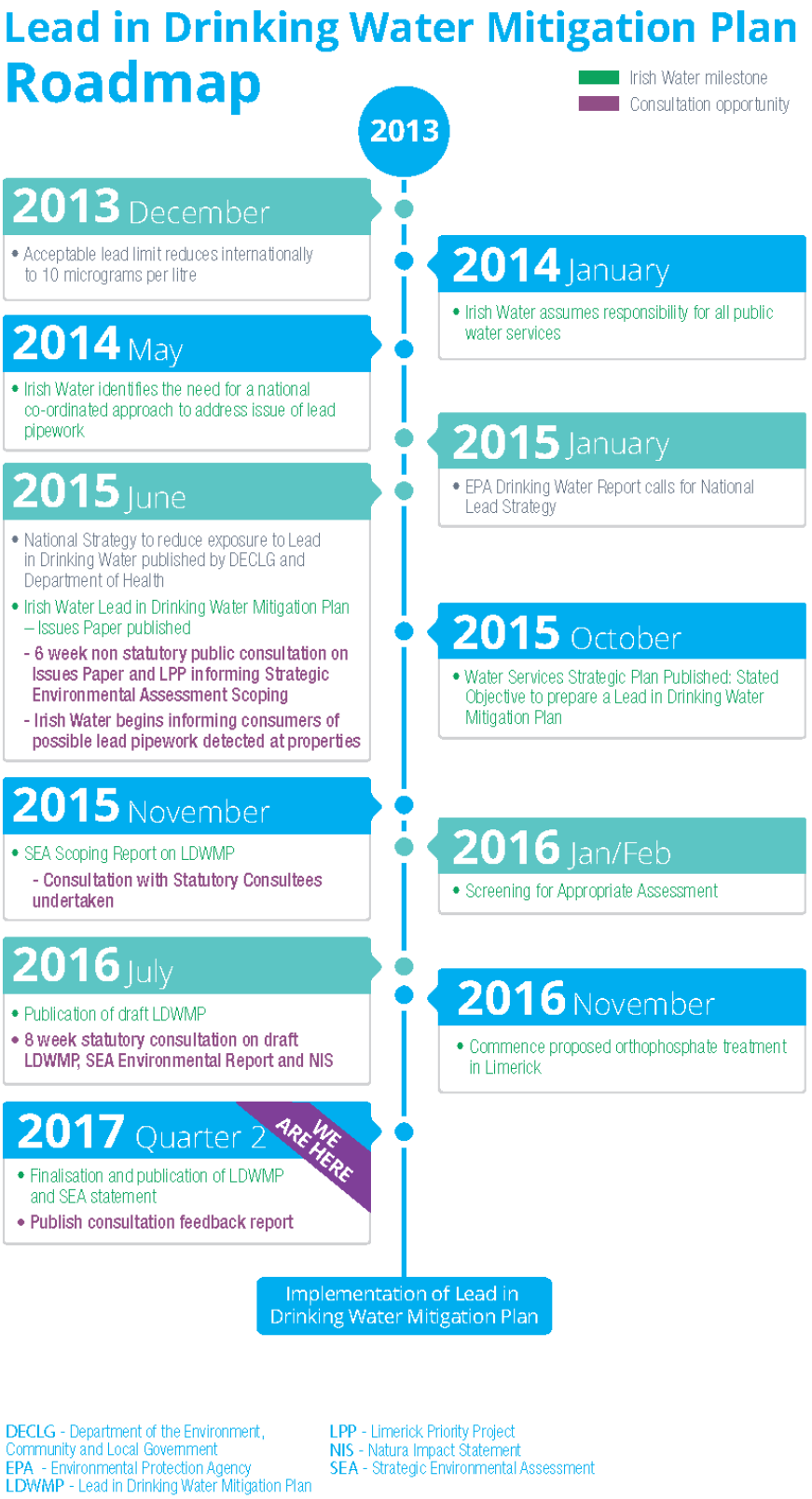


Figure 9: Project Roadmap

consultations have been considered in both the formation and finalisation of the LDWMP and associated documents.

The consultation report provides further details of the consultation process and feedback.

The SEA Statement, published on the website *www.water.ie/lead* provides details on how the Strategic Environmental Assessment, Appropriate Assessment and consultation process have informed the development of the final LDWMP.

The main topics in the submissions received in the public consultation are as follows:-

- The DHPCLG grant for replacing lead pipes;
- The orthophosphate treatment process;
- Health queries
- The prioritisation of human health over environmental protection.

Additional consideration has been given to these topics where applicable and the SEA Statement provides further detail on how these submissions have been considered.

Section 4 Lead Mitigation Options

The mitigation of lead in drinking water issue is a complex challenge and involves a number of stakeholders. There is no quick solution and full compliance will take time.

By not implementing the appropriate mitigation actions, the water supply in an estimated 180,000 residential properties as well as in many commercial and public buildings properties is at risk of not meeting the EU lead standards. During the preparation of the Irish Water Lead in Drinking Water Mitigation Plan, we have researched international mitigation practices. Irish Water, as part of implementing the Plan, will continue to reference international experience and research, and assess various mitigation options.

Prior to the establishment of Irish Water, the lead compliance issue was not addressed nationally in a planned and consistent manner. Successive annual EPA Drinking Water Reports identified the need for Water Services Authorities to plan and implement measures to meet the allowable lead limit. This was completed in an ad-hoc manner with some Local Authorities performing better than others.

This section discusses the following Lead Mitigation Options to reduce exposure to lead in drinking water:

- Do Nothing
- Advice Only
- pH Adjustment
- Point of Use Filters
- Lining of Lead Services
- Lead Service Replacement
- Corrective Water Treatment for the protection of human health

4.1 Do Nothing

The 'do nothing' approach is not acceptable considering the known public health issues associated with lead and the legislative requirements in relation to lead which apply to Irish Water.

4.2 Advice Only

Irish Water is implementing measures including the dissemination of public information and responding to customer queries. To date over 36,000 letters have been sent to houses where lead service connections were identified during Irish Water Metering Programme meter installation works. Irish Water has provided a section on its website, dedicated to providing advice and information to its customers on lead. A link to the HSE & EPA Joint Position Paper, Lead in Drinking Water (HSE/EPA, 2014) and FAQ (HSE, 2014) has been provided on the Irish Water website and owners are advised that private-side lead pipe replacement is recommended. The paper also provides information on how to identify lead piping, advice on flushing, and the use of alternative supplies as methods which can reduce lead risk. Irish Water will continue to expand on this advice and information, developing its range of appropriate 'questions and answers' based on the queries received from its customers.

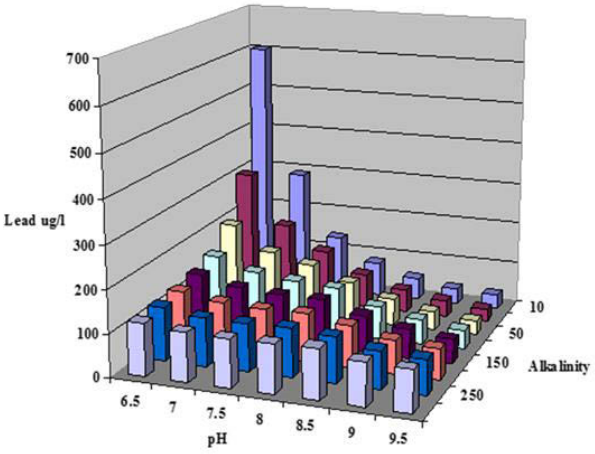
To ensure consistent support is provided to our customers, Irish Water will provide its call centre with updates on the lead programme rollout and specific advice and support to deal with lead related queries.

The replacement of private-side lead supply pipes and internal plumbing is the responsibility of the property owner. In the majority of the cases the private distribution system will be of significantly greater length than the public service connection to the stopcock/meter. Therefore, any property owner with lead pipework needs to be aware of the risk that lead concentrations in excess of the allowable limit in drinking water may arise.

The 'advice only' approach is unacceptable given the public health issues associated with lead and the statutory responsibilities of Irish Water. Customer communication will form an integral part of Irish Water's Lead in Drinking Water Mitigation Plan and each mitigation measure proposed.

4.3 pH Adjustment

To reduce exposure of customers to lead in drinking water, it is recommended to optimise the quality of the treated water to reduce the plumbosolvency of water in the distribution network through control of pH. The amount of lead dissolved from lead pipework into water depends on several factors, including the pH of the water. Previously, pH adjustment has been utilised to minimise lead dissolving from lead pipework. Increasing the pH decreases the solubility of lead in drinking water, particularly for low alkalinity waters, and may result in to the formation of an insoluble calcium carbonate precipitate along the pipe wall. The deposition of calcium carbonate in pipes may help reduce corrosion of lead pipes. The graph below illustrates how pH influences lead concentration in conjunction with alkalinity.



Graph 1: Equilibrium concentration of lead in drinking water as a function of pH and alkalinity - Croll (2000)

Although the adoption of pH adjustment can reduce the solubility of lead, it is generally considered in most cases inadequate to achieve the new lower 10µg/L limit as required by the Drinking Water Regulations. pH elevation will be considered as an interim treatment solution in some situations in advance of more comprehensive corrective water treatment or in situations where comprehensive corrective water cannot be implemented.

In Section 4.7, Corrective Water Treatment, pH Adjustment in conjunction with Orthophosphate treatment is assessed.

4.4 Point-of-Use Filters

This section provides an overview of Point-of-Use (PoU) type water treatment devices used in a residential or similar small scale settings and that claim ability to reduce lead concentrations in drinking water. The information below has been collated by Irish Water and is a combination of research by DHPCLG and Irish Water.

There are various types of water filters marketed in Ireland for residential use. They are commonly called “point-of-use “, “under-sink” or “kettle filters” etc. Following review of guidance and expert literature on the area they are more appropriately termed “Point-of-Use” and “Point-of-Entry” treatment systems:

Types of Domestic Treatment Systems

Point-of-Use (POU): These devices treat water at the point of consumption of the water i.e. as drinking water or for cooking. They are generally fitted in the kitchen and in such circumstances draw water from the rising main to the kitchen tap but using a separate dedicated tap at the sink to supply the treated water as needed. In addition to being fitted under sink they can be found as worktop units, freestanding units, integrated in a refrigerator etc. Some commonly used technologies include: Activated Carbon, Reverse Osmosis, Ultraviolet (UV) Technologies and Distillation (distillation is not common in domestic situations and not all of these technologies are suitable for reduction of lead – as discussed further in text below

Point-of-Entry (POE): These devices are whole-house treatment systems mainly designed to reduce contaminants in water intended for whole of residence use - showering, washing and flushing toilets etc.

The presence of lead in water used in domestic circumstances is not an issue for use other than

drinking and cooking water; therefore the most appropriate systems to consider are the following POU devices.

Overview of POU Treatment Systems

Adsorption/Filtration: These systems rely on a process that occurs when dissolved or suspended matter – the contaminant - adheres to the surface of, or in the pores of, an adsorbent media. Carbon filters are an example of this type of product. They are smaller and more compact than Reverse Osmosis (RO) devices – typically an RO device incorporates such a filter. Filtration products that are marketed as suitable to reduce lead concentrations if present in drinking water aim to achieve under the current drinking water parameter for lead (10 µg/l). Not all adsorption/filtration products that are marketed are suitable for reduction of lead; refer to section below on standards/certifications.

Reverse Osmosis: Reverse Osmosis (RO) systems incorporate a process that uses reverse pressure to force water through a semi-permeable membrane which holds back contaminants. These systems typically consist of cartridges that pre-filter, RO membrane, and one that restores natural minerals in water that are removed by the RO process. RO based systems are stated to be effective in reducing lead concentrations, if present, in drinking water. Manufacturers typically claim reductions ranging from 95-99%

Standards

From investigations carried out by Irish Water, National Sanitation Foundation (NSF) Standards are the industry accepted standards that product manufacturers strive to achieve. The NSF is an independent, not-for-profit, non-governmental American organisation; their standards appear to be used by the industry worldwide. They are accredited by the American National Standards Institute (ANSI). There does not appear to be an equivalent widely accepted European Standard.

The relevant NSF standards are as follows:

1. NSF 53 – Drinking Water Treatment Units - Health Effects - **(relates to filter units)**
2. NSF 58 – Reverse Osmosis Drinking Water Treatment Systems - **(relates to RO units)**

Both standards include similar material, structural, performance and testing requirements. Both also **include the removal of Lead as an elective performance claim**; therefore a unit must be certified to one of the above standard specifically for the reduction of Lead (e.g. a filter may be NSF 53 certified for Cryptosporidium reduction but not necessarily for Lead reduction).

Both of the above standards require a product to reduce the concentration of Lead from a level of 150µg/L (±25%) to below 10µg/L, for the product to be NSF certified for the removal of Lead.

Note: NSF Standard 42: Drinking Water Treatment Units - Aesthetic Effects is not relevant in relation to lead removal.

Are Domestic POU Water Treatment Devices on the Irish Market?

Yes. It should be noted that the performance claims of POU Water Treatment Devices available on the Irish Market vary considerably.

Assessment of POU Filtration Systems

Only a small proportion of available products were certified for lead reduction to NSF 53 as required. Of the certified products that are available the installation price varied between €270 and €450 with operational costs of approx. €125/annum (all prices inclusive of VAT).

Typical POU Water Filter System. Photo: Rainfresh, Canada

Below lists include some of the limitations of POU Filtration Systems:

- System does not address the WHO and Irish Water objectives of long term supply pipe lead removal, thereby leaving a legacy risk for customers.
- Irish Water cannot supervise the installation, operation or maintenance of systems in private properties and therefore cannot stand over the level of compliance achieved.
- NSF certificate performance requirements include for the reduction of lead concentration from 150µg/L to 10µg/L. Should the source water's lead concentration exceed 150µg/L, these units are not certified for reducing lead to compliant levels below 10µg/L. This is a risk for large scale roll-out.
- Installation and maintenance of these units are the responsibility of the property owners. Therefore the property owner would have to ensure units are correctly maintained and consumables are replaced as required.
- On average the combined costs of Capital expenditure (i.e. purchasing the filter) plus Operational expenditure (i.e. maintenance, parts) exceeds the estimated cost of public side lead service replacement over a 6 year period.
- The variation in rate of water consumption by different properties would result in filters needing to be replaced after varying durations of time.
- Reduction in flow rate may be an issue for residents; this problem could be compounded by a further reduction in flow rate relating to filters that have processed high volumes of water.
- Additional risks relating to growth of bacteria in filters should they not be correctly maintained.

Assessment of POU Reverse Osmosis Systems

The majority of POU RO systems that are available on the Irish Market are not appropriate for use in domestic situations, due to the size and cost of the units. In addition only a small proportion are certified for lead reduction to NSF 58 as required. The installation price for a system is approx. €1250 with operational costs of approx. €170/annum (all prices inclusive of VAT).

Typical POU Reverse Osmosis System. Photo: Rainfresh, Canada

Below lists include some of the limitations of POU Reverse Osmosis Systems:

- System does not address the WHO and Irish Water objectives of long term supply pipe lead removal, thereby leaving a legacy risk for customers.
- Irish Water cannot supervise the installation, operation or maintenance of systems in private properties and therefore cannot stand over the level of compliance achieved.
- NSF certificate performance requirements include for the reduction of lead concentration

from 150µg/L to 10µg/L. Should the source water's lead concentration exceed 150µg/L, the units are not certified for reducing lead to compliant levels below 10µg/L. This is a risk for large scale roll-out.

- Units are too large for many domestic situations.
- Additional risk associated with the removal of Fluoride; Water Fluoridation is a major component of HSE's public health policy in Ireland in the prevention and management of tooth decay. RO devices are also effective in reducing fluoride concentrations (suppliers of RO products would typically state a reduction of circa 95%);
- Water wastage associated with the RO process.
- The Capital expenditure cost would exceed the estimated cost of replacement of the public side lead service.
- Installation and maintenance of these units are the responsibility of the property owners. Therefore the property owner would have to ensure units are correctly maintained and consumables are replaced as required.
- The variation in rate of water consumption by different properties would result in filters, membranes & remineralisers needing to be replaced after varying durations of time.
- Reduction in flow rate may be an issue for residents.
- Additional risks relating to growth of bacteria in remineraliser filters should they not be correctly maintained.

Conclusion

Based on the above, Point-of-Use Systems have a number of limitations that make them unsuitable as a control measure that may be implemented on a large scale in order to mitigate the risk of lead in drinking water.

The use of Point-of-Use filters at drinking points with NSF/ANSI 53 accreditation to remove lead could be considered by individual customers and institutions such as schools, crèches, etc. as a short term mitigation option on a case-by-case basis. It is important that proper maintenance is stressed to ensure the filters are changed according to manufacturers' recommendations.

4.5 Lining of Lead Service Connections

Overview

Recent advancements in pipe lining technology have resulted in the ability to line small diameter pipes from 12 mm diameter upwards. This technology originated in Canada and is now applied in the UK through a small number of service providers known to Irish Water.

There are two lining options available:

1. Epoxy Lining - the process involves the application of an epoxy lining, approved for use as a material in contact with drinking water, by the UK Drinking Water Inspectorate.
2. Insertion of PE Tubing – Insert of Polyethylene Terephthalate (PET) tubing into lead service pipe.

