Allen Barber
Engineering Consultants

Deanrock Business Park, Togher, Cork.

Telephone: **021-4319291** Fax: **021-4840832** e-mail rob@allenbarber.ie

FIREWATER RETENTION ASSESSMENT

FOR

IRVING OIL WHITEGATE REFINERY,

WHITEGATE, MIDLETON,

CO. CORK, P25 HD93

Irving Oil Whitegate Refinery

Document Status				
0	Issued to Client	RA 30/4/20	DM 1/5/20	RA 1/5/20
A	Draft	RA 27/4/20	DM 28/4/20	RA 28/4/20
Revision	**For**	**By/Date**	**Checked/Date**	**Approval/ Date**

EXECUTIVE SUMMARY

The Irving Oil Whitegate Refinery (IOWR) has been in operation since the late 1950s on a site southeast of the village of Whitegate close to the entrance to Cork Harbour. The site is now owned by Irving Oil and is known as the Irving Oil Whitegate Refinery (IOWR). The basic refining process consists of the importation of bulk crude oil, the processing of this into various hydrocarbon products, and then selling these products on either through road or marine transport.

The refinery constitutes a Scheduled Activity under the EPA Act of 1992, and operates under an Industrial Emissions Licence (IEL) issued by the Agency. The most recent revision of the IEL, reference P-0266-03, was granted in October 2018. A re-assessment of firewater retention requirements for the IOWR facility in line with the guidance contained in 'EPA Guidance on Retention Requirements for Firewater Run-off' issued in 2019 is now required.

The Refinery's main production area is on the mainland and is connected to the harbour via a long jetty from Corkbeg Island. The "island", is connected to the mainland by a natural coastal isthmus and to Cork Harbour via the refinery jetty enabling the loading/offloading of oil products to and from shipping. For the purposes of this assessment the site can be divided into three basic functional areas:

Process Area, i.e. the area on the mainland where processing of crude oil into saleable products takes place.

Intermediate & Product Tank Farm, where the intermediate stage substances and final products are stored.

Corkbeg Island Tank Farm, where the incoming crude oil is stored for later processing.

The Corkbeg jetty and the road tanker filling facility are not part of the site catchment and are excluded.

The tank farm bunds have been assessed as individual 'areas', using the Excel tool provided in the EPA guidance; the justification for separating these areas will be based on the requirements of HSG 176 'Storage of Flammable Liquids in Tanks' issued by the UK Health & Safety Executive, and referenced in the Agency's guidance document. It will be demonstrated that tank spacing is well in excess of what the code requires.

The EPA guidance document states that it is allowable to consider only one tank in the fire scenario provided that there is automatic fire suppression installed. This assumes that automatic fire suppression is the most effective means of preventing escalation of a fire event by the fire spreading to adjacent or other areas, and this may well be true for many industrial facilities. However, automatic suppression systems are not used in the oil industry, as they are not an appropriate response system for reasons outlined below and discussed further in the main body of the report.

HSG 176 is a document aimed at industries that handle or store large volumes of flammable materials, but is not specific to the oil industry. In its section on Fire Protection, it defers to the Model Safe Code of Practice Part 19, Fire Precautions at Petroleum Refineries and Bulk Storage Installations issued by the Energy Institute, where more detailed recommendations are given. While not directly referenced in the Agency's guidance, this Energy Institute document is considered to be the most appropriate basis for assessment of the IOWR facility fire risk and management.

Neither document recommends automatic fire suppression systems for this type of facility, and in fact the Energy Institute Code of Practice advises against the uncontrolled application of water or foam to a tank fire without on-site assessment by the response team due to the risk of fire escalation. The IOWR facility follows global best practice for the refining and bulk storage industry and its fire suppression design, site procedures and fire response resources, (in terms of reaction time and infrastructure), are adequate to suppress whatever type of fire may arise and to prevent its spread to adjacent areas.

The calculated firewater volume is made up of spilled product, firefighting water and foam, and rainwater accumulations. Calculation methods are set out in the guidance document and FWA Tool, and are followed in the assessment, with any information gaps and assumptions identified.

The results of the assessment can be summarised as follows:

The Process Area is calculated to generate of the order of 11,700m3 of firewater run-off in the type of incident specified in the guidance document. This will be collected by the Oily Water Drainage system and transferred to the API Separator Pond (Skimming Pond) at the IOWR WWTP, which is designed to treat 2,447m3/hour with a residence time of one hour, sufficient to remove any residual hydrocarbons not consumed by the fire. The Skimming Pond is capable of providing primary treatment to the full flow and retaining any hydrocarbons released, and no untreated firewater will be discharged to Corkbeg Bay near the mouth of Cork Harbour.

All Intermediate & Product Tank farm bunds have capacity to retain the calculated firewater volumes without overtopping.

The Corkbeg Island Tank Farm bunds also have adequate capacity, with the exception of Corkbeg East, which has a deficit of ~5,000m3. A major infrastructural project is currently in the planning system, and is expected to be completed in the near future, which will increase retention capacity on the island to 45,368m3 and eliminate this deficit.

INDEX

APPENDICES

1.0 GENERAL

1.1 Background

The Irving Oil Whitegate Refinery (IOWR) has been in operation since the late 1950s on a site southeast of the village of Whitegate close to the entrance to Cork Harbour. The basic refining process consists of the importation of bulk crude oil, the processing of this into various hydrocarbon products, and then selling these products on either through road or marine transport.

The crude oil is taken in from ships on a jetty extending into the harbour from Corkbeg Island and transferred into bulk storage tanks located on the island. This is then fed to the refinery processing area on the mainland, with the resulting products stored on bulk tank farms awaiting distribution.

The refinery constitutes a Scheduled Activity under the EPA Act of 1992, and operates under an Industrial Emissions Licence (IEL) issued by the agency, reference P-0266, the first revision of which was granted in late 1999. This has been reviewed twice since then, with the latest revision, P-0266-03 having been granted in October 2018.

The original licence would have required that the issue of firewater retention be addressed for the facility, due to its exceeding the thresholds of environmentally hazardous materials on site, as detailed in Table 2.1 of the guidance document.

This would have been done using the Agency's 'Draft Guidance Note to Industry on the Requirements for Fire-Water Retention Facilities' issued in 1995. The latest revision requires a re-assessment in line with the requirements of the newer guidance contained in 'EPA Guidance on Retention Requirements for Firewater Run-off' issued in 2019. This report addresses this requirement.

The facility is described in more detail in the following sections.

2.0 FIREWATER RETENTION QUALIFYING CRITERIA

2.1 Qualification

As the refinery is a large-scale processor of petroleum products of various types, it follows that has large quantities of hazardous materials on site. These typically have hazard ratings of H224, H225 and H226 for flammability, and H401 and H411 for environmental hazards, as per data sheet extracts in Appendix 3. The quantities of these materials in each discrete area of the site have been entered into the WRA Tool devised by the Agency, and show that the required minimum threshold limits have generally been exceeded in each area.

It is considered that the refinery does not qualify separately under the Environmental Receptor Criteria as the outfall for all site drainage is into the main part of Cork Harbour via Corkbeg Bay, away from the adjacent SPA in Whitegate Bay.

3.0 FIREWATER RISK ASSESSMENT

3.1 Site Description

The overall site layout is shown on Figure 1, and comprises an area of approximately 70Ha.

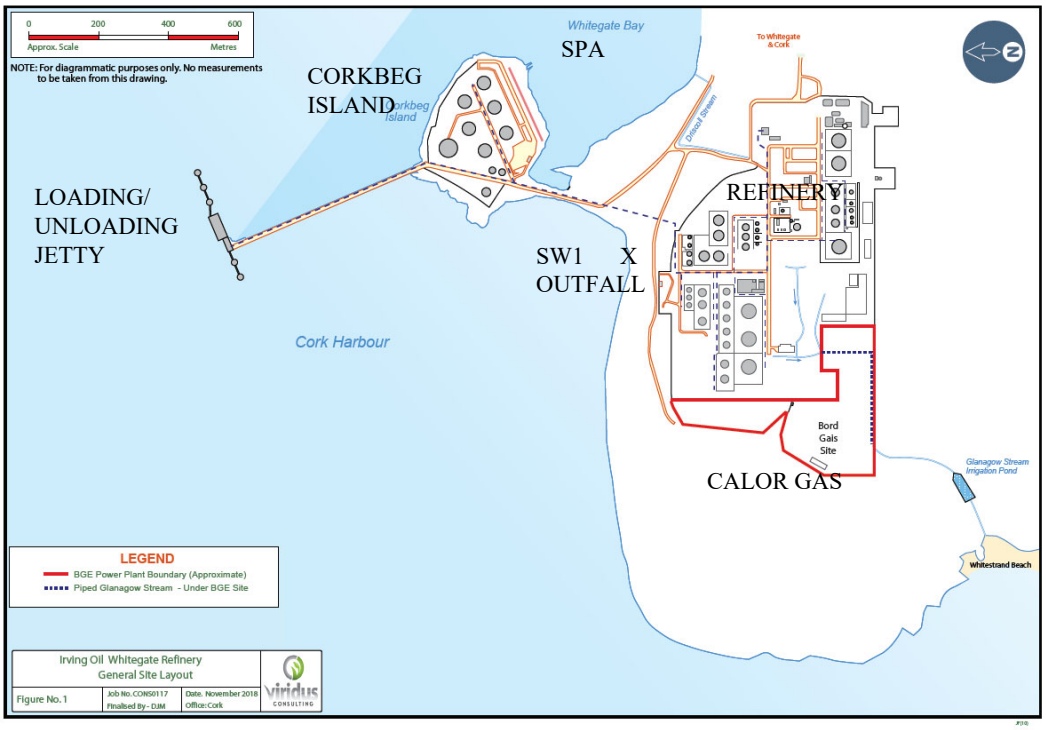


Fig. 1 Overall Site Layout

Incoming crude oil is taken in from bulk tankers on the jetty projecting from Corkbeg Island, and stored in 7no. floating roof tanks on the island. Each tank, with the exception of C6 in bund Corkbeg West, is surrounded by an earthwork berm, designed to limit the extent of a pool fire in the event of a spill. These berms are not designed to provide full containment to 110% of tank capacities as specified in the site's IE Licence, but rather to direct any spill towards the catchment basin, located to the south-east of the island, which is designed to contain 110% of the tanks' capacities. The tank farm is therefore considered as a single bund requiring containment of 25% of the total capacity, and this is provided in the catchment basin.

The crude oil is transferred as required to the processing systems on the mainland, to be broken down into the various products, i.e. Kerosene, Gasoline, Gasoil, Ultra-Low Sulphur Diesel (ULSD), and Heavy Fuel Oil (HFO), produced by IOWR. There is a tank farm attached to the process area which stores the above finished products, as well as intermediate substances, slops and water.

3.2 Containment & Drainage

The mainland tank farm consists of a number of earthwork bunds, some with individual tanks, and others with multiple tanks in a single bund. In many cases, there are intermediate berms designed to reduce the area of potential pool fires in the event of a spill, similar to those on Corkbeg Island. These do not have any material effect on the containment volume calculations of the bunds so will not enter into considerations.

The process area has only limited volume of liquids stored within it, so does not have any significant bunding. The entire area drains to the Oily Water Drainage system, through a network of gullies, channel drains and underground pipelines, which captures any rainfall that may have gathered incidental oil contamination as it passes through the process plant.

The plant buildings, roadways, yards, and other paved areas, also drain to the Oily Water Drainage system, through a mixture of underground pipework and open ditches running along the roadsides. The tank farm bunds are drained periodically to these ditches through a valved outlet which is normally closed, so that the bunds can be considered as being separate when calculating the rainwater component of the retention calculations, as they will not be drained during the fire event.

The above drainage system is illustrated on PM drawing no. 100421-43-DR-001, attached in Appendix 1. Note that the system has flame/vapour traps at strategic locations to ensure that any flammable liquid in the system does not pose a risk of fire spreading between the separate areas of the site.

This system then discharges to the WWTP's Skimming Pond, where the water is retained for a period, allowing any oil to float to the surface and be physically skimmed off for reprocessing as slops. The water is then pumped to the wastewater treatment system for further treatment by Dissolved Air Flotation (DAF), Biological reactors (MBBRs) and final filtration prior to discharge to Corkbeg Bay near the mouth of Cork Harbour via licensed emission point SW1. The treatment system has a capacity of 100m3/h, and a further 200m3/h can be pumped to a balance tank, TK U-13 on Corkbeg Island, which can hold up to 10,652m3 to be returned for later treatment and discharge, as necessary.

The stormwater drainage from the Corkbeg Island tank farm is also pumped to TK U-13 and transferred to the waste water treatment system on the mainland. The original discharge point for this system, SW-2, has been closed off to ensure no untreated discharges to Whitegate Bay located to the east of Corkbeg Island which is a designated Special Pretection Area (SPA) for wintering birds.

Flows to the WWTP on the main site in excess of 300m3/h will overflow from the Skimming Pond through a baffle and weir system designed to retain any floating oil and go directly to the SW1 discharge point. Note that all discharges are monitored by

an in-line composite sampler, and that there is no direct discharge of stormwater to the receiving waters in the harbour.

This arrangement is similar to municipal WWTPs which receive a mixture of domestic sewage and stormwater, with highly variable flows. In these treatment systems a portion of the flows representing dry conditions with limited stormwater receive full treatment, a further proportion receives primary treatment and is stored for full treatment later, and flows above these rates in more extreme storm conditions are discharged with only basic primary treatment, i.e. screening and some settlement.

Note that the discharge point for all stormwater flows from the study area, SW-1, is to the West of the causeway to Corkbeg Island, and cannot physically directly impact on the Whitegate Bay SPA on the Eastern side of the isthmus.

The above system is illustrated on the WWTP Schematic, also attached in Appendix 1.

3.3 Fire Fighting Facilities & Scenarios

The site has a number of fire fighting systems in place, designed to the appropriate global standards for the oil refining industry.

The systems are based on a site hydrant system with a reservoir capacity of 5,048m3 and a site-wide underground pipe network fed by 3no. pumps, one electric and two diesel engine powered. Hydrants, foam cannons and monitors are permanently fitted in various locations as appropriate to the fire risk in each area.

Foam additive is stored on site in mobile tenders housed in a steel building remote from the process area and tank farms. SDS sheets for the foams used are included in Appendix 3, and show that they are non-toxic and biodegradable. Once an alarm is raised, these tenders are mobilised to the location of the incident, the situation and type of fire is assessed by the response team, and the required suppression systems, which are different for different fire scenarios, are operational generally within a 15-20 minute period.

The requirements for fire water and foam for the process areas are complex, due to the different types of equipment installed and the differing nature of the substances being processed. This was the subject of a fire circle analysis carried out by Byrne Ó Cléirigh in 2004, which should be read in conjunction with this report. The analysis assessed the effects of a potential fire in each individual item of equipment, and the adjacent equipment that could be exposed to high levels of radiant heat and would require the application of cooling water; these are referred to as fire circles.

Reference Documents:

There are a number of codes of practice relevant to the issue of fire containment and suppression in the oil industry.

HSG 176: Storage of Flammable Liquids in Tanks, issued by the UK Health & Safety Executive. This is listed as a reference in the Agency's guidance document.

The current (second) edition of this document was published in 2015 and on its front page states that: *'The guidance has been updated to align with the recommendations of the Buncefield report'*, i.e. the lessons learned from a catastrophic fire in a bulk oil depot have been incorporated. The relevant sections of the guidance, and their application to the IOWR facility, are discussed below:

'50 Separation is an important means of providing protection for tanks containing flammable liquids. Separation has particular advantages because it protects people and property from the effects of a fire at the tank, and protects the tank from fires which may occur elsewhere on site.'

'66 The location and layout of a storage installation should be selected with care. The aims are to protect people and property from the effects of a fire at the tank, and to protect the tank from fires which may occur elsewhere on site.'

It is clear from the above that separation distance is seen as the primary factor in the prevention of fire spread to or from an individual tank to other tanks, process facilities or external properties.

Separation distances for 'large' tanks

'82 The minimum recommended separation distances for 'large' tanks are given in Table 4. The table is based on the Energy Institute's Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations.'

Table 4 Minimum separation distances for 'large' tanks

Factor	Minimum separation from any part of the tank
Between adjacent fixed-roof tanks	Equal to the smaller of the following: ▫ the diameter of the smaller tank ▫ half the diameter of the larger tank ▫ 15 m, but not less than 10 m
Between adjacent floating-roof tanks	▫ 10 m for tanks up to and including 45 m diameter ▫ 15 m for tanks over 45 m diameter The spacing is determined by the size of the larger tank
Between a floating-roof tank and a fixed-roof tank	Equal to the smaller of the following: ▫ the diameter of the smaller tank; ▫ half the diameter of the larger tank; ▫ not less than 10 m
Between a group of small tanks and any tank outside the group	15 m
Between a tank and the site boundary, any designated non-hazardous area, process area or any fixed source of ignition	15 m

Appendices 5 and 6 include an assessment of each tank on site that stores either H224 or H226 classified liquids, divided into individual bunds. It can be seen that the minimum recommended distances are complied with in all cases, and in many cases the distances are a multiple of those recommended.

'259 Facilities to deal with larger fires include an adequate water supply for fire and rescue service use. This may consist of hydrants, ponds, canals etc and should be readily accessible and normally no more than 100 m from the tanks. The need for foam and the means of application may be discussed with the fire authority, taking into account the number, size, type, location and contents of tanks. Fixed foam pourers or high-capacity monitors designed to cover the entire liquid surface rapidly with foam together with the associated high capacity water pumps and other equipment has been shown to be able to rapidly extinguish full surface fires and their provision should be considered. Rapid extinguishment of such fires can substantially reduce the potential for escalation and minimise property damage. The total quantity of fire water used is also significantly reduced thus reducing the risk of environmental pollution and reducing clean-up costs. Provision of such systems could be considered for larger sites.'

These facilities are already in place on the IOWR site, as described elsewhere.

'260 An adequate supply of water will also be needed to provide cooling for tanks exposed to heat from a nearby fire. Advice on the required cooling rates for tanks can be found in Annex D of Model Code of Safe Practice Part 19. The required rate will vary with the fire to which the tank may be exposed, but a rate of 10 l/m2/min may be required if the tank could be enveloped in flame. The entire tank wall should be covered with water to prevent hotspots developing. Fixed water sprays or portable monitors are an advantage, but are normally required only where the storage conditions are less than ideal, such as where it is difficult to achieve adequate separation distances.'

Sufficient water is available to cover this requirement.

Model Safe Code of Practice Part 19, Fire Precautions at Petroleum Refineries and Bulk Storage Installations issued by the Energy Institute

This is not directly referenced in the Agency's guidance document, but is frequently referenced in the UK HSE guidance discussed above, and clearly forms the base for many of the recommendations.

This document is specific to the energy industry and is considered to be the most appropriate for the assessment of fire fighting systems at IOWR. While the advice given is lengthy and technically detailed, the more relevant sections are discussed below:

Section 4.8, Installation Layout: This discusses the layout of tankage and plant, and recommends that consideration be given to credible fire scenarios at the installation as well as fire likelihood and consequences. Mitigation measures include separation between items of plant, and/or fixed water or foam systems. The level of fire protection required is related to the separation between plant items, which implies that no protection may be necessary if the minimum distances recommended are observed.

Section 6, Fire Protection: A large range of fire protection systems are discussed and specified in this section, including fixed systems, but there is no reference to automatic fire suppression systems.

Annex C.2, Storage Tanks: This lists the recommended measures for the control of fire in tanks, with fixed, semi-fixed and mobile equipment discussed, but again no reference to automatic systems. It does mention measures such as automatic or semi-automatic shut-down systems and flame/gas traps in the drainage system, both of which are incorporated in the IOWR facility.

Annex C.3, Process Areas: This recommends, among other measures, the provision of fixed monitors for cooling where staffing is low, and wheeled large capacity foam extinguishers, which are incorporated in the IOWR facility.

Annex D.5, Storage Tanks: This discusses the issues regarding the use of water to cool adjacent tanks and again looks at fixed and semi-fixed systems (note that in this instance a hydrant is regarded as fixed). It recommends that the application of water

depends on the prevailing conditions and states the *'Overall the final decision on whether or not to apply cooling water should be the responsibility of the person in charge of the fire attack, and based on the prevailing conditions'*, and discusses how incorrect application of water can cause damage and exacerbate the situation. This is incompatible with the installation of automatic fire suppression systems.

Annex D.11, Incident Experience: This discusses various issues in fighting fires in tanks and process areas, with the general thrust being that each installation and fire must be treated on its merits by experienced personnel. It states that *'Bund and process area fires have been successfully extinguished by both fixed and mobile means. With regard to foam application, standards such as NFPA 11 recognise that portable monitors, foam hose streams or both have been adequate in fighting spillage fires.'* The systems and resources in place at IOWR are in line with this approach.

CIRIA Report C736, 2014: Containment System for the Prevention of Pollution. Secondary, tertiary and other measures for Industrial and Commercial Premises.

This is general guidance for containment systems, again not specific to the oil industry although it does discuss the Buncefield incident under the heading 'Lessons learned from incidents'. In this section, the underlying causes of the incident are listed: The first seven items concentrate on the construction of the bunds, which were reinforced concrete, and how they failed in the fire scenario. The eighth item deals with tertiary containment, but in the context of bund failure. This would not apply to the IOWR facility, where all bunds are of earthworks, which are more suitable for bulk oil storage (as at the Whiddy Island facility).

A summary of retention capacity recommendations is given in Section 4.5 and Table 4.8. This states that for local containment, i.e. bunding, capacity should be '……*based on risk assessment based on credible scenario for multi-tank installation*……'

In the flowsheet given in Fig. 4.3, and included in Appendix 7, the development of a credible scenario is a result of consultations with *'recommendations relevant to your sector'* (detailed in the Energy Institute document discussed above) and *'regulators and fire and rescue service'* (in this case the HSA through the Safety Report and Cork County Fire Service).

It is considered that, following the procedures and recommendations of this document, the worst-case credible scenario is a bund pool fire resulting from a single tank failure. The document also has a section on existing installations which recognises the constraints of retro-fitting, and that risks should be managed to be as low as reasonably practicable (ALARP).

IOWR Safety Report

Under the COMAH Directive, IOWR are obliged to compile a Safety Report to be agreed with the HSA. Section 6.2.2.2 of this report deals with Fire Fighting Scenarios, and identifies '*…the worst case bund fire scenario, i.e. in which the full contents of a tank escape into the bund,…*' as a single tank failure, and speculates whether the bunds have sufficient capacity to contain the required volumes. It is demonstrated elsewhere that the mainland bunds have this capacity, and where local containment is deficient on Corkbeg Island, remote tertiary containment has been provided.

It also states that; '*With the upgrades to the fire protection system in place at Whitegate, Irving Oil have the capability to combat any tank bund scenario that could occur.'*

In summary, the above reference documents, which are applicable to the IOWR facility:

- Recommend space separation as the primary means of preventing escalation of a fire incident by spreading from one tank or process area to another.
- Detail a number of other measures than can be taken, in terms of passive and active fire prevention systems, that can be used if the appropriate separation distanced are not achieved.
- Analyse the merits of mobile, semi-fixed and fixed fire suppression systems, but do not discuss or recommend automatic fire suppression systems for refinery sites.
- Emphasise that each fire, and the prevailing conditions, should be assessed by a competent person in charge of the response team, and warn against the incorrect application of water or foam.

The fire suppression design and operational philosophy of the IOWR site is in compliance with these industry-specific recommendations and clearly are adequate to prevent fire spread at the facility. In most cases, the recommended separation distances are observed, and the appropriate mitigation measures are in place as a back-up.

3.4 Site Separation

As described above, the site can be divided into three distinct functional areas. For the purposes of this assessment, it is proposed to further divide these areas, as follows:

Process Area: Due to the complexity of this area, it is not possible to sub-divide it from a drainage point of view, but fire circles will be used to assess the critical fire event scenarios.

Intermediate & Product Tank Farm: This will be sub-divided into individual bunds and risk-assessed separately.

Corkbeg Island Tank Farm: This will also be sub-divided into individual bunds and risk-assessed separately.

