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Individual
Environmental Risk Analysis

Sector: Storage of Substances

TECHNICAL COMMISSION FOR THE PREVENTION AND REMEDIATION
OF ENVIRONMENTAL DAMAGES

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INDEX

I. INTRODUCTION

The purpose of this study is to carry out an Environmental Risk Analysis aimed at a particular operator in the logistics sector, in order to illustrate how to carry out a specific environmental risk analysis in the event that the sector does not have a sector-specific tool for this purpose - that is to say, when at a sectoral level neither a Rate Table nor a Model Environmental Risk Report (MIRAT) nor a Methodological Guide has been drawn up.

The Ministry of Agriculture, Food and Environment, now Ministry for the Ecological Transition and the Demographic Challenge (MITERD), in collaboration with the Spanish Confederation of Business Organizations (CEOE) were responsible for choosing this facility.

According to *Royal Decree 475/2007, of 13 April, which approves the National Classification of Economic Activities 2009 (CNAE, 2009)*, the facility belongs to the sector included in division 52, section H (Storage and activities related to transport) in CNAE class 5210 -warehousing and storage-.

This Individual Environmental Risk Analysis contemplates the activities carried out at the facility during the operation and exploitation phase, excluding the risks associated with the design and construction of the installations.

It is also worth mentioning that transport has been excluded from the study as this is an independent activity which is assumed to be subcontracted to third parties.

The activity carried out by the facility under study consists of the long-term storage of third-party substances.

The installation remains in operation 365 days/year for 24 hours/day with no shut down for maintenance.

The facility is located in a coastal area, which allows goods to be loaded and unloaded by ship from the quay. Given the location of the plant, in the event of an accident the resource most likely to be affected will be seawater; however, this will be the subject to a more detailed analysis in the following sections.

As this case study is intended to illustrate the methodology, the substances are referred to as Substance A, Substance B, etc. In addition, a small number of substances and areas have been selected in order not to overcomplicate the example. *The data (e.g. volume of storage or extinguishing water) and the characteristics of the environment in the area in which the facility is located (conditioning the resources potentially affected) and of the substances involved in the accident scenarios have also been selected for illustrative purposes.*

Table 1. Clarification on the data used for the realisation of this case study. Source: Own elaboration.

II. DESCRIPTION OF THE ACTIVITY AND THE FACILITY

II.1. Applicable Regulations

II.1.1 Environmental Liability Law

Firstly, with regard to the Environmental Liability normative, the following regulations are applicable:

- Environmental Liability Act, Law 26/2007, of 23 October.
- Royal Decree 2090/2008, of 22 December, approving the Regulation of partial development of Law 26/2007, of 23 October, on Environmental Liability.
- Law 11/2014, of 3 July, amending the Environmental Liability Act, Law 26/2007, of 23 October.
- Royal Decree 183/2015, amending the Regulation of Partial Development of Environmental Liability Act, Law 26/2007, of 23 October, approved by Royal Decree 2090/2008, of 22 December.
- UNE 150008 Standard on Environmental Risk Analysis and Assessment.

In particular, the facility under study is subject to Law 26/2007, of 23 October, on Environmental Liability, under the first section of Annex III:

*"*The operation of facilities subject to authorisation in accordance with *Law 16/2002, of 1 July, on Integrated Pollution Prevention and Control (*IPPC Law*)*.

It also includes any other activities and establishments subject to the scope of application of *Royal Decree 840/2015, of 21 de September, which approves measures to control the risks inherent to serious accidents involving hazardous substances*".

It has been assumed that the facility under study acts as an intermediate storage site for substances for certain companies. Given the nature of these substances, they would be classified as hazardous substances in accordance with RD 8*40/2015*.

Due to the fact that it is subject to the SEVESO standards, this facility is undoubtedly already included in Annex III of Law 26/2007, of 23 October; however, it should be pointed out that its activity would be covered also by the following sections:

- Point 5 of Annex III - "*All discharges into inland waters and territorial sea subject to prior authorisation in accordance with the provisions of Law 22/1988, of 28 July, on Coasts and applicable regional legislation*" -as a consequence of the discharge of treated wastewater resulting from the process into the sea.
- Section 8 of Annex III refers to the manufacture, use, storage, processing, bottling and release into the environment, and the *on-site* transport of dangerous substances and preparations. Substances and preparations with explosive, oxidising, flammable, corrosive, environmentally hazardous, etc. properties are considered dangerous.

Finally, it is worth noting that, in accordance with section 7 of Royal Decree 183/2015, which amends *RD 2090/2008, approving the regulation of partial development of Law 26/2007, on Environmental Liability,* this facility would be subject to the obligation to provide a financial security whenever its risk analysis showed that it might generate environmental damage to a value of more than Eur 300,000. This limit rises to Eur 2,000,000 in the event that the facility is permanently attached to an environmental certification system (ISO 14001 or EMAS).

II.1.2 Other environmental legislation

Other environmental legislation that may apply is listed below.

A. Waters

- Royal Legislative Decree 1/2001, of 20 July, approving the revised text of the Water Law.
- Royal Decree 907/2007 of 6 July 2007, approving the Hydrological Planning Regulations.
- Order ARM/2656/2008, of 10 September, approving the Hydrological Planning Instruction. Modified by Order ARM, of 11 May, which modifies Order ARM, of 10 September, approving the Hydrological Planning Instruction.
- Law 2/2013, of 29 May, on the protection and sustainable use of the coast and amending of Law 22/1988, of 28 July, on Coasts.

B. Waste

- Royal Decree 833/1988 of July 20, 1988, which approves the Regulation for the execution of Law 20/1986, Basic Law on Toxic and Hazardous Waste.
- Law 22/2011, of 28 July, on waste and contaminated soils.

C. Soils

- Royal Decree 9/2005, of 14 January, which establishes the list of potentially soil-polluting activities and the criteria and standards for the declaration of contaminated soils.

D. Products and materials

- Royal Decree 379/2001, of 6 April, approving the Regulation on the storage of chemical products and its complementary technical instructions MIE-APQ-1, MIE-APQ-2, MIE-APQ-3, MIE-APQ-4, MIE-APQ-5, MIE-APQ-6 and MIE-APQ-7.