The methodology involves the cleaning of existing lead service pipes through the use of carborundum abrasive which is introduced into the piping system using compressed air. Spent abrasive is collected at the opposite end in an open pipe scenario or through the flushing of the isolated section of water main in the context of public side service lining.

Subsequent to the cleaning process the pipe is dried using heated compressed air. The epoxy is prepared and mixed manually and blown into the piping system using heated compressed air. The lining is then allowed to cure. The lined pipework is capable of returning to full service within the same working day. Prior to the returning to normal service the lined pipe is flushed for a minimum of 5 minutes at a rate of approximately 25 litres per minute as recommended by the lining manufacturer.

The epoxy linings are proprietary products and generally marketed as having a minimum life span of 40 years. A small number of UK Water Utility companies have embarked on pilot programmes of lining public side lead using these technologies.

In January 2016, Irish Water undertook a trial of lining technologies currently available on the

market. Four lining contractors were asked to demonstrate their services. Refer to Case Study below for details.

The lining solution is capable of isolating the lead service connection pipe from the drinking water where the pipe to be lined is:

- without serious leaks;
- not kinked and where;
- unknown valves are not incorporated within the length to be lined.

Supplier experience to date shows that in a typical street it is possible to use this technology in between 50% to 70% of the target service connection pipes.

The cost will be dictated by the scale of the work available for each location as the equipment set up is similar for a one off as for a whole street. Work being undertaken at present by a number of water utilities in the UK shows that it is possible to complete up to 15 connections per day (two crews working on an urban street).

This system can also be used to line the private side lead piping through to the kitchen sink where the length is no longer than 10-15 metres. The length of pipe that can be lined from a single access point is dictated by the distance travelled in approximately 4 minutes. The time period is dictated by the length of time that the liner remains in a liquid state.

Conclusion

Lining of the lead service connection does not currently address the Irish Water objectives of long term lead removal, thereby leaving some legacy risk for customers. At present, there is limited demonstrative evidence available from Canada, Spain and UK that this technology can meet the required water quality standards. There are a number of risks and factors that could impact on its performance and its suitability for all service connections. The technology has certain advantages and is an ever evolving technology. Irish Water will continue to monitor developments in this area and adjust our Plan as required to ensure that the most effective mitigation measures are utilised to achieve compliance target objectives. Should it be deemed to be an effective mitigation option in the future, this non-invasive lead pipe rehabilitation would be an attractive option for customers and would minimise disruption associated with replacing privately owned lead supply pipes.

Case Study
Lining of Lead Service Connections

In January 2016, Irish Water undertook a trial whereby we commissioned a Contractor to install four test beds within its works compound incorporating six lead water supply pipes in each trench comprising the following:

Pipe No.1
18m length of 12mm lead service pipe – buried, with no leaks present.

Pipe No.2
18m length of 12mm lead service pipe – buried, with a 3mm hole/leak at a known location and 2 no. 90° Joints at a known location on pipe.

Pipe No.3
18m length of 12mm lead service pipe – buried, with no leaks present. The pipe s connected to a Boundary Box (to Irish Water Specification) and includes a kink.

Pipe No.4
18m length of 12.5mm Hydrodare Pipe – buried, with a 5mm hole at a known location on the pipe.

Pipe No.5
18m length of 19mm MDPE Pipe – buried, with a 3mm hole at a known location on the pipe.

Pipe No.6
2m long x 100mm water main at each test bed with 18m x 19mm MDPE pipe off it

Four lining contractors attended on site during the last two weeks of January 2016. Each was afforded an opportunity to demonstrate their specific procedures. This exercise was followed by sampling and pressure testing

Further trials and testing on live scenarios, so as to generate a definitive set of results relating to compliance with the lead limit of 10µg/l. are underway. The success or otherwise in meeting the lead limit is being measured by using a water supply known to have high plumbosolvency characteristics. . At the time of writing, this exercise has to be classified as a work in progress.

It should be stated that this is new technology in Ireland and Irish Water's knowledge to date is based on information provided by suppliers in relation to the manufacturer's guarantee life period. Additionally lined pipes in the UK carry orthophosphate treated water and this adds an extra mitigation measure and protection against exposure to lead in addition to lining.

4.6 Lead Service Replacement

Overview

Irish Water's records show there are no lead water mains in Ireland. There are some lead pipes in the public network, but these are mostly in older shared connections or in the short pipes connecting the (public) water main to the (private) water supply pipes.

At the 10µg/L lead limit, the only way to ensure lead compliance with the Drinking Water Regulations is through complete public and private side lead pipework and fittings replacement, which is recognised internationally as requiring significant capital, involving multiple stakeholders, and the need for a long term delivery programme.

The WHO recommends that total lead replacement (public and private) be considered as the ultimate goal from a health perspective. Research from partial lead pipe replacement trials completed by other water supply utilities indicates that partial lead pipe replacement **does not achieve significant benefits** (in terms of both compliance with the 10µg/l standard and reduced exposure to lead). It is advised that the consumer replaces the lead pipes serving their property at the same time. (DWI, July 2013, 'DWI PR14 Guidance – Lead in Drinking Water). Where lead pipework or plumbing fittings occur within a private property, it is the responsibility of the property owner to replace pipework and fittings.

Refer to the Case Study below that discusses the result of a Study completed by Dublin City Council and shows that 15 out of 16 properties failing the allowable lead limit in Raheny only had private lead supply pipes present and no public lead service pipe.

Irish Water proposes that a national programme of replacement of public side service connections be undertaken, subject to regulatory allowances made by the CER. The level of Capex for 2017 and 2018 has been approved by the CER, as part of its price control process, but Capex beyond 2018 is subject to available funding and CER approval as part of future revenue control processes.

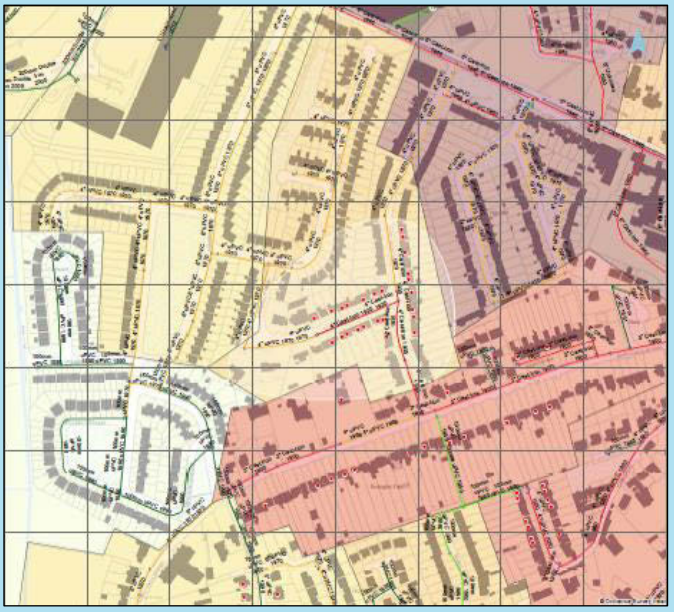
Replacing the public side service connections or the private side supply pipe/internal plumbing of its own will not solve the problem if public and private side lead replacement not implemented in parallel. This strategy will not be effective to reduce lead concentrations in drinking water at customer taps.

Case Study
Raheny, Dublin City. Lead Compliance

Dublin City Council conducted a detailed study of properties in Raheny, North Dublin for compliance with the lead drinking water limit. The key findings were:

– 15 of the 16 properties failing the 10µg/L limit had no **Irish Water owned or controlled lead pipework** (i.e. all lead pipework was within the property).

– Flushing reduced lead concentrations but did **not achieve compliance with the Drinking Water Regulations.**



New Brass Fittings – A Source of Lead in Drinking Water?

Until recently, it was widely considered that lead pipework and lead solder was the only source of lead in drinking water. Recent international experience has indicated that new brass fittings are also a source of lead in drinking water. Brass fittings have been used very commonly in conjunction with copper pipe-work, as elbows, connectors and valves. Brass is an alloy containing copper, zinc and lead.

The case study below looks at this in greater detail.

Case Study
Brass Fittings - a Source of Lead in Drinking Water?

Water Quality Audit monitoring carried out by Fingal County Council/Irish Water identified a number of properties with high levels of lead concentrations within their drinking water supplies. Two of these properties were Public Buildings that are being used by consumers classified as 'most-sensitive customers'.

The notifications delivered in late 2014 prompted the responsible public body to replace the existing internal plumbing network supplying each drinking point with plastic piping. In 2015, after substantial re-plumbing works were completed, the drinking water samples tested continued to show exceedances above the allowable lead limit. It was noted that there were a significant number of brass elbow and tee fittings incorporated into the replacement layout.

The brass fittings were sourced on the basis that they complied with the appropriate EN standard or equivalent. It should be noted that to enhance the machinability of brass, lead is often added in concentrations of around 2%. In the US, prior to 2014, "Lead free brass" could contain up to 8% lead. It is probable that brass with up to 8% lead has been supplied to many other countries, regardless of IS or EN standards.

A subsequent examination of these layouts identified significant scope to reduce the number of brass fittings used. In advance of proceeding with further remediation works, it was decided that the revised plumbing layouts under each drinking point would be tested for its lead content, following a 30 minute stagnation period.

Two rigs were examined as part of these tests:

Both rigs comprised of the plumbing configurations stripped from two drinking points and mounted on boards for testing.

Typical Brass Fitting

Each rig was filled with treated water and stagnated for 30 minutes. Lead residuals were found to be as outlined in Table 1 below:

Lead µg/l	Unit	Date Sampled
44	Rig 1	18.02.16
19	Rig 2	18.02.16

Case Study - continued
Brass Fittings - a Source of Lead in Drinking Water?

As a consequence of these results the plumbing contractor subsequently installed a revised layout using plastic piping and fittings as shown below. Samples drawn from this revised layout in week beginning 16th May 2016 have returned lead residuals below the 10µg/l limit.

Latest installation (June 2016)

Conclusion:

This case study and literature review indicates that new brass fittings can be expected to leach lead at concentrations above the allowable lead concentration in drinking water at the tap. Lead levels from new (unused) brass fittings peak immediately after installation and the concentrations are expected to reduce with length of time in normal regular service, stabilising over a period of a few weeks to a few months. Lead concentrations increase with increasing stagnation time, as may be expected in properties with irregular usage patterns such as schools, businesses, etc.

Recommendations:

1. At the national legislative and standards level, Ireland should take into consideration international developments relating to the regulation of the lead content of brass. In 2014, the US revised their standard definition for "lead free" as a weighted average of 0.25% lead calculated across the wetted surfaces of a pipe, pipe fitting, plumbing fitting, and fixture and 0.2% lead for solder and flux. There are possible changes in the legislation that should be considered to reduce risk of exposure on private supplies before the drinking point in the property – prohibiting the introduction of a pipe or plumbing fitting or fixture that is not lead free, unless the use is for non-drinking purposes.

2. There is no national procedure for auditing or approval of brass alloys used in drinking water fittings installed in Ireland, so there is no guarantee that the standards are adhered to in the supply chain. This should be introduced in Ireland.

3. Studies show that the introduction of corrective water treatment for the protection of human health such as orthophosphate treatment, reduces lead concentrations from brass fittings as well as lead pipework. Phosphate treatment forms a protective coating inside lead pipes and fittings in customer's homes and business, reducing both the time taken to reach stable leaching concentration and reducing this concentration compared with non-phosphate dosed water.

4. Guidance on flushing should form part of the lead mitigation plan. Targeted advice to customers should recommend to flush frequently when brass fittings are new and to flush after prolonged stagnation when fittings are older.

Public Lead Service Connection Replacement Programme

Lead service connection replacement will continue to be carried out by Irish Water and subject to the available funding will be established as a multi-annual programme. The level of Capex for 2017 and 2018 has been approved by the CER, as part of its price control process, but Capex beyond 2018 is subject to available funding and CER approval as part of future revenue control processes.

There is no single database from which lead risk can be assessed fully, but from the available data, it is estimated that there are approximately 180,000 residential properties at risk of lead non-compliances. This figure is broken into individual lead service connections and backyard shared service connections. It is estimated that there are approximately 140,000 houses that are likely to have individual lead service connections from the main to the stopcock as well as thousands of public buildings, schools, medical centres, etc. In addition, there are certain backyard shared services serving an additional 30,000 to 40,000 homes which are deemed to be on the public supply. Irish Water proposes to adopt an accelerated lead replacement programme to remove all public-side lead service connections over an estimated ten year programme, subject to CER regulatory allowances.

Irish Water Metering Programme data supplemented with on-going identification of lead through day to day activities on the networks will be used to indicate the presence of lead services. This programme will take its direction from these data sources for the prioritisation of WSZs, targeting the highest risk and most sensitive customers.

Customer Opt-in Lead Services Connection Replacement

Irish Water have already committed to replacing public-side lead service connection where the customer has replaced the private side lead supply pipework. An application process has been developed to enable customers to apply for the scheme. Additional information relating to this has been published to facilitate the implementation of this scheme.

Private Side Lead Supply Pipe Replacement

Irish Water is responsible for the pipes under the road or paths to the outer edge of the boundary of the property. Replacing the public-side lead service connections alone will not resolve the compliance issues associated with lead. The property owner is responsible for the pipe from the outer edge of the property boundary. For domestic customers, replacing lead supply pipes will represent a challenge in both cost and technical terms.

The Minister for Housing, Planning, Community and Local Government has established a new grant scheme to assist low income households to replace lead pipes in their home as outlined in the Government's "National Strategy to Reduce Exposure to Lead in Drinking Water". The scheme is administered by local authorities and in line with Drinking Water Regulations. The Department have also produced a guidance note on the replacement of lead supply pipes.

Irish Water proposes to have targeted communications to Property Owners to encourage and promote the replacement of privately owned lead pipework and fittings.

4.7 Corrective Water Treatment for the protection of human health

Overview

Virtually all water has the corrosive ability to breach the lead limit if the water flows through lead service connections or internal lead plumbing pipework and/or fittings containing lead. There are corrective water treatment (corrosion control) measures that can be taken by water suppliers to reduce plumbosolvency. Internationally, corrosion control is undertaken by orthophosphate treatment in conjunction with pH adjustment at the water treatment plant. This option is discussed below. The United Kingdom have been treating water with orthophosphate for over ten years to inhibit plumbosolvency and are consistently achieving over 99% compliance with the 10µg/l limit.

Internationally orthophosphate is added into the treated water between 0.5 mg/l to 2 mg/l (Phosphorus) in a process similar to the addition of chlorine for disinfection. The optimum dose for a water treatment plant is complex and depends on a range of factors. Laboratory based testing is being used to fast-track Irish Water's understanding of how plumbosolvency responds to treatment (pH and orthophosphate concentrations). The laboratory testing will identify an optimum annual average concentration – a slightly higher concentration will be required in summer and a slightly lower concentration in winter. This approach maximises the suppression of lead solubility during the warmer summer water temperatures when solubility would be expected to be higher. Initial results indicate that Irish Water will be required to add orthophosphate into the treated water between 0.5 mg/l to 1.5 mg/l (Phosphorus).

Orthophosphate works as a corrosion inhibitor by converting some of the lead carbonate to lead phosphate - forming a protective coating inside lead pipes. This coating helps reduce corrosion that can add lead to the water supply. The conversion process is reversible and the equilibrium between the two compounds is governed by the quality of the water in contact with the corrosion deposit. Orthophosphate is added in the form of an additive called Phosphoric acid. This is a clear and odourless liquid and is entirely safe for human consumption. Phosphoric acid, as a food additive (with the international number E338) is approved for use in food products, such as dairy, cereals, soft drinks, meat and cheese products. The level in soft drinks is 100 times the level in drinking water. The average adult person consumes between 1,000 and 1,500 milligrams of Phosphorus every day as part of the normal diet. The typical concentration of phosphorus ingested from drinking 3 Litres of water per day that has been treated with food grade phosphoric acid at 1.5 mg/l Phosphorus, would only be 4.5 milligrams. On June 14, 2006, the USEPA designated orthophosphate treatment as the optimal corrosion control treatment method for controlling the leaching of lead into drinking water.

A lead pipe, a corroded pipe, and a pipe with protective orthophosphate coating. Photo: USEPA

Since 2010, orthophosphate treatment has been used in Hacketstown Water Treatment Plant, Co. Carlow and is also used in some small areas bordering Northern Ireland which use supplies from Northern Ireland Water treated with orthophosphate. Orthophosphate treatment also commenced in Limerick in November 2016.

Orthophosphate treatment takes a period of 6 to 24 months to develop a full coating, after which an optimised concentration is required to maintain the equilibrium to maintain the desired reduction in lead. It takes this period of time for the corrosion deposits to respond to a new water quality condition, such as a particular orthophosphate concentration. Corrosion deposits on water mains are complex and have varying amounts of silica,

iron, aluminium and organic compounds, as well as lead carbonate. Irish Water will monitor orthophosphate content in the network and effectiveness during the operational phase.

Irish Water proposes to install orthophosphate treatment in all high risk water supplies where it is technically, economically and environmentally viable to do so within a three year period. Through the implementation of this strategy, Irish Water is proposing to investigate roll out of orthophosphate treatment at up to 400 water treatment plants, subject to site specific assessment. These assessments commenced in 2016.

