Radiological Protection Institute of Ireland

An Institiúid Éireannach um Chosaint Raideolaíoch

Guidance Note on the Disposal of Prepared Uranium/Thorium Compounds

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Radiological Protection Institute of Ireland
3 Clonskeagh Square,
Dublin 14

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Introduction

This guidance note has been prepared by the Radiological Protection Institute of Ireland (RPII) in consultation with the Environmental Protection Agency (EPA), and presents protocols for the approved discharge of small quantities of prepared uranium and thorium compounds via the foul sewer system. In all cases, prior approval must be sought from the relevant Local Authority to discharge to the foul sewer in accordance with these protocols.

Pre-notification must forwarded to the RPII, regarding the date and location of the discharge, and following completion of the discharge a record of the operation and a summary report must be completed and forwarded to the RPII as confirmation that the compound has been disposed of as specified.

Uranium and thorium are naturally occurring radioactive substances which are widely distributed in the environment. Natural uranium is a mixture of three isotopes which, from the point of view of weight, occur in the following proportions: U-238 (99.28%), U-235 (0.714%) and U-234 (0.0059%). U-238 has a half-life of 4.5 x 10^9 years; U-235 has a half-life of 7.1 x 10^8 years and U-234 has a half-life of 2.4 x 10^5 years. All three isotopes are alpha particle emitters.

Thorium in the natural environment is essentially a single isotope, Th-232, which has a half life of 1.39 x 10^{10} years and is also an alpha emitter.

Uranium and thorium both occur widely at low concentrations in nature, and measured levels of uranium in Irish soils range from less than 0.005 becquerels per gram (Bq/g) to 0.543 Bq/g with an average value of 0.039 Bq/g. For thorium, the levels found in Irish soils range from less than 0.005 Bq/g to 0.071 Bq/g with an average value of 0.025 Bq/g. This compares to global average values of 0.035 Bq/g and 0.030 Bq/g, respectively[1].

Prepared compounds of uranium and thorium have found widespread use in industry, education and research worldwide. These prepared uranium compounds have been manufactured from both natural uranium and depleted uranium i.e. uranium in which most of the U-235 and U-234 has been removed. Typically, a prepared uranium compound is likely to have a specific activity ranging from 10,000–25,000 Bq/g, depending on whether or not the compound has been prepared from natural uranium or depleted uranium and on the age of the compound.

The specific activity will be highest for prepared uranium compounds manufactured from natural uranium. Prepared thorium compounds are likely to have a specific activity of approximately 4000 Bq/g.

[1] *United Nations Scientific Committee on the Effects of Ionising Radiation Report to the General Assembly on the Sources and Effects of ionizing Radiation (UNSCEAR 2000 Report vol. 1)*

Use of Uranium/Thorium Compounds in Ireland

In Ireland, prepared compounds of uranium and thorium were predominantly used in industry, education and research as staining materials in electron microscopy and as indicators, titrants and analytical reagents in analytical chemistry. Most of the compounds now presently found in Ireland are legacy compounds which were never used by their present owners and were only discovered in recent years. These compounds were originally sold by chemical distributors for use as chemical reagents and the radioactive properties of these compounds was incidental to their use in these applications.

Prepared uranium and thorium compounds do not pose a significant external radiation hazard and the primary radiological hazard arises from the inhalation or ingestion of the compound. The ingestion of small quantities of uranium/thorium is not considered likely to cause significant radiological effects, but the inhalation of uranium/thorium in the form of suspended dust or aerosols is considered to be of greater radiological significance because the clearance from the body is slower and some of the uranium/thorium can be retained in the skeletal structure.

Uranium/thorium compounds generally present in powder form and for this reason care must be taken to prevent the possibility of inhaling fine particles. It is therefore essential to adopt appropriate controls when handling unsealed uranium/thorium compounds such as appropriate personal protective equipment (PPE) (disposable gloves, white coat, and safety glasses), a high level of laboratory cleanliness and the use of spill trays and fume hoods. If unsealed uranium/thorium compounds are handled outside of fume hoods then it would be prudent to use some simple form of respiratory protection.

This document presents protocols for the approved discharge of small quantities of prepared uranium and thorium compounds via the foul sewer system.

Disposal Protocols

The protocols are based on the activity concentrations or exemption values for uranium/thorium specified in Table A, Schedule 5 of the Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000, Statutory Instrument No. 125 of 2000 and on the permissible uranium and thorium concentrations in drinking water specified in the European Communities (Drinking Water), (No 2) Regulations, 2007, Statutory Instrument No. 278 of 2007.