The justification for this approach is based on the following:

- The relevant separation distances between the tanks and process areas to mitigate against fire spread are in compliance with, and generally exceed, the requirements of the relevant industry codes, as described in detail above.

- The mainland tank farm bunds do not routinely drain into the site Oil Water system. They are separated by isolation valves that are only opened after a rainfall event has passed.

- The Oily Water drainage system has flame/vapour traps at strategic points to ensure no spread of fire between separate areas through the drainage system.

- There is a separate drainage system on Corkbeg Island that is indirectly linked to the mainland through a controlled pumping system.

3.5 Rainfall Allowance

The EPA guidance note specifies that as well as the fire water volumes a rainfall allowance be also included, equivalent to the volume generated over the site area by a 24-hour rain storm with a 10-year return period, in this instance 65mm, as per data received from Met Éireann, and attached in Appendix 2.

In considering the process area, it will be assumed that the drained area will include the process area itself, the surfaced plant roadways, and the external slopes of the tank farm bunds. Rainfall within the bunds will be retained for disposal after the event.

A preliminary analysis of the areas described above has been carried out, and an impermeability factor estimated for each type of surface, as follows:

- Process Area, which is a mix of concrete and hardcore surface with some local bunding, and tarmac plant roads: 80%
- Admin & Facilities, which are a mix of roofs and paths with gravel or grass surrounds: 30%
- Bund external slopes and verges, which are exposed soil with some vegetation: 50%

The result of these calculations is an overall volume of 7,237m3 and an average flow rate of 300m3/h (sustained for 20 minutes). Refer to Table 4.1 below for details.

In the case of treatment being provided to the firewater run-off, it is appropriate to consider the maximum flow rate generated by a similar storm, versus treatment capacity. IOWR advise that the Skimming Pond was originally designed for a flow of 2,447m3/hour, equivalent to a rainfall intensity of 1" (25mm) per hour; this is a one in 20 year return event.

Table 4.1 Rainfall Calculations

	AREA	IMPERMEABLE	EFFECTIVE AREA	24 HOUR		1 HOUR
	m2	%	m2	m3	m3/h	m3/h
RAINFALL mm				**65**		
RAINFALL mm/h					**2.7**	**22.0**
ROADS/HARDSTANDING	84,020	80%	67,216	4,369	182	1,479
BUILDINGS/HARDCORE	54,800	30%	16,440	1,069	45	362
BUND SLOPES/VERGES	55,380	50%	27,690	1,800	75	609
				7,237	**302**	**2,450**

3.6 Risk Assessment Methodology

The details of all the areas described above have been entered into the FWA Tool provided by the Agency, and the results are included in Appendix X.

Note that the Corkbeg jetty is excluded from consideration. The road tanker loading facility does not drain through the main site so is also excluded.

It is also assumed that areas that do not store flammable materials, i.e. Gasoil, ULSD, HFO and water, do not need to be included. (Note that any material which has a flash point of more than 15C above maximum ambient (taken as 30C), is not considered flammable, as set out in the guidance document.)

3.6.1 Process Area:

The volumes of firewater generated directly for each potential fire scenario in the process area were calculated in the Byrne Ó Cléirigh report, and it has been confirmed that these are correct and have not changed materially in the interim period. These show varying amounts of firewater being generated, with the maximum flowrate of 377.52m3/h occurring at Fire Circle FC21, as shown on the spreadsheets included in Appendix 4.

The hydrant system will be used as cooling water at its full capacity for a period of six hours, as per the guidance document. This is a conservative assumption, but it is considered reasonable to expect the hydrants to be used in this way as a precaution. Recent testing established that the flowrate to the critical process area, the Isomerisation Unit, was 2150 USgpm, equivalent to 496 m3/h. This was based on a

single pump running. Previous analysis gave a maximum flowrate of 660 to 750m3/h with two pumps running; the higher figure will be used as a working assumption and added to the overall flowrate.

While none of the credible scenarios envisaged in the above report involve a significant release of product, the Safety Report (relevant extract included in Appendix 4) does include this possibility, so allowance for this eventuality will be included in the calculations. The largest vessel in the Process Area has a capacity of 104 tonnes of crude oil with a specific gravity of ~0.9, equivalent to 116m3, and it will be assumed that this will be added to the flow, although it should be noted that this vessel, and others carrying significant volumes of flammable materials, is fitted with a shut-off valve that can be activated remotely by an operator. Assuming conservatively that this is released in the first hour and that none of the contents is consumed in the fire, gives a total maximum flow of 866m3/h.

During an incident in the process area, the Oily Water Drainage system will continue to collect rainwater over the process area and also other site areas draining to this system, as described above.

Deducting the firewater flow of 866m3/hour from the Skimming Pond capacity of 2,400m3/hour, gives a residual capacity of 1,534m3/hour to cater for rainwater flows for the six hours of the fire incident. This is equivalent to an intensity of 13mm/hour, rising to 15mm/hour, and then to 21mm/hour after the six hour period. As the average intensity over the 24-hour period is less than 3mm/hour, it is unlikely that this intensity would be exceeded even in short-term peaks.

It is also appropriate to consider the composition of the firewater that could be generated. This would be predominantly water - hydrant water plus any rainwater that may fall at the time of the event, plus hydrocarbons that have not been consumed in the fire, and foam (which is non-toxic and degradable). If the full capacity of the largest vessel reaches the Skimming Pond, this would be equivalent to an oil layer ~110mm deep accumulating on its surface, which has an area of 1,071m2. As the baffle at the outlet is set 1.5m below the surface, there is little risk of hydrocarbons escaping to the outfall.

This approach is in compliance with the UK HSE guidance document EH 70: The control of fire-water run-off from CIMAH sites to prevent environmental damage, which states in Paragraph 41 that: *'Separators can provide a specified design performance for removal of named non-miscible hydrocarbons from water, allowing the subsequent discharge of the water.'* It is also referenced in Section 7 of the Agency's guidance document.

An extract from the COMAH report, which deals with a pool fire in the process area, is included in Appendix 3. This described the likely release of flammable materials, the likely burn rate and fire duration (note this is the actual fire, not the duration of applying foam and cooling water), and estimates the flow rates involved. It concludes that the Skimming Pond has adequate capacity to provide primary treatment to these flows and that there is no significant threat to the environment

3.6.2 Tank Farms

For the tank farms, four scenarios are envisaged, in ascending order of severity:

1. Rim seal fire on floating roof tanks. In this instance, there are foam spreaders installed around the perimeter of the roofs, with a connecting line running to the outside of the tank bund. A foam tender is brought to this point and connected to the hydrant system and the spreader connection, and a foam/water mix injected which forms foam on the rim seal and smothers the fire at source.
2. Full tank roof fire. This occurs if the rim seal system has not suppressed the fire, the roof has sunk into the tank and flammable liquid has escaped, covering the roof area and igniting. In this case, the foam tender is connected to foam cannons installed at the bund edge, and foam is applied at a rate of 10.5l/m2/minute over the roof area.
3. Bund pool fire without tank rupture. In this instance, a spill has occurred which covers the area of bund within the intermediate berms as described above, and ignited. This is controlled by applying foam as per the roof fire, but at the lower rate of 8l/m2/minute, as the foam can be applied more accurately at ground level.
4. Bund pool fire with tank rupture. In this scenario, a tank has ruptured spilling its entire contents, and covering the full area of the bund floor with flammable liquid, which has ignited. Foam is applied at the rate of 8l/m2/minute as above until the fire is controlled, but over a larger area. Cooling water is applied to 25% of the shell area of adjacent downwind tanks at a rate of 2l/m2/minute. Note that this is likely to be an escalation of one of the above scenarios, and would take some time to develop.

3.6.3 Product/Intermediate Tank Farm:

The four possible fire incident scenarios are set out above. The critical scenario, although the least likely, is seen as a full bund fire with tank rupture, and that will be used in the calculations. Other scenarios will not be considered.

The firewater generation calculations for each bund will include the following:

1. The full capacity of the largest tank in the bund.
2. The volume of the foam to be applied to the pool fire on the bund floor as described above, i.e. 8l/m2/min over the full area for a period of 20 to 30 minutes, depending on the tank affected.
3. The volume of cooling water to be applied to the shell of the closest adjacent tank within the same bund, i.e. 2l/m2/min over 25% of the shell area. Note that cooling water may be applied to tanks in other adjacent bunds, but it is assumed that sufficient retention capacity will be available for this.
4. A volume of water equivalent to 65mm of rainfall over the bund area (taken at the top of the berm), representing a 24-hour storm with a 10-year return period as advised by Met Éireann for the site.

The resultant volume will then be compared with the retention volume available in the bund as provided by IOWR, and any potential overspill added to the retention volume required for the site.

A summary of the calculations is included below in Table 6.1, with a breakdown of each individual bund included in Appendix 5. These show that all bunds considered have sufficient capacity to retain the firewater generated without overspilling.

Table 6.1 Intermediate and Product Tank Bunds Retention Calculations

IOWR INTERMEDIATE AND PRODUCT TANK BUND FIREWATER RETENTION CALCULATIONS							
BUND	PRODUCT m3	FOAM m3	COOLING m3	RAIN WATER m3	TOTAL FW m3	CAPACITY m3	OVERSPILL m3
BU-2B	18,056	2,526	277	741	21,600	24,810	CONTAINED
BU-4A	1,494	561	86	160	2,301	4,540	CONTAINED
BU-5D	4,577	1,056	330	309	6,272	12,401	CONTAINED
BU-5E EAST	5,231	1,080	352	316	6,978	10,258	CONTAINED
BU-5E	4,577	783	154	235	5,749	6,987	CONTAINED
BU-5E WEST	10,040	1,811	244	535	12,630	16,475	CONTAINED
BU-5E NORTH	6,832	1,301	403	413	8,949	12,468	CONTAINED
BU-5F	2,335	444	220	144	3,142	3,745	CONTAINED

The tank capacities, and bund dimensions and capacities used in the calculations are taken from the 2009 report and a bund schedule supplied by IOWR.

3.6.4 Corkbeg Island Tank Farm:

The tank farm on Corkbeg Island consists of 7no. bulk crude oil tanks with floating roofs, ballast water tank, slops tank and the balance tank for the WWTP described above. The ballast water and balance tanks do not contain flammable liquid so will not be considered in the calculations.

As mentioned, the tanks are provided with containment by a mixture of local and remote bunding. The local bunding typically has a relatively low capacity and is intended primarily to limit the size of a potential pool fire following a minor spillage. The remote bunding is provided by a Containment Pond with a current capacity of 30,900m3 at the lower (Eastern) side of the island – the island slopes generally west to east.

This arrangement is illustrated on HD Surveys drawing no. HDS-17124S attached in Appendix 6.

Because of this arrangement, the tank farm is considered as a single bund. The original requirement for containment was based on 110% of the volume of the largest

tank, C6, giving a required volume of 58,555m3, 28,000m3 of which was provided in the local bund Corkbeg West, leaving a balance of 30,555m3 to be provided in the Containment Pond; this also covered the requirement for the other tanks without significant local bunding, which had requirements varying from 26,546m3 to 28,926m3. This has now been changed to 25% of total capacity in line with IE license requirements, giving a required volume of 45,368m3. A project is currently being undertaken to increase the volume of the Containment Pond to cover this requirement.

The scenarios to be considered, in the event of a bund pool fire involving tank rupture, include the following:

Corkbeg South: A pool fire resulting from the rupture of the slops tank will be considered, together with cooling water applied to the adjacent ballast water tank.

Corkbeg West (Tank no. C6): Full tank rupture would involve a pool fire over the area at the top of the bund, with an overspill to the drainage system and from there to the Containment Pond system. It is assumed that the overspill will not be on fire, or will not ignite in the Containment Pond on arrival. Cooling water will be applied to the adjacent tank, C4 as described above.

Corkbeg Mid (C5) and Corkbeg North (C4 & C7): As above for Corkbeg West, with cooling water applied to adjacent tanks in Corkbeg East bund. Cooling may also be required for C6, but it is assumed that there will be sufficient local bunding to contain this.

Corkbeg East (C1, C2, & C3): These tanks have no local bunding and drain directly to the Containment Pond via an open ditch. In this scenario, it cannot be assumed that the spilled oil collected in the Containment Pond is not on fire, so the calculation will include for foam to be applied to the area of the affected tank and the pond, and cooling water applied to the other two tanks in the bund.

In each scenario, a rainfall allowance must be added to the retention requirement. It will be assumed that the Corkbeg West, Mid and North bunds will have enough capacity in their low-level bunds to cater for the 65mm projected rainfall, unless they are involved in the fire. The rainfall from Corkbeg East and the Containment Pond itself must be added in all cases.

The results of the analysis described above are summarised in Table 6.2 below, with detailed calculations included in Appendix 6.

Table 6.2 Corkbeg Tank Farm Retention Calculations

IOWR CORKBEG CRUDE OIL TANK BUND FIREWATER RETENTION CALCULATIONS							
BUND	PRODUCT m3	FOAM m3	COOLING WATER m3	RAIN WATER m3	TOTAL FW m3	CAPACITY m3	OVERSPILL m3
SOUTH	1,288	746	198	234	2,466	6,500	CONTAINED
EAST	26,296	7,345	815	1,331	35,787	0	35,787
NORTH	26,240	1,767	408	589	29,004	4,532	24,473
MID	25,454	1,400	0	379	27,233	2,916	24,317
WEST	53,232	2,411	0	653	56,295	28,123	28,172

The Containment Pond as it stands has capacity for all tank groups apart from Corkbeg East, which has a deficit of ~5,000m3. Note that the calculations will need to be reviewed depending on the new bunding regime proposed for the island.

The tank capacities, and bund capacities used in the calculations are taken from a bund schedule supplied by IOWR. Bund dimensions have been taken from a survey conducted by HD Surveys.

4.0 CONCLUSIONS & RECOMMENDATIONS:

Based on the above analysis and calculations, the following conclusions are offered:

1. Based on the volume of hazardous and/or flammable materials present, the IOWR site qualifies for a firewater retention assessment under the criteria set out in the Agency's guidance document and associated FWA Tool.
2. The IOWR site design and fire suppression equipment and procedures are in line with best practice in the oil industry, as set out in the relevant industry-specific guidance documents.
3. Based on separation distances between plant equipment and tankage, and the fire fighting resources available, the worst-case credible scenario involves a fire in a single tank or process unit, and this is used in firewater generation calculations.
4. There is no direct stormwater discharge from the site to Cork Harbour; all rainwater collected on site is collected in a single system and directed to the Skimming Pond at the WWTP.
5. The Skimming Pond has adequate capacity to provide primary treatment for the firewater run-off associated with a major fire in the Process Area, which is estimated to be less than its design flow rate of 2,400m3/h.
6. Based on conservative assumptions, all bunds in the Product and Intermediate tank farm have adequate capacity to retain firewater without overtopping.
7. Retention capacity on the Corkbeg Island tank farm is currently inadequate, but there is a project under way to increase this. This area will need to be re-examined once the design of the upgrade is finalised.

Recommendations for upgraded or additional works to deal with the current shortfalls would include the following:

1. On the basis of the information available, no significant works are required for the Product and Intermediate tank farm.
2. The requirements for increased bunding capacity and firewater retention on Corkbeg Island should be co-ordinated to ensure both are covered by the upgrades proposed in that area.
3. The reliability of the power supply to the WWTP should be examined to see if it can continue to operate during and after a fire event. Note that the Skimming Pond does not have mechanical moving parts and is not reliant on a power supply.

The above is based on information supplied by the client, and as such is reliant on the accuracy and completeness of said information.

Robert Allen
B.E., M.Sc., C.Eng., M.I.E.I.

APPENDIX 1

SITE DRAINAGE SYSTEM

Oily Water Drainage

WWTP Schematic

Skim Pond Layout

AVENUE 'C' N5000

AVENUE 'B' N4550

AVENUE 'A' N1252880mm

PROCESS AREA WEST LIMIT E12050

3rd STREET E12000

4th STREET

ACCESSWAY 104

ACCESSWAY 105

ACCESSWAY 106

ACCESSWAY 107

CHP PLANT

BOILER PLANT

REACTOR AREA

CONTROL ROOM

SUBSTATION

PROCESS AREA

CHLORINE STORAGE HOUSE

NITROGEN TANKS

VALVE STATION

ANALYSIS HOUSE

MECHANICAL SERVICE BUILDING

EX-MEDICAL CENTRE

EM-LAB / CANTEEN

EX-LAB

EX-ADMIN / CANTEEN

N3080 FLARE STACK

MATCHLINE A

O Fire/Vapour Trap Chambers

LL REPRESENTS INVERT ELEVATION AT BOTTOM OF DRAINAGE DITCH MANHOLES AND UNDERGROUND PIPES AS SHOWN ON PLAN.

C.B. DENOTES CATCH BASIN AS SHOWN ON PLAN.

MH-O-XX DENOTES OILY WATER MANHOLE AS SHOWN THUS ON PLAN.

LL XX'-X"
MH-O-XX
LL XX'-X"

MH-S-XX DENOTES SANITARY SEWER MANHOLE AS SHOWN THUS ON PLAN.

MH-S-XX
LL XX'-X"

BOTTOM OF DITCH TO SLOPE UNIFORMLY BETWEEN INVERT LEVELS GIVEN.

SLOPE OF DITCH SIDES TO BE 1:1 EXCEPT AS FOLLOWS
SLOPE OF DITCH SIDE TO BE 1(V)in 1(H)WHERE ROAD LEVELS ARE RAISED LOCALLY & AT ROAD JUNCTIONS AND AS SHOWN ON PLAN & SECTIONS.

1. CONCRETE PIPE FOR DIRTY WATER SEWERS CONSIST OF:-
9"Ø NON-REINFORCED CONCRETE PIPE ASTM, SPEC C-14 STANDARD.
12", 15" & 18"Ø REINFORCED CONCRETE PIPE ASTM, SPEC C-76 STANDARD.

2. CONCRETE PIPE FOR ROAD CULVERTS CONSIST OF:-
9"Ø 9"Ø NON-REINFORCED CONCRETE PIPE ASTM, SPEC C-14 STANDARD.
12"&15" REINFORCED CONCRETE PIPE ASTM, SPEC C-76EXTRA STRENGTH.

NOTE:- 9" & UNDER CONS. PIPE WHERE USED FOR ROAD CULVERTS TO BE ENCASED IN CONCRETE 9" THICK AROUND PIPE.

LEGEND

SANITARY SEWERS SHOWN THUS ———— ON PLAN.
OILY WATER SEWERS SHOWN THUS ———— ON PLAN.
CONCR. PIPE CULVERTS SHOWN THUS — — — ON PLAN.
SURFACE DRAINAGE SHOWN THUS — — — ON PLAN.
BATTERY LIMITS SHOWN THUS - - - - - - OR PLAN.

REFERENCE DRAWINGS

DRAWING No.	TITLE
LE-4163-427	PLAN OILY WATER, SANITARY & SURFACE DRAINAGE-SHEET 2.
6940-6310-45	900m OILY WATER SEWER.
4163-425	SECTIONS & DETAILS OF OILY WATER, SANITARY & SURFACE DRAINAGE.
4163-153	DETAILS OF MANHOLES.
4163-158	DETAILS OF TANKAGE SUMPS, VALVE BOXES & CATCH BASINS.
4163-159	DETAILS OF TANKAGE SUMPS, VALVE BOXES & CATCH BASINS.
33 S (By JR Boyd Barrett)	FOR DETAILS AT ADMIN, CANTEEN, MEDICAL & LABORATORY.

viridus CONSULTING

IRVING

Irving Oil Whitegate Refinery

Soil and Groundwater Baseline Report 2017

Figure 5a
Oily Water Drain

Job No:	CONS101
Date:	Nov. 2017

Legend:-

Oily Water Drain

ISSUE	DESCRIPTION	DRN	ORIG	AUTH CHK	APP	DATE
11	TRANSFERRED TO ELECTRONIC FORMAT	RH	MC	DW	TN	13.04.22

CLIENT: Irish Refining Co. Ltd

Project Management Group
Cork - Dublin

PROJECT: REFINERY DRAINAGE

TITLE: Block 4 Area Plot Plan Including Oily Water, Sanitary Water & Surface Water Drainage

CLIENT REF.	LE-4163-426	CLIENT DRG No.	LE-4163-426
PROJECT No.	103421	PM DRG No.	100421-43-DR-001
A0 SCALE	1:360		

ELEVATIONS SHOWN RELATE TO IRISH O.D.
L.... REPRESENTS INVERT ELEVATION AT BOTTOM OF DRAINAGE DITCH, MANHOLES AND UNDERGROUND PIPES.

FOR GENERAL NOTES & LIST OF MATERIALS SEE DRG. No. LE 4163-426

LEGEND

SANITARY SEWERS SHOWN THUS ——— ON PLAN.
OILY WATER SEWERS SHOWN THUS ——— ON PLAN.
CONCR. PIPE CULVERTS SHOWN THUS ——— ON PLAN.
SURFACE DRAINAGE SHOWN THUS ——— ON PLAN.

O Fire/vapour trap chambers

viridus CONSULTING

IRVING

Irving Oil Whitegate Refinery

Soil and Groundwater Baseline Report 2017

Figure 5b
Oily Water Drain

Job No:	CONS101
Date:	Nov. 2017

Legend:-

Oily Water Drain

REFERENCE DRAWINGS

100421-43-DR-001	Block 4 Area Plot Plan Including Oily Water, Sanitary Water & Surface Water Drainage
LE-4182-10	Refinery Plan, Sheet 1.
LE-4163-426	Plan-Oily Water, Sanitary & Surface Drainage (Sheet 1 of 2)
LE-4163-428	Sections & Details-Oily Water, Sanitary & Surface Drainage
E4183-156	Details of Manholes
E4183-158	Details of Tankage Sumps, Valve Boxes & Catch Basin
E4183-159	Details of Tankage Sumps, Valve Boxes & Catch Basin
D4163-160	Plan & Details Of U/Ground Drainage at Crementum Interoff Tank & Outfall
E4163-151	General Arrangement of Skimming Pond.
E4182-14	Typical Section of 18" Spillwall.