Phosphate – A finite resource

Phosphorus does not exist as a free element because it is very reactive. It is typically found in combination with other elements, for example phosphates. The price of phosphate is determined by global supply and demand. In 2008, the price of phosphate spiked significantly in one year. Phosphate ore is a finite resource. Irish Water will continue to monitor availability and cost of phosphate.

Site Specific Environmental Assessment

A site specific environmental assessment will be carried out on each water supply zone including Environmental Assessment Methodology and Appropriate Assessment. Where the Environmental Assessment Methodology (EAM) identifies significant risk to environment receptors associated with orthophosphate treatment, a number of environmental protection measures may need to be introduced. Further information on the EAM is provided in Section 5 below.

The extent and cost of the mitigation measures required in relation to the Strategic Environmental Assessment and Appropriate Assessment of the Irish Water Lead in Drinking Water Mitigation Plan will only be finalised post site specific assessments.

The environmental impact from orthophosphate treatment is expected to be low. In the UK, food additives are estimated to contribute 29% of the domestic load; automatic dishwashing detergents contribute 9% (and potentially increasing); domestic laundry 14% (including contributions from phosphonates, but decreasing); orthophosphate treated tap water 5%; food waste disposed of down the drain 1%; and personal care products 1%. Although UK data is presented here, it is anticipated that similar impacts would be expected for other developed economies (Combera, 2012). Specific local circumstances will be considered for each WSZ. In some cases constraints on orthophosphate treatment may apply (IWA 2010).

Irish Water will also examine the potential impact of orthophosphate treatment on other aspects of the water treatment and distribution system e.g. potential algal formation in the open storage reservoirs at Stillorgan and Ballyboden.

Environmental Protection Measures

Environmental protection measures that may need to be introduced include selected placement of orthophosphate treatment point, enhanced wastewater treatment (to remove an equivalent amount of phosphorus levels arising from the Orthophosphate treatment at the Water Treatment Plant), water network leakage control, etc. Water Network Leakage Control in areas where groundwaters are identified as being significantly at greater environmental risk due to orthophosphate treatment. In addition to repairing leaks, such areas could also be managed to minimise leakage through a programme of carefully optimised pressure control included in the Pressure Management Programme currently being delivered in the Capital Investment Plan.

Reduction in the leakage of Orthophosphate treated drinking water would minimise additional Phosphate loads to immediate groundwater receptors and to receiving surface waters downstream.

Standards

To ensure the construction of safe, robust and reliable orthophosphate treatment systems, Irish Water has developed a technical standard specification for designers and contractors,

incorporating good engineering practice and 'lessons learnt' for the procurement of standardised package orthophosphate treatment units.

Figure 10: Benefits of Standardisation

In addition to orthophosphate treatment, pH adjustment will be required to maintain the optimum pH level throughout the WSZ. Where the WTP does not already have a suitable pH adjustment system, Irish Water propose to install a new or upgraded dosing system that meets the requirements of our pH/Alkalinity Adjustment Standard Design Specification, to maintain pH within the optimal pH range for the specific Water Supply Zone. Optimum corrective water treatment is achieved through the specific combination of pH adjustment and Orthophosphate treatment.

To ensure the on-going performance of the corrective treatment solution, standard operating procedures and maintenance routines will be developed under the national programme and operator training will be rolled out prior to orthophosphate treatment commencing in a WSZ. On-going performance verification through the operational monitoring programme and third party support will be provided to ensure that the target dose and controls are maintained by the operator to achieve the maximum compliance benefit.

Possible Interference due to Chemical Reaction in Network

Iron discolouration will exacerbate lead dissolution from lead pipes and will need to be minimised if fully effective plumbosolvency control is to be achieved by corrosion inhibitor dosing. Manganese and aluminium can also interfere with the desired chemical reaction required to coat the internal surface of the lead pipework. Organic matter, particularly humic and fulvic acids, will exacerbate lead dissolution and will need to be minimised if fully effective plumbosolvency control is to be achieved. There is substantial opportunity to reduce the plumbosolvent characteristics of soft upland waters through improved removal of organics.

The water treatment process must be optimised (i.e. optimum dose, with other parameters such as pH, alkalinity, hardness and colour taken into

consideration) to achieve stability in the network to minimise the risk of exceedances of 10 µg/l .

Health

Orthophosphate treatment has been used successfully in many countries for several years to protect public health. The HSE has recognised that there is no health concern linked to the addition of orthophosphate to drinking water following extensive use across the UK for over a decade and in many other major metropolitan settings, including New York, where reduced lead levels in drinking water had resulted. ("Lead treatment poses no threat", Irish Medical Times, 6th October 2015). ('Phosphorous is an essential element and widely present in the diet as phosphate e.g. in milk (**including breast milk 124mg/l**), meat, etc.", HSE, Nov 2016)). The amount of phosphorous in breast milk is over 100 times greater than the amount than would be in treated water.

Any additives used as part of the corrective water treatment process for the protection of public health, will be required to be on the UK Drinking Water Inspectorate 'List of Approved Products for use in Public Water Supply in the United Kingdom'. The products in this list have been assessed for safety for use in water supplies.

Mr. Roger Aertgeerts, World Health Organisation has stated that "all other practical measures to reduce total exposure to lead, including corrosion control should be implemented. Treatment to reduce plumbosolvency usually involves pH adjustment and, additionally, dosing with ortho-phosphate may be necessary". ("IWA Best Practice Guide on the Control of Lead in Drinking Water, 2010)

Decommissioning

Orthophosphate treatment is being considered as an interim measure for the reduction of lead concentrations in drinking water. The treatment would be required to continue whilst lead pipework are still in use, subject to annual review on a scheme by scheme basis.

Irish Water will also prepare a programme for decommissioning of the orthophosphate treatment from water supplies. The programme will be put in place when Irish Water has completed the replacement of known public side lead services and the annual sampling programme indicates that the risk to households has reduced to compliant levels. The compliance improvement will be dependent on the performance of the Government's National Lead Strategy for removal of private side lead supply pipes. If implementation of the National Lead Strategy by private and public stakeholders is not completed in parallel and to the same timeframe, this may necessitate the continuation of corrective water treatment for the protection of human health. In this instance, Irish Water will consult with DHPCLG, HSE, EPA and the CER as appropriate.

4.8 Options Assessment

A multi-criteria high level assessment of the mitigation options available to Irish Water is presented in the table below. The assessment criteria as discussed in the text above are weighted accordingly. Each mitigation option receives a score of 0, 1 or 2 against the relevant assessment criterion.

Table 8: Multi-Criteria High Level Options Assessment

		Mitigation Options						
		Replacement of Public Side Lead Service Pipe	Replacement of Public & Private Side Lead Pipes	Rehabilitation of Public Lead Pipework using lining technology	Point of Use (POU) filters	Water Chemistry Optimisation – pH Control only	Corrective Water Treatment – Orthophosphate Treatment & pH Control	Irish Water Weighting
Assessment Criteria	Complexity of Installation	1	0	1	0	1	1	2
	Complexity of Operation	2	2	2	0	1	1	2
	Time to achieve supply zone wide compliance	0	0	1	2	0	2	4
	Availability of Appropriate Standards	2	2	0	1	2	2	3
	Large Scale Adoption by other Water Utilities	2	0	0	0	0	2	4
	Level of Compliance Expected	0	2	0	1	0	2	5
	Compliance Reliability	0	2	0	0	0	2	5
	Capital Cost	0	0	1	1	2	1	3
	Operation and Maintenance Costs	2	2	2	0	1	1	3
	Total Score	26	36	19	19	19	52	
	Ranking	**3**	**2**	**4**	**4**	**4**	**1**	

2	Performs **very well** against this criteria relative to other options in this table
1	Performs **moderately** against this criteria relative to other options in this table
0	Performs **poorly** against this criteria relative to other options in this table

The final ranking of the mitigation options are as follows:

(1) Corrective Water Treatment for the protection of human health – Orthophosphate Treatment and pH Control;
(2) Replacement of Public and Private Side Lead Pipes;
(3) Replacement of Public Side Lead Service Pipes;
(4) Point of Use Filters
(5) Rehabilitation of Lead Pipework using lining technology;
(5) Water Chemistry Optimisation – pH Control only.

The preferred combination of lead mitigation options and the approach that Irish Water is proposing to adopt is discussed in greater detail in Section 6.

The Case Studies below provide an overview of two different approaches adopted by Northern Ireland and France to mitigate against lead in Drinking Water and protect human health.

Case Study
Northern Ireland Water, Lead Mitigation Plan

Country: Northern Ireland

Utility: Northern Ireland Water

Population Served: 1.8 million

Northern Ireland Water (NIW) commenced treatment with orthophosphate, as a corrosion inhibitor, in 2006. Orthophosphate treatment was introduced at all 25 Water Treatment Plants ranging in size from 0.5 MLD to 160 MLD, to address the problems associated with Plumbosolvency and leaching of lead from old lead pipework into the domestic water supply.

Orthophosphate is now dosed at all of NIW's drinking water treatment works serving all of the population. The average dose rate is 1.0 mg/l of orthophosphate as P.

The Orthophosphate Treatment programme is optimised annually, based on compliance with the allowable lead limit of 10µg/l. Random Daytime sampling and analysis currently shows a 97.45% compliance level with this limit.

In tandem with orthophosphate treatment, Northern Ireland Water also has a 25 year programme to identify and replace public-side lead pipes within its infrastructure. As part of this programme customers are informed when lead communication pipes have been replaced and are encouraged to replace their lead supply pipe work. In addition at the request of a customer, NIW will replace the communication pipe free of charge provided that the customer replaces their supply pipe in the first instance.

The programme, which has been in operation for some 10 years, has been allocated funding of £500,000 per year for 2013/14 and 2014/15. They project to replace 11,000 public side lead service connections over a five year period.

Case Study
France, Lead Mitigation Plan [1] [2]

Country:	France
Utilities:	Multiple utilities including Syndicat des Eaux d'Ile-de-France (SEDIF); Suez Environnement; Eau de Paris (Paris Water)
Population Served:	23.5 million service connections (~66 million people in France)

Overall Lead Strategy

The long term solution is to remove public and private lead connections while targeting the most sensitive customers such as schools, nurseries and maternity hospitals initially. As part of their replacement programme, French water companies inform customers when public side lead connections have been replaced and encourage them to replace the private side.

Replacement of Lead Pipes and Connections:

Authorities have introduced programmes of replacement of public side lead service connections (between the public water main and private supply pipe). In the past 15 years, 2.7 million public connections have been replaced in France at a cost, estimated by the Council of the Environment and Sustainable Development (CGEDD), of €5 billion. This work also helped reduce the leakage of public connections. At the end of 2013, it was reported that there was an additional 1.2 million public lead service connections to be replaced, which equated to a little less than 5% of the total number of service connections in France.

Replacement of Private Lead Supply Pipes:

There are no statistics on private supply pipes in France. In 2012, it was estimated that there were 7.5 million homes in France with private lead pipes. The estimated replacement cost is € 17 Billion.

Based on the 35,000 test samples taken between 2009 and 2010, the number of lead exceedances is lower than the estimated percentage of home with lead pipes. Replacement of private lead supply pipes by homeowners has been very low and well below what was hoped 15 years previous. At the current rate of replacement, typically when a house is being refurbished, it would be 100 years before private lead is removed from private housing stock.

In general, the national agency of Habitat (ANAH) can subsidise the rehabilitation work undertaken by owner-occupiers (means tested), landlords (not tested) or condominium (for works on communal areas).

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[1] General Council of Environment and Sustainable Development, Ministry of Ecology, Sustainable Development and Energy (France, 2013). Lead and Quality of Drinking Water

[2] Ministry of Health and Social Affairs as cited at *http://social-sante.gouv.fr/sante-et-environnement/eaux/article/eau-et-plomb* [Accessed 26 May 2016]

Case Study
France, Lead Mitigation Plan (Contd.) [1 2]

Corrective Water Treatment:

In accordance with the provisions of the code of public health, distributed water should be of a slightly calco-carbonic equilibrium (water should have a pH of greater than seven to promote the precipitation of lime and reduce aggressiveness of water). The water supplier is required, for compliance purposes, to sample at the point of delivery (i.e. at the tap). As such, it continuously monitors the quality of distributed water and aims to provide water that is neither aggressive nor corrosive.

However, when a non-compliance is determined to result from the private distribution system it is deemed that the property owner is responsible for the non-compliance and any resulting rectification works if they are required.

Orthophosphate treatment was has been introduced at two Water Treatment Plants in recent years operated by SEDIF and Eau de Paris to control corrosion of lead pipes. Following an assessment of the results collected over several years and an analysis of advantages / disadvantages, ANSES (French Agency for Food, Environmental and Occupational Health & Safety) recommended to extend treatment of orthophosphate to other regions.

Overview - Compliance with Drinking Water Regulations

Sampling and analysis over a 5 year period between 2008-2013 showed 94% of samples complying with the 10µg/l lead in drinking water standard. Despite the significant investment in the replacement of public side lead service connections, there is no recent data to suggest the compliance rate has improved.

A large public lead service replacement programme has been underway for the past 15 years, which resulted in the replacement of 2.7 million public lead service connections but with very little work completed in private homes. The percentage of samples exceeding the limit of 10µg/l remains unchanged and has always correlated to approximately 6% of samples taken.

Section 5 Environmental Assessment Processes

5.1 Strategic Environmental Assessment and Appropriate Assessment

Strategic Environmental Assessment (SEA) is a process by which environmental considerations are integrated into the preparation of plans and programmes prior to their final completion. The objective of the process is to provide for a high level of protection of the environment and to promote sustainable development by contributing to the integration of environmental considerations into the preparation and adoption of specified plans and programmes. The SEA process also gives interested parties an opportunity to comment on the environmental impacts of implementation of a proposed Plan or Programme and to be kept informed during the decision making process. In accordance with Article 9 of S.I. 435 of 2004 (as amended), Irish Water, as the lead authority for the Lead in Drinking Water Mitigation Plan, carried out an SEA which informed the plan. The SEA of the Lead in Drinking Water Mitigation Plan is available as a separate document.

The EU Council Directive 92/43/EEC on the conservation of natural habitats and wild flora and fauna, better known as the '*Habitats Directive*', provides legal protection for habitats and species of European importance through the designation of EU wide network of sites known as Natura 2000. These sites are Special Areas of Conservation (SAC) designated under the Habitats Directive and Special Protection Areas (SPA) designated under the Birds Directive (2009/147/EC). Article 6(3) of the Habitats Directive establishes the requirement for Appropriate Assessment (AA) of plans and projects likely to affect Natura 2000 sites. An AA of the Lead in Drinking Water Mitigation Plan was carried out in parallel to the SEA process and is available as a separate document. The figure below illustrates the roadmap for the SEA and AA processes.

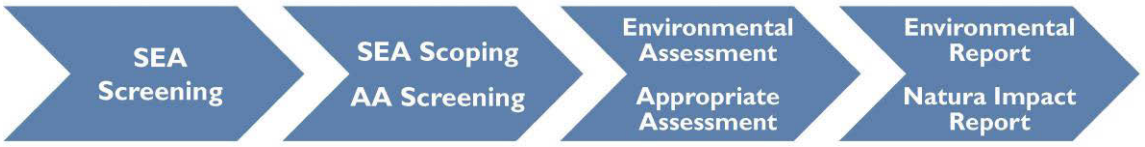


Figure 11 - SEA and AA Roadmap

All of the SEA stages illustrated in the figure above have been completed for the Lead in Drinking Water Mitigation Plan. The final stage, the SEA Statement will be prepared following the consideration of submissions made during the consultation period on the draft plan and environmental report.

Critical to the successful application of the SEA and AA processes is the integration with the plan making. This has been achieved for this plan through close integration of all stages of the plan making.

5.2 Environmental Assessment Methodology (EAM)

In terms of the orthophosphate treatment measure, the added orthophosphate in the proposed dosing concentration range has no human health implications. However, phosphorus has the potential to impact on the environment and in particular water bodies, through the process of nutrient enrichment and promotion of excessive plant growth (eutrophication). Therefore, it is necessary to consider the risk of environmental impact and the pathways by which the added phosphorus may reach environmental receptors, i.e. aquatic flora and fauna, causing adverse effects

and possible mitigation measures to offset any impact.

To this end, Irish Water has devised an Environmental Assessment Methodology (EAM) to facilitate specific environmental risk assessment of any proposed orthophosphate treatment and provide a methodology to determine the risk to the receiving environment of this corrective water treatment. The EAM will assess both surface and subsurface pathways to receiving waters and will include for assessment under the EU Habitats Directive on a water supply zone by water supply zone basis. The model has been developed to be flexible to allow for assumptions to be changed or alternative scenarios to be assessed, e.g. where the dosing rate is reduced or leakage management improves. Irish Water in consultation with the EPA will continue to review and improve the EAM based on monitoring results and as datasets improve.

The conceptual model allows for the quantification of Phosphorous loads in a mass balance approach to identify potentially significant pathways as part of the risk assessment process for specific water suply zones where orthophosphate treatment is proposed. The EAM assesses if there will be any significant impact on the environment. The EAM will also be the basis of the decision support matrix to inform any mitigation programmes developed as part of the Lead Plan.