E. Industrial safety

- Royal Decree 400/1996, of 1 March 1996, which lays down the provisions for the application of European Parliament and Council Directive 94/9/EC on equipment and protective systems intended for use in potentially explosive atmospheres.
- Royal Decree 1196/2003, of 19 September, approving the Basic Civil Protection Directive for the control and planning against the risk of serious accidents involving hazardous substances.
- Royal Decree 2267/2004, of 3 December, approving the fire safety regulations in industrial establishments.
- Royal Decree 393/2007, of 23 March, approving la Basic Self-Protection Regulation for centres, establishments and facilities involved in activities that may give rise to emergency situations.

F. Other legislation

- Royal Decree 1254/1999 of 16 July 1999, approving measures to control the risks inherent to serious accidents involving hazardous substances.

II.2. Environmental Certification Systems

Although environmental certification systems are not compulsory, they have been introduced here since, according to Article 28 of Law 26/2007, of 23 October, on Environmental Liability, for those operators that are adhered to the environmental management system UNE-EN ISO 14001 in force or to the Community Eco-Management and Audit Scheme (EMAS), the limit value above which they will be obliged to provide a financial security, increases from EUR 300,000 to EUR 2,000,000.

The facility under study is adhered to both environmental certification systems. Therefore, it will only be obliged to provide a financial security for environmental liability in the event that the value of the damage exceeds EUR 2,000,000.

II.3. General outline of the production process

The activity carried out by the facility is the intermediate storage of chemical substances for third parties. In other words, the plant does not carry out any process or treatment of the substances it receives. It only limits itself to storing them in optimum conditions (so that the substances do not lose their properties and so that there can be no leaks that could lead to environmental damage). These storages are generally long-term, as a reserve for the client companies.

II.3.1 Main equipment

A. Tank loading dock

The plant has a loading/unloading system for tank trucks, equipped with two loading islands, each one with a weighing system. This system controls the filling of the tanks and stops the filling when the tanks reach the pre-determined quantity. The filling flow rate is approximately 30 m3/h.

This tank loading bay is used for both the arrival at the plant of substances to be stored and their departure when required by a customer.

The loading bay is equipped with fire and spill detectors, emergency push buttons and a fire protection system.

B. Ship loading dock

In addition, as the facility is located in a port area, it is able to receive substances for storage by ship and send them to the destination customers by the same route. The filling flow rate is approximately 300 m3/h.

As in the previous case, the ship loading/unloading area is equipped with fire and spillage detectors, emergency buttons and a fire protection system.

II.3.2 Auxiliary systems

A. Water System

The plant receives water from the public supply network. The circuit is divided into two branches, one for drinking water in the plant (distribution in buildings, safety showers, eyewashes and other uses of drinking water) and the other for service water, which is mainly used for the fire-fighting water circuit. There is a freshwater storage tank for the fire-fighting system with a capacity of 150 m3.

B. Electrical system

The electrical system of the plant includes both the substation for the electrical connection to the terminal and the electrical substation with cabinets, equipment and wiring, necessary to supply electrical power to the terminal receivers and two transformers.

II.4. Prevention and avoidance measures

This section briefly mentions prevention, containment and extinguishing measures. These measures, in the event of an accident, could prevent or mitigate a possible damage to the receiving environment.

The following table shows the main existing measures in the different areas of the installation as well as those measures that are global (common to the whole plant).

PREVENTION AND AVOIDANCE MEASURES BY ACTIVITY				
Zone code	**Zone**	**Preventive measures**	**Containment measures**	**Extinguishing measures**
1	Tank loading dock	- Loading and unloading protocol - Fire detectors	- Mobile spill collection system.	- Fire extinguishers and dry powder.
2	Ship loading dock	- Loading and unloading protocol - Fire detectors	- Mobile spill collection systems.	- Fire extinguishers and dry powder. - Flood.
3	Storage park	- Protocol for the storage of substances - Level detector and alarm - Fire detection with alarm	- Buckets. - Emergency spill collection kits.	- Fire extinguishers and dry powder. - Deluge
4	Electrical substation (including emergency generator)	- Level detector and alarm - Fire detection with alarm	- Waterproofed floor with slope towards a watertight pit in the transformers. - Buckets. - Loading and unloading mouth inside the bucket.	- Fire extinguishers and dry powder.
Global measurements (common to the whole installation)		- Automated operations - Option of manual activation of measures and closing of valves. - Emergency telephones and push buttons - Fire and spill detectors - Training - Drills - Other prevention systems	- Paving. - Tightness tests. - Crack inspection.	- Fire system piping network. - Fresh water fire tank.

The prevention, containment and extinguishing measures implemented by the plant to prevent spills and control fires indicated in the previous table will be developed in greater detail below, indicating in which specific areas they are located:

- Global measures

As a general rule, the different operations carried out in the installation are automated, reducing the possibility of failure. In addition, most of the extinguishing measures can be activated manually, should the automatic activation fail. The valves can be closed manually or automatically. Furthermore, in the event of a leak, the direction of flow can be changed or the leaking section can be isolated.

Emergency telephones and pushbuttons are distributed throughout the facility, in order to ensure that the necessary measures to neutralise or reduce the effects of an initiating event are implemented as soon as possible. In addition, personnel have received training, especially in fire prevention methods, so they are familiar with the protocol for action in the event of an emergency. To supplement this training, emergency exercises are carried out periodically.

The entire plant is paved and the pavement is in good condition. In addition, substances that could contaminate natural resources are contained in APQ-compliant tanks, which are inspected frequently to prevent the appearance of cracks that would be repaired if necessary.

Periodic leak tests are carried out at the plant to confirm the correct condition of the equipment, tanks and pipes.

The facility has fire and spillage detectors in the different areas depending on the intrinsic risk associated with each area as a result of the processes carried out. In addition, fire protection measures include a freshwater storage tank with a capacity of 150 m3 and a network of fire protection pipes distributed throughout the plant.

In the event of an anomaly being detected from the control room, the fire water can also be directly activated from the control room.

There are no shutdowns for maintenance at the installation; The substances are stored according to demand and the plant is dimensioned so that it always remains active.