ISSUE	DESCRIPTION	DRN	CHKD	AUTH CHK	APP	DATE
0	TRANSFERRED TO ELECTRONIC FORMAT	RH	IRC	DJW	TN	6/06/07

CLIENT: Irish Refining Co. Ltd

Project Management Group
Cork - Dublin

PROJECT: REFINERY DRAINAGE

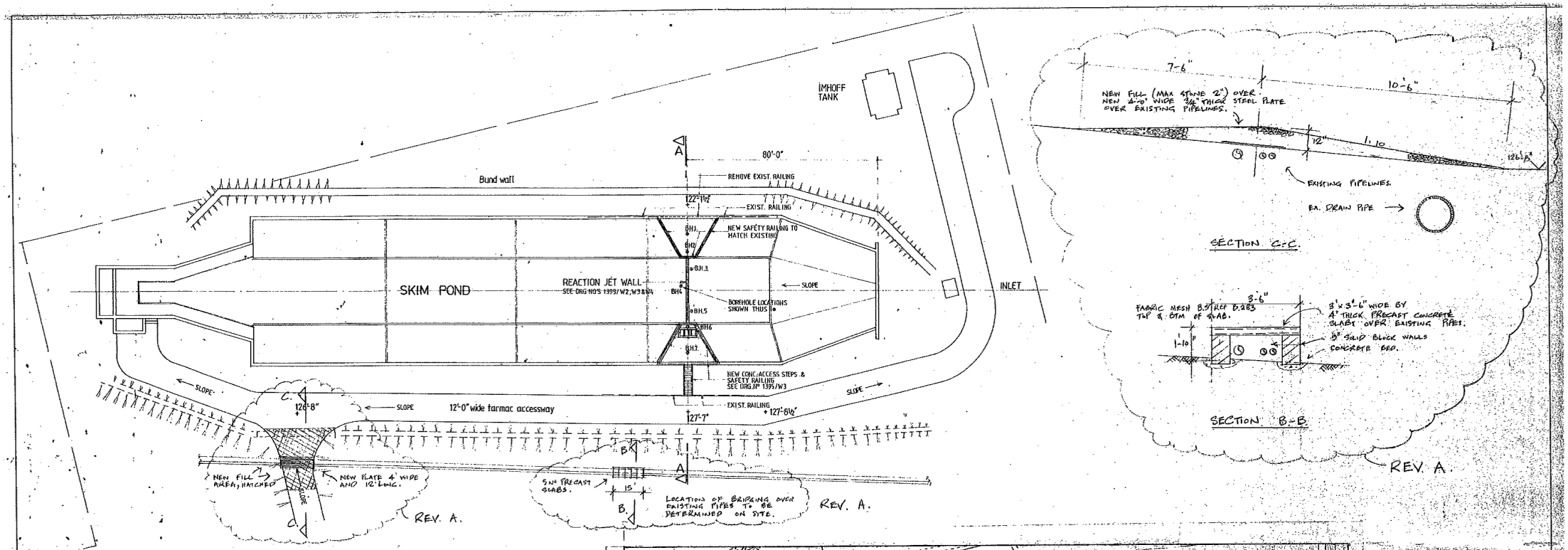
TITLE: PLOT PLAN
OILY WATER, SANITARY
& SURFACE DRAINAGE

CLIENT REF.	LE-4163-427	CLIENT DRG No.	LE-4163-427
PROJECT No.	100421		
A0 SCALE	1:600	PM DRG No.	100421-43-DR-002

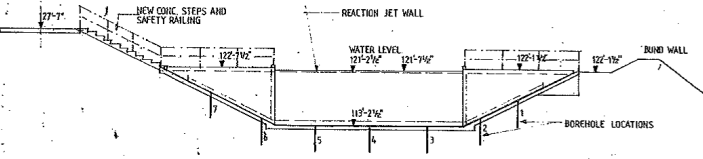
DRAWING WAS CREATED USING AUTOCAD R14

WWTP Schematic

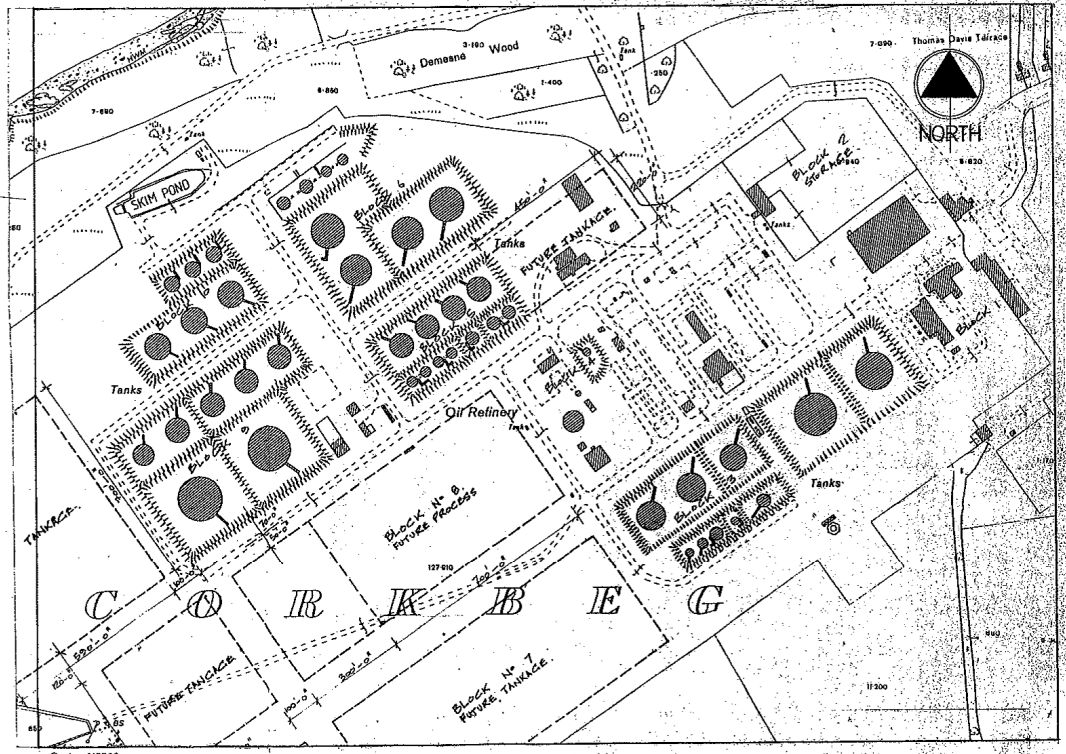
Water
LT-018
Polymer
P-8A
P-8B
XV-011
FT-003
WW-MX-9
TK-9
P-9A
P-9B
WW-FI-004
XV-010
FT-008
LT-015
NaOH
P-7A
P-7B
XV-007A
XV-007B
FT-007
LT-016
LT-017
Aluminium Sulphate
P-6A
P-6B
XV-006A
XV-006B
FT-006
HIC-053/ST-053
Air
XV-008
P-13A
P-13B
DAF
XV-005
XV-001
XV-003
XV-004
FIC-016
LT-014A
TK-14A
TK-14B
LT-014B
Water
XV-015
P-14A
P-14B
FT-014
DC-1
LT-070
TK-15
LT-060A
Spillback
P-21A
P-21B
AT-007
TK-17
LT-060B
P-12A
P-12B
P-12C
TI-001
XV-012A
XV-012B
XV-012C
FT-012
XV-009
LT-057
P-18A/B
Nitrogen
LT-058
P-19A/B
Phosphoric Acid
LT-059
P-20A/B
Carbon
Basins
XV-065A
XV-065B
TK-19
XV-063A
XV-063B
A Reactor
B Reactor
Air
BL-01 A/B
GI-P-16
LT-012
POND
FI-025
FQI-025
TK-13
LC-01
XV-067
SF-01A
SF-01B
SF-01C
TK-21
XV-070
SITE Discharge
TK-20
LT-067
P-22 A/B
Belt press
SKIP



LAYOUT PLAN
1/2" = 10'-0"



SECTION A-A
1"=10'-0"



ConocoPhillips Whitegate Refinery
Thu, 13 Oct 2005 15:10:58
No: 1395/W1
By: MCONNM
20228

Rev.	Date	Description
A	6.6.95	[illegible]

Project:
IRISH REFINING PLC.
WHITEGATE, CO. CORK.

Title:
SKIM POND MODIFICATIONS.
SITE LOCATION / SITE LAYOUT.

Malachy Walsh and Partners
Consulting Engineers
Boreenmanna Rd. Cork. tel. 962868 telex 28487

Scale	[illegible]	Dig. No.	A
Drawn	CJC	1395/W1	
Date	14-5-1995		
Checked	LJ		

This pond is not to be filled with water until backfilling of walls has been completed

Mesh reinforcement to be placed centrally in slab.

All concrete to be of 1:2:4 nominal mix with the exception that "PROLAPIN" waterproofer is to be added to the mix at the rate of one gallon per 15 gallons of water.

The min. compressive strength at 28 days on a 6" cube shall be 3750 lbs/ins

Any soft spots found on completion of excavation are to be removed & made up with weak mix concrete.

All levels refer to IRISH O.D.

BILL OF MATERIALS

Quan.	Unit.	Description	Regn No.
2260	sq yds	W.N.F B.S.S 1221A Ref no 126	R.4163-16
230	cu yds	CONCRETE FOR LINING etc	"
130	Lbs	Rd^d Reinforcing bars	"
27	"	½"ø " "	"
932	Lin. Ft.	⅝" Expandite Hydrafoil for joints	R.4163-3
ALL	—	Filler for joints.	"

REFERENCE DRAWINGS

Title	No.
R.C. details of Flumes	E4163-152
Steel work details	E4163-154
Sump cover & Pump support details	E4163-156

4163	2	0	IRC	ESC	FIELD			LINING TO SKIMMING POND ADDED.			
4163	3	0	IRC	ESC	FIELD		3	ISSUED TO ISOLATE INTERCEPTOR DITCH & ANCHORED CULVERTS ONLY.			
4163	2	0	FIELD				2	ACCESS RAMP, SUMP & WEIR PIT ADDED			
4163	1	0	IRC	ESC	FIELD		1	INTERCEPTOR DITCH MOVED. CULVERT ADDED.			
4163	1	0	IRC	ESC	FIELD		1	APPROVED FOR CONSTRUCTION			

Conoco Phillips Whitegate Refinery
Thu, 18 Dec 2003 10:59:52
No: E4163-151
By: MCONU
1708

IRISH REFINING CO. LTD.
WHITEGATE REFINERY

THE LINIMUS COMPANY LIMITED
LONDON

1-11-57			
4163	AD	A-2082	

GENERAL ARRANGEMENT OF SKIMMING POND

APPENDIX 2

MET EIREANN DATA

Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 183301, Northing: 63080,

	Interval		Years											
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	150,	200,	250,	500,
5 mins	2.9,	4.1,	4.7,	5.6,	6.2,	6.7,	8.2,	10.0,	11.1,	12.7,	14.2,	15.3,	17.0,	18.3,	19.4,	N/A ,
10 mins	4.1,	5.7,	6.5,	7.8,	8.7,	9.3,	11.5,	13.9,	15.5,	17.8,	19.7,	21.3,	23.6,	25.5,	27.0,	N/A ,
15 mins	4.8,	6.7,	7.7,	9.2,	10.2,	11.0,	13.5,	16.4,	18.3,	20.9,	23.2,	25.0,	27.8,	29.9,	31.7,	N/A ,
30 mins	6.3,	8.7,	10.0,	11.8,	13.1,	14.0,	17.1,	20.6,	22.9,	26.0,	28.8,	30.9,	34.2,	36.8,	38.8,	N/A ,
1 hours	8.4,	11.4,	12.9,	15.2,	16.8,	17.9,	21.7,	25.9,	28.6,	32.4,	35.7,	38.3,	42.1,	45.1,	47.6,	N/A ,
2 hours	11.1,	14.8,	16.8,	19.6,	21.5,	22.9,	27.5,	32.6,	35.8,	40.4,	44.3,	47.3,	51.9,	55.4,	58.3,	N/A ,
3 hours	13.0,	17.3,	19.5,	22.7,	24.8,	26.5,	31.6,	37.3,	40.9,	45.9,	50.2,	53.6,	58.6,	62.4,	65.6,	N/A ,
4 hours	14.6,	19.3,	21.7,	25.2,	27.5,	29.3,	34.9,	41.0,	44.9,	50.3,	54.9,	58.5,	63.9,	68.0,	71.3,	N/A ,
6 hours	17.2,	22.6,	25.3,	29.3,	31.8,	33.8,	40.1,	46.9,	51.2,	57.1,	62.3,	66.2,	72.1,	76.6,	80.3,	N/A ,
9 hours	20.3,	26.4,	29.5,	33.9,	36.8,	39.0,	46.0,	53.6,	58.4,	65.0,	70.7,	75.0,	81.5,	86.4,	90.4,	N/A ,
12 hours	22.8,	29.4,	32.8,	37.7,	40.8,	43.2,	50.8,	58.9,	64.1,	71.2,	77.3,	81.9,	88.8,	94.1,	98.3,	N/A ,
18 hours	26.8,	34.4,	38.2,	43.7,	47.2,	49.9,	58.4,	67.4,	73.1,	80.9,	87.6,	92.7,	100.3,	106.0,	110.7,	N/A ,
24 hours	30.1,	38.4,	42.6,	48.5,	52.3,	55.3,	64.4,	74.1,	80.3,	88.6,	95.8,	101.2,	109.3,	115.4,	120.4,	137.3,
2 days	39.4,	48.8,	53.4,	60.0,	64.2,	67.3,	77.0,	87.2,	93.6,	102.2,	109.4,	114.8,	122.9,	129.0,	133.9,	150.3,
3 days	47.1,	57.4,	62.4,	69.4,	73.9,	77.2,	87.4,	98.1,	104.6,	113.4,	120.8,	126.4,	134.6,	140.7,	145.6,	162.0,
4 days	54.0,	65.0,	70.3,	77.7,	82.4,	85.9,	96.6,	107.6,	114.4,	123.4,	130.9,	136.6,	144.9,	151.0,	156.0,	172.5,
6 days	66.3,	78.5,	84.4,	92.4,	97.5,	101.3,	112.6,	124.3,	131.4,	140.8,	148.6,	154.4,	163.0,	169.3,	174.3,	191.0,
8 days	77.5,	90.7,	97.0,	105.5,	110.9,	114.9,	126.9,	139.0,	146.4,	156.1,	164.2,	170.1,	178.9,	185.3,	190.5,	207.4,
10 days	87.9,	102.0,	108.6,	117.6,	123.3,	127.4,	139.9,	152.5,	160.1,	170.1,	178.4,	184.5,	193.4,	199.9,	205.1,	222.3,
12 days	97.8,	112.6,	119.6,	129.0,	134.8,	139.2,	152.1,	165.0,	172.9,	183.1,	191.5,	197.7,	206.8,	213.4,	218.8,	236.1,
16 days	116.6,	132.6,	140.1,	150.2,	156.4,	161.0,	174.6,	188.2,	196.4,	207.0,	215.7,	222.1,	231.4,	238.3,	243.7,	261.3,
20 days	134.3,	151.4,	159.3,	169.9,	176.5,	181.3,	195.5,	209.6,	218.0,	229.0,	237.9,	244.5,	254.0,	260.9,	266.4,	284.3,
25 days	155.4,	173.6,	182.0,	193.2,	200.0,	205.1,	219.9,	234.5,	243.2,	254.5,	263.7,	270.4,	280.1,	287.1,	292.7,	310.8,

NOTES:
N/A Data not available
These values are derived from a Depth Duration Frequency (DDF) Model
For details refer to:
'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

APPENDIX 3

DATA SHEETS

Hydrocarbon H Numbers

Foam SDSs

H Classifications

Crude oil MSDS

CLP Classification (EC No 1272/2008)

H224 -- Flammable liquids -- Category 1
H304 -- Aspiration Hazard -- Category 1
H319 -- Eye damage/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H350 -- Carcinogenicity -- Category 1B
H373 -- Specific target organ toxicity (repeated exposure) -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Amber to Black
Physical Form:	Liquid
Odour:	Petroleum; Rotten egg / sulphurous
Odour Threshold:	N/D
pH	N/A
Melting/Freezing Point:	N/D

Initial Boiling Point/Range:	-89 to 538 °C
Flash Point:	< -7 °C
Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	6.0
Lower Explosive Limits (vol % in air):	1.1
Vapour Pressure:	4-70 kPa @37.8°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.7 - 1.1 @ 20°C
Solubility (ies):	Solubility in water: Negligible
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	310 °C
Decomposition Temperature:	N/D
Viscosity:	< 20.5 cSt cSt @ 40°C
Explosive Properties:	N/D
Oxidising Properties:	N/D

Heavy Fuel Oil (Atmospheric Tower Residue)

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H332 -- Acute toxicity, Inhalation -- Category 4
H350 -- Carcinogenicity -- Category 1B
H361d -- Reproductive toxicity -- Category 2
H373 -- Specific target organ toxicity (repeated exposure) -- Category 2
H400 -- Hazardous to the aquatic environment, acute toxicity -- Category 1
H410 -- Hazardous to the aquatic environment, chronic toxicity -- Category 1

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	dark brown. Very viscous liquid at ambient temperature.
Physical Form:	Liquid
Odour:	Hydrocarbon
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	350 - 550 °C
Flash Point:	> 110 °C
Evaporation Rate (nBuAc=1):	Relatively nonvolatile
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	6.0
Lower Explosive Limits (vol % in air):	1.0
Vapour Pressure:	<0.1 kPa @40°C
Relative Vapour Density (air=1):	N/D
Relative Density (water=1):	0.92-0.96 @ 15°C
Solubility (ies):	N/D
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	>350 °C
Decomposition Temperature:	N/D
Viscosity:	N/D
Explosive Properties:	N/D
Oxidising Properties:	N/D

Diesel / Gasoil

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H226 - Flammable liquids -- Category 3
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H332 -- Acute toxicity, Inhalation -- Category 4
H351 -- Carcinogenicity -- Category 2
H373 -- Specific target organ toxicity (repeated exposure) -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Clear red or yellow brown
Physical Form:	Liquid

Odour:	Pungent Petroleum
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	180 - 390 °C
Flash Point:	> 60 °C; (Closed Cup)
Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	Combustible
Upper Explosive Limits (vol % in air):	5.0
Lower Explosive Limits (vol % in air):	0.5
Vapour Pressure:	<0.1 kPa @20°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.82-0.88 @ 15°C
Solubility (ies):	Insoluble in water
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	250 °C
Decomposition Temperature:	N/D
Viscosity:	4.8 mm²/s @ 20°C; 1.5-5.5 mm²/s @ 40°C
Explosive Properties:	N/D
Oxidising Properties:	N/D

Heavy Naphtha

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H225 -- Flammable liquids -- Category 2
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H340 -- Germ cell mutagenicity -- Category 1B
H350 -- Carcinogenicity -- Category 1B
H361d -- Reproductive toxicity -- Category 2
H361f -- Reproductive toxicity -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Colourless to light yellow
Physical Form:	Liquid
Odour:	Gasoline
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	65 - 230 °C
Flash Point:	< 23 °C
Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	9.0
Lower Explosive Limits (vol % in air):	1.0
Vapour Pressure:	<10 kPa @40°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.72-0.77 @ 15°C
Solubility (ies):	N/D
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	232 °C
Decomposition Temperature:	N/D
Viscosity:	N/D
Explosive Properties:	N/D
Oxidising Properties:	N/D

Isomerate (Isomerisation Naphtha)

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H224 -- Flammable liquids -- Category 1
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H361f -- Reproductive toxicity -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Colourless
Physical Form:	Liquid
Odour:	Gasoline
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	20 - 80 °C
Flash Point:	< 23 °C
Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	9.0
Lower Explosive Limits (vol % in air):	1.0
Vapour Pressure:	50-100 kPa @40°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.65-0.68 @ 15°C
Solubility (ies):	N/D
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	232 °C
Decomposition Temperature:	N/D
Viscosity:	N/D
Explosive Properties:	N/D
Oxidising Properties:	N/D

Kerosene

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H226 - Flammable liquids -- Category 3
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Colourless
Physical Form:	Liquid
Odour:	Mild paraffinic
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	150 - 290 °C
Flash Point:	> 38 °C
Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	6.0
Lower Explosive Limits (vol % in air):	0.5
Vapour Pressure:	3 kPa @20°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.77-0.82 @ 15°C
Solubility (ies):	Solubility in water: Negligible
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	250 °C
Decomposition Temperature:	N/D
Viscosity:	1.0-2.0 mm^2/s @ 20°C
Explosive Properties:	N/D
Oxidising Properties:	N/D

Reformate (Light catalytic reformed naphtha)

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H224 -- Flammable liquids -- Category 1
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H340 -- Germ cell mutagenicity -- Category 1B
H350 -- Carcinogenicity -- Category 1B
H361d -- Reproductive toxicity -- Category 2
H361f -- Reproductive toxicity -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Clear straw to green
Physical Form:	Liquid
Odour:	Petroleum
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	35 - 190 °C
Flash Point:	< 23 °C
Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	8.0
Lower Explosive Limits (vol % in air):	1.0
Vapour Pressure:	50-100 kPa @40°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.75-0.82 @ 15°C
Solubility (ies):	N/D
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	280 °C
Decomposition Temperature:	N/D
Viscosity:	N/D
Explosive Properties:	N/D
Oxidising Properties:	N/D

LVN (Light Straight Run Naphtha)

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H224 -- Flammable liquids -- Category 1
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H340 -- Germ cell mutagenicity -- Category 1B
H350 -- Carcinogenicity -- Category 1B
H361d -- Reproductive toxicity -- Category 2
H361f -- Reproductive toxicity -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Colourless to light yellow
Physical Form:	Liquid
Odour:	Gasoline
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	20 - 80 °C
Flash Point:	< 23 °C

Evaporation Rate (nBuAc=1):	N/D
Flammability (solid, gas):	N/A
Upper Explosive Limits (vol % in air):	9.0
Lower Explosive Limits (vol % in air):	1.0
Vapour Pressure:	50-100 kPa @40°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.65-0.68 @ 15°C
Solubility (ies):	N/D
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	232 °C
Decomposition Temperature:	N/D
Viscosity:	N/D
Explosive Properties:	N/D
Oxidising Properties:	N/D

Gasoline

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

CLP Classification (EC No 1272/2008)

H224 -- Flammable liquids -- Category 1
H304 -- Aspiration Hazard -- Category 1
H315 -- Skin corrosion/irritation -- Category 2
H336 -- Specific target organ toxicity (single exposure) -- Category 3
H340 -- Germ cell mutagenicity -- Category 1B
H350 -- Carcinogenicity -- Category 1B
H361f -- Reproductive toxicity -- Category 2
H361d -- Reproductive toxicity -- Category 2
H411 -- Hazardous to the aquatic environment, chronic toxicity -- Category 2

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Data represent typical values and are not intended to be specifications. N/A = Not Applicable; N/D = Not Determined

Appearance:	Clear, pale yellow (may be dyed various colours)
Physical Form:	Liquid
Odour:	Pungent Petroleum
Odour Threshold:	N/D
pH:	N/A
Melting/Freezing Point:	N/D
Initial Boiling Point/Range:	25 - 215 °C
Flash Point:	-40 °C; (Closed Cup)
Evaporation Rate (nBuAc=1):	10-11@ 20°C
Flammability (solid, gas):	Not applicable
Upper Explosive Limits (vol % in air):	7.6
Lower Explosive Limits (vol % in air):	1.3
Vapour Pressure:	45-100 kPa @20°C
Relative Vapour Density (air=1):	>1
Relative Density (water=1):	0.725-0.775 @ 15°C
Solubility (ies):	Solubility in water: Negligible
Partition Coefficient (n-octanol/water) (Kow):	N/D
Auto-ignition Temperature:	445 °C
Decomposition Temperature:	N/D
Viscosity:	0.5-1.5 mm^2/s @ 20°C
Explosive Properties:	N/D
Oxidising Properties:	N/D

ANGUS FIRE

MATERIAL SAFETY DATA SHEET

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY

1.1 Product Identification

FP70

1.2 Application and Use

Fire fighting foam concentrate

1.3 Manufacturer/Supplier

Angus Fire Armour Ltd, Thame Park Road, Thame, Oxfordshire, OX9 3RT

Telephone: (01844) 265000 Fax: (01844) 265156

Emergency Telephone Number (24 hours)

For information and supply: Angus Fire (015242) 61166

1.4 Product Description

Hydrolysed protein solution containing fluorosurfactants and glycol solvent.

2. COMPOSITION

Substance	Synonyms	Concentration %	Health class	Cas-No.
Hexylene glycol	1,2-Hexanediol 2-Methylpentan-2,4-diol	1 – 5	X_i , R36/38	107-41-5
Sodium chloride		5 – 10		7647-14-5
Other metal salts		1 – 5		
Zinc oxide		< 1		1314-13-2
Bactericide		< 1	X_n ,R22,43	
Hydrolysed protein		~ 30		
Fluorosurfactants		< 5	X_i ,R36,37,38	
Water		Balance		

3. HAZARDS IDENTIFICATION

Human health hazards: Not classified as hazardous under CHIP. May cause sensitisation by skin contact.

4. FIRST AID MEASURES

4.1 General

First aiders should know and take the precautions appropriate to avoid danger to themselves and the casualty.

Take casualty together with material safety data sheet of this product to hospital or doctor, if necessary.

First Aid - Skin: Remove contaminated clothing. If there is skin contact, wash immediately with plenty of clean, gently flowing water. If persistent irritation occurs, obtain medical attention.

First Aid - Eye: If there is eye contact, wash immediately with plenty of clean, gently flowing water for 10 minutes.

ANGUS FIRE

First Aid - Ingestion: If ingestion is suspected, do not induce vomiting. Send casualty to hospital immediately.

First Aid - Inhalation: Remove casualty from exposure. If there is breathing difficulty or cough, keep patient at rest seated in position of maximum comfort.

5. FIRE FIGHTING MEASURES

General Hazards
Fire fighting measures are not applicable as FP70 is a fire extinguishing medium. If product containers are involved in fire, then a suitable extinguishing agent should be applied.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Avoid contact with skin, eyes and clothing. Do not breathe mists, aerosols.
Personal protection:	Wear protective clothing specified for normal operations.
Environmental precautions:	SPILLAGE: The practice of washing spills into drains should be avoided if at all possible and should under no circumstances be allowed without first consulting the local Water Authority and the Environment Agency.
Clean-up methods - small spillage:	Absorb or contain liquid with sand, earth or spill control material. Shovel up and place in a labelled, sealable container for subsequent safe disposal.