This conceptual model of phosphorus (P) transfer through the orthophosphate treatment is illustrated in the figure below.

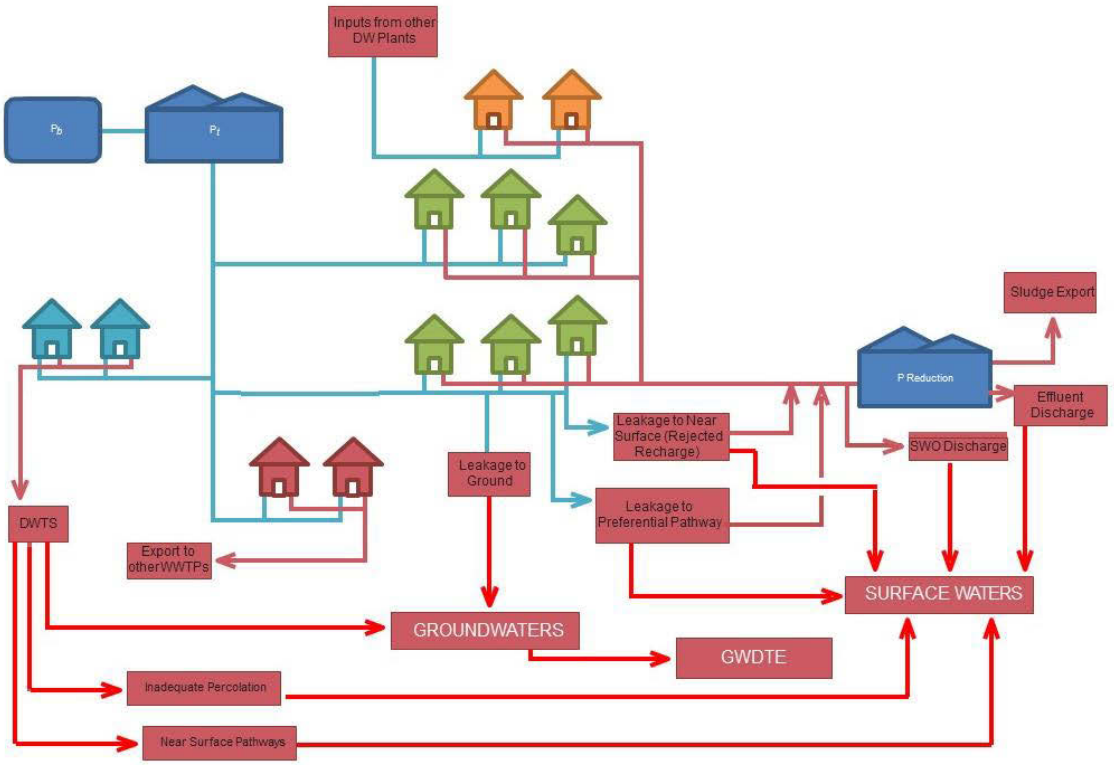


Figure 12: Conceptual Model of Phosphorus Transfer

Where:

P: Phosphorous
DW: Drinking Water
DWWTS: Domestic Waste Water Treatment System
WWTPs: Wastewater Treatment Plants
SWO: Surface Water Overflow
GWDTE:Groundwater Dependent Terrestrial Ecosystem

The various sources of P detailed in the model are:-

P_b Background P present in the raw water source abstracted for drinking water

P_t Additional P due to drinking water treatment to reduce plumbosolvency

P_e Wastewater P derived from dietary excretion, industrial uses, household chemicals etc.

The main sources and receptors addressed in the model are outlined in the following sections.

Drinking Water Distribution

Phosphorus (P) concentration in the drinking water distribution system is the sum of background P concentration in the raw water source and the P added to treat the final drinking water (P_b + P_t). Leakages from the drinking water distribution system provide a direct pathway to groundwater. Current leakage from Irish Water's ageing water main infrastructure is high. The current national average unaccounted for water (UFW) figure is 45% of the total volume of drinking water produced nationally.

Where a treatment plant supplies only to zones where there is no or small number of lead service connections, it will not be necessary to dose at such plants. However, where lead pipes are present, Orthophosphate Treatment will be carried out at all plants supplying that distribution zone. Premises supplied by other treatment plants (with or without Orthophosphate Treatment) are indicated by yellow symbols in Figure 12. Since these premises may also be contributing to the P-treated agglomeration's wastewater system, they may influence P loading downstream and should be included in mass balance estimates.

By contrast, other premises (depicted in red in Figure 12) may be in the treatment area but may be discharging to other collecting systems. As in the scenario above, this loading must be accounted for elsewhere. If there are premises within the treatment area that are not served by municipal sewer (depicted in blue in Figure 12) but discharging to ground via domestic wastewater treatment systems, they constitute an additional load to groundwater.

The purpose of orthophosphate treatment is to reduce plumbosolvency. Orthophosphate reduces lead solubility by converting some of the lead carbonate in the corrosion scale to lead phosphate. It takes 6 to 24 months for corrosion deposits to respond to a new water quality condition, such as a particular orthophosphate dose and achieve the required equilibrium. Therefore deposition of dosed orthophosphate in pipework may be most significant during the initial stabilisation phase. During this phase P sequestration in pipes may reduce the potential load to subsoils through leakage. Thereafter the system may approach equilibrium, with dosage rate broadly equivalent to net export from distribution. In this case the export from the distribution system may be as particulate/insoluble P. Based on results from random daytime tests attenuation of the dosed orthophosphate within the distribution system is expected to be no more that 10%.

Waste Water Collection and Treatment

Phosphorus in waste water is derived from a number of sources including dietary excretion, food additives, industrial uses, household chemicals and detergents (P_b+ P_t+ P_e). Note that Phosphorus may also be imported from areas outside the treated agglomeration through import of sludge or

leachates for treatment at the wastewater treatment plant. The additional Phosphorus load due to corrective water treatment at drinking water plants is likely to comprise a relatively small fraction of the wastewater treatment plant influent concentration, some UK studies have suggested of the order of 5% (UKWIR, 2012). The efficiency of Phosphorus removal at waste water treatment plants (WWTP) depends on treatment type, works capacity and process operational efficiency.

The disposal and use of Phosphorus removed in wastewater sludge is regulated (cf. Nutrient Management Plans) and should not pose further threat of environmental impact. The remaining P discharged in plant effluent streams is also subject to regulation by the EPA and emission limit values are stipulated. However, it is necessary to consider Phosphorus trends and capacity in receiving waters and the risk to water status from any increase in Phosphorus load resulting from orthophosphate treatment operations.

In some wastewater collecting systems ingress (infiltration) of waters may be significant. Depending on source, these may be of varying Phosphorus loadings. If ingress to the sewerage system forms a significant portion of the measured WWTP influent volumes, the actual increases in P load will be less than that computed on the basis of all of the WWTP hydraulic loads being subject to orthophosphate treatment. Therefore in order to ensure that infiltration to the sewage collection system does not result in an over estimation of the additional P load from the orthophosphate treatment the additional loading to a WWTP are based on the WSZ production figures less estimated leakage volumes and the proportion of this volume which contributes to the WWTP influent hydraulic load for the agglomeration under consideration. This proportion can be determined on the basis of the sum of the entire PE for the agglomerations and domestic waste water treatment systems (DWWTS) within the WSZ and the proportion of the agglomeration Population Equivalent (PE) within the WSZ.

Leakage to ground from the sewer network may also occur but on a scale that is far below that recorded for pressurised drinking water distribution systems and so is not considered to be significant with the main leakage to ground assumed to be from the pressurised water mains.

A significant pathway for P transfer from wastewater systems to surface water environmental receptors is through activation of storm water overflows. Consideration is also given to the frequency and volumes so discharged to inform the risk assessments.

Environmental Receptors

In terms of assessment of risk to environmental receptors, the primary focus is the additional Phosphorus added for the purposes of reducing plumbosolvency (P_t). Receptors include surface waters (rivers, lakes, transitional and coastal waters), groundwaters, and groundwater dependent terrestrial ecosystems (GWDTE) that are hydrologically connected to P sources within the treated water supply zones.

The groundwater contribution to surface water bodies and wetlands varies because of differences in rainfall distribution, soil and subsoil type, aquifer type, hydraulic connectivity with the receptor etc. Individual risk assessments will consider the site-specific dilution and attenuation factors and the groundwater contribution to the associated receptor.

Identification of relevant receptors is followed by an assessment of their sensitivity to any additional

Phosphorus load which includes the establishment of the conservation objectives of Natura 2000 sites potential impacted by the additional Phosphorus loading and their sensitivity to additional Phosphorus. In this regard, coastal waters are unlikely to be sensitive since primary productivity in marine systems is generally limited by nitrogen availability. It is assumed that the orthophosphate treatment will not have a significant impact on coastal waters receiving discharges from WWTP via long sea outfalls.

5.3 Limerick Corrosion Treatment Priority Project

The Limerick Priority Project was highlighted in the Irish Water 'Lead in Drinking Water Mitigation Plan – Issues Paper that was published for non-statutory public consultation in June 2015 and also in the draft version of this document that was published for statutory public consultation in July 2016. The priority project has been developed in consultation with the HSE and EPA. Orthophosphate as a 'corrosion inhibitor' has been used successfully in the UK and other metropolitan regions for over ten years. It is added to drinking water to reduce levels of lead found in drinking water from the tap for the protection of human health.

Limerick was chosen as the priority project because of the high level of properties with lead service pipes and also because the waste water is not discharged into an inland fresh water river or waterway. The Clareville Water Treatment Plant in Limerick City supplies drinking water to homes and businesses in Limerick City and its environs. The drinking water produced at Clareville Water Treatment Plant does not contain lead. There are also no known lead water mains in the distribution system. However, water entering homes and businesses can pick up lead as it passes through lead supply pipes and fittings, where these exist within the property boundary.

The higher proportion of older housing in parts of Limerick City makes it more likely that private lead pipework will be present. A number of homes in Limerick have confirmed levels of lead in their drinking water higher than the relevant limit allowed under the Drinking Water Regulations. This presents a health risk, especially to infants and young children for which orthophosphate treatment is the only practical short-term option. Until all lead pipework is replaced, the introduction of orthophosphate treatment in Limerick has the potential to protect customers and reduce lead concentrations below the drinking water regulation limit for properties that have lead in the private distribution system and service connection to the property boundary. A programme of lead service replacement in Limerick is currently underway and approximately 2,000 lead connections in the city have been replaced as of January 2017.

Irish Water are testing water at randomly selected customer taps through the water supply network to monitor the effectiveness of orthophosphate treatment to protect public health and the levels of lead present.

The Limerick Project has been advanced in order to assess environmental impacts of orthophosphate introduction. Irish Water will continue to monitor the impact of phosphorus on the water environment.

Irish Water, in consultation with the EPA and other environmental stakeholders, has developed a comprehensive environmental assessment methodology to assess any potential impacts and ensure that the necessary actions undertaken to protect the natural environment. The orthophosphate treatment in Limerick has been subject to an Appropriate Assessment under the Habitats Directive. The Appropriate Assessment has determined that there will not be any significant direct, indirect or cumulative impact on the environment.

The wastewater treatment plants in Limerick have treatment stages, which reduce the levels of phosphate being discharged to the receiving water bodies. Irish Water will closely study the potential environmental impacts from orthophosphate treatment on the receiving waters on a continuing basis.

Extensive baseline sampling was completed to enable us measure benefit once treatment commenced. Orthophosphate treatment commenced on 30th November 2016 and this subsequently triggered the commencement of operational monitoring. These studies will provide our stakeholders with a comprehensive Environmental Assessment Methodology to apply to the national rollout of this decision making tool.

Section 6 The Plan

6.1 Preferred Options and Approach

The preferred options and approach that Irish Water is adopting is discussed below. The Plan provides a detailed framework of measures for implementation to effectively address lead in drinking water. The approach to be taken by Irish Water through the implementation of the Plan is to improve lead compliance nationally on a risk prioritisation basis.

The Plan will be monitored and adjusted as required to ensure it is effective and delivering the compliance target objectives.

The Plan consists of two primary elements which will run in parallel as follows:

1. **Risk Prioritisation:** Irish Water will identify and prioritise public water supply areas and properties nationally at risk of failing to meet the lead standards.
2. **Mitigation Identification and Implementation:** in order to achieve our targeted compliance levels Irish Water will implement the most appropriate actions in prioritised areas within our remit to reduce the potential danger to human health. Irish Water will apply the most economic method to reduce the risk for the greatest numbers of customers having due regard to prioritisation of high risk categories of the population.

The steps that Irish Water will follow to deliver these elements of the Plan are set out in the following sections.

Risk Prioritisation Steps

Irish Water has commenced gathering relevant baseline information to inform the risk prioritisation, including the following:

- Water chemistry in the area given that some water types are more prone to plumbosolvency (ability of water to dissolve lead into water supplies from lead pipes);
- Locations of properties with lead services from our metering programme and mains rehabilitation programmes;
- Watermain types to determine areas most at risk of having lead pipes;
- Central Statistics Office (CSO) small area property age maps to determine areas most at risk of having lead pipes.

The output, to be completed in 2017, will include mapped areas with lead services and a "Plumbosolvency Map" highlighting the areas at risk. These maps will be used to prioritise areas for action.

This information will be validated through an enhanced lead monitoring regime to determine the levels of lead in the drinking water network and adjust the risk prioritisation score for each WSZ as required. Inventory sampling commenced in June 2016 and this involves an estimated 36,000 samples being carried out across WSZs to establish the full annual lead risk profile. Further sampling will be ongoing throughout the Plan period in order to assess the Plan's effectiveness

Implementation Steps

Certain implementation steps are already underway including:

- General Public awareness communication following publication of our issues paper in June 2015.
- Direct customer communication and advice where lead services are identified.
- Replacement of public water service pipes in conjunction with mains rehabilitation projects.
- Inventory sampling to establish the full annual lead risk profile
- Treated water quality analysis.
- Environmental assessments on WSZs for rollout of corrective water treatment

Full implementation of actions to increase compliance in a co-ordinated national approach will commence as soon as areas are prioritised and a tailored WSZ specific Plumbosolvency Control Plan developed to include a combination of the following:

- A more extensive sampling programme to assess levels of lead and define priority areas for action.
- Ongoing communication with customers to provide advice and inform them directly where they are at risk.
- Corrective Treatment Options; pH adjustment and orthophosphate treatment to reduce plumbosolvency risk over the short to medium term where allowed following Environmental Assessment
- An accelerated national programme of lead service pipe replacement (Irish Waters responsibility) in a phased manner. Higher risk properties will be prioritised.
- Ongoing provision of our "opt-in" scheme and other targeted communications to encourage property owners to remove lead pipework that is their responsibility.

The two main mitigation measures – Lead Replacement and Corrective Water Treatment will proceed in parallel as illustrated below.

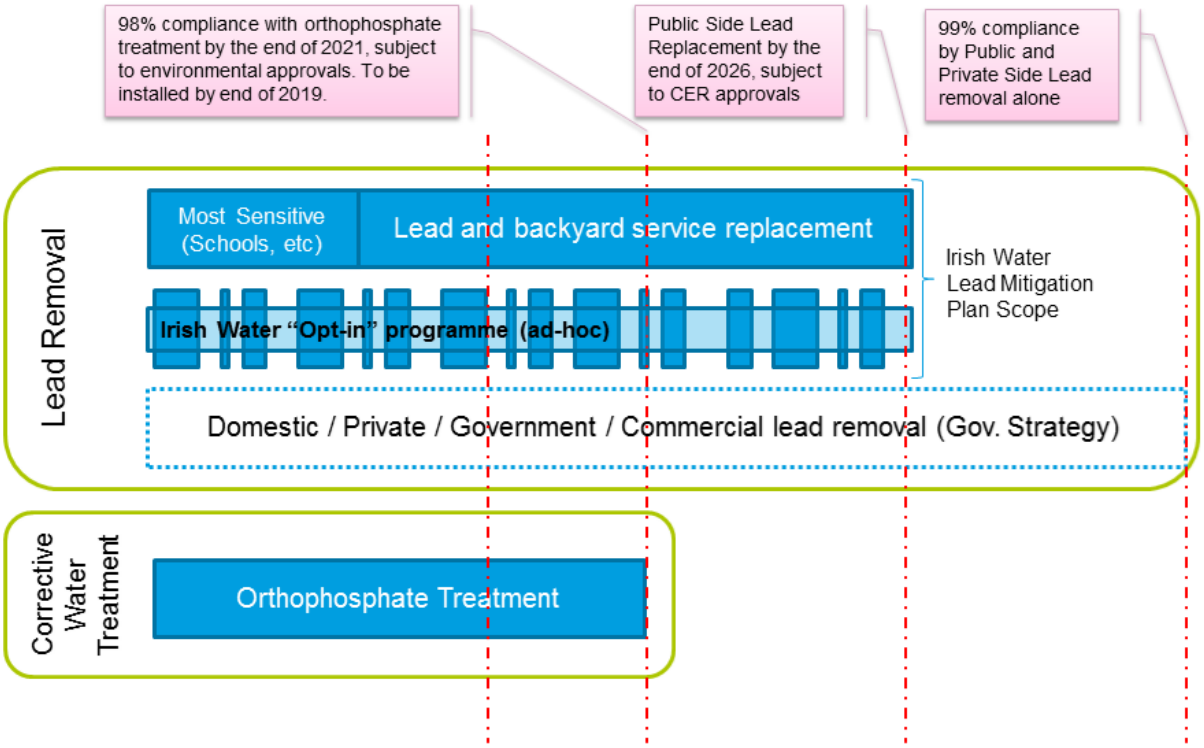


Figure 13: Proposed Programme for Lead Service Removal and Corrective Water Treatment

6.2 Timelines for Key Components of Lead in Drinking Water Mitigation Plan

The high level estimated timeline for implementation, including commencement and completion of each action/measure proposed is outlined below. The implementation of this timeline, which spans to 2026, is subject to CER regulatory approvals.