Finally, it should be noted that electronic equipment is not permitted in the process area and that antistatic gowns and footwear must be worn. This prevents the possible generation of sparks and the consequent risk of explosion/fire.

- Tanker truck loading dock

There is a prevention and action chest in this area to contain and prevent any spills that may occur during the loading/unloading of tanks.

It is also equipped with fire detection systems. In the event of fire, extinction methods include water from the freshwater tank mentioned above (150 m3), dry powder and fire extinguishers.

- Ship loading dock

This area is equipped with fire detectors. In addition, a loading and unloading protocol exists to minimise the possibility of accidents.

Additionally, the area has mobile chests containing material for the containment and cleaning of spills with floating barriers, etc.

Emergency buttons can be used to activate the extinguishing measures in the event that they are not activated automatically.

In addition, it is equipped with an automatic deluge system, which would be activated in the event of such an initiating event. This deluge is designed with a flow rate of 500 m3/h for 3 hours. Dry powder and fire extinguishers can also be used for extinguishing.

- Storage park

Spill containment and clean-up kits are available.

There is a protocol for the storage of substances in order to avoid incompatibilities between substances and possible chain or synergistic effects in the event of an accident. All tanks are equipped with level detectors with alarms that permit a spill to be identified as fast as possible.

This area is equipped with fire detection systems with an alarm and automatic deluge system, which would be activated in the event of a fire. This deluge is designed with a flow rate of 750 m3/h for 3 hours. Dry powder and fire extinguishers can also be used for extinguishing.

- Electrical substation

This area has a waterproofed floor sloping towards a watertight pit.

The tanks in this area have a level detector, and the control panel also warns if the tanks are overfilled or filled incorrectly. As an additional safety measure, the loading and unloading mouth is inside the tank.

The area has a fire detection system with alarm, and dry powder and fire extinguishers can be used for extinguishing.

II.5. Potentially affected natural resources

In relation to the provisions of Law 26/2007, of 23 October, this report must indicate which natural resources could be affected by possible damage.

In this case, following cross-referencing with geographic information systems (GIS) of the hypothetical location of the facility with the base coverages of natural resources, it is concluded that the natural resources potentially affected would be, as a general rule, seawater (and, where appropriate, the seabed) and marine species.

Possible damage to surface water has been ruled out as it has been confirmed (also by means of GIS) that there are no river courses within a radius of 500 metros. Likewise, possible damage to groundwater bodies has been ruled out, given that the nearest bodies of water are located about two kilometres away and are under soil with a low permeability.

Finally, possible damage to the soil is ruled out as the land is urban.

III. METHODOLOGY FOLLOWED FOR THE ENVIRONMENTAL RISK ANALYSIS

Article 33 of the Regulation for partial development of Law 26/2007 establishes environmental risk analysis as the basic instrument for establishing the amount of the financial security. This introduces each operator’s obligation to evaluate their risks in order to estimate the financial security to be provided.

The preparation of this environmental risk analysis must in any case be based on the UNE150008 standard or other equivalent standard. This Individual Risk Analysis has been carried out based on the methodological scheme indicated in the UNE150008:2008 standard.

The following subsections briefly describe the different phases into which this individual risk analysis has been structured, together with the objectives. These phases are developed in detail in sections *IV* to *X.*

III.1. Zoning of the installation

Prior to identifying the initiating events and accident scenarios, it was necessary to carry out a zoning of the facility. Only those areas of the facility that imply a certain degree of risk were considered. Consequently, areas without any relevant hazard were eliminated.

III.2 Identification of initiating events and their causes

Once the zoning of the installation had been completed in order to identify the risks of each of the zones, the sources of danger existing in each zone were identified. Based on the sources of danger, the initiating events were determined.

Initiating events are defined as physical events that can generate an incident or accident depending on their evolution in space and time.

III.3 Conditioning factors

After determining the initiating events, the conditioning factors were determined. A conditioning factor is understood to be that which, once the initiating event has occurred, and depending on the sequence of events, can act as an element that enhances or mitigates the damage, causing the environmental consequences of the initiating events to be greater or lesser.

The conditioning factors constitute the second part of the event trees, in accordance with the scheme set out in the UNE 150008 standard. They enable the identification of the accident scenarios associated with the activity performed at the facility under study.

III.4 Accident scenarios

Once the necessary parameters have been obtained for the complete construction of the event trees (initiating events and conditioning factors), the accident scenarios are perfectly identified.

For each of the initiating events and conditioning factors that intervene in each of the event trees, their probability of occurrence and associated volume of spillage is identified.

In addition, for each of these scenarios, the natural resources that may be affected are identified for the application of the Environmental Damage Index (IDM).

III.5 Selection of the reference scenario

Once the accident scenarios have been identified, for those with a probability of occurrence and an associated volume other than zero, the IDM is applied to select the reference scenario, in application of the new methodology introduced by Royal Decree 183/2015, which modifies the Regulations for the partial development of Law 26/2007 on Environmental Liability.

III.6 Quantification and monetisation of the reference scenario

Once the reference scenario is selected, the steps for determining the financial security are as follows:

i) Quantification of the environmental damage generated in the selected scenario.

   The environmental damage must be quantified in accordance with the provisions of article 11 and following of the Regulations for the partial development of the law. This operation involves determining the extent, intensity and time scale of the damage.

ii) Monetisation of the environmental damage generated in this reference scenario, the value of which will be equal to the cost of the primary remediation project.

III.7 Determination of the amount of Financial Security

The cost of the primary remediation obtained as a result of monetisation is the amount proposed for the Financial Security, which will be mandatory whenever it exceeds the value of EUR 300,000. This limit increases to EUR 2,000,000 in the event that the installation, as in this case, is permanently and continuously adhered to an environmental management and audit system (EMAS) or to the ISO 14001 environmental management system in force.

If, according to the above-mentioned criterion, there is an obligation to provide financial security, the cost of damage prevention and avoidance measures should be added to the primary remediation cost. This cost can be estimated using two options:

a) Apply a percentage to the total amount of the compulsory security.

b) Estimate these prevention and avoidance costs through a specific assessment within the environmental risk analysis.

The regulations indicate that in any case the amount of the expenses for the prevention and avoidance of damage must be at least ten percent of the amount of the financial security (cost of the primary remediation), calculated in the previous phases.