7. HANDLING AND STORAGE

No special handling techniques required. For best results, the product should be stored in sealed, original containers above -13^{o}C and below 40^{o}C. Freezing and thawing do not affect the substance properties but care must be taken to avoid freezing the container and its contents since the expansion of the container contents may cause cracking of a completely rigid container as ice forms.

Personal Protective Equipment - Fire Fighting

Angus Fire Foam Concentrates will be used by professional fire-fighters to control and extinguish flammable liquid fires. The nature of this process may involve exposure to heat, flame and possibly toxic vapours and fumes. It is normal procedure to wear appropriately designed personal protective equipment designed for use in firefighting situations. Angus Fire advises that this form of personal protective equipment should be used if the packaging materials become involved in fire.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

Engineering control measures: Use only in well ventilated areas

Occupational Exposure Limit:
Pure hexylene glycol: Occupational Exposure Standard (OES)
Long term exposure limit (8 hour time weighted average): 25ppm
Short term exposure limit (10 minutes): 25ppm

Personal Protective Equipment - Other Handling
Avoid prolonged, extensive or repeated inhalation or contact to eyes and skin.

Hand Protection Wear impervious gloves of an approved type (e.g. neoprene).

Eye Protection Wear safety goggles of an approved type (BS 2092).

ANGUS FIRE

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid	pH at 20^{0}C:	7 – 8
Colour:	Dark brown	Boiling point:	100^{0}C at 760 mm Hg
Odour:	Organic	Freeze point:	-13^{0}C
		Flash point:	>100^{0}C
		Flammability:	Not flammable
		Solubility:	Miscible with water in all proportions
		Viscosity at 20^{0}C:	10cs
		Specific gravity:	1.15 - 1.17

10. STABILITY/REACTIVITY

Stability
Generally stable. As with all aqueous solutions FP70 should be excluded from contact with any materials which have violent reactions with water.

Hazardous Decomposition Products
Do not expose containers to heat or flame, since the containers are made from high density polyethylene and will burn.
Thermal decomposition of containers and/or products may generate acrid smoke and fumes and traces of Na_2O,Cl^-,SO_X,NO_X, and HF.

11. TOXICOLOGICAL INFORMATION

Inhalation
Inhalation of hazardous amounts is unlikely when used as intended. May cause irritation to respiratory tract when inhaled.

Ingestion
Low oral risk when used as intended. May cause nausea, vomiting and diarrhoea when ingested.

Contact to eyes or skin
Low risk if appropriate precaution measures are taken (see section 6). May cause skin and eye irritation when in contact with eyes or skin. May cause sensitisation by skin contact.

Aquatoxicity

Rainbow Trout (Ocorhynchus mykiss)	
LC_{50} (24hrs)	3860 ppm
LC_{50} (48hrs)	3400 ppm
LC_{50} (72hrs)	3220 ppm
LC_{50} (96hrs)	2540 ppm

Water Flea (Dapnia magna)	
EC_{50} (24hrs)	8906 ppm
EC_{50} (48hrs)	4977 ppm

12. ECOLOGICAL INFORMATION

Persistence/degradability:	Biodegradable.
Bioaccumulation:	Bioaccumulation is unlikely to occur due to metabolism and excretion.

Biodegradation

ANGUS FIRE

Biodegradable:	COD	0.46 gg^{-1}	
	BOD (5 day)	0.44gg^{-1}	(96%)
Sewage treatment:	Data not available.		

13. DISPOSAL CONSIDERATIONS

Disposal
Waste should be disposed via local authority waste collection service or registered waste carrier. Ensure the destination is a licensed facility.

Local legislation:	Control of Pollution Act 1974 Hazardous Waste Regulations 2005 Environmental Protection Act 1990

14. TRANSPORT INFORMATION

Label for conveyance: **No Transport Warning Sign Required**

Road:

UN No: N/C

Rail:

Rail Transport Class No: N/C

Sea:

Sea Transport Class No: N/C EmS No: N/C
MFAG Table No: N/C

Air:

Air Transport Class No: N/C

15.REGULATORY INFORMATION

Risk phrases:	R43	May cause sensitisation by skin contact.
Safety phrases:	S24,28	Avoid contact with the skin. After contact with skin, wash immediately with plenty of water.

UK Regulatory References:

Health and Safety at work Act 1974.

Chemicals (Hazard Information & Packaging for Supply) Regulations 1994 / Amendment Regulations 1996.

EC Directives: Substances Directive 67/548/EEC as amended by 69/81/EEC, 70/189/EEC, 73/146/EEC, 75/409/EEC, 79/831/EEC General Preparations Directive 88/379/EEC.
Statutory Instruments: Chemicals (Hazard Information and Packaging for Supply) Regulations.
Approved Code of Practice:

Classification and Labelling of Substances and Preparations Dangerous for Supply.

Guidance Notes: Occupational Exposure Limits EH40/96.

ANGUS FIRE

16. OTHER INFORMATION

Uses and restrictions:

Sources of Information

Clayton, G.D. and F.E. Clayton: Patty's Industrial Hygiene and Toxicology. Fourth edition volumes I - III (1991).
Sax, N.I. and R.J. Lewis, Sr: Dangerous Properties of Industrial Materials. Seventh edition volumes I - III (1991).
Health & Safety Executive: Occupational Exposure Limits (EH 40/96).
Note: EH40 is revised on an annual basis and newest issue should be applied.

Huntingdon Research Centre:	May 1990
Huntingdon Research Centre:	August 1982
Acer Environmental:	RT-ESV-023-01/R3

Other information:

ANGUS FIRE

MATERIAL SAFETY DATA SHEET

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY

1.1 Product Identification NIAGARA 3-3

1.2 Application and Use

Fire Fighting Foam Concentrate

1.3 Manufacturer/Supplier

Angus Fire Armour Ltd, Thame Park Road, Thame, Oxfordshire, OX9 3RT

Telephone: (01844) 265000 Fax: (01844) 265156

Emergency Telephone Number (24 hours)

For information and supply: Angus Fire (015242) 61166

1.4 Product Description

Hydrolysed protein solution containing fluorocarbon surfactants and glycol solvents.

2. COMPOSITION

Substance	Synonyms	Concentration %	Health class	Cas-No.
Hexylene glycol	1,2-Hexanediol 2-Methylpentan-2,4-diol	< 10	X_i , R36/38	107-41-5
Sodium chloride		5 - 10		7647-14-5
Hydrolysed protein		20 - 40		
Fluorosurfactants		< 5	X_i , R36,37,38	
Bactericide		< 2	X_n , R22,43	
Water		Balance		

3. HAZARDS IDENTIFICATION

Human health hazards: Not classified as hazardous under CHIP. May cause sensitisation by skin contact.

4. FIRST AID MEASURES

4.1 General

First aiders should know and take the precautions appropriate to avoid danger to themselves and the casualty.

Take casualty together with material safety data sheet of this product to hospital or doctor, if necessary.

First Aid - Skin: Remove contaminated clothing. If there is skin contact, wash immediately with plenty of clean, gently flowing water. If persistent irritation occurs, obtain medical attention.

First Aid - Eye: If there is eye contact, wash immediately with plenty of clean, gently flowing water for 10 minutes.

First Aid - Ingestion: If ingestion is suspected, do not induce vomiting. Send casualty to hospital immediately.

First Aid - Inhalation: Remove casualty from exposure. If there is breathing difficulty or cough, keep patient at rest and seated in position of maximum comfort.

ANGUS FIRE

5. FIRE FIGHTING MEASURES

General Hazards
Fire fighting measures are not applicable as Niagara 3-3 is a fire extinguishing medium. If product containers are involved in fire, then a suitable extinguishing agent should be applied.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Avoid contact with skin, eyes and clothing. Do not breathe mists, aerosols.
Personal protection:	Wear protective clothing specified for normal operations.
Environmental precautions:	SPILLAGE: The practice of washing spills into drains should be avoided if at all possible and should under no circumstances be allowed without first consulting the local Water Authority and the Environment Agency.
Clean-up methods - small spillage:	Absorb or contain liquid with sand, earth or spill control material. Shovel up and place in a labelled, sealable container for subsequent safe disposal.

7. HANDLING AND STORAGE

No special handling techniques required. For best results, the product should be stored in sealed, original containers above -18^{O}C and below 40^{O}C. Freezing and thawing do not affect the substance properties but care must be taken to avoid freezing the container and its contents since the expansion of the container contents may cause cracking of a completely rigid container as ice forms.

Personal Protective Equipment - Fire Fighting

Angus Fire Foam Concentrates will be used by professional fire-fighters to control and extinguish flammable liquid fires. The nature of this process may involve exposure to heat, flame and possibly toxic vapours and fumes. It is normal procedure to wear appropriately designed personal protective equipment designed for use in firefighting situations. Angus Fire advises that this form of personal protective equipment should be used if the packaging materials become involved in fire.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

Engineering control measures: Use only in well ventilated areas

Occupational Exposure Limit:
Pure hexylene glycol: Occupational Exposure Standard (OES**)**
Long term exposure limit (8 hour time weighted average): 25ppm
Short term exposure limit (10 minutes): 25ppm

Personal Protective Equipment - Other Handling
Avoid prolonged, extensive or repeated inhalation or contact to eyes and skin.

Hand Protection Wear impervious gloves of an approved type (e.g. neoprene).

Eye Protection Wear safety goggles of an approved type (BS 2092).

ANGUS FIRE

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid	pH at 20^0C:	6.6 – 7.6
Colour:	Dark brown	Boiling Point:	100^0C at 760 mm Hg
Odour:	Organic	Freeze Point:	-18.5^0C
		Flammability:	Not flammable
		Solubility:	Miscible with water in all proportions
		Viscosity at 20^0C:	18cs
		Specific Gravity:	1.16

10. STABILITY/REACTIVITY

Stability
Generally stable. As with all aqueous solutions Niagara 3-3 should be excluded from contact with any materials which have violent reactions with water.

Hazardous Decomposition Products
Do not expose containers to heat or flame, since the containers are made from high density polyethylene and will burn.
Thermal decomposition of containers and/or products may generate acrid smoke and fumes and traces of Na_2O,Cl^-,SO_X,NO_X, and HF.

11. TOXICOLOGICAL INFORMATION

Inhalation
Inhalation of hazardous amounts is unlikely when used as intended. May cause irritation to respiratory tract when inhaled.

Ingestion
Low oral risk when used as intended. May cause nausea, vomiting and diarrhoea when ingested.

Contact to eyes or skin
Low risk if appropriate precaution measures are taken (see section 6). May cause skin and eye irritation when in contact with eyes or skin. May cause sensitisation by skin contact.

Aquatoxicity.

Rainbow Trout (Ocorhynchus mykiss)
LC 50 (0.25 hrs) > 10
LC_{50} (24hrs) 6230 ppm
LC_{50} (48hrs) 4410 ppm
LC_{50} (72hrs) 2830 ppm
LC_{50} (96hrs) 2830 ppm

Water Flea (Daphnia magna)
EC_{50} (48hrs) 34860ppm

12. ECOLOGICAL INFORMATION.

Persistence/degradability:	Biodegradable.		
Bioaccumulation:	Bioaccumulation is unlikely to occur due to metabolism and excretion.		

Biodegradation

Biodegradable:	COD	0.45 gg^{-1}	
	BOD (7 day)	0.13 gg^{-1}	(30 %)

	BOD (28 day)	0.43 gg^{-1}	(95.2 %)

Sewage treatment: Data not available.

13. DISPOSAL CONSIDERATIONS

Disposal
Waste should be disposed via local authority waste collection service or registered waste carrier. Ensure the destination is a licensed facility.

Local legislation: Control of Pollution Act 1974
Hazardous Waste Regulations 2005
Environmental Protection Act 1990

14. TRANSPORT INFORMATION

Label for conveyance: **No Transport Warning Sign Required**
Road:

UN No: N/C

Rail:

Rail Transport Class No: N/C

Sea:

Sea Transport Class No: N/C EmS No: N/C
MFAG Table No: N/C

Air:

Air Transport Class No: N/C

15.REGULATORY INFORMATION

Risk phrases:	R43	May cause sensitisation by skin contact.
Safety phrases:	S24,28	Avoid contact with the skin. After contact with skin, wash immediately with plenty of water.

UK Regulatory References:

Health and Safety at work Act 1974.

Chemicals (Hazard Information & Packaging for Supply) Regulations 1994 / Amendment Regulations 1996.

EC Directives: Substances Directive 67/548/EEC as amended by 69/81/EEC, 70/189/EEC, 73/146/EEC, 75/409/EEC, 79/831/EEC General Preparations Directive 88/379/EEC.
Statutory Instruments: Chemicals (Hazard Information and Packaging for Supply) Regulations.
Approved Code of Practice:Classification and Labelling of Substances and Preparations Dangerous for Supply.

Guidance Notes: Occupational Exposure Limits EH40/96

ANGUS FIRE

16. OTHER INFORMATION

Uses and restrictions:

Sources of Information

Clayton, G.D. and F.E. Clayton: Patty's Industrial Hygiene and Toxicology. Fourth edition volumes I - III (1991).
Sax, N.I. and R.J. Lewis, Sr: Dangerous Properties of Industrial Materials. Seventh edition volumes I - III (1991).
Health & Safety Executive: Occupational Exposure Limits (EH 40/96).
Note: EH40 is revised on an annual basis and newest issue should be applied.

Huntingdon Life Sciences: AFA 024/990185
Centre de Recherche Industrielle du Quebec 640 – PC 27403
Bundesamt fur Wehrtechnik und Bechaffung: (no reference no. available).
Societe Eau et Feu: Personnel communication

Other information:

APPENDIX 4

PROCESS AREA

Inventory

Fire Circle Analysis FWA

Tool

Extract from Safety Report

Ref: 306-X0056 Rev 6
March 2017

4.2.1 Process Units

The cooling water demand for the process units was calculated as the sum of the engulfed cooling water demands for the individual fire circles within that unit[7]. The quantity of cooling water that may be required for cooling plant and equipment in adjacent fire circles subject to radiant heat was not included in this calculation. These cooling water requirements are available in the Fire Circle Data Tables for the adjacent fire circles.

Table 6: Calculated Process Unit Firewater Demands

I.D.	Process Unit	Fire Water Demand (l/min)	Fire Circles
200	Powerformer	25,653	1 – 18
300 & 400	Naphtha Fractioning & Pipestill	34,042	19 – 35
500	Hydrofiner (old)	5,228	36 – 41
600	Sulphur Recovery	4,619	42
800	Isomerisation	30,772	43 – 61
900	Hydrofiner (new)	13,719	62 – 69

The largest cooling water demand for the process units is 34,042 l/min for the Pipestill Unit. The largest cooling water demand for a single fire circle within the process units is for Fire Circle No. 21 with a demand of 13,144 l/min. This fire circle contains twenty-four items of plant and equipment: four towers, seventeen heat exchangers and two drums / vessels.

It should be noted that the figures listed in Table 6 refer to the entire process unit and, in practice, this quantity of water is unlikely to be required unless a fire were to develop and engulf the entire unit.

The largest firewater demand for cooling a fire circle subject to radiant heat is 877 l/min for Fire Circle 42 containing the sulphur recovery unit. However, it should be noted that, for radiant heat cooling, the number of fire circles potentially at risk is dependent upon the location of the fire source and that several such circles may require the application of cooling water simultaneously.

[7] This approach is based upon ConocoPhillips Refinery Engineering Practice REP 3-5-2 *Firewater Systems*.

PROCESS EQUIPMENT WITH SIGNIFICANT INVENTORIES

The following process equipment have significant inventories of hazardous substances.

Vessel No.	Inventory, Tonnes	Temperature, (deg. F)	Pressure, (psig)	Materials present
T-201	15.0	290	270	Heavy Naphtha
T-202	16.0	395	305	Reformate
T-204	0.7	234	300	LPG
T-208	30.0	475	240	Heavy Naphtha, LPG
D-202	9.3	95	245	Heavy Naphtha
D-204	9.0	80	305	Reformate
D-205	5.0	150	278	LPG
D-209	2.9	100	290	LPG
D-220	3.6	100	230	LPG
T-301	25.0	260	55	Naphtha, LPG
T-302	1.5	230	100	Light Naphtha
D-301	2.8	90	50	Light Naphtha, LPG
D-302	1.9	100	95	LPG
D-303	1.2	100	350	LPG, Caustic
T-401	27.4	695	15	Heavy Fuel Oil, Gasoil, Naphtha
T-402	0.3	270	18	Naphtha
T-403	8.0	515	20	Gasoil
T-404	4.0	385	18	Kerosene
T-405	8.0	520	20	Gasoil
D-401	68.0	60	5	Crude Oil
D-402	10.0	100	15	Naphtha, LPG
D-406	104.0	275	270	Crude Oil
T-501	0.7	650	245	Gasoil or Kerosene
T-503	0.3	635	75	Gasoil or Kerosene
D-502	2.0	200	100	Gasoil or Kerosene
D-503	2.0	150	255	Gasoil or Kerosene
T-701	8.5	120	85	Light Naphtha
D-701	21.0	120	70	Light Naphtha
T-801	6.0	305	140	Light Naphtha
T-841	12.0	345	205	Isomerate
T-843	36.0	240	20	Isomerate
D-801	9.0	150	60	Light Naphtha
D-803	6.1	100	325	Light Naphtha
D-804	1.8	115	135	Light Naphtha
D-841	20.0	100	100	Light Naphtha
DR-842A/B	6.0 / 6.0	100	105	Light Naphtha
D-844	13.6	85	200	Isomerate
D-846	0.7	135	15	Isomerate
D-810	26.5	365	5	Heat Transfer Fluid

TOTAL 351.4T

HDS Unit Fire Circles

Fire Circle	Description	Unit Cooling (l/min)	Unit Cooling (m3/hr)	Adjacent equipment radiant cooling (l/min)	Adjacent equipment radiant cooling (m3/hr)	Engulfed Unit Firewater (l/min)	Engulfed Unit Firewater (m3/hr)	Foam Demand (l/min)	Foam Demand (m3/hr)	Water for Foam Demand (m3/hr)	Assumptions	0-1 hr *	1 - 2 hrs **	Time to fill pond if continue at *	Time to fill pond if continue at **	Adjacent Fire Circles
FC62	E904, E905, E913, E914, E915, E916	182	10.92	382	22.92	910	54.6	8405	504.3	489.171	Pool fire on E904, with adjacent equipment cooling	22.38	50.22	N/A	N/A	63,64,65,66, 67,69
FC63	C901A/B, C902A/B, C903A/B	135	8.1	405	24.3	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	20.25	32.4	N/A	N/A	62,64,69
FC64	907A/B	8	0.48	8	0.48	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	0.72	0.96	N/A	N/A	62,63,69
FC65	D913	38	2.28	0	0	0	0	0	0	0	Pool fire not credible, cooling of unit, no adjacent equipment cooling	2.28	2.28	N/A	N/A	62,64
FC66	D901, D903, D905, D912, E911A, E911B, E912, P901A/B, P902A/B, P903A/B, P905A/B, P908A/B, P909A/B, T901, T902	348	20.88	326	19.56	1741	104.46	5770	346.2	335.814	Pool fire on D901, with adjacent equipment cooling	30.66	71.79	N/A	N/A	62,67,69
FC67	D902, E901A/B, E902A/B/C, E903	0	0	0	0	2081	124.86	5113	306.78	297.577	No initial unit cooling, full firewater demand with no adjacent equipment cooling	124.9	124.86	N/A	N/A	62,65,66,68
FC68	F901	0	0	0	0	0	0	2011	120.66	117.04	Foam Demand Only	0	0	N/A	N/A	65,67
FC69	D906	0	0	0	0	92.000	5.520	489.000	29.34	28.4598	No initial unit cooling, full firewater demand with no adjacent equipment cooling	5.520	5.520	N/A	N/A	62,63
FC70	C310,V110, V130, V310	53	3.18	101	6.06	265	15.9	411	24.66	23.9202	Pool fire on V110/V310, with adjacent equipment cooling	6.21	14.01	N/A	N/A	71,72
FC71	Loading Gantry	975	58.5	0	0	4875	292.5	2377	142.62	138.341	Pool fire on loading gantry, with no adjacent equipment cooling	58.5	146.25	N/A	N/A	70,72
FC72	Additive Tanks 1 to 9	137	8.22	1096	65.76	687	41.22	2029	121.74	118.088	Pool fire on unit, with adjacent equipment cooling	41.1	86.37	N/A	N/A	70,71
									max	489.171						

* Cool unit for one hr, begin	** Continue cooling adjacen

Old Hydrofiner & Sulphur Recovery Unit Fire Circles

Fire Circle	Description	Unit Cooling (l/min)	Unit Cooling (m3/hr)	Adjacent equipment radiant cooling (l/min)	Adjacent equipment radiant cooling (m3/hr)	Engulfed Unit Firewater (l/min)	Engulfed Unit Firewater (m3/hr)	Foam Demand (l/min)	Foam Demand (m3/hr)	Water for Foam Demand (m3/hr)	Assumptions	0-1 hr *	1 - 2 hrs **	Time to fill pond if continue at *	Time to fill pond if continue at **	Adjacent Fire Circles
FC36	D504, F501	49	2.94	0	0	245	14.7	1422	85.32	82.7604	Pool fire on D504, with no adjacent equipment cooling	2.94	7.35	N/A	N/A	37
FC37	E504A, E504B	0	0	0	0	235	14.1	498	29.88	28.9836	No initial cooling of unit, Full firewater demand, no adjacent equipment cooling	14.1	14.1	N/A	N/A	1,36
FC38	P501X, P502A, P502B, P504A, P504B	11	0.66	44	2.64	105	6.3	332	19.92	19.3224	Pool fire with adjacent equipment cooling	1.98	5.79	N/A	N/A	20,35,41
FC39	E503, T501, T502	0	0	741	44.46	48	2.88	3475	208.5	202.245	Pool fire on T501, No initial cooling of unit, Full firewater demand, with adjacent equipment cooling	47.34	47.34	N/A	N/A	40,41
FC40	D501, D505	0	0	122	7.32	1139	68.34	2406	144.36	140.029	Pool fire on D505, No initial cooling of unit, Full firewater demand, with adjacent equipment cooling	75.66	75.66	N/A	N/A	39
FC41	D502, D503, E501, E502, E505X	54	3.24	166	9.96	271	16.26	1792	107.52	104.294	Pool fire on E501/E502 with adjacent equipment cooling	8.22	18.09	N/A	N/A	38,39,40
FC42	D601, P613A, P613B, P613C, T601, T602	517	31.02	361	21.66	2587	155.22	2202	132.12	128.156	Pool fire on D601 with adjacent equipment cooling	41.85	99.27	N/A	N/A	25,27
								max	202.245							