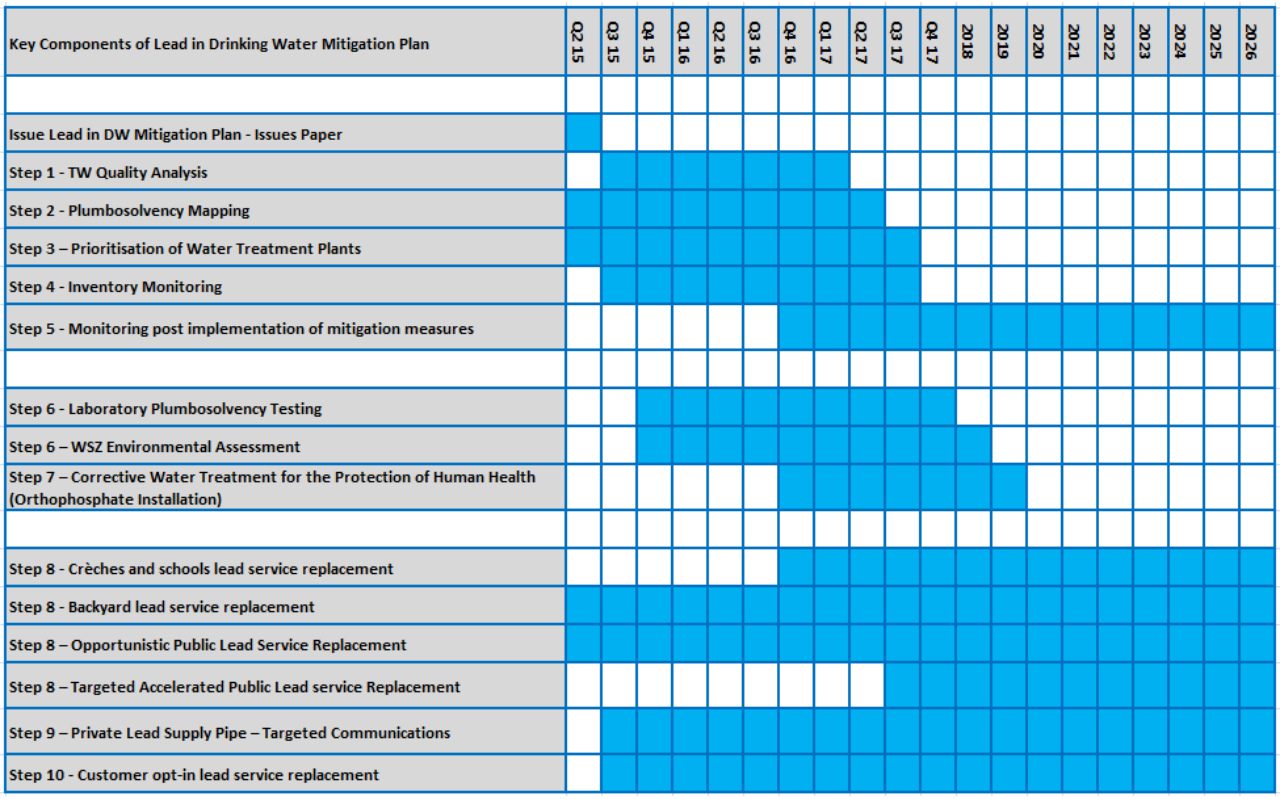


Figure 14: Lead in Drinking Water Mitigation Plan High level Timeline

Irish Water intends to deliver the Plan under an ambitious timeframe. The capital programme for the installation and implementation of orthophosphate treatment is planned to be delivered over the next three years. Irish Water proposes to replace all public-side lead service connections for which it is responsible, (including looped backyard service connections in terraced houses). This lead replacement programme will run for a much longer period, currently estimated to be at least ten years and a number of investment cycles.

The level of Capex for 2017 and 2018 has been approved by the CER, as part of its price control process, but Capex beyond 2018 is subject to available funding and CER approval as part of future revenue control processes. A review of performance of private side lead service replacement will be undertaken at regular intervals. Should compliance targets be achieved by corrective water treatment, the funding and timelines for the accelerated lead replacement programme will be reviewed and may be adjusted in discussion with the CER, DHPCLG, EPA and HSE.

In the event that the overall project programme extends significantly beyond 2026, the findings of the SEA and AA completed for this plan will be reviewed based on the evidence base derived during the treatment regime undertaken and a revised set of mitigation measures will be agreed with the EPA as appropriate.

6.3 Indicators and Targets

Indicators and targets for the Lead in Drinking Water Mitigation Plan are presented in the table below and align with the 25 year Irish Water – Water Services Strategic Plan 2015-2040.

ENSURE A SAFE AND RELIABLE WATER SUPPLY					
Indicators	**Definition**	**Current Baseline**	**End of 2021 Target**	**End of 2027 Target**	**2040 Target**
AIM WS2	Manage the Availability, Sustainability and Reliability of Water Supplies Now and into the Future				
Drinking Water Lead standards	% of national samples meeting Lead Compliance Standards sampled in the public network.	Estimated 85–95% meeting standard of 10µg/l*	98% meeting standard of 10µg/l**	99%**	99.5% meeting standard of 10µg/l
* To be established through a comprehensive national monitoring programme ** Based on technological alternative to lead replacement being available					

Figure 15: Indicators and Targets for Drinking Water Lead Standards

The Plan proposes the following indicators and targets for the implementation of the Lead in Drinking Water Mitigation Plan.

- Irish Water will identify areas at high risk as far as practicable in 2017.
- Establish current national baseline meeting Drinking Water Lead standard of 10 µg/L.
- Corrective Water Treatment for the protection of human health - Irish Water will install orthophosphate treatment and pH adjustment facilities (where not already in place) in all high risk water supplies where it is technically, economically and environmentally viable to do so within a three year period,(i.e. by the end of 2019). Irish Water expects it to take 6 to 24 months of orthophosphate treatment of the water supply before a reduction in lead levels below the allowable limit can be demonstrated throughout the network. Irish Water will monitor orthophosphate content in the network and effectiveness during the operational phase
- Irish Water proposes to remove all public lead service connection pipes over a ten year programme (i.e. by the end of 2026). Ongoing provision of our “opt-in” scheme and other targeted communications to encourage customers to remove private lead pipes which are their responsibility. Both public and private lead replacement need to take place in parallel in order to achieve targets.
- Irish Water will also prepare a programme for decommissioning / discontinuing orthophosphate treatment from water supplies. The programme will be put in place when Irish Water has completed

the replacement of known public side lead services and the annual sampling programme indicates that the risk to households has reduced to target compliance levels. It will subject to annual review on a scheme by scheme basis.

The compliance improvement will be dependent on the performance of the Government's National Lead Strategy for removal of private side lead supply pipes. If implementation of the National Lead Strategy by private and public stakeholders is not completed in parallel and to the same timeframe, this may necessitate the continuation of corrective water treatment for the protection of human health. In this instance, Irish Water will consult with DHPCLG, HSE, EPA and the CER as appropriate.

Section 7 Ten Step Process

Irish Water has developed a comprehensive ten step plumbosolvency control strategy which deals with all aspects of the Drinking Water Regulation requirements and comprises four main components, each of which has customer communication as a key integral component.

As discussed in Section 6, the Plan provides a detailed framework of measures for implementation to effectively address lead in drinking water. The approach to be taken by Irish Water through the implementation of the Plan is to improve lead compliance nationally on a risk prioritised basis.

The figure below illustrates the key components of the Plan and the steps which are required for an informed and robust implementation plan for each WSZ.

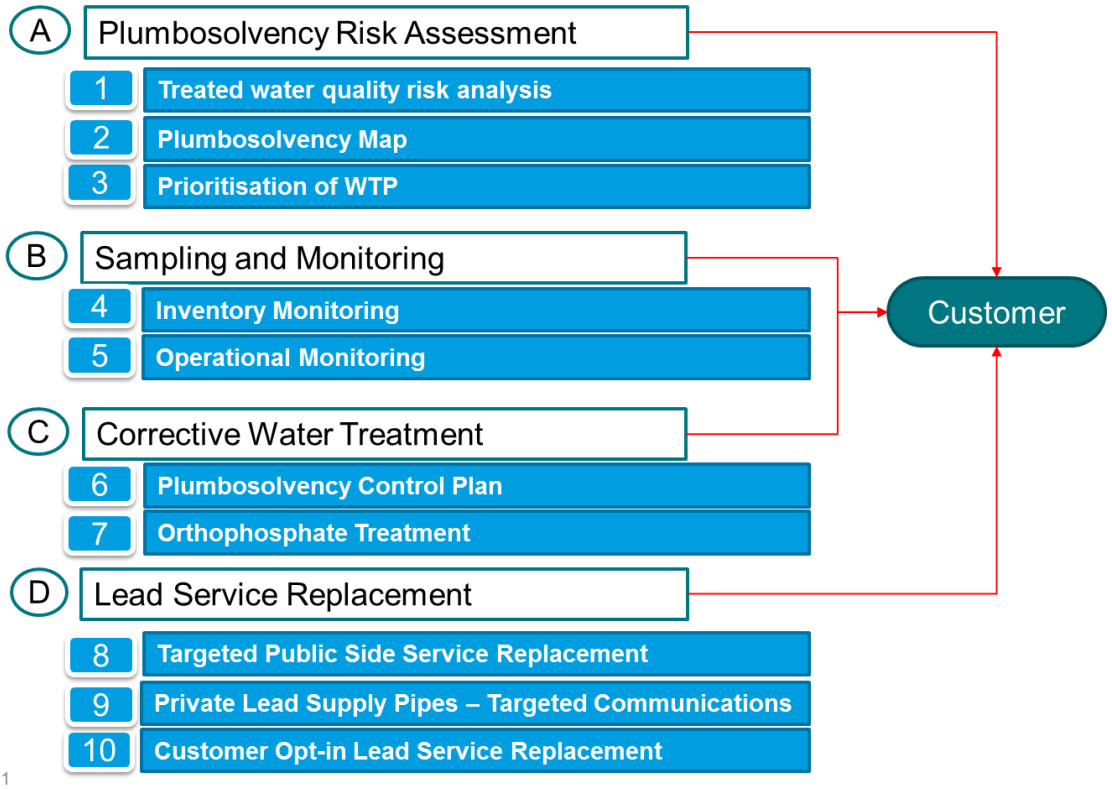


Figure 16: Key Components of Lead in Drinking Water Mitigation Plan

Steps 1 to 5 relate to establishing a true picture of the lead problem in a Water Supply Zone and to support the implementation of corrosion control measures under the Plan. A combination of Steps 6 to 10 will be adopted to address lead in drinking water. A detailed technical overview of each of the steps is provided below.

Part A: Plumbosolvency Risk Assessment

Step 1: Treated Water Quality Risk Analysis

Virtually all drinking water is sufficiently plumbosolvent to cause an exceedance of the parametric limit for lead in drinking water, if a corrosion inhibitor is not added and/or if pH correction is not applied (pH > 8.0) [IWA 2010].

On the basis that virtually all drinking water is sufficiently plumbosolvent, the first risk assessment criterion is based on the WSZ relative lead solubility risk; high risk waters are more likely to produce higher lead concentrations and pose a greater health risk to customers. The factors that have the greatest impact on lead concentrations in water are temperature, length of lead pipe, flow, pH, dissolved inorganic carbon (DIC), alkalinity, natural organic matter and buffer intensity where:

- **Temperature** can increase lead solubility by a factor of 2 between winter and summer;
- **Length of pipe and flow** directly impact the length of time the water is in contact with the lead pipe. Low flow rate and/or longer pipes contribute to contact time increasing lead concentrations;
- **pH** is a measure of acidity, also known as hydrogen ion concentration. Values less than 7 are considered high risk, whereas 7 to 8 is considered moderate risk;
- **Alkalinity** is the capacity of water to neutralize acid and is the sum of carbonate, bicarbonate and hydroxide anions. Values less than 50 mg/l $CaCO_3$ represent a high risk;
- **Dissolved Inorganic Carbon (DIC)** is an estimate of the amount of total carbonates in the form of carbon dioxide gas, bicarbonate ion and carbonate ion in water. The level of DIC affects lead solubility and the stability of pH;
- **Buffer Intensity** is a measure of the resistance of water to changes in pH. Maintaining sufficient buffering is very important when using corrective treatment solutions, because plumbosolvency control requires particular pH ranges to be effective;
- **Natural organic matter**, particularly humic and fulvic acids will exacerbate lead dissolution from lead pipes and will need to be minimised if fully effective plumbosolvency control is to be achieved by corrective water treatment. Surface derived waters, particularly with a total organic carbon content greater than 3mg/l; and
- **Additional factors** such as disinfectant residual, ammonia, chloride and sulphate levels also influence the chemistry and characteristics of the water. Many of these factors are inter- related and can have an effect on the characteristics of water.

Due to the complexity of the relationship between the above parameters and the treated water's plumbosolvency, Irish Water is currently quantifying the relative plumbosolvency of each of the top 400 WTPs in the country (based on the number of properties served) using a standardised reproducible laboratory test.

The test incorporates a lead pipe rig with a sample of treated water from each of the WTPs being tested under standardised controlled laboratory conditions. All water samples will be disposed of in a responsible manner. After 30 minutes of stagnation time the water is removed and analysed for concentrations of lead (in µg/L). This figure is then used to compare the relative plumbosolvency of each of the treated waters. Using this method, Irish Water will rank the treated water in order to determine the lead solubility risk for each WSZ.

Step 2: Plumbosolvency Map

The next step (2) will use GIS information from metering, metering surveys (backyard services), watermain type and CSO small area property age maps, to identify the estimated number of properties with lead services that are being fed by each WTP. This stage will provide plumbosolvency maps of:

- Housing areas with stock older than 1980 (CSO)
- Known lead service connection pipes (Metering, mains rehabilitation projects and GIS)
- Backyard Services (Metering Survey)
- Most Sensitive consumer properties e.g. crèches and schools (GeoDirectory and Non- domestic customer records from Local Authority systems)
- Local Authority knowledge of expected public-side lead service connections through administering lead replacement grants and historical operation and maintenance of the networks. Irish Water is liaising with Local Authorities to collate this data.

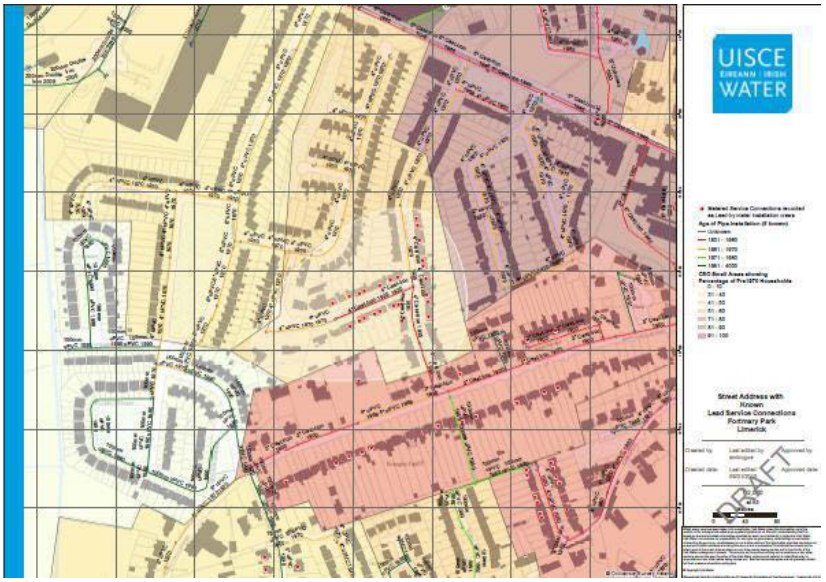


Figure 17: Sample Plumbosolvency Map

The mapping exercise will produce estimated number of properties at risk from the number of houses older than 1980, known or expected lead service connection pipes, backyard services, watermain type and most sensitive consumer properties which is used to select the most appropriate plumbosolvency control measure:

- Corrective water treatment; or
- Public-side lead service replacement

Public-side lead service connection replacement (Step 8 Priority 1) will be prioritised for all known service connections supplying most sensitive customers including crèches, schools, etc. The metering programme has identified over 36,000 properties to date with known lead supply pipes. Where lead has been physically confirmed (e.g. through metering) or confirmed via a lead result from their property that exceeds the lead parametric value, Irish Water will proactively investigate identified hot spot areas in a controlled and strategic manner with the aim of identifying all potential customers / properties with lead supply pipes.

Note: Data provided by CSO with relation to age of properties is provided per small area which equates to approx. 100 properties. Therefore this data cannot be used to ascertain the approximate age of individual properties.