IV. IDENTIFICATION OF INITIATING EVENTS AND ACCIDENT SCENARIOS

The methodology chosen for the analysis and evaluation of environmental risk is the UNE150008:2008 standard, which establishes two distinct stages for risk analysis. The first involves the definition of the causal scenarios that give rise to the initiating event, and the second, the determination of the consequential scenarios.

In accordance with the methodology, in order to identify the most likely causal scenarios, the facility has been zoned according to its potential risk. This enables the identification of the most relevant risk sources that might trigger each initiating event.

IV.1 Zoning

The following risk areas have been identified at the facility under study:

1. Tank loading dock.
2. Ship loading dock.
3. Storage parks.
4. Electrical substation.

IV.2 Risk Sources

The risk sources identified for each risk zone are shown below. It is important to mention that in most cases the risk sources are the substances stored. This is due to the danger of spillage associated with the substances and because of the possibility of generating explosive atmospheres or fires. However, certain elements of the installation itself may also entail an associated risk (e.g. short-circuit).

The following table shows the substances involved and/or generated or other processes that may be risk sources for each area of the plant.

RISK SOURCES		
Zone code	**Zone**	**Risk Sources**
1	Tank loading dock	- Substance A - Substance B
2	Ship loading dock	- Substance C
3	Storage park	- Substance A - Substance B - Substance C
4	Electrical substation, transformers and emergency generator	- Substance C - Substance D - Short circuit

Table 2: Sources of danger.

Source: Own elaboration.

IV.3 Initiating events

The previous section identified the possible risk sources for each of the areas of the facility under study. On the basis of this information, the causal scenarios determining the existence of the relevant initiating events at the facility were identified. These initiating events may be defined as those physical events that have been identified on the basis of a causal analysis, and that might generate an incident or accident depending on their evolution over space and time. It should be noted that, as indicated above, in this case the identification of the initiating event is carried out prior to that of its causes - a common procedure in the case of very common and well-known events or those that may simply be intuitive.

In the risk analysis, based on the sources of danger identified, three types of initiating events have been detected:

1. Spill initiating event
2. Explosion initiating event
3. Fire initiating event

The following table provides information on the most common causes of each of the types of initiating events considered for the installation (spill, explosion and fire).

IDENTIFICATION OF THE MOST COMMON CAUSES OF EACH INITIATING EVENT	
Initiating event	**Causes**
Spill	Overfilling Insufficient containment basin Loading/unloading operations Detection and alarm system failure Human error Material failure
Explosion	Explosive atmospheres Human error
Fire	Flammable substances Detection and alarm system failure Spark Short circuit Human error

Table 3: Most common causes of each initiating event.

Source: Own elaboration.

Therefore the following causes of a spill are defined:

- Overfilling: caused by overfilling with the storage elements, which leads to overflowing.
- Insufficient containment: when the capacity of the containment basins is less than that of the tanks or reservoirs they house.
- Failures in loading/unloading operations: this refers to the poor execution of the loading and unloading process. This may be due to different reasons such as: human error (poor hose connection), hose breakage, hose leakage or mechanical impact (shock impacts caused, for example, by the collision of vehicles against storage elements).
- Failure of detection and alarm systems that prevents prompt action in the event of a possible spill.
- Human error: errors of the installation personnel due to insufficient training, lack of vigilance, distractions, etc.
- Material failure: deterioration of a material due to the action of external agents, such as pore presence, breakage, etc. Increased pressure in pipes or machinery can also lead to the appearance of cracks that cause leaks or spills.

The following possible causes are defined for the explosion initiating event:

- Explosive atmospheres: an explosive atmosphere is defined as a mixture with air, under normal atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts, in which, after ignition, combustion spreads to the entire unburned mixture.
- Human error: as mentioned above, this refers to errors made by the workers at the installation as a result of insufficient training, lack of vigilance, distractions, etc.

Finally, the following causes are considered for the fire initiating event:

- Presence of flammable substances in the installation which, when combined with oxygen and a heat source, generate a fire.
- Failure of detection and alarm systems, preventing prompt action in the event of a possible fire.

- Spark in machinery as a result of friction between equipment parts, etc.
- Short circuit in the electrical substation.
- Human error: errors by installation personnel as a result of insufficient training, lack of vigilance, distractions, etc.

The following table shows the initiating events identified for each of the risk zones defined in this document.

INITIATING EVENTS			
Zone code	Zone	Initiating event code	Initiating event
1	Tank loading dock	1	Spillage of substance A in loading/unloading of trucks
		2	Spillage of substance B in loading/unloading of trucks
2	Ship loading dock	3	Spillage of substance C in loading/unloading of ships
3	Storage park	4	Substance A spill from tank
		5	Substance B spill from tank
		6	Substance C spill from tank
		7	Substance A spill from pipeline
		8	Substance B spill from pipeline
		9	Substance C spill from pipeline
4	Electrical substation, transformers and emergency generator	10	Substance C spill from tank
		11	D-substance spill from tank
		12	Fire in electrical substation

Table 4: Initiating events.

Source: Own elaboration.

IV.4 Conditioning factors

Once the initiating events have been identified, it is important to determine the conditioning factors that will play a relevant role. These conditioning factors refer to:

- The human environment
- Installation factors

The conditioning factors taken into account in this individual risk analysis are as follows:

1. Immediate ignition. This conditioning factor considers certain aspects that may favour ignition at the moment of leakage (immediate), i.e. without the gas cloud mixing with the air, in such a way that the fuel and the air are incorporated, by diffusion, into the flame front.
2. Detection and extinction systems. This conditioning factor includes any prevention and avoidance measure that allows the detection of a possible cause of fire in the shortest possible time. In this sense, the installation has flame detectors installed.

It also covers fire extinguishing and fire containment measures, such as fire extinguishers, hydrants or dry powder.

3. Leak containment systems. This conditioning factor brings together the possible containment measures (manual or automatic) that, once the spill has taken place, are able to contain it. Two types of automatic containment measures/systems have been identified:

    A. Buckets

    B. Ponds

    The application of this factor is contemplated, where appropriate, in the case of leaks from tanks or pipes.