* Cool unit for one hr,	** Continue cooling adjacen

Isomerisation Unit Fire Circles

Fire Circle	Description	Unit Cooling (l/min)	Unit Cooling (m3/hr)	Adjacent equipment radiant cooling (l/min)	Adjacent equipment radiant cooling (m3/hr)	Engulfed Unit Firewater (l/min)	Engulfed Unit Firewater (m3/hr)	Foam Demand (l/min)	Foam Demand (m3/hr)	Water for Foam Demand (m3/hr)	Assumptions	0-1 hr *	1 - 2 hrs **	Time to fill pond if continue at *	Time to fill pond if continue at **	Adjacent Fire Circles
FC43	F801, F802	0	0	0	0	0	0	2815	168.9	163.833	Foam demand Only	0	0	N/A	N/A	49
FC44	P808	4	0.24	0	0	0	0	0	0	0	Pool fire not credible, unit cooling only with no adjacent equipment cooling	0.24	0.24	N/A	N/A	50,52
FC45	D807, P803, P804A	16	0.96	10	0.6	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	1.26	1.56	N/A	N/A	48,57
FC46	D842, P842A, P842B, P843A, P843B	36	2.16	18	1.08	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	2.7	3.24	N/A	N/A	54,59
FC47	C801A, C801B, C802	81	4.86	162	9.72	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	9.72	14.58	N/A	N/A	51,56,60
FC48	D801, D803, D804, P801A, P801B, P802A, P802B	0	0	157	9.42	553	33.18	1697	101.82	98.7654	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	42.6	42.6	N/A	N/A	45,53,57,58, 61
FC49	D802, D806, E801A/B/C/D/E/F	57	3.42	0	0	283	16.98	1755	105.3	102.141	Pool fire on D806 with no adjacent equipment cooling	3.42	8.49	N/A	N/A	43
FC50	D805, D810, P805A, P806A, P806A, P806B, P846A	0	0	35	2.1	668.000	40.080	1413.000	84.78	82.2366	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	42.180	42.180	N/A	N/A	44,52,57
FC51	D808, D809, D811, D812	25	1.5	57	3.42	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	3.21	4.92	N/A	N/A	47,56,58,60, 61
FC52	D813, D807A/B	75	4.5	14	0.84	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	4.92	5.34	N/A	N/A	44,50
FC53	D841, D846, E845, E846, E847, P809A, P841A, P841B	0	0	38	2.28	690	41.4	3468	208.08	201.8376	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	43.68	43.68	N/A	N/A	48,54,61
FC54	D843A/B, DR841A/B, DR842A/B, E842, E843	160	9.6	17	1.02	802	48.12	2657	159.42	154.6374	Pool Fire on D843A, with adjacent equipment cooling	10.11	25.08	N/A	N/A	46,53,59,61
FC55	D844	82	4.92	0	0	411	24.66	783	46.98	45.5706	Pool fire on D844 with no adjacent equipment cooling	4.92	12.33	N/A	N/A	60
FC56	D845	145	8.7	0	0	724	43.44	858	51.48	49.9356	Pool fire on D845 with no adjacent equipment cooling	8.7	21.72	N/A	N/A	47,51,60
FC57	E802A, E802B, E802C, E803, T801	0	0	0	0	1211	72.66	1106	66.36	64.3692	No initial cooling of unit, Full firewater demand, no adjacent equipment cooling	72.66	72.66	N/A	N/A	45,48,50,58
FC58	E804, E804, E806, E807, E808, E809, E810, E818	154	9.24	479	28.74	769	46.14	1909	114.54	111.1038	Pool fire on E804 with adjacent equipment cooling	23.61	51.81	N/A	N/A	48,51,57
FC59	E841, E844, E849A./B, E845, E855	154	9.24	381	22.86	769	46.14	5321	319.26	309.6822	Pool fire on E849 A/B with adjacent equipment cooling	20.67	45.93	N/A	N/A	46,54,60,61
FC60	E848, E850, E851, E852, P844A, P844B, P845A/B, P847A/B, P848A/B, P849A/B, P850A, T841, T842, T843	0	0	116	6.96	5564.000	333.84	6632	397.92	385.9824	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	340.8	340.8	4.76	4.76	55,56
FC61	E858A, E853B, E843C, E843D	221	13.26	663	39.78	1104.000	66.24	3440	206.4	200.208	Pool fire with adjacent equipment cooling	33.15	72.9	N/A	N/A	48,51,53,60
									max	385.982						

* Cool unit for one hr, begin	** Continue cooling adjacen

FC60	0.1	0	0	116	6.96	556.400	33.384	6632	397.92			40.34	40.344	N/A	N/A	55,56
FC60	0.2	0	0	116	6.96	1112.800	66.768	6632	397.92			73.73	73.728	N/A	N/A	55,56
FC60	0.3	0	0	116	6.96	1669.200	100.152	6632	397.92			107.1	107.112	N/A	N/A	55,56
FC60	0.4	0	0	116	6.96	2225.600	133.536	6632	397.92			140.5	140.496	N/A	N/A	55,56
FC60	0.5	0	0	116	6.96	2782.000	166.92	6632	397.92			173.9	173.88	N/A	N/A	55,56
FC60	0.6	0	0	116	6.96	3338.400	200.304	6632	397.92			207.3	207.264	N/A	N/A	55,56
FC60	0.7	0	0	116	6.96	3894.800	233.688	6632	397.92			240.6	240.648	N/A	N/A	55,56
FC60	0.8	0	0	116	6.96	4451.200	267.072	6632	397.92			274	274.032	N/A	N/A	55,56
FC60	0.9	0	0	116	6.96	5007.600	300.456	6632	397.92			307.4	307.416	26.21	26.21	55,56
FC60	1	0	0	116	6.96	5564.000	333.84	6632	397.92			340.8	340.8	4.76	4.76	55,56

% of Tower engulfed	Time to overfill pond for fire on T401N	Time to overfill pond for fire on T844	% of T843 engulfed
10	N/A	N/A	10
20	N/A	N/A	20
30	N/A	N/A	30
40	N/A	N/A	40
50	N/A	N/A	50
60	N/A	N/A	60
70	N/A	N/A	70
80	23.86	N/A	80
90	4.54	26.21	90
100	2.51	4.76	100

Pipestill Fire Circles

Fire Circle	Description	Unit Cooling (l/min)	Unit Cooling (m3/hr)	Adjacent equipment radiant cooling (l/min)	Adjacent equipment radiant cooling (m3/hr)	Engulfed Unit Firewater (l/min)	Engulfed Unit Firewater (m3/hr)	Foam Demand (l/min)	Foam Demand (m3/hr)	Water for Foam Demand (m3/hr)	Assumptions	0-1 hr *	1 - 2 hrs **	Time to fill pond if continue at *	Time to fill pond if continue at **	Adjacent Fire Circles
FC19	P301AN, P301BN, P302AN, P303A, P303B, P304X, P305AX, P305BN, P306AN, P306BN, P401A, P401B, P416A, P416B	12	0.72	146	8.76	116	6.96	1514	90.84	88.1148	Pool fire on unit, with adjacent equipment coooling	5.1	12.24	N/A	N/A	17,20,21
FC20	D401, DR301, DR401X, DR402X, DR405, DR409, FIL301, FIL402, FIL403, FIL404, FIL408, P402AN, P402BN, P403AX, P403BX, P404N, P405AX P405BX, P405C, P406A, P406B, P406C, P406N, P407A, P407B, P409AN, P409BN	364	21.84	503	30.18	1821	109.26	2843	170.58	165.4626	Pool fire on D401, with adjacent equipment cooling	36.93	84.81	N/A	N/A	16,17,18,19, 21,22,35,38
FC21	D302, D402, E301A, E301B, E302N, E305A, E305B, E306B, E403AX, E403BX, E403CX, E403DX, E405, E406, E407N, E409AX/BX/CX/DX, T32, T401N, T402X, T403X	0	0	511	30.66	5781	346.86	4633	277.98	269.6406	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	377.5	377.52	2.51	2.51	19,20,22,23, 35
FC22	T404, T405	0	0	0	0	743	44.58	3161	189.66	183.9702	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	44.58	44.58	N/A	N/A	20,21,32,35
FC23	D301N, E303AN, E303BN, T301N	0	0	266	15.96	4249	254.94	1658	99.48	96.4956	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	270.9	270.9	N/A	N/A	21,24,31
FC24	GKD1, GKD2, GKTK1, GKTK6	52	3.12	116	6.96	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	6.6	10.08	N/A	N/A	23,25,31
FC25	D404, GKD10,GKD12, GKP10, GKP11, GKP2A, GKP2B, P417A, P417B	52	3.12	102	6.12	261	15.66	1198	71.88	69.7236	Pool fire on GK D10, with adjacent equipment cooling	6.18	13.95	N/A	N/A	23,24,27,31
FC26	D406	0	0	0	0	1751.000	105.060	1422.000	85.32	82.7604	No initial cooling of unit, Full firewater demand, no adjacent equipment cooling	#####	105.060	N/A	N/A	27,29,31.34
FC27	E418A, E418B, E418C, P414A, P414B, TK401	0	0	30	1.8	148	8.88	278	16.68	16.1796	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	10.680	10.680	N/A	N/A	24,25,26,31
FC28	E425, E425B	93	5.58	93	5.58	465	27.9	2193	131.58	127.6326	Pool fire with adjacent equipment cooling	8.37	19.53	N/A	N/A	29,30
FC29	DR407, FIL406	20	1.2	9	0.54	98	5.88	133	7.98	7.7406	Pool fire on DR407, with adjacent equipment cooling	1.47	3.48	N/A	N/A	26,28,34
FC30	E409E, E409F	0	0	0	0	215	12.9	158	9.48	9.1956	No initial cooling of unit, Full firewater demand with adjacent equipment cooling	12.9	12.9	N/A	N/A	28
FC31	P413, P413N, P418AX, P418BX	14	0.84	35	2.1	141	8.46	417	25.02	24.2694	Pool fire on P413, with adjacent equipment cooling	1.89	6.33	N/A	N/A	24,25,26,27, 34
FC32	F401	0	0	0	0	0	0	1895	113.7	110.289	Foam demand Only	0	0	N/A	N/A	22,33,35
FC33	F402	1	0.06	1	0.06	1	0.06	667	40.02	38.8194	Foam demand Only	0.09	0.09	N/A	N/A	32
FC34	E416X, E417AX, E417BX, E419, E422AN, E422BN, E424	0	0	0	0	191	11.46	809	48.54	47.0838	No initial cooling of unit, Full firewater demand, no adjacent equipment cooling	11.46	11.46	N/A	N/A	26,27,29,31
FC35	D403, D405, D407	80	4.8	92	5.52	400	24	495	29.7	28.809	Pool fire on D405/D407, with adjacent equipmnt cooling	7.56	17.52	N/A	N/A	20,21,22,38
									max	269.641						

* Cool unit for one hr, begin	** Continue cooling adjacen

T401N Fire Analysis

FC21	0.1	0	0	511	30.66	578.1	34.686	4633	277.98			65.35	65.346	N/A	N/A	19,20,22,23, 35
FC21	0.2	0	0	511	30.66	1156.2	69.372	4633	277.98			100	100.032	N/A	N/A	19,20,22,23, 35
FC21	0.3	0	0	511	30.66	1734.3	104.058	4633	277.98			134.7	134.718	N/A	N/A	19,20,22,23, 35
FC21	0.4	0	0	511	30.66	2312.4	138.744	4633	277.98			169.4	169.404	N/A	N/A	19,20,22,23, 35
FC21	0.5	0	0	511	30.66	2890.5	173.43	4633	277.98			204.1	204.09	N/A	N/A	19,20,22,23, 35
FC21	0.6	0	0	511	30.66	3468.6	208.116	4633	277.98			238.8	238.776	N/A	N/A	19,20,22,23, 35
FC21	0.7	0	0	511	30.66	4046.7	242.802	4633	277.98			273.5	273.462	N/A	N/A	19,20,22,23, 35
FC21	0.8	0	0	511	30.66	4624.8	277.488	4633	277.98			308.1	308.148	23.86	23.86	19,20,22,23, 35
FC21	0.9	0	0	511	30.66	5202.9	312.174	4633	277.98			342.8	342.834	4.54	4.54	19,20,22,23, 35
FC21	1	0	0	511	30.66	5781	346.86	4633	277.98			377.5	377.52	2.51	2.51	19,20,22,23, 35

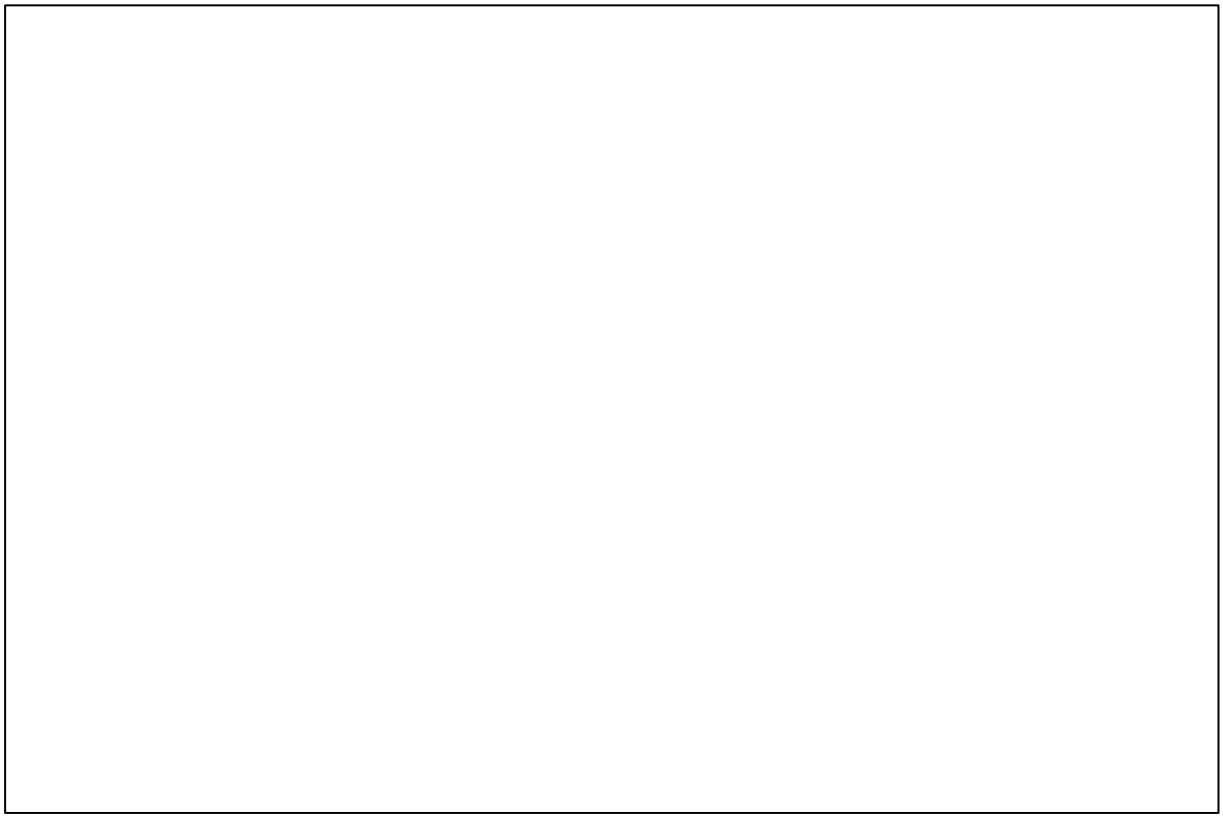
	% of tower engulfed	Time to overfill pond
FC21	0.1	N/A
FC21	0.2	N/A
FC21	0.3	N/A
FC21	0.4	N/A
FC21	0.5	N/A
FC21	0.6	N/A
FC21	0.7	N/A
FC21	0.8	23.86
FC21	0.9	4.54
FC21	1	2.51

Powerformer Fire Circles

Fire Circle	Description	Unit Cooling (l/min)	Unit Cooling (m3/hr)	Adjacent equipment radiant cooling (l/min)	Adjacent equipment radiant cooling (m3/hr)	Engulfed Unit Firewater (l/min)	Engulfed Unit Firewater (m3/hr)	Foam Demand (l/min)	Foam Demand (m3/hr)	Water for Foam Demand (m3/hr)	Assumptions	0-1 hr *	1 - 2 hrs **	Time to fill pond if continue at *	Time to fill pond if continue at **	Adjacent Fire Circles
FC1	F210X, F202AX, F202B, F202C, F204, F206, F207	0	0	0	0	0	0	5212	312.72	303.3384	Foam demand Only	0	0	N/A	N/A	2,14,37
FC2	F203	0	0	0	0	0	0	142	8.52	8.2644	Foam demand Only	0	0	N/A	N/A	1,14
FC3	P204AX, P204BX, P204X, P216A, P216B, P222A, P222B, P232	8	0.48	56	3.36	80	4.8	7151	429.06	416.1882	Pool fire, with adjacent equipment cooling	2.16	5.76	N/A	N/A	4,5,10,11
FC4	D202, D204, FIL208, FIL209	120	7.2	114	6.84	602	36.12	569	34.14	33.1158	Pool fire on powerformer separator with adjacent equipment cooling	10.62	24.9	N/A	N/A	3,5,6,10,15
FC5	D201	0	0	0	0	564	33.84	722	43.32	42.0204	Pool fire on unit, no adjacent equipment cooling	33.84	33.84	N/A	N/A	3,4,6,10,15
FC6	P202AX, P202BX, P206A, P206B, P213AX, P213BX	8	0.48	40	2.4	80	4.8	324	19.44	18.8568	Pool fire, with adjacent equipment cooling	1.68	4.8	N/A	N/A	4,5,10,13
FC7	P201AX, P201BX, P2O5A, P205B, P207AX, P207BX, P211A, P211B, P212, P231	17	1.02	81	4.86	167	10.02	671	40.26	39.0522	Pool fire on P201AX/BX, with adjacent equipment cooling	3.45	9.87	N/A	N/A	8,9,13
FC8	D206, D207, D208, E201CX, E201DX, E213, E223X, T202X, T203, T204X	635	38.1	233	13.98	2177.000	130.620	1316.000	78.96	76.5912	Pool fire on T202X (powerformer stabiliser), with adjacent equipment cooling	45.09	79.29	N/A	N/A	6,7,9,13
FC9	D225, D226, P228	26	1.56	12	0.72	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	1.92	2.28	N/A	N/A	7,8
FC10	E201AX, E201BX, E232A, E232B, E234, E237, FIL201, T201	0	0	0	0	2955	177.3	1390	83.4	80.898	Pool fire on E204BX, no cooling of unit first, no adjacent equipment cooling	177.3	177.3	N/A	N/A	3,4,5,6,8,11
FC11	E204AX, E204BX, E215X, E220X, E240	0	0	0	0	464	27.84	1622	97.32	94.4004	Pool fire on T201, no cooling of unit first, no adjacent equipment cooling	27.84	27.84	N/A	N/A	3,10,12,14
FC12	D220, D222, D223, D224, P203AX, P203BX, P223A, P223B, P224A, P224B, P226, P227, P229, T208	0	0	117	7.02	2471	148.26	1691	101.46	98.4162	Pool fire on T208, no cooling of unit first, with cooling of adjacent equipment	148.3	148.26	N/A	N/A	2,11,14
FC13	D205, D209	79	4.74	64	3.84	393	23.58	475	28.5	27.645	Pool fire on D205, with adjacent equipment cooling	6.66	15.63	N/A	N/A	6,7,8
FC14	D203A, D203B, D203D, D203S, E211	123	7.38	410	24.6	613	36.78	927	55.62	53.9514	Pool fire on D203 A/B/D/S, with adjacent equipment cooling	19.68	42.99	N/A	N/A	1,2,11,12
FC15	FIL202A, FIL202B, FIL203	24	1.44	28	1.68	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	2.28	3.12	N/A	N/A	3,4,5,6
FC16	D216, T207X	51	3.06	5	0.3	257	15.42	714	42.84	41.5548	Pool fire on T207X, with adjacent equipment cooling	3.21	8.01	N/A	N/A	17,18
FC17	P214A, P214B, P225A, P225B, TK201N, TK202A, TK202B	62	3.72	90	5.4	0	0	0	0	0	Pool fire not credible, cooling only, 1-2 hrs full cooling on unit and adjacent equipment	6.42	9.12	N/A	N/A	18
FC18	E205X, E225	360	21.6	201	12.06	1802	108.12	3017	181.02	175.5894	Pool fire on E225, with adjacent equipment cooling	27.63	66.12	N/A	N/A	16,17
									max	416.188						

* Cool unit for one hr, begin	** Continue cooling adjacen

F



5.2.9 Pool Fire in Process Area

5.2.9.1 Major Accident Scenarios

A pool fire could occur when an accumulation of liquid in a pool on the ground or on water is ignited. A steadily burning fire is rapidly achieved since the fuel vapour required to sustain the flames is provided by evaporation of the liquid by the heat from the flames. The rate of consumption of fuels is dependent on properties of fuel such as latent heat, and is equivalent to a pool depth regression in

the range 6 to 13 mm/minute. The flames from the pool fire behave entirely under the influence of their own buoyancy and are easily displaced by the wind.

The HazId team identified two types of incident which could lead to a pool fire in the process area. Mechanical failure of vessel due to an impinging jet fire, corrosion or fatigue could lead to the loss of a complete vessel contents. The Team assigned a likelihood of occurrence in the range 10^{-4} to 10^{-3} per year to this event at the Refinery.

The second incident would be the failure of a small bore fitting leading to a loss of containment. Maximum inventories were calculated based on pump rates through the units, assuming that it would take 30 minutes to shut down the pumps as a conservative assumption (see Section 5.1.8). The HazId team assigned a likelihood of occurrence in the range 10^{-1} to 10^{-3}. This is consistent with the Purple Book data, which quotes a frequency of 5×10^{-7} m^{-1} y^{-1} for leaks from a pipeline of nominal diameter greater than 150 mm. The Refinery has an estimated length of some 500 km of pipeline, which would give a leak frequency of 0.25 y^{-1}. Given that ignition is also required in order to give rise to a pool fire, the frequency range assumed by the HazId team is reasonable.

The consequences of an incident involving a release of product within the Refinery processing area would be largely confined to that area. The inventories are much smaller than those in storage tanks, but on the other hand, the process operates at elevated temperatures and pressures, and this constitutes the hazard.

In 2008, Byrne Ó Cléirigh conducted a study identifying 'fire circles' at the Refinery. These 'fire circles' group adjacent items of plant and equipment into common groups based upon their potential to give rise to, or to be exposed to, a common fire scenario (for example, a group of heat exchangers within a common bund may be grouped into a single 'fire circle'). A total of 100 'fire circles' were identified for the site based upon the two types of potential pool fire scenario that could arise.

5.2.9.2 General Description of Consequences

The main consequence of a hydrocarbon pool fire would be thermal radiation and smoke, as described in Sections 5.2.3.2 and 5.2.7.2. The 'fire circle' study estimated the extent of the thermal radiation from the worst case pool fire scenario applicable to each circle.

5.2.9.3 Consequence Modelling

The largest inventory within a single process vessel at Irving Oil which could lead to a pool fire in the process area in the event of an uncontrolled release is the crude desalter, D406. The vessel has an inventory of 104 tonnes of crude/water at a temperature of 135°C and a pressure of 18.6 Bar.

In the event of a total loss of inventory and subsequent ignition, a large unbunded pool fire could result. The thermal radiation effects of an unbunded pool fire arising in the event of a complete loss of containment from the vessel were estimated using EFFECTS. Distances have been calculated to three different target heat fluxes:

- 25 kW/m^2: Damage level 2 (serious discolouration of the metal surface, peeling of paints and/or appreciable deformations of structural elements) from the Green Book by The Netherlands Organisation of Applied Scientific Research (TNO);

- 12.6 kW/m^2: limit for secondary fires (sufficient for wood to ignite after prolonged exposure);
- 4kW/m^2: threshold radiation level recommended in the second Canvey report at which a person could be exposed for periods longer than one minute without suffering serious injury.

We have assumed a pool depth of 20 mm, and have modelled the inventory as liquid gasoline as the material in the EFFECTS database which has properties most similar to those which would be involved in the fire. The results are summarised in Table 5.41.

Table 5.41: Thermal Radiation – unbunded pool fire (D406) (quasi-instantaneous release)

	Wind Speed	
	5 m/s	10m/s
Maximum Pool Radius	43 m	43 m
Distance from flame front to 25 kW/m^2	28 m	33 m
Distance from flame front to 12.6 kW/m^2	58 m	55 m
Distance from flame front to 4 kW/m^2	103 m	91 m

The pool fire would be of short duration; EFFECTS software predicts that the fire would burn out in less than 6 minutes.

If the Level Interface Controller on this vessel failed, hot crude oil could accumulate in the dirty water blow-down drum at about 2.52 kg/s resulting in the crude light-ends burning in the flare and crude overflowing the baffle to end up in the skimming pond (area 1,071 m^2). Again, the thermal radiation effects have been estimated using EFFECTS, and the results are summarised in Table 5.42.

Table 5.42: Thermal radiation – pool fire in skim pond

	Wind Speed	
	5 m/s	10m/s
Distance from flame front to 25 kW/m^2	17 m	19 m
Distance from flame front to 12.6 kW/m^2	31 m	30 m
Distance from flame front to 4 kW/m^2	54 m	47 m

As stated in Section 5.2.9.3, the thermal radiation from the worst case pool fire for each of the 'fire circles' at the site was estimated based upon the maximum pool size.