Step 3: Prioritisation of WTP

Irish Water intends to initially prioritise the WTPs that require corrective water treatment based on the information gathered in Step 1 and Step 2.

The Plumbosolvency of each of the waters, based on the controlled testing completed in Step 1 must be multiplied by the estimated number of known and expected lead services being fed by the relevant WTP, figure from Step 2. Irish Water is liaising with Local Authorities to collate this data where available. In the interim Irish Water will use the current available data from the CSO property age maps.

After 12 months of Inventory monitoring, data from Step 4 will be used in lieu of data from Step 2 in order to revise the prioritisation of each WTP.

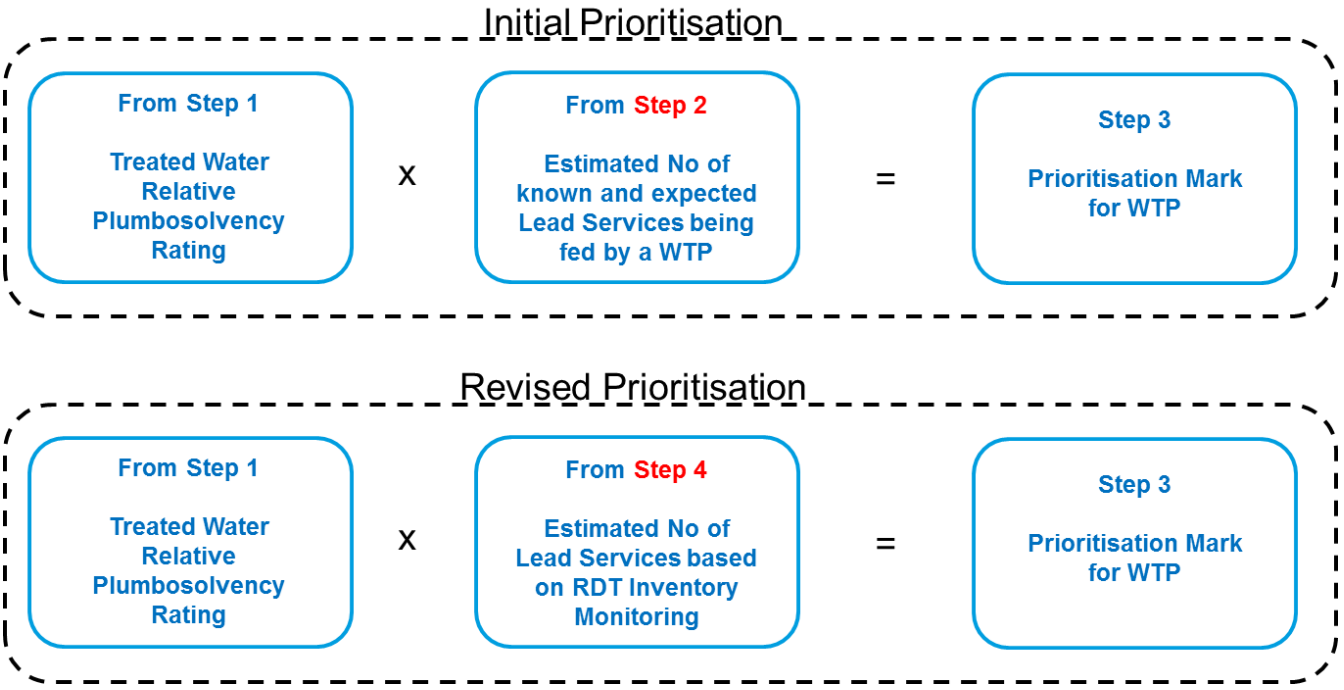


Figure 18: Implementation plan Step 3 – Prioritisation of WTP Areas

The Prioritisation Mark may then be used to prioritise the implementation of corrective water treatment for each of the WTPs. WTPs with higher Prioritisation Marks to be prioritised for completion of Step 6.

The prioritisation approach will direct resources to populations at greatest risk. Corrective water treatment solution will be implemented in WSZs with system wide plumbosolvency problems.

Prior to the implementation of any corrective water treatment solution for the protection of human health, it is important to look at the cause and extent of plumbosolvency problems in each WSZ. Part (B) Sampling and Monitoring of the Lead in Drinking Water Mitigation Plan will establish the scale and concentration levels of lead non-compliance in each WSZ, to confirm that corrective water treatment is the most appropriate reduction measure prior to planning its implementation.

Part B: Sampling & Monitoring

Step 4: Inventory Monitoring

The aim of inventory monitoring is to establish (estimate) a baseline lead compliance level in the WSZ and ensure resources are focused and prioritised on the customers at highest risk. A Random Day Time (RDT) sampling programme commenced in June 2016. RDT will enable Irish Water to identify elevated lead concentrations at properties that would otherwise have not been identified and which may be caused by private side factors such as brass plumbing fittings, lead solder or lead pipework within the distribution system.

Irish Water will use RDT on the basis that a large number of samples can be taken relatively quickly across a large number of properties. Investigation into representativeness of RDT sampling for lead concluded (Hayes and Croft 2012):

- *RDT sampling as practised in UK is adequately representative of the range of circumstances that occur;*
- *For houses with daytime residency, RDT is not sensitive to time period of sampling;*

Because of the seasonal effects of temperature and water source quality, 6 sampling periods (sampling every second month) will be used to gather a full annual profile of lead compliance. To achieve an adequate level of statistical confidence in the results, no property should be sampled more than once per year. Due to the large number of smaller WTPs in Ireland, the sampling frequency will be reviewed with Dr. Colin Hayes (formerly Swansea University, UK; Chairman of COST Action 637 and the International Water Association Specialist Group on Metals and Related Substances in Drinking Water). Sampling programmes will be limited to standard compliance monitoring for WTPs supplying less than 250 properties, where the number of lead connections is unlikely to economically justify orthophosphate treatment. This assumption will be reviewed as the programme develops.

Table 9: Inventory sampling programme requirements (adapted from IWA 2010)

WSZ Sampling Band	Number of Connections	Number of Supplies	No. of Samples / year	No. of Samples / bi-monthly	Inventory Samples
B	250 - 1,000	205	30	5	6,150
C	1,000 - 5,000	188	60	10	11,280
D	5,000 - 10,000	39	180	30	7,020
E	>10,000	39	300	50	11,700
Totals		**471**			**36,150**

Inventory sampling will require an estimated 36,150 RDT samples to be carried out across all WSZs (supplying 98% of the population) to establish the full year lead risk profile. This represents a significant increase in sampling activity when compared to the 2,000-3,000 lead samples reported by the Local Authorities to the EPA in the drinking water returns 2015 and a very significant increase over the number of compliance monitoring samples required by the Drinking Water Regulations. This enhanced national sampling programme will also monitor other water quality parameters of interest and will monitor for other water quality issues at customer taps.. All

water samples will be disposed of in a responsible manner.

The results of the sampling will be used to determine the next level of prioritisation as illustrated in Step 3 above. The prioritisation approach will direct resources to populations at greatest risk. Corrective water treatment solutions will be implemented in WSZs with system wide plumbosolvency problems. Where sampling indicates that lead non-compliance is limited to a small number of properties or clusters, public-side service connection replacement without corrective treatment will be implemented.

The results of all monitoring undertaken by Irish Water will be maintained in a central database and will be made available for inspection to the EPA at any time.

Note: The number of Inventory Monitoring Samples will be based on the number of properties in each WSZ, this will allow Irish Water to establish the extent of the lead problem per WSZ. This data can then be converted to analyse the extent of the lead problem in each WTP area.

The number of Operational Monitoring Samples is based on number of properties being fed by each WTP. This will allow Irish Water to accurately monitor the effectiveness of implemented plumbosolvency control measures for each of the WTPs.

Step 5: Operational Monitoring

Whereas inventory monitoring is used to establish baseline compliance levels, and to select and prioritise the appropriate plumbosolvency control measures, the objective of step (5) operational monitoring is to demonstrate the level of compliance with the lead parametric value, in order to provide the data required to demonstrate the success or otherwise of the plumbosolvency control measures post implementation and review and / or reprioritise if required.

In addition to the parameters for inventory monitoring, operational monitoring includes additional sampling for pH, alkalinity and phosphate at the water treatment plant and throughout the distribution network.

Table 10: Operational sampling programme requirements

WTP Sampling Band	Number of Connections	No. of Samples / year	No. of Samples / bi-monthly
B	250 - 1,000	30	5
C	1,000 - 5,000	60	10
D	5,000 - 10,000	180	30
E	>10,000	300	50

Sampling, analysis and prioritisation will be managed directly by national programme team. The sample points will be distributed throughout the network to ensure they are representative and that localised problems are not over-looked.

In order to optimise the combination of orthophosphate treatment and pH adjustment, it is also planned to monitor the water quality samples from selected Repeat Sampling Properties known to have lead connections. Stagnation sampling can benchmark treatment changes at suitably selected houses and provide a direct measure of the reductions in plumbosolvency achieved. This sampling will be undertaken on a bi-monthly basis so as to better inform the optimisation process.

It is entirely at the discretion of the property owner to permit repeated sampling at their premises. The advice provided to these properties by Irish Water will encourage in the first instance that any private side lead be replaced. If a property owner decides to follow this advice, then they will no longer be considered for repeat sampling purposes.

It is proposed to collate all sampling data available post-implementation of corrective actions and complete performance review after a sufficient period of sampling. With groundwater supplies, a minimum period of sampling of one year may well be adequate. However, with surface derived waters, particularly those with total organic carbon content greater than 3 mg/l, sampling for at least two years will likely be necessary. The results of all operational monitoring undertaken by Irish Water will be maintained in a central database and will be made available for inspection to the EPA at any time.

After the sampling period, the orthophosphate dose can be adjusted depending on the optimisation criteria that have been set. Should the standard of 10µg/l not be met at the customer's tap post-optimisation, the replacement of the public-side lead service connection will be prioritised.

In addition to the operational inventory monitoring, environmental monitoring in line with the SEA Environmental Monitoring Programme will also be carried out. In particular, Irish Water will liaise with the EPA to ensure that ambient water quality monitoring data gathered by the EPA under the Water Framework Directive is collated and tracked to identify risks and trends of key parameters such

as phosphates and biological water quality in areas where corrective water treatment is implemented. Collation of Irish Water inventory monitoring and EPA environmental monitoring will be undertaken by Irish Water and reviewed on a quarterly basis with the EPA to identify risks and trends and assess the environmental impact of any treatment undertaken. Where required, a set of agreed mitigation measures can be implemented to ensure no significant impact. The monitoring will also be used to inform the future development of the EAM and future corrective water treatment regimes.

Under the Limerick Priority Project, Irish Water is gathering a comprehensive set of baseline and operational inventory and environmental monitoring data through 2016 and 2017, pre and post corrective water treatment. This monitoring will inform the evolution of the EAM and the identification of mitigation measures for corrective water treatment in other WSZs.

Irish Water does not propose to implement a national monitoring regime over and above that undertaken by the EPA under the WFD. However, Irish Water does retain the option to carry out monitoring regimes in some WSZ where such monitoring provides additional value to the WFD monitoring data. The monitoring regime, parameters, frequency and duration will be devised on a WSZ basis and will be dependent on the extent and quality of existing information available from the WFD.

Part C: Corrective Water Treatment

Step 6: WSZ Plumbosolvency Control Plan

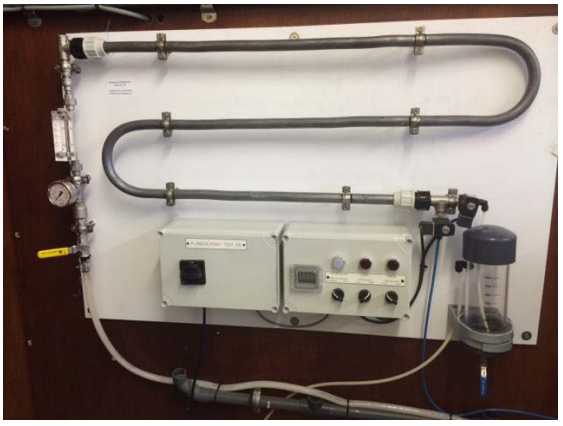
A threshold of 50 lead service connections will serve as Irish Water's initial starting point for assessment and represents the anticipated economic crossover point at which the costs associated with orthophosphate treatment become equivalent to lead service removal. This crossover point will be reviewed throughout the programme at WTP level to determine the most cost effective and efficient method to deliver compliance and may vary depending on a number of factors including technical complexity, cost and benefits.

The following basis for prioritisation is recommended for each water supply system in the European Guidance on sampling and monitoring for lead in drinking water (Joint Research Centre, European Commission, 2009).

Table 11: Recommended Prioritisation Basis based on RDT Survey Results

Percentage of samples exceeding 10 µg/l	Priority for attention
< 2.0	Low priority
2.0 to < 5.0	Investigate any localised clusters
5.0 to < 10	System-wide measures may be required in addition to resolving localised clusters
10 to < 20	System-wide measures required
20 to < 50	Significant problems require attention
>50	Very significant problems require urgent attention

Where corrective water treatment is selected as the appropriate action, Irish Water will use specialist laboratory services to investigate the estimated orthophosphate treatment response, establish the optimum dosing rates and capture organic influences and to understand the interaction of the treated water with lead pipes (i.e. plumbosolvency characteristics of particular water). This approach will fast-track Irish Water's understanding of the orthophosphate treatment response. In consequence corrective water treatment will be more precise and costs and any environmental impacts will be minimised.



A typical lead pipe test rig. Photo: Irish Water

In fluoridated water supplies, there is a potential for the formation of fluorapatite in hot water systems where the temperature reaches in excess of 80°C (UK Water Industry Research, 2008), posing a risk to the Irish Water's industrial

customer's processes. The model from the UKWIR research is being used by Irish Water to assess the likelihood of fluorapatite formation in each water supply zone. Preliminary investigations indicate that fluorapatite formation potential can be managed through pH and orthophosphate adjustment. Where there is a high risk and likely impact on Irish Water customers, simultaneous orthophosphate and fluoride dosing may not be possible. If this scenario arises, Irish Water will examine the options available to achieve compliance. Preliminary analysis suggests, that at the levels of orthophosphate Irish Water are proposing, the risk is very low. However, if a high risk is observed Irish Water will examine the impact, consulting the HSE, Department of Health, EPA and the CER as required.

The Irish Expert Body on Fluorides and Health has sought advice from the Center for Disease Control in the US and from the Dental Public Health, Public Health England regarding the use of orthophosphate in the treatment of public water supplies. Their advice concluded that "the addition of orthophosphate in the fluoridation process does not give rise to problem of fluorapatite formation", (The Irish Expert Body on Fluorides and Health, 2016)

An objective assessment of the environmental impact in wastewater catchments will be completed for each water supply zone where orthophosphate treatment is proposed to ensure that any subsequent environmental controls are justified (CIWEM, 2011).

In general, the environmental impact resulting from orthophosphate treatment is expected to be minimal. In the UK, food additives are estimated to contribute 29% of the domestic load; automatic dishwashing detergents contribute 9% (and potentially increasing); domestic laundry 14% (including contributions from phosphonates - but decreasing); orthophosphate treated drinking water 5%; food waste disposed of down the drain 1%; and personal care products 1%. Although UK data is presented here, it is anticipated that similar impacts would be expected for other developed economies (Combera, 2012). Specific local circumstances will be considered for each WSZ. In some cases, constraints on orthophosphate treatment may apply (IWA 2010).

A site specific environmental assessment will be carried out on each water supply zone including Environmental Assessment Methodology and Appropriate Assessment. Where the Environmental Assessment Methodology (EAM) identifies significant risk to environment receptors associated with orthophosphate treatment a number of mitigation measures are possible. Possible mitigations measures may include selected placement of orthophosphate treatment point, enhanced wastewater treatment (to potentially remove equivalent phosphorus levels related to the Orthophosphate treatment at the Water Treatment Plant), reduced treatment rate, water network leakage control, etc. The extent and cost of the mitigation measures required in relation to the Strategic Environmental Assessment and Appropriate Assessment of the Irish Water Lead in Drinking Water Mitigation Plan will only be finalised post site specific assessment, which are due to be completed 2016-2017 on up to 400 water treatment plants (supplying 98% of the population).

Under the Habitats Directive, Irish Water is required to follow the statutory process of Appropriate Assessment before commencement of this corrective water treatment for the protection of human health. This EU statutory environmental process must be complied with before orthophosphate treatment can commence. Details of all Appropriate Assessment undertaken will be provided to the Development Applications Unit of the Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (DARRGA) at least six weeks in advance of any treatment.

Irish Water has developed a high-level WSZ Health Assessment Tool, which will weigh public health risk against environmental risk. The Water Policy Advisory Committee (WPAC) is currently finalising the establishment of the Lead Mitigation Advisory Group (LMAG) who will review and advise on the WSZ Health Assessments and the decision making

methodology. It is proposed this group comprises of representatives from the DHPCLG, HSE, EPA and DARRGA.