Maximum permissible concentrations (MPC) in drinking water have been recommended for uranium and for thorium in the European Communities (Drinking Water), (No 2) Regulations, 2007, Statutory Instrument No. 278 of 2007. These are:

- Uranium -238: 3 Bq per litre
- Thorium-232: 0.6 Bq per litre

These MPCs are based on the concentrations being present throughout the year, and an annual ingestion of 730 litres of drinking water.

Discharges under these protocols will only take place to the foul sewer system, and will only consist of weak radioactive acidified aqueous solutions. The acidified solution will ensure that the radioactive compounds will remain in solution up to and beyond dispersal in the foul sewer system and passage through a municipal Waste Water Treatment Plant (WWTP).

Dilution of these weak radioactive acidified aqueous solutions in the foul sewer system followed by further dilution in a WWTP, and further dilution in the receiving river or estuary will result in uranium and thorium concentrations, in the final discharges, which are below the permissible uranium and thorium concentrations for drinking water in Statutory Instrument No. 278 of 2007.

The assumptions and calculations which form the basis of the protocols are presented in the Appendix.

Disposal Protocol for Prepared Uranium Compounds via the Foul Sewer System

Prepared uranium compounds may be disposed through the foul sewer system if the activity concentration of uranium is less than the concentration specified for uranium in Column 3, of Table A in Schedule 5 of Statutory Instrument No. 125 of 2000. The most restrictive value specified for uranium-238 at 1 kBq/kg has been adopted in this protocol.

The prepared uranium compound must be in water soluble solution with an activity concentration less than 1 kBq/kg or 1 kBq/l of uranium-238. To achieve this, the following steps must be followed: (see Appendix, Figure 1).

Assumptions Made:

- Specific Activity of uranium=25,000 Bq/g (Assumed Worst Case)
- 2 g of prepared uranium compound for disposal at any one time

1. *Weigh out 2 g of prepared compound adhering to good laboratory practice. To prevent the possibility of accidentally ingesting or inhaling any of the uranium compounds the weighing operation should be performed in a fume cupboard. General laboratory health and safety procedures should be adhered to. In particular, staff involved in this operation should wear laboratory coats, disposable gloves and safety spectacles.*

2. *Dissolve the measured 2 g of prepared uranium compound fully in a beaker of warm water with dilute acetic acid (5% regular acetic acid solution). The acid solution will ensure that the uranium compound will remain in solution up to and beyond dispersal in the foul sewer system and passage through a WWTP.*

3. *Dilute the acid solution in 60 litres of water to attain an activity concentration less than 1 kBq/l.*

   2 g of uranium compound with an assumed maximum specific activity of 25,000 Bq/g gives rise to a maximum possible total activity of 50 kBq. Diluting this in 60 litres of water will result in a concentration of approximately 0.8 kBq/l, which is below the specified exemption value of 1 kBq/l in Statutory Instrument No. 125 of 2000.

4. *Flush the dissolved uranium compound down a designated drain/access point, which is directly connected to the foul sewer system.*

   The solution should be flushed down the drain/access point with approximately 10 times its volume of water (600 litres) to achieve further dilution. The drain/access point should then be washed with dilute acetic acid solution to ensure that no residue of the compound is adsorbed on its surface.

5. *The disposal of the uranium solution may be carried out in a single operation or over a few days. Each disposal should be carried out by a competent person adhering to good laboratory practice. General laboratory health and safety procedures should be adhered to.*

6. *The external radiological hazard from uranium compounds, in both solid form and in dilute acidified solution, is minimal. Nevertheless, the time spent handling the material should be kept to a minimum.*

7. *A record of the operation and a summary report must be completed and forwarded to the RPII as confirmation that the uranium compound has been disposed of as specified.*

For different amounts of prepared uranium compound then the dilutions must be adjusted accordingly.

Disposal Protocol for Prepared Thorium Compounds via the Foul Sewer System

Prepared thorium compounds may be disposed through the foul sewer system if the activity concentration of thorium is less than the concentration specified for thorium in Column 3, of Table A in Schedule 5 of Statutory Instrument No. 125 of 2000. The value specified for thorium-232 at 1 kBq/kg has been adopted in this protocol.

The prepared thorium compounds must be in water soluble solution with an activity concentration less than 1 kBq/kg or 1 kBq/l of thorium-232. To achieve this, the following steps must be followed: (see Appendix, Figure 2).