5.2.9.4 Incident Escalation

Any process vessels engulfed within the pool radius may exhibit serious damage due to impingement fire. This may result in secondary pool fires, jet fires or flash fires in the vicinity. It should be noted that the duration of the pool fire is expected to be short (estimated 6 minutes from EFFECTS) which will serve to reduce the risk. In addition, the development of 'fire circles' at the site has identified the plant and equipment that may be subject to direct impingement fire attack from adjacent

equipment, while the identification of adjacent fire circles allows the potential impact of radiant heat (calculated to 8 kW/m^2) from nearby pool fires to be assessed. The information from the 'fire circle' study has been used to refine the fire response plans for the different areas of the site.

Distances estimated to a thermal heat flux of 25 kW/m^2 (corresponding to Damage level 2: serious discolouration of the metal surface, peeling of paints and/or appreciable deformations of structural elements) are very short. This, combined with the short duration of the fire in the process area, indicate that the impacts of thermal radiation on adjacent structures will not be too severe.

5.2.9.5 Human Consequences

We have estimated the human consequences resulting from thermal radiation these scenarios in Table 5.43.

Table 5.43: Fatality Levels – Pool Fires in Process Areas

	Unbunded Pool Fire (D406)		Pool Fire in Skim Pond (D406)	
	5 m/s	10 m/s	5 m/s	10 m/s
50% Lethality	52 m	50 m	29 m	28 m
10% Lethality	69 m	64 m	37 m	34 m
1% Lethality	81 m	74 m	42 m	38 m

The results predict a worst case consequence distance of 81 m to 1% lethality for an unbunded pool fire in the process area, and 42 m from the skim pond in the event that the fire spreads to the skim pond. During operating hours at the Refinery, there would generally be a maximum of 16 electricians, 34 mechanical staff and 14 operators carrying out various tasks around the Refinery who could conceivably be outdoors in the vicinity where they could be affected by the thermal radiation from a pool fire. However, generally it would also take some time for a pool fire of this scale to develop, this would allow a person in the open air to take evasive action such as moving away from the heat source or taking shelter, and for search and rescue procedures to be implemented.

Another hazard associated with pool fires in the process areas of the plant is the risk of escalation due to flame impingement on process vessels or other items of equipment. This is discussed in more detail in Section 5.2.10.

5.2.9.6 Safety of Occupied Buildings

As noted in Section 5.2.3.6, there are four main areas of population density at the Refinery - the Main Control Room, the laboratory, the administration building and the workshop. The Main Control Room is a reinforced concrete frame construction. The administration building and laboratory are mass concrete, while the workshop is a steel portal frame structure.

Table 5.44: Distances from D406 to occupied buildings at the Refinery

Building	Distance from D406
Main Control Room	87 m
Laboratory	282 m
Workshop	254 m
Administration Block	349 m

Based on the maximum estimated radius of the pool fire, none of the buildings will be engulfed by the fire. Incident heat flux on the laboratory, workshop and administration block will be less than 4kW/m^2, and is not expected to present a hazard.

The Main Control Room is designated as a shelter in place, and can be used as such for most major accident scenarios. The worst case incident thermal radiation on the Main Control Room is predicted to be 18 kW/m^2. This heat flux is not sufficiently high to cause structural damage to the building. However it may be decided to evacuate the building if there is deemed to be a risk of incident escalation. The Chemical Industries Association "Guidance for the location and design of occupied buildings on chemical manufacturing sites" notes that while a pool fire has the potential to generate very high levels of thermal radiation and smoke, it may take a reasonable time to reach maximum burning rate, thus allowing the building to be evacuated if threatened.

In the event of the loss of use of the Main Control Room, the whole plant is controllable from RIB 1, located just east of the Isomerisation Unit. RIB 3, within the new Hydrofiner Unit, also provides the same back-up function. Finally, in the event of total loss of the control system, the process units on site are mechanically designed for worst case scenarios and control valves will fail to their fail safe positions. All units are equipped with safety relief valves, which will depressurise the units safely to the flare header or atmosphere. Safety relief valves are sized for the worst case engulfment fire. Further details of the Refinery control system are included in Section 4.2.4.

5.2.9.7 Environmental Consequences

Considerable quantities of firewater could be generated in fighting a fire in the process area. However, the process areas are concrete lined and kerbed. There are multiple drains at low points distributed across each process element. Therefore, any hydrocarbon spillage and firewater will drain via the nearest sewer to the skim pond for separation and dilution prior to discharge.

The maximum design hourly throughput of the skim pond is 2,447m^3/hr. The maximum firewater generating capacity at the site is 1,225 m^3/hr. The normal daily pond outflow is approximately 60 m^3/hr, increasing up to 300 m^3/hr during heavy rainfall. Therefore, even in the event of a fire during heavy rainfall, the maximum flow to the skim pond would be approximately 1,590 m^3/hr, significantly lower than the design capacity of the system. There would therefore be minimal adverse impact on the environment arising due to firewater generated.

5.2.9.8 Risk Reduction Measures

Layout of the original process areas was in accordance with Esso Engineering Standards of the 1950s. The different processing units, and the individual items of equipment – e.g. vessels, furnaces,

exchangers, rotating equipment - are spaced to ensure that there is adequate access for fire-fighting, separation to minimise the spread of fire, and access for operation and maintenance.

The process units were designed and constructed in accordance with accepted international and industry standards and recommended practice. Further detail regarding the design standards for the process unit and the safety devices installed is included in Section 4.2.11. The processing unit operating manuals contains all information necessary to operate the units safely.

As noted in Section 4.2.3, it is Irving Oil's maintenance policy is to preserve the integrity of the plant and equipment to the specified standards and codes of practice, such that there is no loss of containment and no mechanical failures leading to hazardous situations. Irving Oil's maintenance regime is described in Section 2.5.5.

5.2.9.9 Mitigation Measures

Irving Oil's Emergency Plan is described in detail in Section 6. The Plan outlines the roles that must be undertaken by all relevant individuals in the event of an emergency onsite.

APPENDIX 5

INTERMEDIATE & PRODUCT

TANK FARM CALCULATIONS

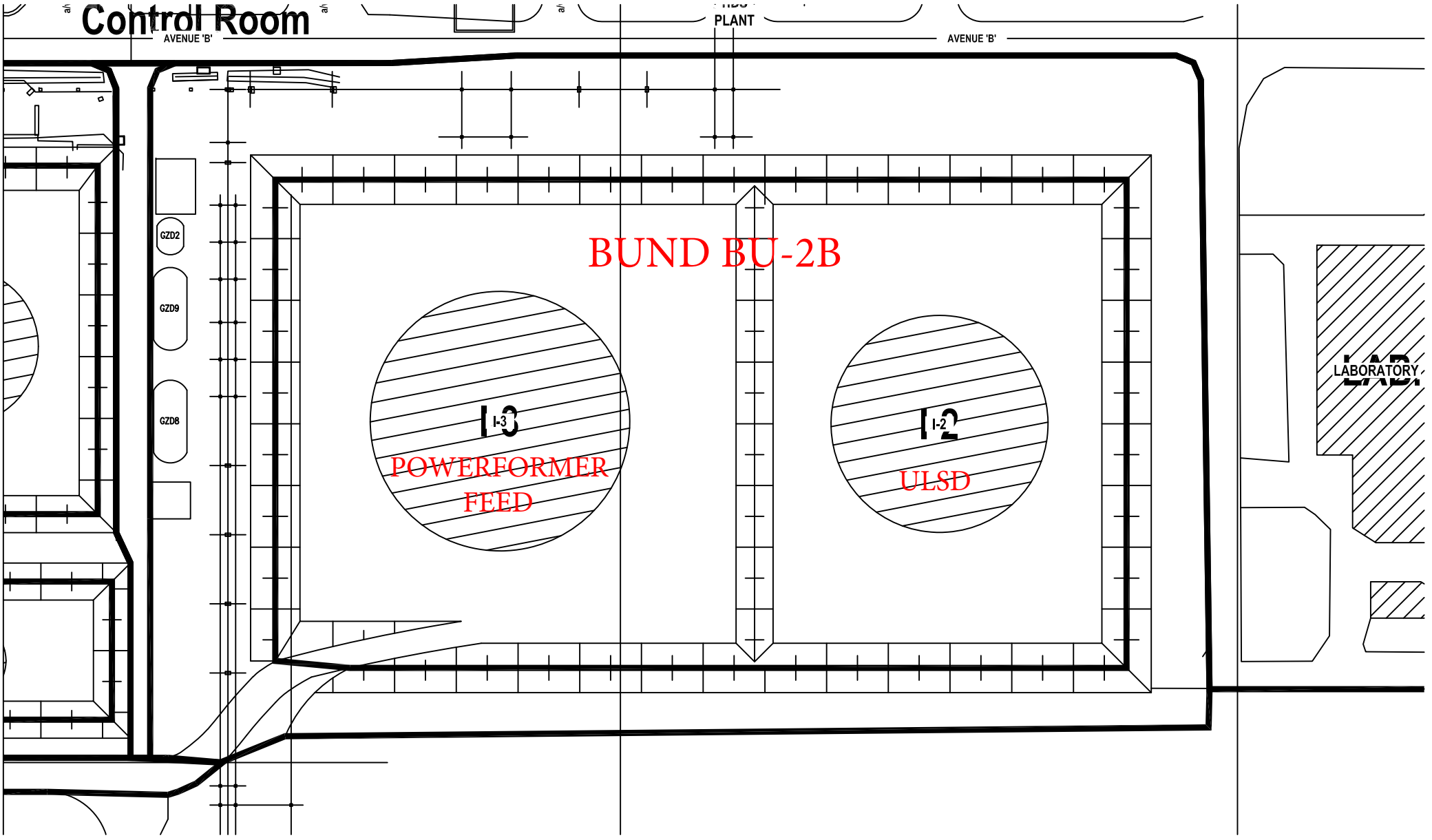
Separation Distances

Bund Calculations

FWA Tool

IOWR INTERMEDIATE AND PRODUCT TANK BUND FIREWATER RETENTION CALCULATIONS

BUND	PRODUCT m3	FOAM m3	COOLING m3	RAINWATER m3	TOTAL FW m3	CAPACITY m3	OVERSPILL m3
BU-2B	18,056	2,526	277	741	21,600	25,262	CONTAINED
BU-4A	2,696	592	39	176	3,504	4,442	CONTAINED
BU-5D	4,577	1,056	330	309	6,272	11,411	CONTAINED
BU-5E EAST	5,231	1,080	352	316	6,978	10,796	CONTAINED
BU-5E	4,577	783	154	235	5,749	7,597	CONTAINED
BU-5E WEST	10,040	1,811	244	535	12,630	19,760	CONTAINED
BU-5E NORTH	6,832	1,301	403	383	8,918	12,363	CONTAINED
BU-5F	2,335	444	220	132	3,131	4,872	CONTAINED


Control Room
AVENUE 'B'
PLANT
AVENUE 'B'
GZD2
GZD9
GZD8
BUND BU-2B
I-3
POWERFORMER
FEED
I-2
ULSD
LABORATORY

BUND NUMBER BU-2B

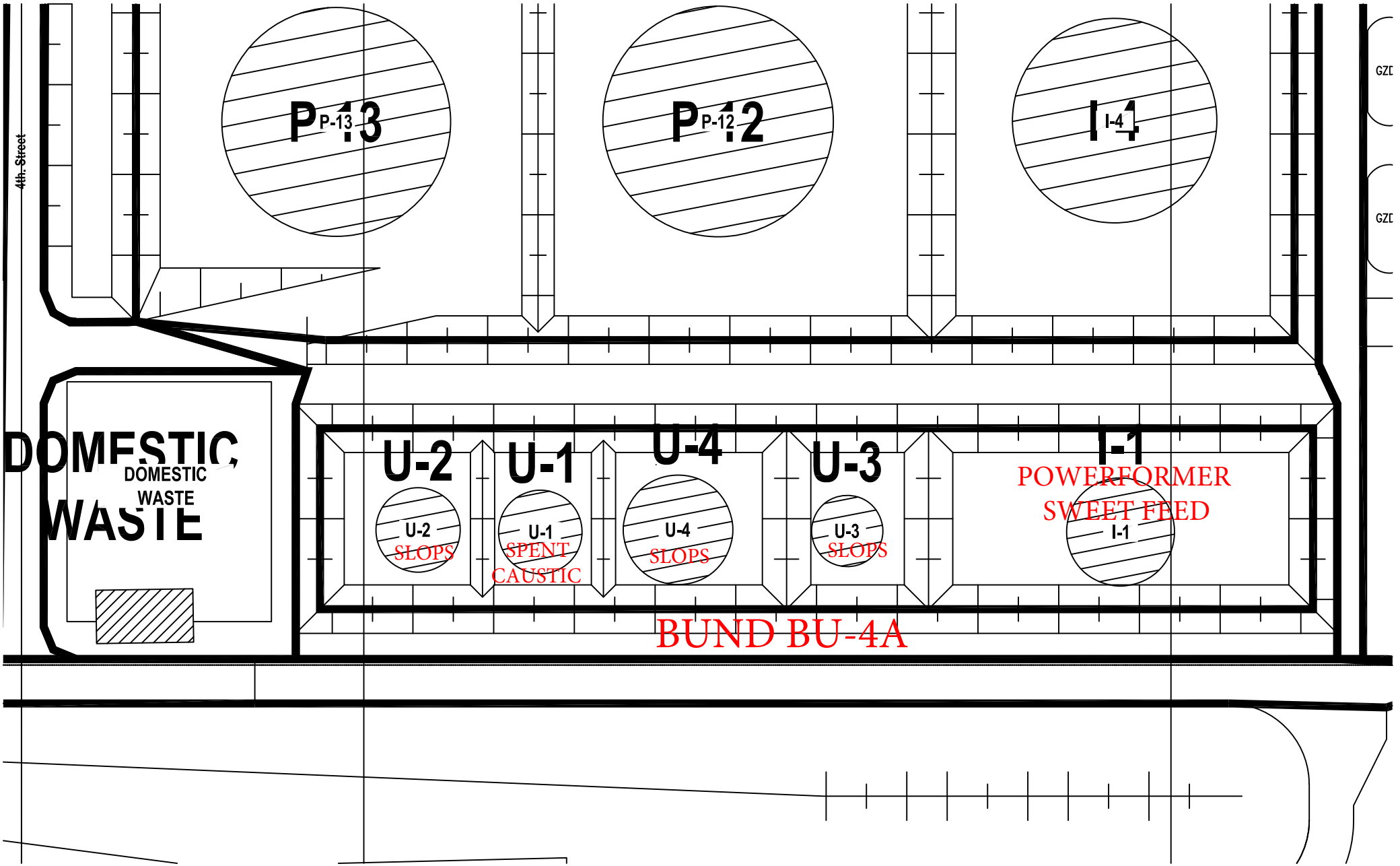
TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
I2	Ultra Low Sulphur Diesel		Floating	33.5				Non-flammable
	Adjacent Tanks							
	I3	Powerformer Feed	Floating	39.6	10.0	32.6	YES	
	I4	Ultra Low Sulphur Diesel	Cone	25.3	10.0	53.8	YES	Non-flammable
I3	Powerformer Feed		Floating	39.6				
	Adjacent Tanks							
	I2	Ultra Low Sulphur Diesel	Floating	33.5	10.0	32.6	YES	Non-flammable

BUND NUMBER BU-2B

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
I2	Ultra Low Sulphur Diesel	12,942	33.5	14.6	882	1,537	Non-flammable
I3	Powerformer Feed	18,056	39.6	14.6	1,232	1,817	

ASSUME FIRE IN I3 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF I2 SHELL				COMMENT
Product Contribution m3			18,056	Full inventory of largest tank
Bund Surface Area m2	9,294			Area of bund floor
Pool Fire Surface Area m2	10,526			Bund floor plus ruptured tank footprint
Foam Contribution m3	10,526	m2 @ 8l/min/m2 for 30 mins	2,526	As per specification
Cooling Water I2 m3	384	m2 @ 2l/min/m2 for 6 hours	277	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	11,407	m2 @ 65mm	741	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**21,600**	

BUND HEIGHT m	2.40	
BUND VOLUME	25,262	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**


4th. Street
P-13
P-12
I-4
GZC
GZC
DOMESTIC WASTE
DOMESTIC WASTE
U-2
U-1
U-4
U-3
I-1
U-2 SLOPS
U-1 SPENT CAUSTIC
U-4 SLOPS
U-3 SLOPS
POWERFORMER SWEET FEED
I-1
BUND BU-4A

BUND NUMBER BU-4A

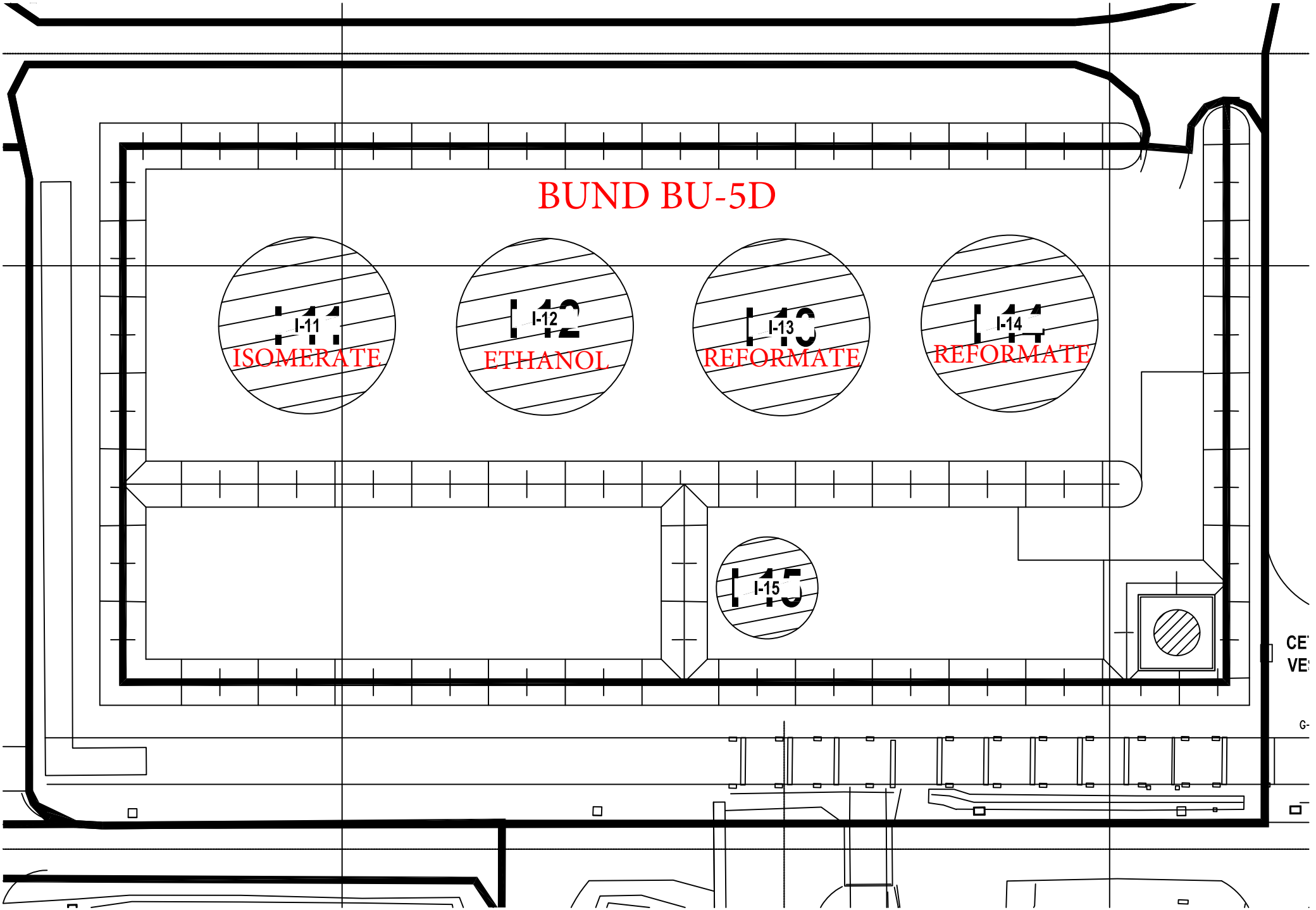
TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
I 1	Powerformer Sweet Feed		Cone	12.8				*Recommended distance was originally 30' This converts to 9.14m, but was rounded up to 10m when guidance was revised in SI units.
	Adjacent Tanks							
	I4		Cone		10.0	31.6	YES	
	U3	Slops	Floating	7.6	10.0	22.7	YES	
U 1	Spent Caustic		Cone	9.1				Non-flammable
	Adjacent Tanks							
	U2	Slops	Cone	9.1	10.0	4.7	NO	
	U4	Slops	Cone	12.2	10.0	5.1	NO	
	P12	Diesel	Cone	28.6	10.0	29.5	YES	Non-flammable
U 2	Slops		Cone	9.1				
	Adjacent Tanks							
	U1	Spent Caustic	Cone	9.1	10.0	4.7	NO	
	P13	Diesel	Cone	28.6	10.0	31.1	YES	Non-flammable
U 3	Slops		Cone	7.6				
	Adjacent Tanks							
	I1	Powerformer Sweet Feed	Cone		10.0	22.7	YES	
	U4	Slops	Cone	12.2	10.0	9.7	NO*	
	P12	Diesel	Cone	28.6	10.0	29.5	YES	Non-flammable
U 4	Slops			12.8				
	Adjacent Tanks							
	U1	Spent Caustic	Cone	9.1	10.0	5.1	NO	
	U3	Slops	Floating	7.6	10.0	9.7	NO*	
	P12	Diesel	Cone	28.6	10.0	29.5	YES	Non-flammable

BUND NUMBER BU-4A

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
I 1	Powerformer Sweet Feed	1,494	12.2	12.8	117	491	
U 1	Spent Caustic	601	9.1	9.1	65	260	Non-flammable
U 2	Slops	601	9.1	9.1	65	260	
U 3	Slops	417	7.6	9.1	45	217	
U 4	Slops	1,494	12.2	12.8	117	491	

ASSUME FIRE IN U 4 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF SHELLS OF U 1 AND U 3				COMMENT
Product Contribution m3			2,696	Full inventory of largest tank*
Bund Surface Area m2	2,221			Area of bund floor
Pool Fire Surface Area m2	2,468			Bund floor plus ruptured tank footprints
Foam Contribution m3	2,468	m2 @ 8l/min/m2 for 30 mins	592	As per specification
Cooling Water I2 m3	54	m2 @ 2l/min/m2 for 6 hours	39	Applied to 25% of adjacent tank shells area
Rainwater Contribution m3	2,715	m2 @ 65mm	176	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**3,504**	

BUND HEIGHT m	1.80	* As the distances between tanks U1, U2 and U4 are less that recommended, they will be considered as a single tank
BUND VOLUME	4,442	
OVERSPILL TO RETENTION SYSTEM m3	**Contained**	


BUND BU-5D
I-11
ISOMERATE
I-12
ETHANOL
I-13
REFORMATE
I-14
REFORMATE
I-15

BUND NUMBER BU-5D

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 175 COMPLIANT Y/N	COMMENT
I 11	Isomerate		Floating	14.6				
	Adjacent Tanks							
	I12	Ethanol	Floating	21.3	10.0	9.1	NO*	
	P16	Gasoil	Floating	29.4	10.0	57.5	YES	Non-flammable
I 12	Ethanol		Floating	14.6				
	Adjacent Tanks							
	I11	Isomerate	Floating	21.3	10.0	9.1	NO*	*Recommended distance was originally 30'
	I13	Reformate	Floating	21.3	10.0	9.1	NO*	This converts to 9.14m, but was rounded up to 10m when guidance was revised
I 13	Reformate		Floating	12.8				in SI units.
	Adjacent Tanks							
	I12	Ethanol	Floating	21.3	10.0	9.1	NO*	
	I14	Reformate	Floating	21.3	10.0	9.1	NO*	
	I15		Floating		10.0	15.8	YES	
I 14	Reformate		Floating	12.8				
	Adjacent Tanks							
	I13	Reformate	Floating	21.3	10.0	9.1	NO*	
	P14	Gasoil	Floating	31.8	10.0	57.8	YES	Non-flammable