Hacketstown Water Treatment Plant Orthophosphate Treatment facility. Photo: Irish Water

At the treatment risk assessment step (6d) Irish Water will examine the potential impact of orthophosphate treatment on other aspects of the water treatment and distribution system e.g. potential algal formation at the open storage reservoirs at Stillorgan and Ballyboden. Irish Water plan to replace the Ballyboden Reservoir with a covered storage facility by the end of 2017 and to replace Stillorgan with a covered facility by the end of 2020. Orthophosphate treatment upstream of these open reservoirs will not be feasible until the covered storage is provided. Irish Water is presently reviewing options to find the optimum interim solution to protect customers.

In addition to orthophosphate treatment, pH adjustment will be required to maintain the optimum pH level. This can reduce the capacity of the lead to dissolve in the water. Adjusting pH of treated water can impact on the primary disinfection process and production of disinfection by-products. A review of the Primary Disinfection Chlorination Ct calculation is required to ensure that primary disinfection is not compromised as a result of increasing pH levels. Disinfection of water is the highest priority and any increase pH levels should not impact on achieving the required Ct.

Upon completion of the Environmental Assessments for all Water Supply Zones, Irish Water propose to devise a more detailed programme for each Water Supply Zone highlighted the selected lead mitigation measure to be adopted.

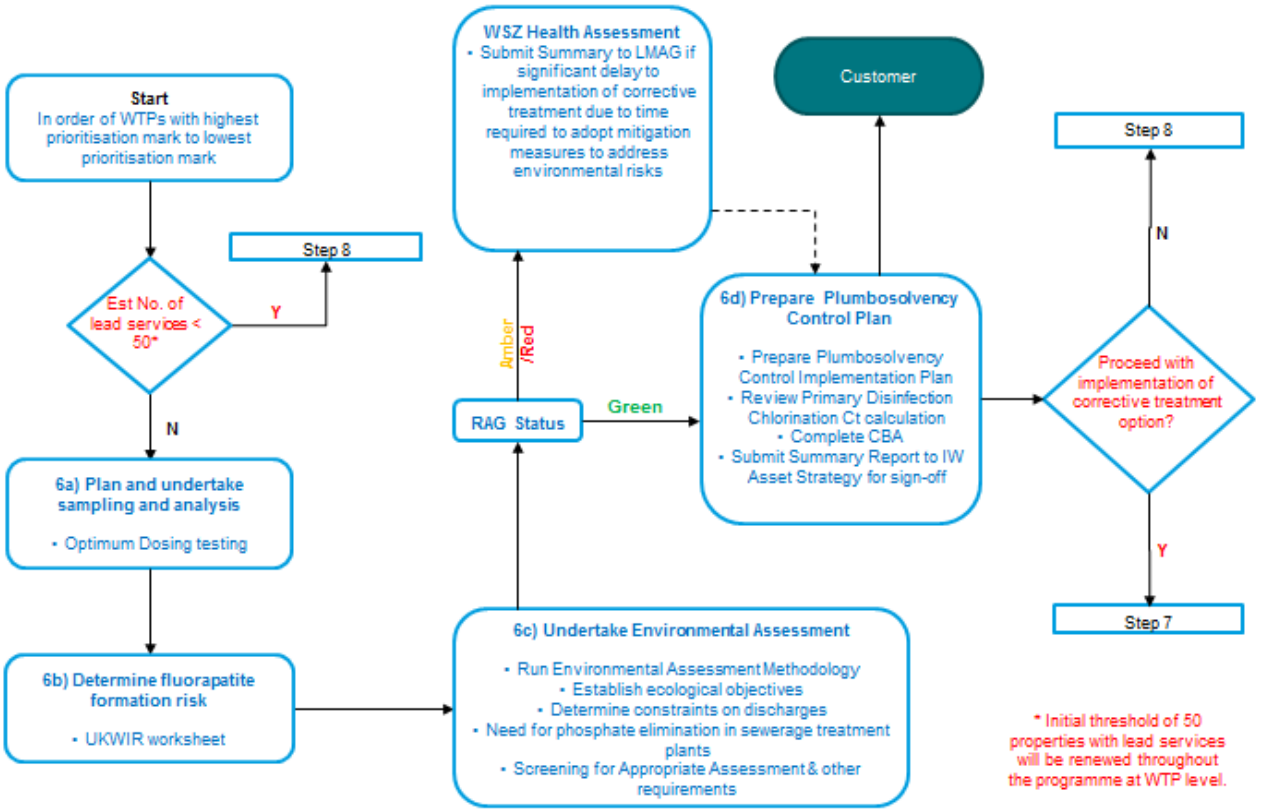


Figure 19: Implementation plan Step 6 – WSZ Plumbosolvency Control Plan

Step 7: Orthophosphate Treatment

To ensure the construction of safe, robust and reliable orthophosphate treatment systems, Irish Water has developed a technical standard specification for designers and contractors, incorporating good engineering practice and 'lessons learnt' for the procurement of standardised package Orthophosphate Treatment units. Programme priority will be given to the WTPs with the highest priority marking from Step 3.

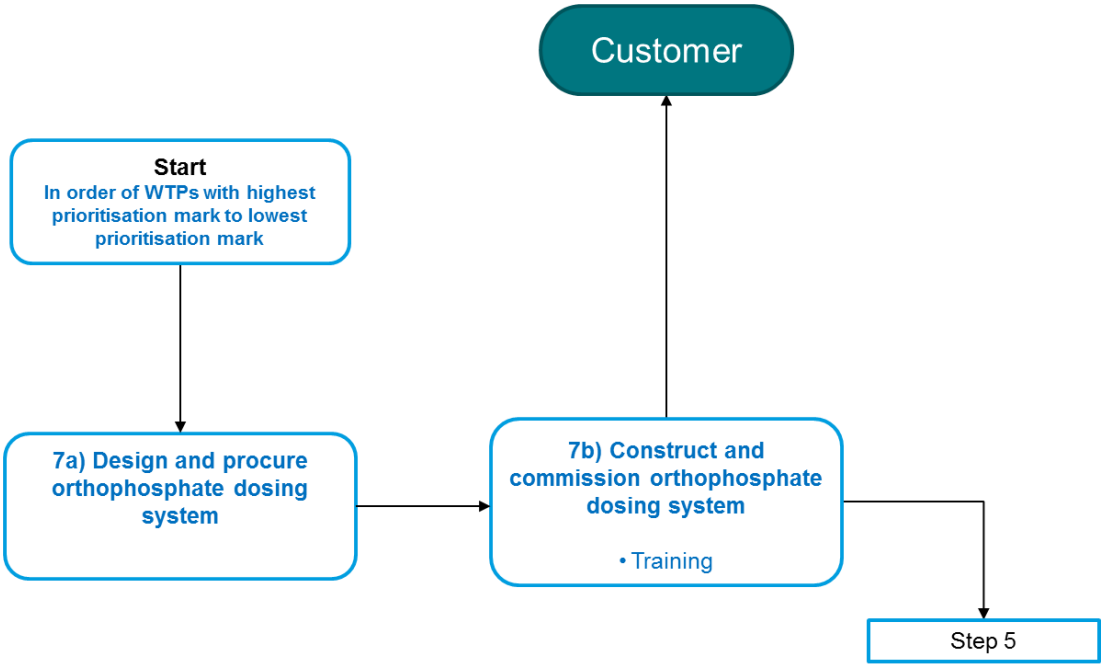


Figure 20: Implementation plan Step 7 – Orthophosphate treatment

In addition to orthophosphate treatment, pH adjustment will be required to maintain the optimum pH level. Where the WTP does not already have a suitable pH adjustment system, Irish Water will install a new or upgraded dosing system that meets the requirements of our pH/Alkalinity Adjustment Standard Design Specification.

To ensure the on-going performance of the corrective treatment solution, standard operating procedures and maintenance routines will be developed under the national programme. Operator training will also be rolled out prior to orthophosphate treatment commencing in a WSZ. On-going performance verification through the operational monitoring programme and third party support will be provided to ensure that the target dose and controls are maintained by the operator to achieve the maximum compliance benefit.

A typical orthophosphate treatment unit

The agricultural use of wastewater sludge from WWTP where corrective water treatment is undertaken will account for any additional phosphorous loading in the Nutrient Management Plans.

The table below shows the typical range of dosing rates for water supply schemes in the UK based on the treated water quality type.

Table 12: Typical range of orthophosphate treatment rates in the UK

Orthophosphate dose range (mg/L P)	% of high alkalinity ground waters	% of high alkalinity surface waters	% of low alkalinity surface waters
0.5 to 0.6	6.5	0	33.7
0.9 to 1.2	60.9	26.7	38.6
1.4 to 2.0	32.6	73.3	23.8
2.2 to 2.8	0	0	3.9

Hayes, 2008

Part D: Lead Service Replacement

Step 8: Targeted Public-Side Lead Service Replacement

Irish Water recognises that the most effective long-term strategy is to remove all lead supply pipes. However this is not feasible as the most significant portion of lead pipework lies outside of Irish Water's ownership, in private property. Irish Water has no authority to replace supply pipes on a customer's property and invest in assets outside of our regulated asset base.

Certain implementation steps are already underway including the replacement of public water lead service pipes in conjunction with mains rehabilitation projects.

This Plan highlights the need for collective action, involving property owners and a number of public (Step 8) and private stakeholders (Step 9) to reduce customer's exposure to lead in drinking water. Irish Water proposes to undertake sensitive customers as shown in the figure below. Backyard Lead Service pipes will be prioritised for replacement by Irish Water, in accordance with the National Lead Strategy, as the increased length of lead pipe poses a higher risk of lead exposure.

an accelerated ten year programme to identify and replace lead service pipes and lead backyard services that are our responsibility in a phased and prioritised manner. In the case of backyard lead services, Irish Water is proposing to continue an established practice of providing a new service pipe from the main in the front (roadway) to connect to the householder's supply pipe generally located at the rear wall. The Plan will be implemented subject to regulatory allowances made by the CER. The level of capital expenditure (Capex) for 2017 and 2018 has been approved by the CER, as part of its price control process, but Capex beyond 2018 is subject to available funding and CER approval as part of future revenue control processes.

As set out in previous sections, metering data supplemented with on-going identification of lead through day to day activities on the networks will be used to indicate the presence of lead. This programme will take its direction from these data sources for the prioritisation of WSZs, targeting the highest risk and most

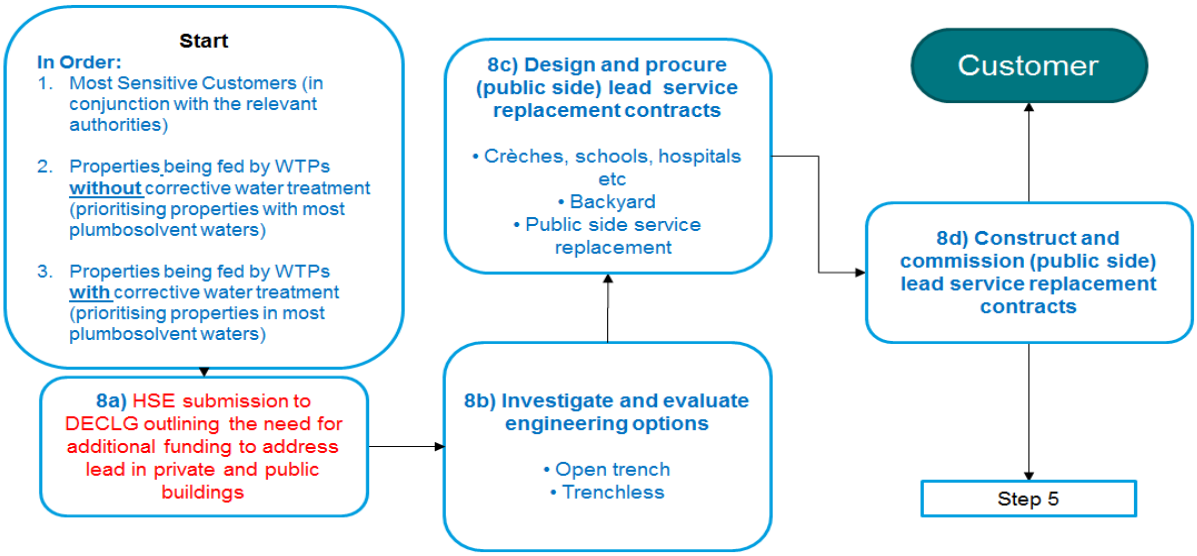


Figure 21: Implementation plan Step 8 – Targeted Lead Mains and Services Replacement

Presently, if Irish Water identifies any lead pipework during mains rehabilitation projects, the lead service connection will be replaced wherever possible;

From 2017, under the proposed new Water Network Management Programme, If Irish Water discovers a lead service connection during meter installation, the contractor will also remove the lead service connection pipe from the water main to customer boundary.

There are a number of implementation issues that may occur during construction such as the risk that partial lead pipe replacement (public side only) may not be effective and may make matters worse (AWWA 2008) as a consequence of, physical disturbance of deposits in remaining pipe or, possible galvanic corrosion between remaining lead and other metals such as new copper. Recent advice from the USEPA National Drinking Water Advisory Council indicated that **short-term elevated lead levels were a concern for both full and partial lead service pipe replacement.**

Irish Water will monitor these potential implementation issues using the data from the operational sampling programme (Step 5) and will investigate and carry out remedial action to address any potential danger to human health in consultation with the HSE (Regulation 9). Irish Water will provide advice to Customers in relation to flushing internal plumbing and other measures following replacement for a period of time as per the latest international best practice guidance.

International experience has shown that strategic replacement of public side lead service connections by water companies does not achieve significant benefits, unless the customer replaces privately-owned lead supply pipes at the same time.

Step 9 outlines how Irish Water proposes to actively encourage customers to remove lead pipes which are in their ownership and therefore their responsibility.

Step 9: Private Lead Supply Pipes– Targeted Communications

As already discussed in Step 8, the most significant portion of the lead pipework lies outside of Irish Water's ownership in private property. It is beyond Irish Water's authority to replace supply pipes on a customer's property and invest in assets outside of our regulated asset base.

The WHO recommends that total lead replacement (public and private) be considered as the ultimate goal from a health perspective. The National Lead Strategy highlights the need for collective action, involving property owners and a number of public and private stakeholders over many years to reduce exposure of the public to lead in drinking water.

Research from partial lead pipe replacement trials completed by other water supply utilities indicates that partial lead pipe replacement does not achieve significant benefits (in terms of both compliance with the 10µg/l standard and reduced exposure to lead), unless the consumer replaces the lead pipes serving their property at the same time. (DWI, July 2013, 'DWI PR14 Guidance – Lead in Drinking Water).

Via targeted communications, Irish Water will actively encourage property owners to remove lead pipes which are their responsibility at the same time that the public-side is being replaced and offer the following for customers with lead pipework.

- If a property owner replaces the lead pipework within their property boundary, Irish Water will also replace the pipework between the water main and the property boundary free of charge, if this has not already been removed;
- If Irish Water find any lead pipework during mains rehabilitation projects or routine maintenance work, the lead service connection will be replaced to the property boundary wherever possible;

- If Irish Water carry out a leak repair under the First Fix Free Scheme and find that the external supply pipe is lead material, we will replace the lead external supply pipe up to point of entry to the dwelling free of charge and subject to the Property Owner's consent;
- Public Information Campaign - Provision of detailed information on lead exposure risk to households in a proactive and targeted manner when lead pipework is identified or being replaced.
    - Information leaflets on lead in drinking water and the benefits of the replacement of privately-owned lead supply pipes will be distributed in advance of public-side lead service replacement contracts; If any works are required in Public Roadways, we are proposing that the contract will require this to be scheduled at least 8 weeks ahead of excavations, but in any case no less than 28 days
    - Information is provided on Irish Water's website

Irish Water will co-operate with any initiatives proposed by DHPCLG or CER to provide a service to the customer to replace the customer's lead pipework within their property boundary.

The replacement of private side lead supply pipes and internal plumbing is the responsibility of the property owner. International experience indicates that a substantial level of property owners may be reluctant to replace their lead pipes because of the disruption and costs involved.

If the Plan's metrics are to be met through replacement of lead pipes, it is imperative that the other responsible Stakeholders i.e. Department of Housing, Planning, Community and Local Government, Local Authorities and other public and private stakeholders remove lead supply pipes from the housing stock and public buildings. Otherwise the targets will only be achieved through the introduction of treatment using orthophosphate in all high risk water supplies where it is technically, economically and environmentally viable to do so.

Grant Scheme to Replace Lead Pipes

Department of the Housing, Planning, Community & Local Government has announced a grant scheme that is available to homeowners to assist with the cost of replacing lead pipes in their property. This scheme is administered by the Local Authorities. They have also published a new guidance note on the replacement of lead supply pipes ***http://www.housing.gov.ie/water/water-quality/lead-drinking-water***

The new grant scheme has been established in line with the National Lead Strategy approved by Government in 2015.

Standard advice for customers should also be provided on the appropriate Domestic Plumbing Standards Policy based on international best practice.

Pipe Fittings

Brass fittings have been routinely used within plumbing systems in conjunction with copper pipe-work, as elbows, connectors and valves. Brass is an alloy containing copper, zinc and lead. To enhance the machinability of brass, lead is often added in concentrations of around 2%. Up to 2014, brass was considered to be "lead-free" in the US if the lead content was less than 8%. In 2014, the US revised their standard definition for "lead free" as a weighted average of 0.25% lead calculated across the wetted surfaces of a pipe, pipe fitting, plumbing fitting, and fixture. The lead content for all brass fittings for use on domestic potable water drinking systems should be independently verified, however no mechanism exists in Ireland to enforce this.