4. Delayed ignition. This conditioning factor takes into account the possibility of ignition occurring at a certain distance from the point of escape; depending on the obstacles that the flammable vapour cloud encounters in its path, an explosion or deflagration may occur.

5. Water and spillage management. This conditioning factor takes into account whether in certain operations (e.g. loading and unloading of certain substances), the possibility exists to create a closed circuit in such a way that, in the event of a spillage, it can be contained.

The following table shows the conditioning factors that have been considered for each of the identified initiating events:

CONDITIONING FACTORS APPLIED TO EACH INITIATING EVENT							
Initiating event code	**Initiating event**	**Immediate ignition**	**Flame detection and extinguishing**	**Automatic containment**	**Manual containment**	**Delayed ignition**	**Water management**
1	Spillage of substance A in loading/unloading of trucks	X	X		X	X	
2	Spillage of substance B in loading/unloading of trucks	X	X		X	X	
3	Spillage of substance C in loading/unloading of ships	X	X		X	X	
4	Substance A spill from tank	X	X	X		X	
5	Substance B spill from tank	X	X	X		X	
6	Substance C spill from tank	X	X	X		X	
7	Substance A spill from pipeline	X	X		X	X	
8	Substance B spill from pipeline	X	X		X	X	
9	Substance C spill from pipeline	X	X		X	X	
10	Substance C spill from tank	X	X	X		X	
11	D-substance spill from tank	X	X	X		X	
12	Fire in electrical substation		X				X

Table 5: Conditioning factors applied to each initiating event.

Source: Own elaboration.

IV.5 Calculation of probabilities

In this risk analysis we have opted for a probability calculation based on a quantitative method, i.e. based on specialised literature (e.g. *Purple Book*).

To obtain the probability of occurrence of the accident scenario, we must start from the probability of occurrence of the initiating event, correcting it with the probability of occurrence of the conditioning factors. The following sections show how each of these probabilities has been calculated.

It is worth noting that, given that the purpose of this practical exercise is merely illustrative (not intended to be an exhaustive analysis) in those initiating events that may be due to different causes (each with a different probability), the practical exercise has been simplified by only considering the cause that offers a higher probability of initiating event (since the tree of events is the same, and the probabilities of the conditioning factors are also the same). As an example, the initiating event "Chemical spill in loading/unloading of tanker" may be due to the following causes:

- Human error (bad hose connection)
- Hose breakage
- Hose leakage
- Mechanical impact

Depending on the cause of the initiating event, the probability of occurrence will be different, as shown in the following table:

CAUSES and PROBABILITIES OF THE INITIATING EVENT "SPILL IN LOADING/UNLOADING OF TANKER".			
Initiating event	**Causes**	**Probability**	**Source**
Chemical spill during loading/unloading of tanker	Human error	1,00E-03	TNO 1988
	Hose breakage	4,00E-06	TNO 1999
	Hose leakage	4,00E-05	TNO 1999
	Mechanical impact	1,00E-08	DGPC (1994)

Table 6: Causes and probabilities of the initiating event "Spill in tank loading/unloading".

Source: Own elaboration.

In a real case it would be necessary to analyse which of these causes might occur at the facility under study, and to make as many different trees as initiating events with different probabilities were obtained, or a single tree with a probability of an initiating event including all the possible causes[1]. However, as mentioned above, since this is an illustrative case, it has been simplified by indicating only one initiating event instead of four or as many as might be appropriate in each case.

[1] For the assumption that an initiating event can take place due to three possible causes (A, B and C), the probability of the initiating event due to cause A, or cause B or cause C (it is important to emphasise that it is not necessary for all the causes to occur simultaneously for the initiating event to take place, but that it is sufficient for one of them to occur), would be expressed by the following equation:

$$P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(A \cap C) - P(B \cap C) + P(A \cap B \cap C)$$

IV.5.1 Initiating events

The following table shows how the probability was calculated for each of the initiating events considered in this individual risk analysis.

The table is structured in the following columns:

- Initiating event. Description of the initiating event.
- Initiating event code.
- Calculation of probability, which includes:
  - Calculation method. The mathematical expression used for the calculation of the probability is indicated, if necessary.
  - Data. The data used to solve the equation of the probability calculation are presented.
  - Source. The bibliographic source is shown.
- Result obtained for each initiating event: this is the probability of the initiating event expressed in units of occasions/year.

CALCULATION OF PROBABILITIES OF INITIATING EVENTS					
Initiating Event (SI)	SI Code	Calculation of the probability			Probability of the Initiating Event (occasions/year)
		Calculation method	Data	Source	
Spillage of substance A in loading/unloading of trucks	SI1	1,00E-03	-	TNO (1988)	1,00E-03
Spillage of substance B in loading/unloading of trucks	SI2	1,00E-03	-	TNO (1988)	1,00E-03
Spillage of substance C in loading/unloading of ships	SI3	3.00E-08*h*no. arms	h = 3*15*30 15 loads/year.arm 30 hours/charge 3 arms	TNO (1999)	4,05E-05
Substance A spill from tank	SI4	5,00E-06	-	TNO (1999)	5,00E-06
Substance B spill from tank	SI5	5,00E-06	-	TNO (1999)	5,00E-06
Substance C spill from tank	SI6	5,00E-06	-	TNO (1999)	5,00E-06
Substance A spill from pipeline	SI7	5.00E-07*L(m)	L = 230 m	TNO (1999)	1,15E-04
Substance B spill from pipeline	SI8	5.00E-07*L(m)	L = 150 m	TNO (1999)	7,50E-05
Substance C spill from pipeline	SI9	5.00E-07*L(m)	L = 50 m	TNO (1999)	2,50E-05
Substance C spill from tank	SI10	5,00E-06	-	TNO (1999)	5,00E-06
D-substance spill from tank	SI11	5,00E-06	-	TNO (1999)	5,00E-06
Fire in electrical substation	SI12	3.00E-08*h	h = 24*365	TNO (1999)	8,76E-03

Table 6: Calculation of probabilities of the initiating events.

Source: Own elaboration.

Note: h = operating time (hours); L = length of pipe (meters).