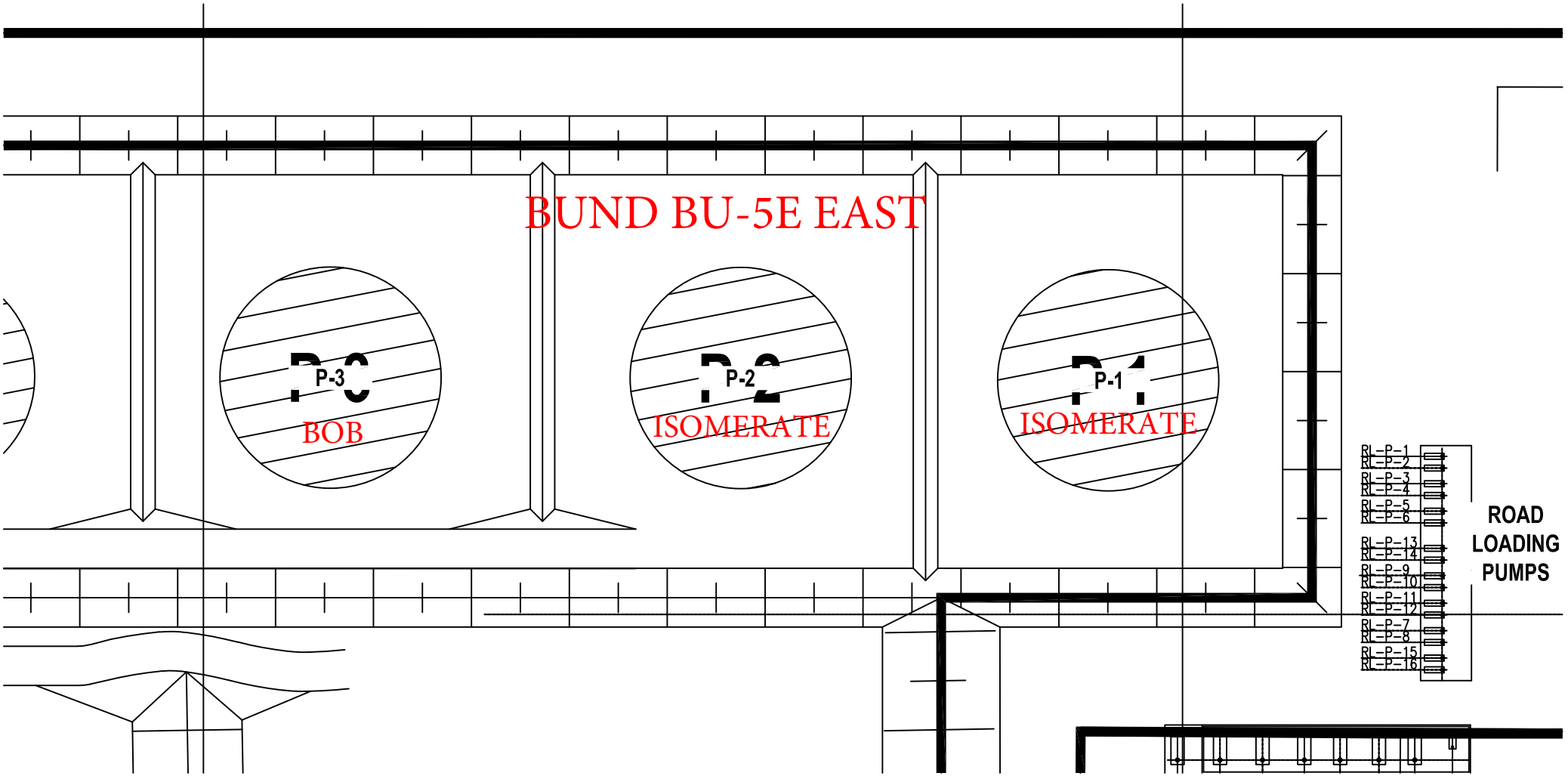
BUND NUMBER BU-5D

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
I 11	Isomerate	5,231	21.3	14.6	356	977	
I 12	Ethanol	5,231	21.3	14.6	356	977	
I 13	Reformate	4,577	21.3	12.8	356	857	
I 14	Reformate	4,577	21.3	12.8	356	857	

ASSUME FIRE IN I 12 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE
COOLING WATER APPLIED TO 25% OF I 11 AND I 13 SHELLS

				COMMENT
Product Contribution m3			4,577	Full inventory of largest tank
Bund Surface Area m2	4,042			Area of bund floor
Pool Fire Surface Area m2	4,398			Bund floor plus ruptured tank footprint
Foam Contribution m3	4,398	m2 @ 8l/min/m2 for 30 mins	1,056	As per specification
Cooling Water I2 m3	458	m2 @ 2l/min/m2 for 6 hours	330	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	4,755	m2 @ 65mm	309	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**6,272**	

BUND HEIGHT m	2.40	
BUND VOLUME	11,411	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**


BUND BU-5E EAST
P-3
BOB
P-2
ISOMERATE
P-1
ISOMERATE
RL-P-1
RL-P-2
RL-P-3
RL-P-4
RL-P-5
RL-P-6
RL-P-13
RL-P-14
RL-P-9
RL-P-10
RL-P-11
RL-P-12
RL-P-7
RL-P-8
RL-P-15
RL-P-16
ROAD
LOADING
PUMPS

BUND NUMBER BU-5E EAST

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
P 1	Isomerate		Floating	14.6				
	Adjacent Tanks							
	P2	Isomerate	Floating	21.3	10.0	15.2	YES	
	P4	BOB	Floating	24.4	10.0	50.6	YES	
	P16	Gasoil	Cone	29.4	10.0	82.0	YES	Non-flammable
P 2	Isomerate		Floating	14.6				
	Adjacent Tanks							
	P1	Isomerate	Floating	21.3	10.0	15.2	YES	
	P3	BOB	Floating	21.3	10.0	19.3	YES	
	P18	HFO	Cone	44.1	10.0	32.0	YES	Non-flammable
P 3	BOB		Floating	14.6				
	Adjacent Tanks							
	P2	Isomerate	Floating	21.3	10.0	19.3	YES	
	P7	Kerosene	Cone	21.3	10.0	18.9	YES	
	P6	BOB	Floating	24.4	10.0	50.6	YES	

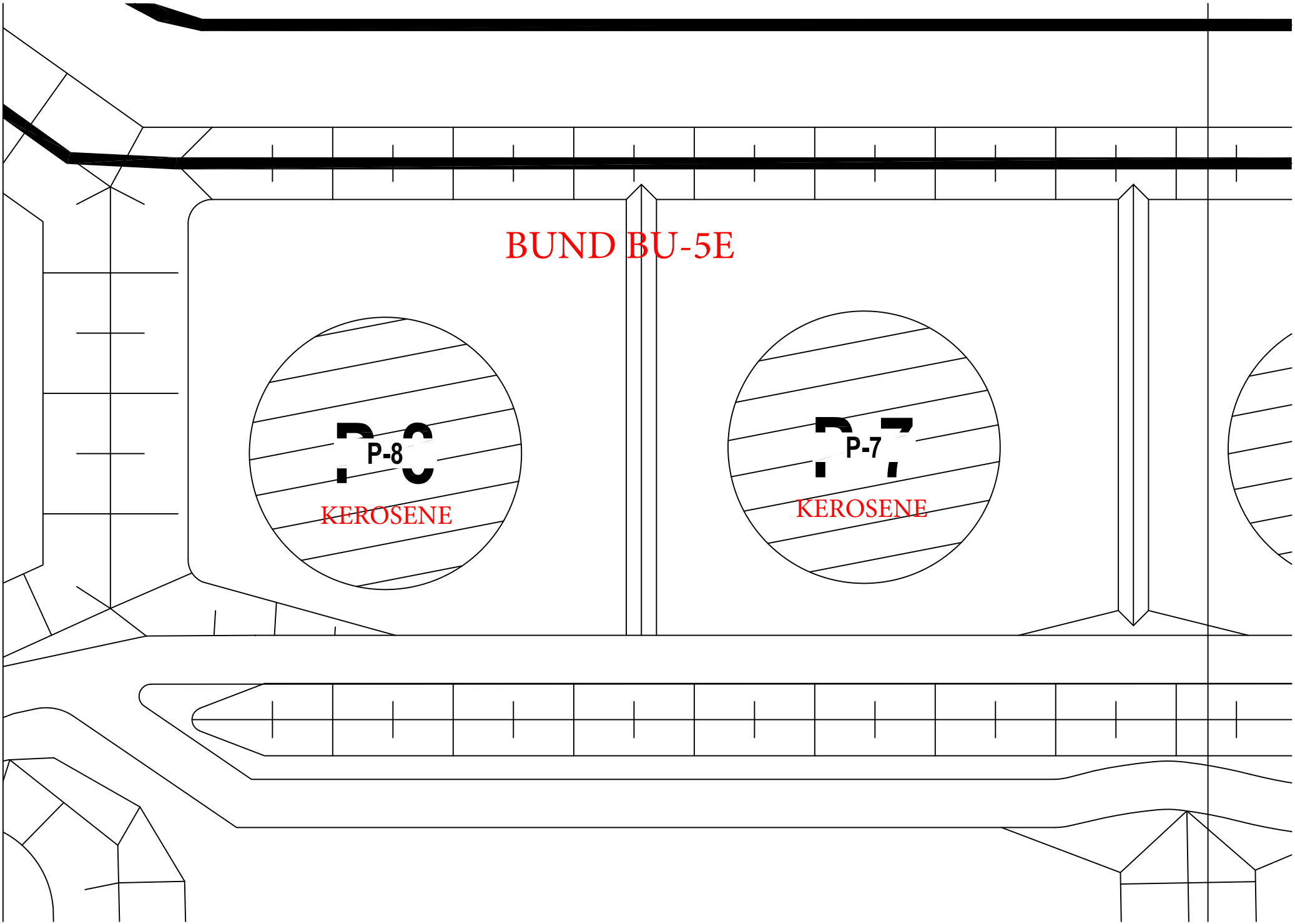
BUND NUMBER BU-5E EAST

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
P 1	Isomerate	5,231	21.3	14.6	356	977	
P 2	Isomerate	5,231	21.3	14.6	356	977	
P 3	BOB	5,231	21.3	14.6	356	977	

ASSUME FIRE IN P 2 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE
COOLING WATER APPLIED TO 25% OF P 1 AND P 3 SHELLS

				COMMENT
Product Contribution m3			5,231	Full inventory of largest tank
Bund Surface Area m2	4,142			Area of bund floor
Pool Fire Surface Area m2	4,498			Bund floor plus ruptured tank footprint
Foam Contribution m3	4,498	m2 @ 8l/min/m2 for 30 mins	1,080	As per specification
Cooling Water I2 m3	489	m2 @ 2l/min/m2 for 6 hours	352	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	4,855	m2 @ 65mm	316	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**6,978**	

BUND HEIGHT m	2.40	
BUND VOLUME	10,796	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**


BUND BU-5E
P-8
KEROSENE
P-7
KEROSENE

BUND NUMBE BU-5E

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
P 7	Kerosene		Cone	12.8				
	Adjacent Tanks							
	P3	BOB	Floating	21.3	15.0	18.9	YES	
	P19	HFO	Cone	44.1	15.0	31.6	YES	Non-flammable
	P8	Kerosene	Cone	21.3	15.0	17.1	YES	
P 8	Kerosene		Cone	12.8				
	Adjacent Tanks							
	P7	Kerosene	Cone	21.3	15.0	17.1	YES	
	P19	HFO	Cone	44.1	15.0	31.1	YES	Non-flammable
	P20	Kerosene	Cone	29.6	15.0	28.6	YES	

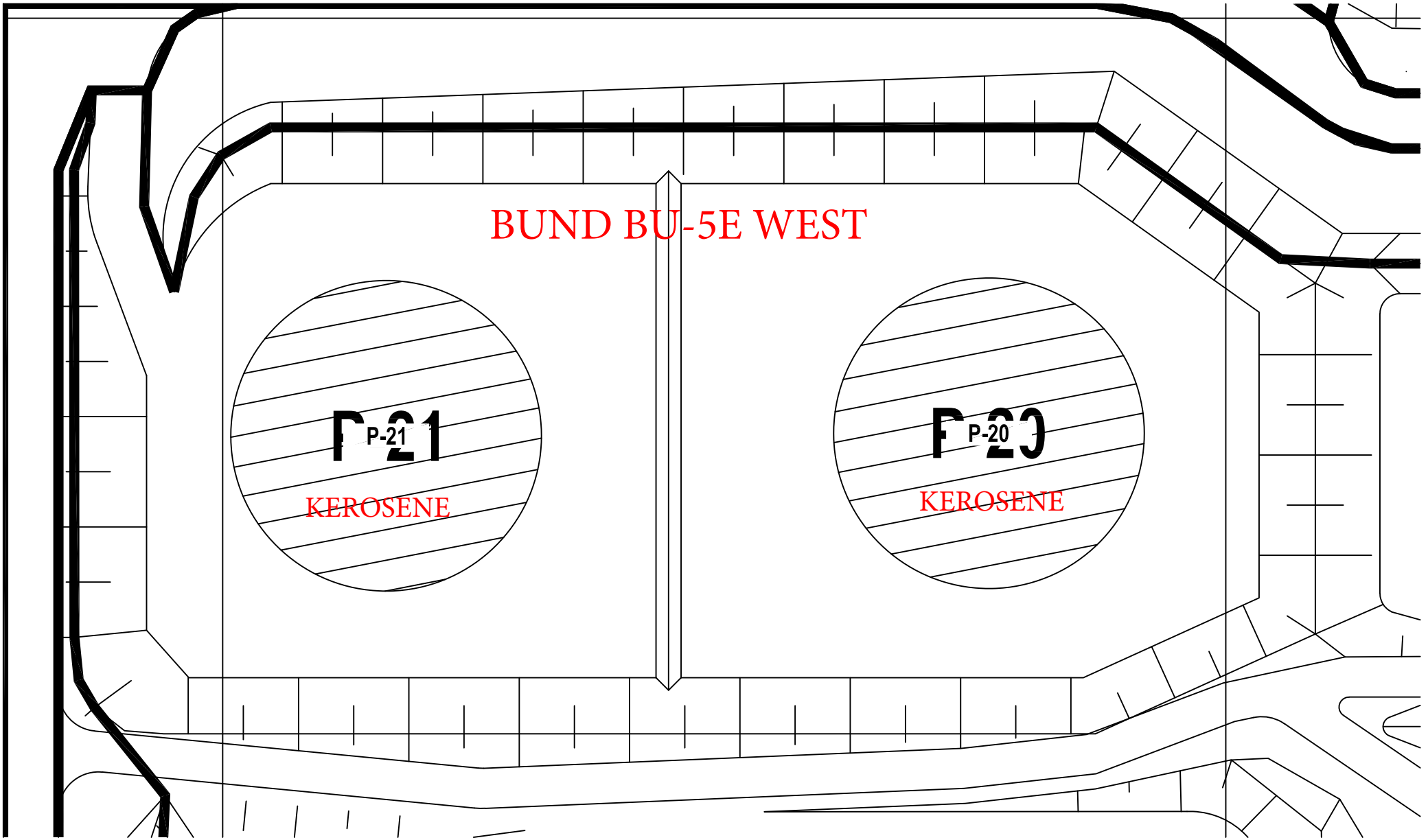
BUND NUMBER BU-5E

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
P 7	Kerosene	4,577	21.3	12.8	356	857	
P 8	Kerosene	4,577	21.3	12.8	356	857	

ASSUME FIRE IN P 7 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE
COOLING WATER APPLIED TO 25% OF P 8 SHELL

				COMMENT
Product Contribution m3			4,577	Full inventory of largest tank
Bund Surface Area m2	2,905			Area of bund floor
Pool Fire Surface Area m2	3,261			Bund floor plus ruptured tank footprint
Foam Contribution m3	3,261	m2 @ 8l/min/m2 for 30 mins	783	As per specification
Cooling Water I2 m3	214	m2 @ 2l/min/m2 for 6 hours	154	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	3,618	m2 @ 65mm	235	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**5,749**	

BUND HEIGHT m	2.10	
BUND VOLUME	7,597	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**


BUND BU-5E WEST
P-21
KEROSENE
P-20
KEROSENE

BUND NUMBER BU-5E WEST

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
P 20	Kerosene		Cone	14.6				
	Adjacent Tanks							
	P8	Kerosene	Cone	21.3	15.0	28.6	YES	
	P23	HFO	Cone	53.0	15.0	35.3	YES	
	P21	Kerosene	Cone	29.6	15.0	29.1	YES	
P 21	Kerosene		Cone	14.6				
	Adjacent Tanks							
	P20	Kerosene	Cone	29.6	15.0	29.1	YES	
	P23	HFO	Cone	53.0	15.0	31.2	YES	

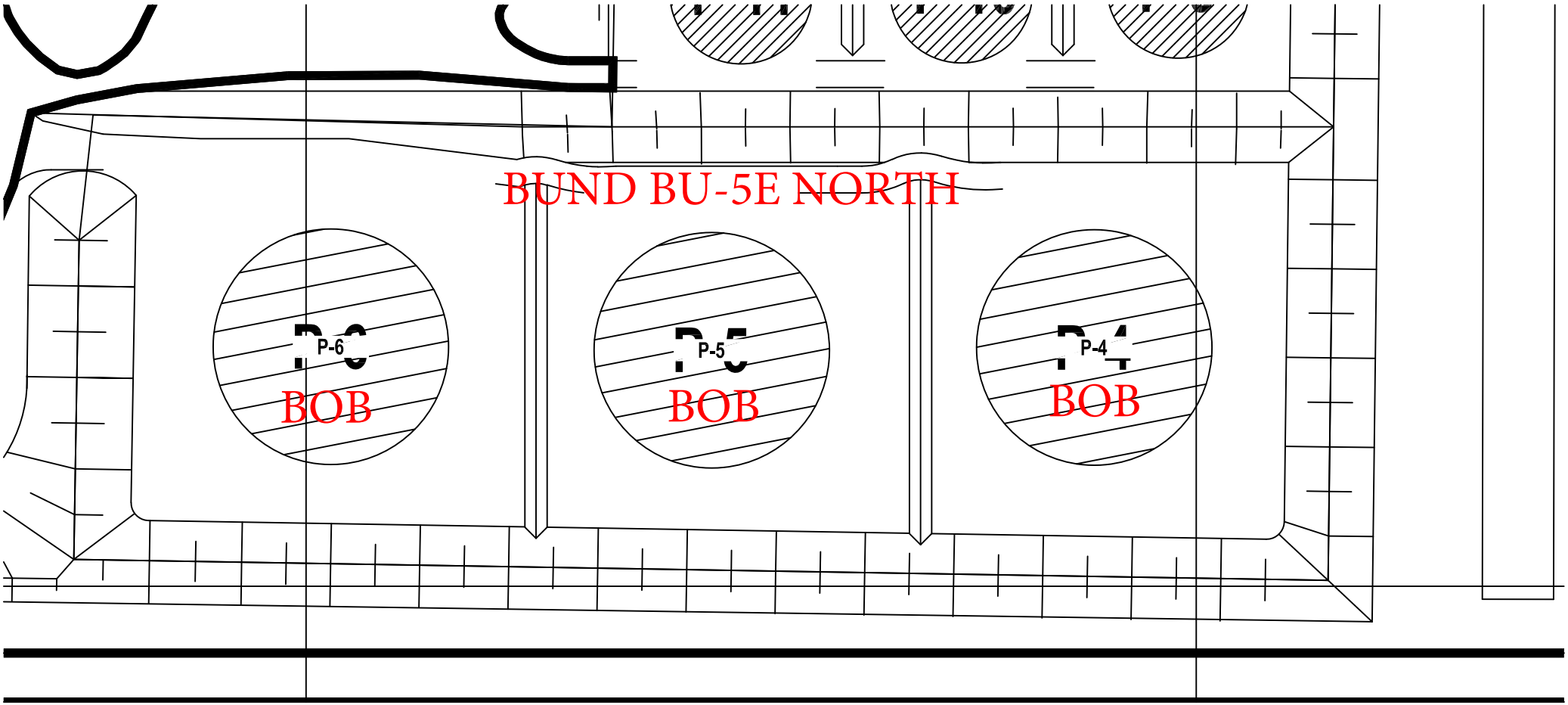
BUND NUMBER BU-5E WEST

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
P 20	Kerosene	10,040	29.6	14.6	688	1,358	
P 21	Kerosene	10,040	29.6	14.6	688	1,358	

ASSUME FIRE IN P 20 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE
COOLING WATER APPLIED TO 25% OF P 21 SHELL

				COMMENT
Product Contribution m3			10,040	Full inventory of largest tank
Bund Surface Area m2	6,857			Area of bund floor
Pool Fire Surface Area m2	7,545			Bund floor plus ruptured tank footprint
Foam Contribution m3	7,545	m2 @ 8l/min/m2 for 30 mins	1,811	As per specification
Cooling Water I2 m3	339	m2 @ 2l/min/m2 for 6 hours	244	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	8,233	m2 @ 65mm	535	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**12,630**	

BUND HEIGHT m	2.40	
BUND VOLUME	19,760	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**


BUND BU-5E NORTH
P-6
BOB
P-5
BOB
P-4
BOB

BUND NUMBER BU-5E NORTH

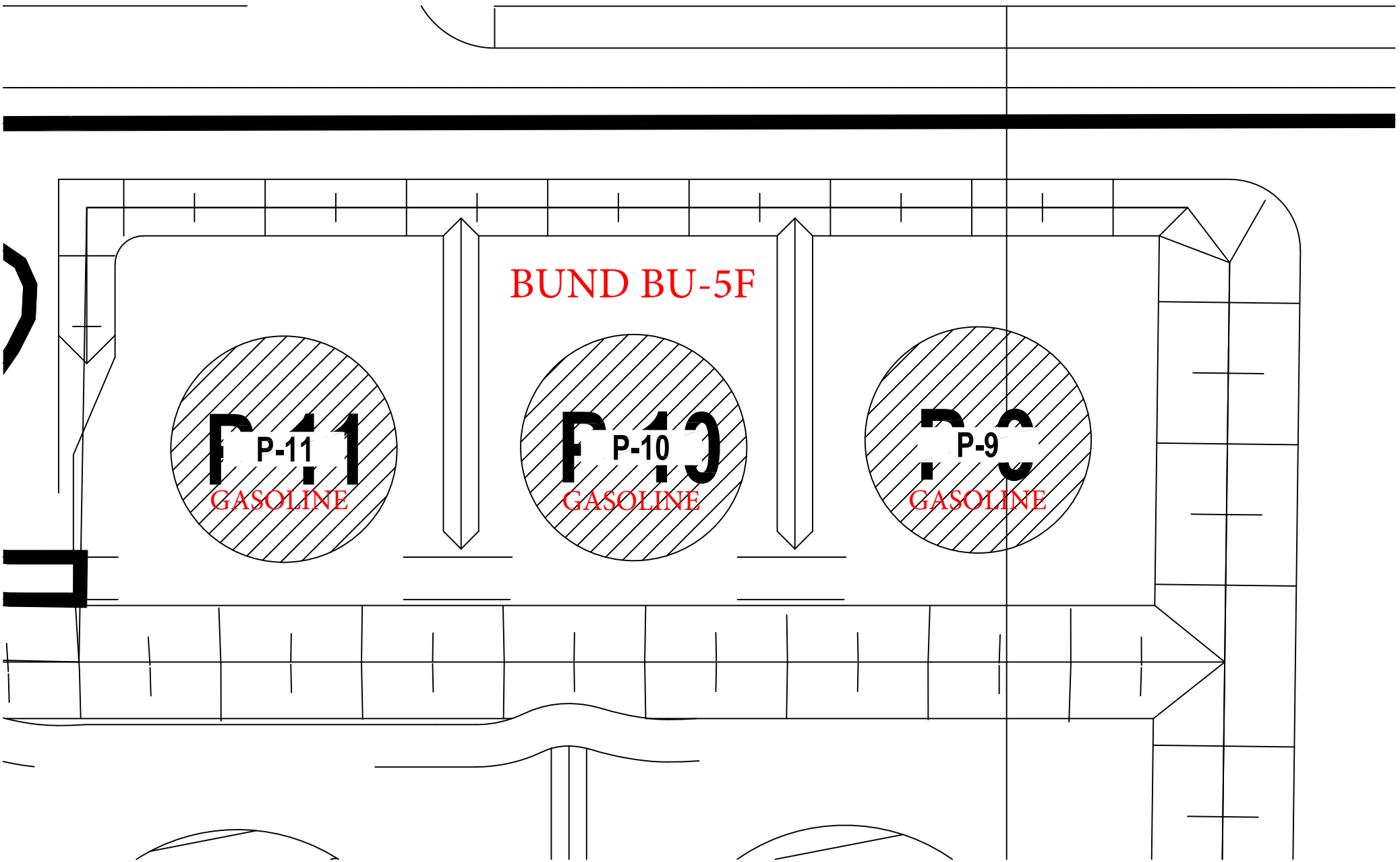
TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
P 4	BOB		Floating	14.6				
	Adjacent Tanks							
	P9	Gasoline	Floating	15.2	10.0	19.3	YES	
	P17	HFO	Cone	31.8	10.0	84.4	YES	Non-flammable
	P1	Isomerate	Floating	21.3	10.0	50.7	YES	
	P5	BOB	Floating	24.4	10.0	16.5	YES	
P 5	BOB		Floating	14.6				
	Adjacent Tanks							
	P4	BOB	Floating	24.4	10.0	16.5	YES	
	P2	Isomerate	Floating	21.3	10.0	50.6	YES	
	P6	BOB	Floating	24.4	10.0	16.3	YES	
	P11	Gasoline	Floating	15.2	10.0	18.9	YES	
P 6	BOB		Floating	14.6				
	Adjacent Tanks							
	P5	BOB	Floating	24.4	10.0	16.3	YES	
	P3	BOB	Floating	21.3	10.0	50.6	YES	