Step 10: Customer Opt-In Lead Services Replacement

Irish Water will continue to commit to replacing public-side lead services where the customer has replaced the private side lead pipework. An application process has been developed to enable customers to apply for the scheme. As the Customer Opt-In offer is developed, a suite of information relating to this will also be published and issued to the customer for information and to facilitate the implementation of this scheme. This is free-of-charge to the customer.

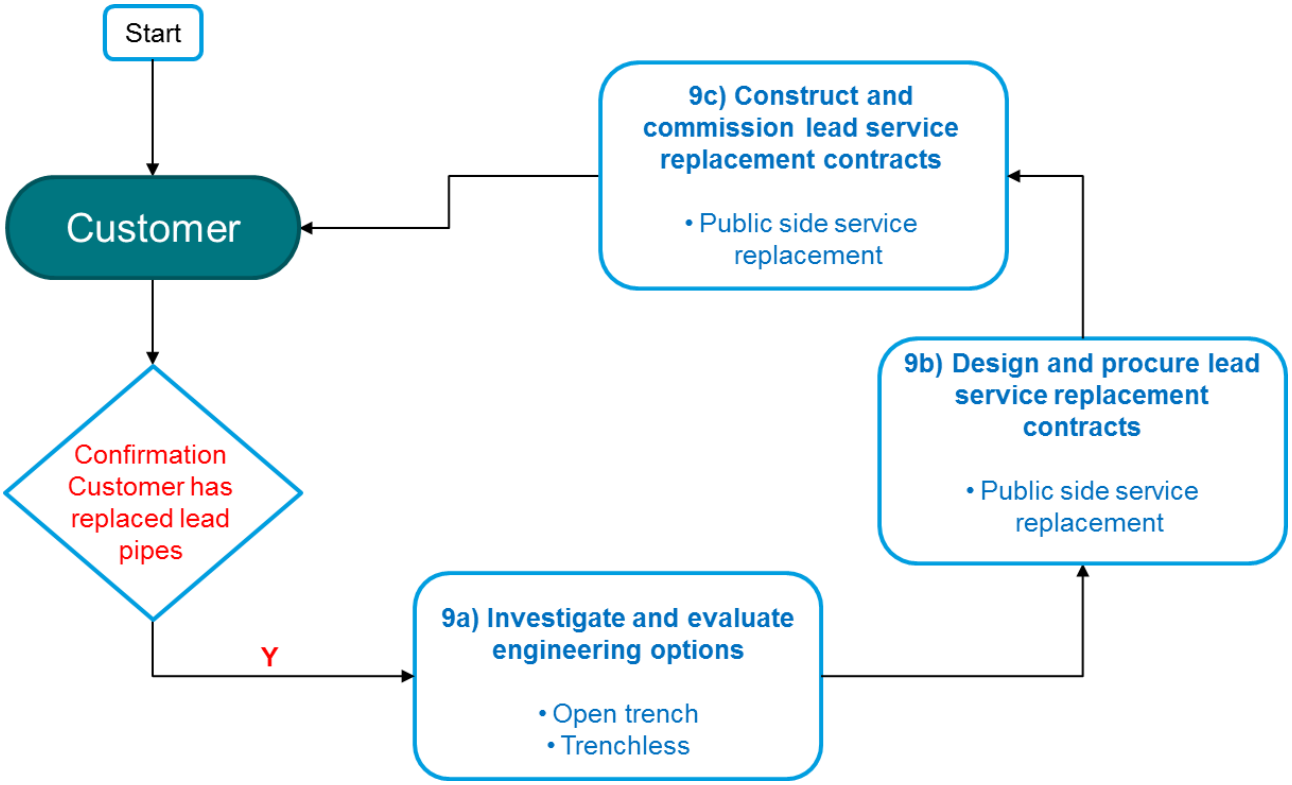


Figure 22: Implementation plan Step 10 – Customer Opt-in Lead Services Replacement

Section 8 - Public Information Campaign

8.1 Liaising with Stakeholders

As set out in the National Lead Strategy, Irish Water will continue to liaise with Health Service Executive (HSE) and Environmental Protection Agency (EPA) on issues arising where lead exceedances are detected or lead pipes are discovered through the Irish Water metering or water mains rehabilitation programmes.

Irish Water has commenced a public information programme that was initiated in June 2015, involving all major stakeholders including the Environmental Protection Agency (EPA) and the Health Services Executive (HSE). This has been facilitated by a range of communications materials and using various communication channels, targeted at customers who may have lead pipes in their properties. This is the most effective way to address what is a national public health issue.

Lead exceedances found at properties identified during the national sampling programme will generate customer advice agreed with HSE and EPA. The EPA and HSE will also be notified at regular intervals.

8.2 Public Communications

Customer communication forms an integral part of Irish Water's Lead in Drinking Water Mitigation Plan and each mitigation measure proposed.

Irish Water will continue to provide information through the following means:

- Press releases to the media informing of the availability of information.
- Printed leaflets delivered to all properties identified as having lead pipework from the metering project, sampling programmes and other Irish Water projects.
- Dedicated webpage with advice and downloadable leaflets, videos and infographics.
- Briefing local authority staff and elected representatives.
- Telephone and email advice made available (telephone number and email contact details would be included on our webpage and leaflets); and
- Social media (Irish Water's Facebook and Twitter accounts) would be used to broaden the message.

Irish Water will continue to recommend practical steps customers can take, until the property owner replaces the lead pipework in their property. These include:

- How to identify lead pipes
- Flushing of pipework after several hours of non-use. Evidence from international and local studies indicates that this is likely to reduce the concentration although it does not guarantee compliance with the lead limit.
- Take water for drinking and cooking directly from the mains-fed tap. This is normally the cold tap at the kitchen sink and is likely to have the least risk.
- Never use water from the hot water tap for drinking or cooking. Heating increases the amount of lead that can be absorbed from plumbing.
- Use of bottled water for most sensitive persons to lead exposure, particularly children and pregnant women. Bottled water for infant feeds should be checked to ensure it is low in sodium; and
- Boiling water does not reduce lead concentrations in the water.

A key objective of this Plan and the associated public engagement is to alert all customers potentially at risk to the fact that they may have lead concentrations in their water supply that are in excess of the current limit. While the presence of lead piping in a property does not automatically mean that lead concentrations will exceed the limit, Irish Water estimate that this is likely to be the case in the majority of properties.

More detailed information for households - Irish Water will communicate lead exposure risks in a proactive and targeted manner when lead pipework is disturbed when being replaced and provide advice in relation to flushing internal plumbing following replacement for a short-period of time as per the latest international best practice guidance.

Via targeted communications, Irish Water will actively encourage property owners to remove lead pipes that are their responsibility. This is discussed in greater detail above in Section 7Step 9.

8.3 Direct Notification of Customers

Irish Water is notifying customers directly where lead pipework has been physically confirmed through metering, mains rehabilitation works, lead shared service replacement, or through sampling. Sampling includes Regulatory, Non-Regulatory, private sampling undertaken by the householder, and through the dedicated National Lead Monitoring Programme, a new comprehensive programme of national Random Daytime Sampling whereby we expect to sample c.36,000 premises over the next 12 months. This process is driving strategic notifications to householders of lead risk evidenced by the various work programs.

The process of notifying customers in a controlled strategic manner has already commenced in respect of customers identified through the metering project. Irish Water will be providing regular progress updates to the HSE and EPA on the roll-out of this programme (i.e. sample locations, test results etc.). Irish Water will be contacting the customer directly where sampling has confirmed the presence of lead pipework or has had a lead exceedance.

Irish Water will proactively investigate, in a controlled and strategic manner, any identified hot spot areas where lead pipework or fittings are giving rise to elevated lead levels in drinking water. The anticipated sample numbers to be taken as part of the National Lead Monitoring Programme, in addition to the on-going data gathering of connection details by our metering team, should provide a comprehensive picture of lead risk across our public water supplies.

Through the Opt-in Scheme discussed above in Section 7 Step 10, Irish Water is committing to replace any public side lead on a connection after the customer has replaced all private side lead, no repeat or follow up sampling will be undertaken by Irish Water until these works are completed.

Advice is available to customers on the Irish Water website should they wish to test their water for presence of lead. They should use a laboratory with INAB accreditation for testing for lead in drinking water.

8.4 Most Sensitive Customers

In the preparation of a WSZ specific Plumbosolvency Control Plan, Irish Water will identify most sensitive customers including but not limited to:

- Crèches
- Children and maternity hospitals
- Schools
- Other non-domestic or similar properties that have occupants below six years of age will be considered as they are presented.

The list of most sensitive customers will be generated for each WSZ from Local Authority non-domestic customer data (when available) and GeoDirectory records. Via targeted communications, Irish Water will actively encourage the most sensitive customers to remove lead pipes, which are their responsibility, through the Customer Opt-in Scheme. Irish Water will provide the necessary information to the most sensitive customers and advice will also be available on Irish Water's website.

To comply with its obligations under the regulations, Irish Water will ensure that **premises' owners** affected are advised of any possible remedial action which could be taken by them. The advice will include private-side lead pipework removal and mitigation measures such as flushing. Flushing will reduce the risk of exposure but may not eliminate the risk entirely as there are other factors to

consider including plumbosolvency and flushing performance. Further advice is provided by the HSE, and will recommend the use of bottled water or water from another property where lead piping is not present.

8.5 Effective communication channels

A number of documents have been published setting out how Irish Water will communicate with our customers.

The Customer Handbook, published by the Commission for Energy Regulation (CER) provides guidelines on the required levels of customer service. The Handbook is available at;

https://www.cru.ie/home/customer-care/water/customer-protection-2/

The Codes of Practice and Customer Charter set out our commitments for effective communication with our customers.

The Customer Charter (*https://www.water.ie/docs/Customer-Charter.pdf*)

sets out the service provided and service quality levels offered to our customers. It also sets out a number of commitments where charter payments apply for domestic customers.

Irish Water understands that some of our customers have different needs when it comes to using our water services and communicating with us. Irish Water has developed a register of vulnerable customers, which includes:

- a special services register for those customers who require additional support communicating or receiving services from us and;
- A priority services register for those customers who are critically dependent on water for their medical needs.

The Vulnerable Customer Code of Practice https://www.water.ie/our-customer-commitment/ gives details of how Irish Water plan to respond and adapt the services and communications provided to suit the needs of customers who tell us they are vulnerable.

Irish Water are committed to providing an excellent service to our customers that meets their evolving needs and requirements, while taking into account the challenges we face in establishing a modern water utility and the necessary upgrade of our assets to provide a reliable water supply.

Section 9 - Continuous Improvement, Data and Reporting

The mitigation of lead in drinking water is recognised worldwide to be a very complex issue and a number of uncertainties exist due to limited data availability. The Plan provides a detailed framework of measures for implementation to effectively address lead in drinking water. This will require significant capital investment over a number of investment cycles and proactive commitment from all stakeholders in order to effectively address the risk of failure to comply with the drinking water quality standard for lead.

The National Lead Programme Team will provide continuous feedback on the location of removal of lead service connections and the performance of corrective water treatment towards lead compliance and the protection of human health. Asset records will be updated to reflect lead service removal as progress is made towards the ultimate goal of zero public lead pipework. The programme management function will ensure that updates to asset information as a result of investigations, metering or water chemistry data will be continuously reviewed against the Plan to ensure that Irish Water targets the highest risk areas at all times.

Our Plan will be monitored and adjusted as required to ensure it is effective and delivering the compliance target objectives.

Irish Water will provide progress reports to the EPA, CER and HSE indicating the number of services, length of lead main removed and remaining, number of customers availing of the opt-in scheme each year. In addition, the inventory and operational monitoring will provide more robust reporting on national lead compliance.

Irish Water will continue operational sampling post-project to ensure that effective plumbosolvency control is maintained in normal operations and to monitor lead exposure risk. Where the risk has been significantly reduced by both public and private side lead removal programmes, Irish Water will consult DHPCLG, HSE and EPA to determine if it is appropriate to cease orthophosphate treatment.

Glossary and Acronyms

Acronyms	
AA	Appropriate Assessment
ANSI	American National Standards Institute
AWWA	American Water Works Association
Capex	Capital Expenditure
CBA	Cost Benefit Analysis
CER	Commission for Energy Regulation
CIP	Capital Investment Plan
CIWEM	Chartered Institution of Water and Environmental Management
CSO	Central Statistics Office
DAHRRGA	Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs
DECLG	Department of Environment, Community Heritage and Local Government
DHPCLG	Department of Housing, Planning, Community and Local Government
DIC	Dissolved Inorganic Carbon
DIY	Do It Yourself
DoH	Department of Health
DW	Drinking Water
DWI	Drinking Water Inspectorate
DWSP	Drinking Water Safety Plan

DWWTS	Domestic Waste Water Treatment System
EAM	Environmental Assessment Methodology
EC	European Commission
EEC	European Economic Community
EPA	Environmental Protection Agency
EU	European Union
GIS	Geographical Information System
GWDTE	Groundwater Dependent Terrestrial Ecosystem
HSE	Health Service Executive
IWA	International Water Association
LA	Local Authority
LMAG	Lead Mitigation Advisory Group
LDWMP	Lead in Drinking Water Mitigation Plan
NFGWS	National Federation of Group Water Schemes
NSF	National Sanitation Foundation
Opex	Operational Expenditure
P	Phosphorus
PE	Population Equivalent
POE	Point of Entry
POU	Point of Use

RDT	Random Day Time
RO	Reverse Osmosis
SEA	Strategic Environmental Assessment
SWO	Storm Water Overflow
TBC	To Be Confirmed
TW	Treated Water
UFW	Unaccounted for Water
UKWIR	UK Water Industry Research
USEPA	U.S. Environmental Protection Agency
UV	Ultraviolet
VOC	Volatile Organic Compounds
WPAC	Water Policy Advisory Committee
WHO	World Health Organisation
WRZ	Water Resource Zones
WSSP	Water Services Strategic Plan
WSTG	Water Services Training Group
WSZ	Water Supply Zone
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Glossary	
Abstraction	The removal of water from a river, lake or groundwater usually with the use of a pump.
Asset	Infrastructure (e.g. buildings, treatment plants) and equipment (e.g. pumps, screens, treatment units, disinfection systems and control panels) controlled and operated by Irish water to deliver water and wastewater services. Irish Water divides these into Below Ground Assets such as pipework and valves and Above Ground Assets such as treatment plants.
Compliance monitoring	Monitoring at the point of compliance to verify that water supplied for human consumption is in compliance with its quality requirements
Customer	Occupier of the Dwelling.
Discharge	Treated effluent from a wastewater treatment plant which is returned to the water environment. This is usually from a pipe and outflow structure into a river or the sea.
Drinking Water Regulations	European Union (Drinking Water) Regulations 2014 - S.I. No. 122 of 2014.
Economic regulator	An independent body that regulates a range of economic, customer and safety functions.
European Directive	A legal act of the European Union which requires member states to achieve a particular result. Examples are the Drinking Water Directive, Urban Wastewater Treatment Directive and the Water Framework Directive.
External Supply Pipe	Water supply pipework serving the Property, which pipework runs between the point that is (i) 225mm outside the boundary to the Property and (ii) just before such pipework enters the Dwelling (the latter point being determined at Irish Water's discretion, acting reasonably). External Supply Pipe excludes: (1) external plumbing systems, standpipes, irrigation systems or other external water supplies; and/or (2) pipework that exceeds 15 metres in length; and/or (3) pipework that runs under buildings or structures on the Property; and/or (4) Pipework with an inside diameter exceeding 25 millimetres.
Groundwater	Water located beneath the ground surface in soil and rock pore spaces and fractures within rock formations.
Fluorapatite	A phosphate mineral with a hard crystalline structure.
Inventory monitoring	Monitoring to estimate the lead problem in a water supply zone or country
Network	The interconnection of pipes and pumping stations used for the distribution of treated water and the collection of wastewater.
Operational monitoring	Monitoring activity to check the quality of source water, and to validate the operation of the water treatment plant, the distribution network and the domestic distribution system up to the tap.
Plumbosolvency	The ability of water to dissolve lead into water supplies from lead pipes.

Property	Dwelling and includes the curtilage to that Dwelling
Raw Water	Water abstracted for drinking water purposes before treatment.
Standard Operating Procedures	Detailed, written instructions and rules for managing and operating assets.
Water Body	A defined section of river, lake or groundwater identified in the water body characterisation of the River Basin Management Plans developed under the Water Framework Directive.
Water Body Objectives	Environmental objectives set for each water body assessed within the River Basin Management Plans. The objectives could relate to achieving Good Status for the water body (requiring improvements to water quality, ecology, channelisation or other factors) or to no deterioration in status.
Water safety plan	A Water Safety Plan is a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. It comprises as a minimum the three essential actions that are the responsibility of the drinking-water supplier in order to ensure that drinking-water is safe. These are: a system assessment, effective operational monitoring, and management.
Water Supply Zone	The area supplied by an individual water supply scheme. This typically includes one or more abstractions (from a river, lake or groundwater), a treatment plant, storage in reservoirs and the distribution pipe network to deliver the water to each household or business.