IV.5.2 Accident scenarios

Once the probability of occurrence of the initiating events has been estimated, it is necessary to estimate the probability associated with each of the conditioning factors that apply in each case.

The probability of each accident scenario will result from the combination (product) of the probability of the initiating event that caused it and that of each of the conditioning factors in the tree of events that condition the occurrence of that specific accidental scenario.

The following table shows the bibliographic sources used to calculate the probabilities of the different conditioning factors.

BIBLIOGRAPHIC SOURCES OF THE CALCULATION OF PROBABILITIES OF THE CONDITIONING FACTORS		
Conditioning factor	**Bibliographic source**	**Description of the data used**
Immediate ignition	TNO 1999	Immediate ignition
Flame detection and extinguishing system activation	TNO 1999	Other enforcement systems
Manual containment	TNO 1999	Human error: Operator fails to act
Containment in bucket	F.G., 2009	Passive suppression systems
Delayed ignition	LEES, F.P. (1996)	Delayed ignition (depending on the likelihood of reaching an ignition source)
Containment in water and spill management system	TNO 1999	Other enforcement systems

Table 7: Bibliographic sources of the calculation of probabilities of the conditioning factors.

Source: Own elaboration.

The probability of occurrence associated with each of the conditioning factors applied to the different initiating events is shown below.

CONDITIONING FACTORS APPLIED TO EACH INITIATING EVENT							
Initiating event code	Initiating event	Immediate ignition	Flame detection and extinguishing	Automatic containment	Manual containment	Delayed ignition	Water management
1	Spillage of substance A in loading/unloading of trucks	0.065	0.950		0.999	0.200	
2	Spillage of substance B in loading/unloading of trucks	0.065	0.950		0.999	0.200	
3	Spillage of substance C in loading/unloading of ships	0.065	0.950		0.999	0.200	
4	Substance A spill from tank	0.065	0.950	1.000		0.200	
5	Substance B spill from tank	0.065	0.950	1.000		0.200	
6	Substance C spill from tank	0.065	0.950	1.000		0.200	
7	Substance A spill from pipeline	0.065	0.950		0.999	0.200	
8	Substance B spill from pipeline	0.065	0.950		0.999	0.200	
9	Substance C spill from pipeline	0.065	0.950		0.999	0.200	
10	Substance C spill from tank	0.065	0.950	1.000		0.200	
11	D-substance spill from tank	0.065	0.950	1.000		0.200	
12	Fire in electrical substation		0.950				0.950

Table 8: Conditioning factors applied to each initiating event.

Source: Own elaboration.

IV.6. Calculation of volumes

The volumes are calculated by associating a volume of pollutant released to each of the steps of the event tree. In this way, we start from an initial volume (the one associated with the initiating event) and this volume increases or decreases depending on the different sequence of events generated.

Therefore, the volume that appears in each initiating event or conditioning factor is the volume that, if the event tree were to end at that point, would correspond to the accident scenario. In other words, in each case the corresponding retention volume has already been deducted (e.g. manual containment) or the additional volume released (e.g. water from the extinguishing systems) has been added.

Thus, five types of volume can be distinguished in the event trees:

1. Volume of the initiating event
2. Volume associated with fire-fighting measures
3. Volume associated with manual containment measures
4. Volume associated with automatic containment measures
5. Volume associated with water management and spill control system

A brief explanation of the procedure for estimating each of these volumes is given below.

IV.6.1. Volume of the initiating event.

Depending on the type of initiating event, the associated pollutant release volume is calculated differently.

The following table shows the calculation method associated with each type of initiating event, as well as the specific initiating events for which this methodology has been used and the calculation data common to all the initiating events that follow the same calculation method[2].

[2] These data have been obtained from a panel of experts.

METHOD OF CALCULATING THE VOLUME ASSOCIATED WITH EACH TYPE OF INITIATING EVENT			
Type of initiating event	**Calculation method [3]**	**Common calculation data**	**Initiating events to which it applies**
Spillage in loading/unloading of tankers	V = q x t	q = 30 m3/h t = 10 min	1, 2
Spillage in loading/unloading of ships	V = q x t	q = 300 m3/h t = 10 min	3
Spill from tank	Average filling volume of the maximum capacity tank [4]	Depends on the tank in question	4, 5, 6, 10, 11
Spill from cistern pipe to tank	V = q x t	q = 30 m3/h t = 10 min	7, 8
Spill from ship's pipeline to tank	V = q x t	q = 300 m3/h t = 10 min	9
Fire in electrical substation	--- [5]	---	12

Table 9: Method of calculating the volume associated with each type of initiating event.

Source: Own elaboration.

Finally, the table below shows the volume associated with each initiating event resulting from applying the methods indicated in the table above.

VOLUME ASSOCIATED WITH EACH INITIATING EVENT		
Initiating Event Code	**Description of the Initiating Event**	**Volume associated with the Initiating Event**
1	Spillage of substance A in loading/unloading of trucks	5
2	Spillage of substance B in loading/unloading of trucks	5
3	Spillage of substance C in loading/unloading of ships	50
4	Substance A spill from tank	900 [6]
5	Substance B spill from tank	1.250 [7]
6	Substance C spill from tank	1.600 [8]
7	Substance A spill from pipeline	15
8	Substance B spill from pipeline	15
9	Substance C spill from pipeline	150
10	Substance C spill from tank	10
11	D-substance spill from tank	25
12	Fire in electrical substation	0

Table 10: Volume associated with each type of initiating event.

Source: Own elaboration.

[3] In those cases where the associated volume is estimated by the expression V = q x t, V is the volume to be estimated; q is the flow rate; and t is the time.
[4] In this case study, the initiating tank spill events that represent the worst possible case for each substance have been taken into account, i.e. the tank with the largest volume of substance stored has been considered (the maximum capacity of the tank and the average filling percentage of the tank have been taken into account for this purpose).
[5] In the case of a fire in the electrical substation, the initiating event is caused by a spark generated by a short circuit, therefore, it does not have a substance or, consequently, an associated volume.
[6] This is a tank with a capacity of 1,500 m3, with an average filling rate of 60%.
[7] This is a tank with a capacity of 2,500 m3, with an average filling rate of 50%.
[8] This is a tank with a capacity of 4,000 m3, with an average filling rate of 40%.