BUND NUMBER BU-5E NORTH

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
P 4	BOB	6,832	24.4	14.6	468	1,119	
P 5	BOB	6,832	24.4	14.6	468	1,119	
P 6	BOB	6,832	24.4	14.6	468	1,119	

ASSUME FIRE IN I3 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF I2 SHELL				COMMENT
Product Contribution m3			6,832	Full inventory of largest tank
Bund Surface Area m2	4,952			Area of bund floor
Pool Fire Surface Area m2	5,420			Bund floor plus ruptured tank footprint
Foam Contribution m3	5,420	m2 @ 8l/min/m2 for 30 mins	1,301	As per specification
Cooling Water I2 m3	560	m2 @ 2l/min/m2 for 6 hours	403	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	5,887	m2 @ 65mm	383	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**8,918**	

BUND HEIGHT m	2.10	
BUND VOLUME	12,363	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**


BUND BU-5F
P-11
GASOLINE
P-10
GASOLINE
P-9
GASOLINE

BUND NUMBER BU-5F

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
P 9	Gasoline		Floating	12.8				
	Adjacent Tanks							
	P1	Isomerate	Floating	21.3	10.0	70.5	YES	*Recommended distance was originally 30'
	P4	BOB	Floating	24.4	10.0	19.3	YES	This converts to 9.14m, but was rounded
	P10	Gasoline	Floating	15.2	10.0	9.1	NO*	up to 10m when guidance was revised in SI units.
P 10	Gasoline		Floating	12.8				
	Adjacent Tanks							
	P9	Gasoline	Floating	15.2	10.0	9.1	NO*	
	P11	Gasoline	Floating	15.2	10.0	9.1	NO*	
P 11	Gasoline		Floating	12.8				
	Adjacent Tanks							
	P10	Gasoline	Floating	15.2	10.0	9.1	NO*	
	P5	BOB	Floating	24.4	10.0	18.9	YES	

BUND NUMBER BU-5F

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
P 9	Gasoline	2,335	15.2	12.8	181	611	
P 10	Gasoline	2,335	15.2	12.8	181	611	
P 11	Gasoline	2,335	15.2	12.8	181	611	

ASSUME FIRE IN I3 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF I2 SHELL				COMMENT
Product Contribution m3			2,335	Full inventory of largest tank
Bund Surface Area m2	1,667			Area of bund floor
Pool Fire Surface Area m2	1,848			Bund floor plus ruptured tank footprint
Foam Contribution m3	1,848	m2 @ 8l/min/m2 for 30 mins	444	As per specification
Cooling Water I2 m3	306	m2 @ 2l/min/m2 for 6 hours	220	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	2,030	m2 @ 65mm	132	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**3,131**	

BUND HEIGHT m	2.40	
BUND VOLUME	4,872	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**

APPENDIX 6

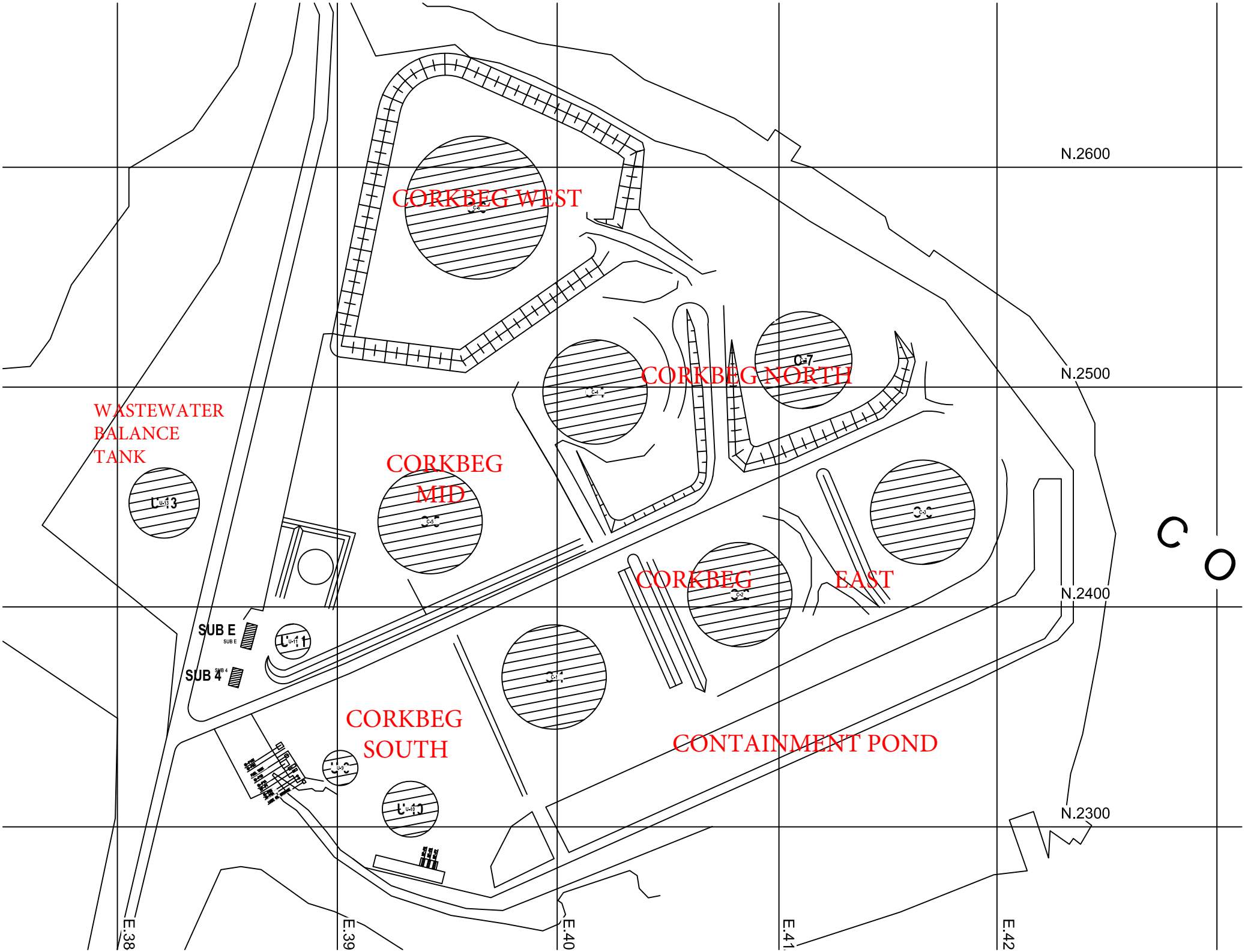
CORKBEG ISLAND

TANK FARM CALCULATIONS

Separation Distances

Bund Calculations

FWA Tool


CORKBEG WEST
CORKBEG NORTH
WASTEWATER
BALANCE
TANK
CORKBEG
MID
CORKBEG
EAST
SUB E
SUB 4
CORKBEG
SOUTH
CONTAINMENT POND
N.2600
N.2500
N.2400
N.2300
E.38
E.39
E.40
E.41
E.42

IOWR CORKBEG CRUDE OIL TANK BUND FIREWATER RETENTION CALCULATIONS

BUND	PRODUCT m3	FOAM m3	COOLING WATER m3	RAIN WATER m3	TOTAL FW m3	CAPACITY m3	OVERSPILL m3
SOUTH	1,288	746	198	234	2,466	6,500	CONTAINED
EAST	26,296	7,345	815	1,331	35,787	0	35,787
NORTH	26,240	1,767	408	589	29,004	4,532	24,473
MID	25,454	1,400	0	379	27,233	2,916	24,317
WEST	53,232	2,411	0	653	56,295	28,123	28,172

BUND NUMBER CORKBEG SOUTH

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
U-9	Slops		Cone	7.3				
	Adjacent Tanks							
	U10	Ballast Water	Cone	14.0	15.0	15.2	YES	Non-flammable
	C1	Crude Oil	Floating	46.5	10.0	47.7	YES	
U-10	Ballast Water		Cone	14.0				Non-flammable
	Adjacent Tanks							
	U9	Slops	Cone	7.3	15.0	15.2	YES	
	C1	Crude Oil	Floating	46.5	10.0	47.7	YES	

BUND NUMBER CORKBEG SOUTH

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
U-9	Slops	1,288	15	7.3	177	344	
U-10	Ballast Water	6,891	25	14	491	1,100	Non-flammable

ASSUME FIRE IN U-9 (ONLY FLAMMABLE TANK), WITH FULL CONTENTS AND TANK RUPTURE
COOLING WATER APPLIED TO 25% OF U-10 SHELL

				COMMENT
Product Contribution m3			1,288	Full inventory of largest flammable tank
Bund Surface Area m2	2,932			Area of bund floor
Pool Fire Surface Area m2	3,109			Bund floor plus ruptured tank footprint
Foam Contribution m3	3,109	m2 @ 8l/min/m2 for 30 mins	746	As per specification
Cooling Water I2 m3	275	m2 @ 2l/min/m2 for 6 hours	198	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	3,600	m2 @ 65mm	234	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**2,466**	

BUND HEIGHT m	2.40	
BUND VOLUME	6,500	
OVERSPILL TO RETENTION SYSTEM m3		**Contained**

BUND NUMBER CORKBEG EAST

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
C-1	Crude Oil		Floating	46.5				
	Adjacent Tanks							
	C2	Crude Oil	Floating	46.5	15.0	44.9	YES	
	C5	Crude Oil	Floating	46.5	15.0	39.8	YES	
	U10	Ballast Water	Cone	14.0	15.0	47.7	YES	
C-2	Crude Oil		Floating	46.5				
	Adjacent Tanks							
	C1	Crude Oil	Floating	46.5	15.0	44.9	YES	
	C3	Crude Oil	Floating	46.5	15.0	43.7	YES	
	C4	Crude Oil	Floating	46.5	15.0	63.0	YES	
C-3	Crude Oil		Floating	46.5				
	Adjacent Tanks							
	C2	Crude Oil	Floating	46.5	15.0	39.2	YES	
	C7	Crude Oil	Floating	46.5	15.0	43.7	YES	

BUND NUMBER CORKBEG EAST

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
C-1	Crude Oil	26,296	46.5	15.5	1,698	2,265	
C-2	Crude Oil	26,296	46.5	15.5	1,698	2,265	
C-3	Crude Oil	26,296	46.5	15.5	1,698	2,265	

ASSUME FIRE IN C-2 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF SHELLS OF C-1 AND C-3				COMMENT
Product Contribution m3			26,296	Full inventory of largest tank
Bund Surface Area m2	12,755			Area of bund floor
Pool Fire Surface Area m2	14,453			Bund floor plus ruptured tank footprint
Foam Contribution m3	14,453	m2 @ 8l/min/m2 for 30 mins	3,469	As per specification
Cooling Water I2 m3	1,132	m2 @ 2l/min/m2 for 6 hours	815	Applied to 25% of adjacent tank shells area
Rainwater Contribution m3	16,152	m2 @ 65mm	1,050	Based on 24 hour storm with 10 year return
Pond Surface Area m2	4,320			
Pond Foam Contribution m3	4,320	m2 @ 8l/min/m2 for 30 mins	3,876	As per specification
Pond Rainwater Contribution m3	4,320	m2 @ 65mm	281	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**35,787**	

BUND HEIGHT m	0.00	
BUND VOLUME	0	
OVERSPILL TO RETENTION SYSTEM m3		**35,787**

BUND NUMBER CORKBEG NORTH

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
C-4	Crude Oil		Floating	46.5	15.0			
	Adjacent Tanks							
	C2	Crude Oil	Floating	46.5	15.0	63.2	YES	
	C5	Crude Oil	Floating	46.5	15.0	44.7	YES	
	C6	Crude Oil	Floating	46.5	15.0	42.0	YES	
	C7	Crude Oil	Floating	46.5	15.0	47.0	YES	
C-7	Crude Oil		Floating	46.5				
	Adjacent Tanks							
	C3	Crude Oil	Floating	46.5	15.0	39.2	YES	
	C4	Crude Oil	Floating	46.5	15.0	47.0	YES	

BUND NUMBER CORKBEG NORTH

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
C-4	Crude Oil	26,240	46.5	15.5	1,698	2,265	
C-7	Crude Oil	24,133	46.5	15.5	1,698	2,265	

ASSUME FIRE IN I 12 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF I 11 AND I 13 SHELLS				COMMENT
Product Contribution m3			26,240	Full inventory of largest tank
Bund Surface Area m2	5,666			Area of bund floor
Pool Fire Surface Area m2	7,365			Bund floor plus ruptured tank footprint
Foam Contribution m3	7,365	m2 @ 8l/min/m2 for 30 mins	1,767	As per specification
Cooling Water C-7 m3	566	m2 @ 2l/min/m2 for 6 hours	408	Applied to 25% of adjacent tank shell area
Rainwater Contribution m3	9,063	m2 @ 65mm	589	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**29,004**	

BUND HEIGHT m	0.50	
BUND VOLUME	4,532	
OVERSPILL TO RETENTION SYSTEM m3		**24,473**

BUND NUMBER CORKBEG MID

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
C-5	Crude Oil		Floating	45.7				
	Adjacent Tanks							
	C1	Crude Oil	Floating	46.5	15.0	39.8	YES	
	C4	Crude Oil	Floating	46.5	15.0	44.7	YES	

BUND NUMBER CORKBEG MID

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
C-5	Crude Oil	25,454	45.7	15.5	1,641	2,226	

ASSUME FIRE IN P 2 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF P 1 AND P 3 SHELLS				COMMENT
Product Contribution m3			25,454	Full inventory of largest tank
Bund Surface Area m2	4,191			Area of bund floor
Pool Fire Surface Area m2	5,832			Bund floor plus ruptured tank footprint
Foam Contribution m3	5,832	m2 @ 8l/min/m2 for 30 mins	1,400	As per specification
Cooling Water I2 m3	0	m2 @ 2l/min/m2 for 6 hours	0	No other tank in bund requiring cooling
Rainwater Contribution m3	5,832	m2 @ 65mm	379	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**27,233**	

BUND HEIGHT m	0.50			
BUND VOLUME	2,916			
OVERSPILL TO RETENTION SYSTEM m3			**24,317**	

BUND NUMBER CORKBEG WEST

TANK NO.	CONTENTS		ROOF TYPE	DIAMETER m	SEPARATION DISTANCE REQUIRED m	SEPARATION DISTANCE ACTUAL m	HSG 176 COMPLIANT Y/N	COMMENT
C-6	Crude Oil		Floating	66.2				
	Adjacent Tanks							
	C4	Crude Oil	Floating	46.5	15.0	42.1	YES	

BUND NUMBER CORKBEG WEST

TANK NO.	CONTENTS	VOLUME m3	DIAMETER m	HEIGHT m	ROOF AREA m2	SHELL AREA m2	COMMENT
C-6	Crude Oil	53,232	66.2	15.5	3,442	3,224	

ASSUME FIRE IN P 7 (LARGEST TANK), WITH FULL CONTENTS AND TANK RUPTURE COOLING WATER APPLIED TO 25% OF P 8 SHELL				COMMENT
Product Contribution m3			53,232	Full inventory of largest tank
Bund Surface Area m2	6,602			Area of bund floor
Pool Fire Surface Area m2	10,044			Bund floor plus ruptured tank footprint
Foam Contribution m3	10,044	m2 @ 8l/min/m2 for 30 mins	2,411	As per specification
Cooling Water I2 m3	0	m2 @ 2l/min/m2 for 6 hours	0	No other tank in bund requiring cooling
Rainwater Contribution m3	10,044	m2 @ 65mm	653	Based on 24 hour storm with 10 year return
TOTAL FIREWATER TO BE RETAINED m3			**56,295**	

BUND HEIGHT m	2.80			
BUND VOLUME	28,123			
OVERSPILL TO RETENTION SYSTEM m3			**28,172**	

APPENDIX 7

EXTRACT FROM CIRIA

REPORT C736

4.5 SUMMARY OF RETENTION CAPACITY RECOMMENDATIONS

In the absence of any regulatory specific recommendations, such as facilities that fall within the scope of the OSR or COMAH containment policy, Table 4.8 summarises the guidance on containment capacity requirements and the process for estimating containment capacity is shown by Figure 4.3.

Table 4.8 Summary of retention capacity recommendations

Factor to be considered	Local containment capacity recommendations	Remote and combined system capacity recommendations
Primary storage capacity (ie possible storage inventory) Note this may be limited by the credibility of the scenario and need not necessarily result in a complete loss of inventory	Capacity at least 100% of primary capacity for single tank installations. Capacity based on risk assessment based on credible scenario for multi-tank installation taking into account tertiary containment provision.	Capacity at least 100% of primary capacity. Include capacity of all primary tanks in multi-tank installations.
Rainfall	For uncovered bunds provide sufficient freeboard for 10% AEP rainfall for: ■ 24-hour ■ the duration of the incident, plus ■ eight days (or other period appropriate to the particular site circumstances).	As for local containment capacity recommendations plus an allowance for rain falling directly on to remote containment and areas of the site draining into it.
Firefighting and cooling water	No allowance specifically for firefighting water. Addressed via tertiary containment. Allowance for cooling water, or procedures for re-circulating cooling water, to be agreed with the Fire and Rescue Service.	Allowance for extinguishing and cooling water delivered through fixed and non-fixed installations based a credible scenario agreed with regulators and the Fire and Rescue Service. Development of the scenario can be informed with reference to the methods contained in ISO/TR 26368:2012 and by BS EN 12845.2004.
Firefighting agents (foam)	Allow freeboard height of containment required for primary inventory and rainwater of not less than 100 mm.	Allow freeboard height of containment required for primary inventory and rainwater of not less than 100 mm
Dynamic effects	Allow freeboard as set out in Box 4.5. For high hazard situations, consider impact of overtopping of the containment resulting from a catastrophic failure of the primary containment. Consider remote secondary or tertiary containment.	More appropriate means of containing inventory following a catastrophic failure of the primary containment.

The designer of the containment system should take into account the probability of a number of events occurring simultaneously. The worst case scenario for containment is represented by the design return period rainfall (eg the rainfall that is likely to occur, eg once in 10 years) coinciding with the sudden and total loss of primary containment and a fire involving applied firefighting water. At low risk sites or sites where it can be demonstrated that the probability of a simultaneous occurrence of events is sufficiently low, it may be possible to apply less stringent capacity requirements. Such relaxations should be subject to the designer's and site operator's discretion and the agreement of the various regulatory bodies in the light of the particular circumstances.

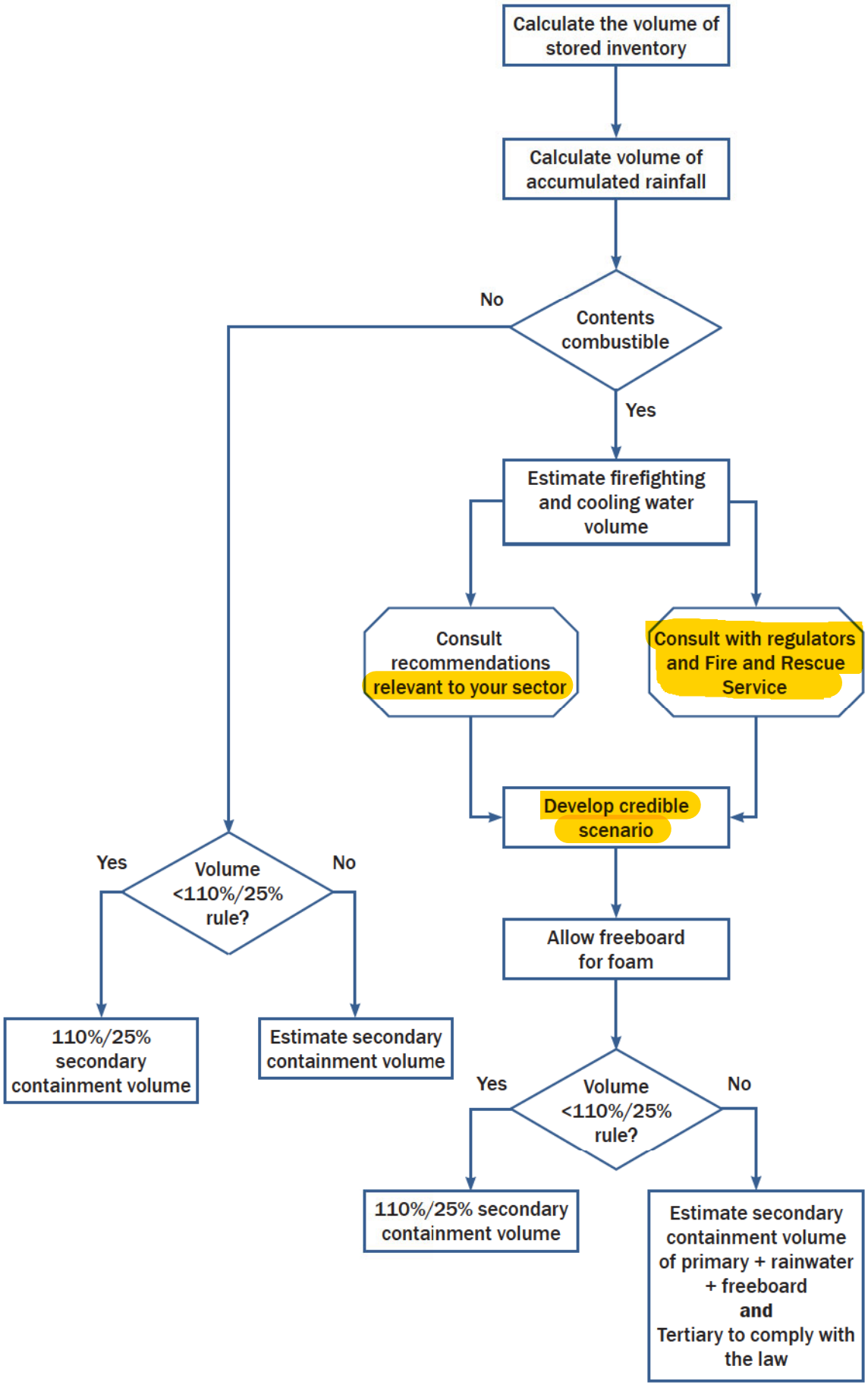


Figure 4.3 *Process for estimating containment capacity*