Assumptions Made:

- Specific Activity of thorium = 4000 Bg/g (Assumed Worst Case)
- 10 g maximum of prepared thorium compound for disposal at any one time

1. *Weigh out 10 g of prepared compound adhering to good laboratory practice. To prevent the possibility of accidentally ingesting or inhaling any of the thorium compounds the weighing operation should be performed in a fume cupboard. General laboratory health and safety procedures should be adhered to. In particular, staff involved in this operation should wear laboratory coats, disposable gloves and safety spectacles.*

2. *Dissolve the measured 10 g of prepared thorium compound fully in a beaker of warm water with dilute acetic acid (5% regular acetic acid solution). The acid solution will ensure that the thorium compound will remain in solution up to and beyond dispersal in the foul sewer system.*

3. *Dilute the acid solution in 60 litres of water to attain an activity concentration less than 1 kBq/l.*

   10 g of thorium compound with an assumed maximum specific activity of 4000 Bq/g gives rise to a maximum possible total activity of 40 kBq.

   Diluting this in 60 litres of water will result in a concentration of approximately 0.7 kBq/l, which is the below the specified exemption value of 1 kBq/l in Statutory Instrument No. 125 of 2000.

4. *Flush the dissolved thorium compound down a designated drain/access point, which is directly connected to the foul sewer system. The solution should be flushed down the drain/access point with approximately 10 times its volume of water (600 litres) to achieve further dilution. The drain/access point should then be washed with dilute acetic acid solution to ensure that no residue of the compound is adsorbed on its surface.*

5. *The disposal of the thorium solution may be carried out in a single operation or over a few days. Each disposal should be carried out by a competent person adhering to good laboratory practice. General laboratory health and safety procedures should be adhered to.*

6. *The external radiological hazard from thorium compounds, in both solid form and in dilute acidified solution, is minimal. Nevertheless, the time spent handling the material should be kept to a minimum.*

7. *A record of the operation and a summary report must be submitted to the Regulatory Services Division of the RPII as confirmation that the thorium compound has been disposed of as specified.*

For different amounts of prepared thorium compound then the dilutions must be adjusted accordingly.

Disposal of Uranium/Thorium Compounds (Already In Solution)

It may be the case that uranium and thorium compounds are already in solution and the disposal of these solutions to the foul sewer system will require careful consideration.

If the solutions consist of water based aqueous solutions then it should be assumed that the maximum quantity of uranium/thorium present in the solution is equivalent to the volume of the solution in which it is dissolved. For example, 200 ml of a uranium based solution should be taken to contain a maximum of 200 g of uranium with a maximum specific activity of 25,000 Bq/g. The standard disposal protocols in this Guidance Note will then apply.

In cases where the uranium/thorium solutions are believed to contain solvents then advice must be sought from the Environmental Protection Agency (EPA) and the Local Authority regarding the requirements and regulations in relation to the disposal of solvents to the foul sewer system.

If the solvents are miscible and are permitted to be disposed of via the foul sewer system then the standard disposal protocols in this Guidance Note will apply.

In circumstances where the solvents are not permitted to be disposed of via the foul sewer system then consideration will have to be given to pre-treating these solutions in order to remove the solvents under controlled conditions.

If the solvents can be removed in this manner then the disposal protocols in this Guidance Note will apply. If pre-treatment is not feasible then disposal via the foul sewer system will not be possible.

APPENDIX

Assumptions built into Disposal Protocols

In the disposal protocol for prepared uranium compounds the worst case specific activity (25,000 Bq/g) has been adopted, and the most restrictive activity concentration or exemption value for uranium-238 (1 kBq/kg or 1 kBq/l) contained in Table A in Schedule 5 of Statutory Instrument No. 125 of 2000 has also been adopted.

Likewise, the worst case specific activity (4000 Bq/g) has been adopted for prepared thorium compounds.

Assumptions regarding Dilution Factors built into Disposal Protocols

The primary assumptions relate to Dilution Factors (DF) for a typical municipal Waste Water Treatment Plants (WWTP) and for the receiving waters be they rivers or estuaries.

In a WWTP with a catchment area of 30,000 people the flow to the WWTP would be 7500 m^3/day or c.5 m^3 per minute. This is based on a contributing flow in the catchment area of the order of 200-300 litres per head per day.