IV.6.2. Volume associated with fire extinguishing measures.

In those initiating events in which flammable substances are involved and, therefore, associated fire scenarios exist, the additional volume represented by the contribution of extinguishing water is considered. This may drag substances in its path, being totally or partially contaminated.

As previously discussed, it is assumed that the facility has two main firefighting measures:

1. Water tank for fire fighting
2. Deluges in certain areas

The deluges are located in the areas that are considered as the most dangerous: the ship loading/unloading area and the storage yard. For the rest of the areas, water from the fire-fighting reservoir is used.

The following table shows, according to the characteristics of the fire-fighting tank and the deluges present in the different zones, the maximum volume of fire extinguishing water available in each zone. This extinguishing volume is applicable to all initiating events occurring in that zone.

MAXIMUM EXTINGUISHING VOLUME ASSOCIATED WITH EACH ZONE		
Zone code	**Zone description**	**Volume (m3)**
1	Tank loading dock	150
2	Ship loading dock	1,500
3	Storage park	2,250
4	Electrical substation, transformers and emergency generator	150

Table 11: Maximum extinguishing volume associated with each zone.

Source: Own elaboration.

Once the extinguishing water has been released, depending on the solubility of the substances present in that area, the volume of pollutant will be higher or lower. Thus, in the case of slightly soluble substances, the volume of polluting agent would be the volume of the polluting substance itself plus a minimum volume of water that could be contaminated when the polluting substance is solubilised.

In this case study, the four substances present in the installation are classified as insoluble, as they have very low, almost negligible solubilities. For this reason, in principle, they would not be diluted in the extinguishing water. However, given that the solubility is very low but not zero, following a criterion of prudence, it is assumed that a minimum part of the extinguishing water could be contaminated. Specifically, it is assumed that this volume would represent only 1% of the extinguishing water.

Two tables with extinguishing water data are presented below. One shows the fields indicated for the activation of the extinguishing water after immediate ignition, while the other lists the fields after delayed ignition. In the latter case the volume of the pollutant substance that is mixed with the extinguishing water must be taken into account, since the part of the volume released in the initiating event that could have been retained by the manual containment systems and that, therefore, would be eliminated from the accident scenario since this volume is not likely to reach the natural resources. It is important to note that, in the case of containment in a containment vessel, none of the polluting substance is removed as the total volume retained in the vessel could be subject to delayed ignition.

The following tables provide a summary of the different initiating events, specifying for each one:

- The code of the zone in which the initiating event originates.
- The code of the initiating event from which the scenario starts.
- The description of the initiating event
- The substance released in the initiating event.
- The volume (m3) associated with the initiating event (Table 12): volume of the substance released by the initiating event.
- Volume (m3) associated with containment (Table 13): volume not retained after the implementation of manual containment systems, i.e. volume that could potentially affect natural resources after discounting the volume that is retained (and eliminated) by manual containment measures.
- The volume of contaminated extinguishing water (m3): this is the volume of the substance plus 1% of the maximum volume of extinguishing water associated with that zone.

VOLUME OF CONTAMINATED AGENT ASSOCIATED WITH THE ACTIVATION OF FIRE DETECTION AND SUPPRESSION MEASURES FOLLOWING IMMEDIATE IGNITION					
Zone code	Initiating Event Code	Description of the Initiating Event	Substance released in the Initiating Event	Volume (m3) of the Initiating Event	Volume (m3) of contaminated extinguishing water
1	1	Spillage of substance A in loading/unloading of trucks	A	5	6.50
	2	Spillage of substance B in loading/unloading of trucks	B	5	6.50
2	3	Spillage of substance C in loading/unloading of ships	C	50	65.00
3	4	Substance A spill from tank	A	900	922.50
	5	Substance B spill from tank	B	1,250	1,272.50
	6	Substance C spill from tank	C	1,600	1,622.50
	7	Substance A spill from pipeline	A	15	37.50
	8	Substance B spill from pipeline	B	15	37.50
	9	Substance C spill from pipeline	C	150	172.50
4	10	Substance C spill from tank	C	10	11.50
	11	D-substance spill from tank	D	25	26.50
	12	Fire in electrical substation	---	---	26.50 [9]

Volume of contaminated agent associated with the activation of fire detection and extinguishing measures after immediate ignition.

Source: Own elaboration.

[9] In the case of a fire in an electrical substation, it is assumed that it is the result of a short circuit in the transformers. Therefore, there is no substance associated with the initiating event. However, once the fire has started, it will affect the substances involved, facilitating their spillage and the eventual contamination of a certain volume (1%) of the extinguishing water. It is important to note that in this case, although it is not necessary to distinguish between immediate ignition and delayed ignition, in order to simplify the structure of the document, the data relating to the activation of extinguishing water due to fire by short circuit are indicated in this table, leaving the data in Table 13 blank.

VOLUME OF CONTAMINATED AGENT ASSOCIATED WITH THE ACTIVATION OF FIRE DETECTION AND SUPPRESSION MEASURES AFTER DELAYED IGNITION					
Zone code	Initiating Event Code	Description of the Initiating Event	Substance released in the Initiating Event	Volume (m3) after manual containment [10]	Volume (m3) of contaminated extinguishing water
1	1	Spillage of substance A in loading/unloading of trucks	A	4	5.50
	2	Spillage of substance B in loading/unloading of trucks	B	4	5.50
2	3	Spillage of substance C in loading/unloading of ships	C	40	55.00
3	4	Substance A spill from tank	A	---	922.50
	5	Substance B spill from tank	B	---	1,272.50
	6	Substance C spill from tank	C	---	1,622.50
	7	Substance A spill from pipeline	A	12	25.50
	8	Substance B spill from pipeline	B	12	25.50
	9	Substance C spill from pipeline	C	120	142.50
4	10	Substance C spill from tank	C	---	11.50
	11	D-substance spill from tank	D	---	26.50
	12	Fire in electrical substation	---	---	---

Volume of contaminated agent associated with the activation of fire detection and extinguishing measures after delayed ignition**.**

Source: Own elaboration.

[10] In the event that manual containment measures are not foreseen in the tree of a given initiating event, this field has not been completed, as the volume indicated in Table 12 would be maintained, i.e., that which was released in the initiating event.