Retention in the WWTP for the plug of flow affected by the discharge of a uranium/thorium solution to the foul sewer system is taken to be equivalent to 6 hours or in this example equivalent to 1800 m^3 of input. Depending on the operation of the WWTP this could result in a minimum dilution of the uranium/thorium discharge (660 litres) in a volume of 900 m^3 or a DF of the order of 1360. The maximum DF could be of the order of 2730. In these protocols, a DF of 200 is assumed for a typical municipal WWTP.

Further dilution of the discharge will occur at the output of a typical WWTP. If the receiving water is a river then a further dilution of the discharge of a factor of 8 is assumed, whereas, if the receiving water is an estuary then a further dilution of the discharge of a factor of 20 is assumed.

In cases where the foul sewer to be used for the disposal leads to a WWTP, the output of which may be subject to downstream usage as a drinking water supply, the relevant Local Authority must confirm that the dilution factor (DF) at the WWTP is greater than 200.

Figure 1

Flow Chart of Process – Uranium Compounds

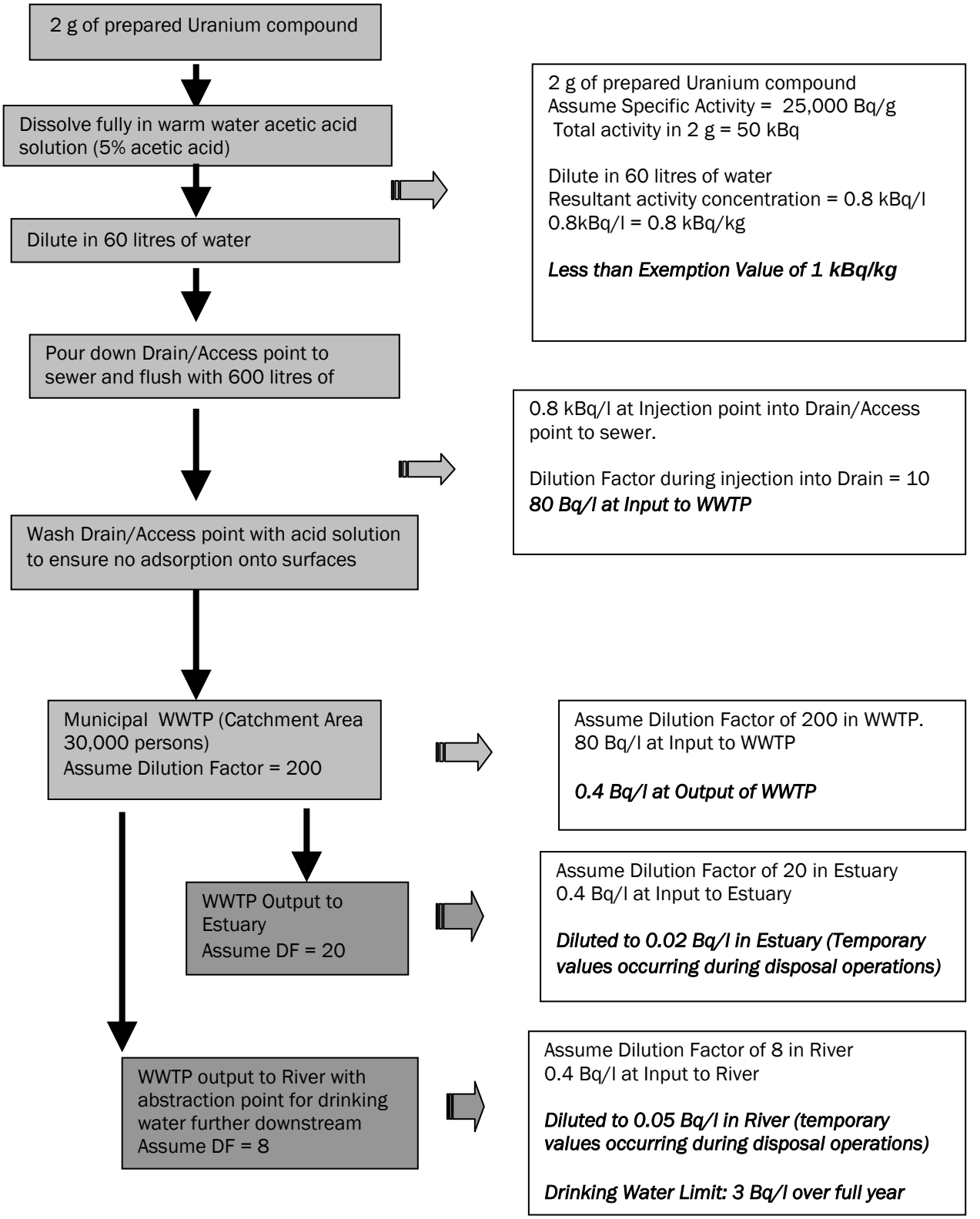
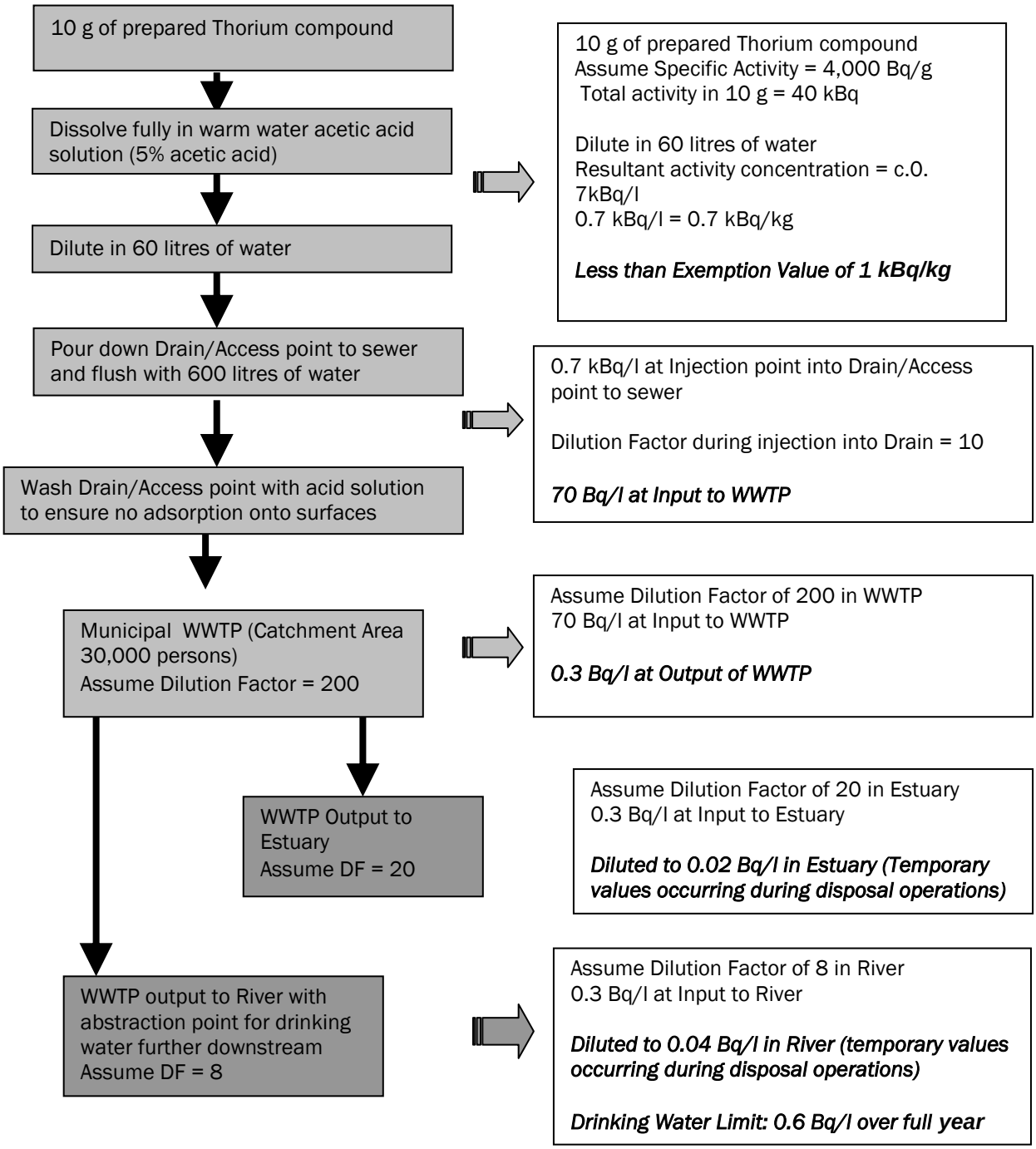


Figure 2

Flow Chart of Process – Thorium Compounds



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Contact us

Radiological Protection Institute of Ireland (RPII)
3 Clonskeagh Square
Dublin 14,
Ireland
Tel: +353 1 2697766
Fax: +353 1 2697437
Web: www.rpii.ie