IV.6.3. Estimation of the volume retained by manual containment systems

In the case of manual containment it is assumed that, based on industry expert judgement, in the event of a spill at least 20% of the spill would be retained by manual containment systems.

Taking a conservative approach, the worst case scenario is considered, i.e. taking this percentage (20%) as the maximum that could be retained by this type of containment system.

The following table shows the volume retained by this type of system for each of the initiating events for which the "manual containment" conditioning factor is applicable:

VOLUME RETAINED BY MANUAL CONTAINMENT SYSTEMS FOR EACH INITIATING EVENT				
Initiating Event Code	Description of the Initiating Event	Volume (m3) of the Initiating Event	Volume retained (m3) by manual containment systems	Volume (m3) associated with the conditioning factor "manual containment".
1	Spillage of substance A in loading/unloading of trucks	5	1	4
2	Spillage of substance B in loading/unloading of trucks	5	1	4
3	Spillage of substance C in loading/unloading of ships	50	10	40
7	Substance A spill from pipeline	15	3	12
8	Substance B spill from pipeline	15	3	12
9	Substance C spill from pipeline	150	30	120

Table 13. Volume retained by the manual containment systems in each initiating event.

Source: Own elaboration.

Therefore, as shown in the table, in the event trees, the volume associated with the manual containment factor - that is, the volume that would follow the tree and, if applicable, could damage natural resources - would be the result of subtracting the amount (m3) retained by the manual containment systems from the volume of the initiating event.

IV.6.4. Estimation of the volume retained by automatic containment systems

In the case of automatic containment systems however, the volume which, depending on the further development of the event tree, could reach natural resources and cause environmental damage, has not been reduced. This is due to the possibility of delayed ignition as explained below.

As can be seen in the tables included in the section on the calculation of probabilities, in this risk analysis it is assumed that the probability that the tanks will function correctly (contain all of the spillage) is 100% in all cases. This has been estimated by taking into account the bibliographical sources consulted, and also considering their characteristics, capacity and the good condition in which they are found.

However, once the spilled volume is retained in the bucket, as long as there is delayed ignition, the entire retained volume wo uld be exposed to ignition. Therefore, despite the existence of a containment measure and its correct functioning, there will be no volume decrease in this step of the tree.

IV.6.5. Estimate of the volume retained by the containment in the water and spill management system.

This conditioning factor only appears in the area of the electrical substation, as it is assumed that there is a network of manholes that connect to a watertight pit with a capacity of 50 m3.

As this is the last conditioning factor of the tree, it is understood that this volume, once retained, no longer represents a risk. Therefore, this volume (50 m3) has been discounted in order not to consider it in the accidental scenario.

IV.7 Event trees

Event trees show the evolution of an initiating event as a function of the so-called conditioning factors and hence the occurrence of different accident scenarios. The events begin with the occurrence of an initiating event and lead to a certain accident scenario, depending on the action of the conditioning factors.

The structure of the trees is shown in Figure 1.

Initiating event	Prob.	Vol. (m^3)	Factor 1	Prob.	Vol. (m^3)	Factor 2	Prob.	Vol. (m^3)	Factor n	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
			Yes			Yes			Yes						
									No						
						No			Yes						
									No						
			No			Yes			Yes						
									No						
						No			Yes						
									No						

Figure 1. Diagram of the consequential trees.

Source: Own elaboration.

The fields considered in the trees are as follows:

a) Initiating event. This is the description of the initiating event to which the consequential tree corresponds. The list of initiating events considered in this risk analysis can be consulted in chapter IV.3.

b) Prob. This is the probability of occurrence of the initiating event and of each of the conditioning factors. The probability associated with each initiating event used in this risk analysis is given in section IV.5.1. On the other hand, the probability of success of each conditioning factor is given in section IV.5.2, and more specifically, the data collected in Table 8 is particularly useful.

c) Vol. (m3). This is the volume that overcomes each of the conditioning factors and moves on to the next element of the tree. The first volume of the tree coincides with the amount of agent released under the hypotheses established in each initiating event, and the last volume with the amount of agent that would come into contact with the natural resources. The calculation of the amount of agent released in each initiating event is described in chapter IV.6.

d) Factor. This is the name of each conditioning factor, a detailed description of which can be found in section IV.4.

- **e) Esc code.** This is the code of the accident scenario. These codes have a structure of type *SX.EY,* where *X* is the initiating event code and *Y* is the scenario number within that event.
- **f) Prob. Esc.** This is the probability of occurrence of the accident scenario calculated in accordance with the methodology described in section IV.5.2 of this report.
- **g) Vol. Esc.(m3).** This is the volume released into the environment under the hypotheses established in each accident scenario calculated in accordance with the methodology indicated in chapter IV.6.
- **h) Relevant.** Indicates whether or not the scenario is considered relevant. In this sense, a scenario is considered relevant for the evaluation of its possible environmental damage if the probability of occurrence and the volume released are greater than zero. In this sense, if the probability of the accidental scenario is zero, it is referred to as an "impossible scenario", while if the volume is zero, it is a "controlled scenario with no environmental consequences".

IV. 7.1 Event trees by zones

The event or consequential trees designed for each of the 12 initiating events identified in this risk analysis are shown below. As mentioned above, these trees start from the initiating event and evaluate the effect that the different conditioning factors have on its evolution. Specifically, in the model proposed, the conditioning factors act in two ways: by modifying the probability of occurrence and by modifying the quantity of agent released.

The display of the event trees is ordered according to the zone of the facility where the initiating event originating the consequential tree appears. The following table shows the number of initiating events and relevant accident scenarios in each of the four zones identified in this case study.

DISTRIBUTION OF INITIATING EVENTS AND ACCIDENT SCENARIOS BY INSTALLATION ZONE		
Zone	**Number of initiating events**	**Number of accident scenarios**
Zone 1: Tank loading dock	2	16
Zone 2: Ship loading area	1	8
Zone 3: Storage Park	6	33
Zone 4: Electrical substation	3	8

Number of initiating events and accidental scenarios by zone**.**

Source: Own elaboration.

The event tree for each one is shown below.

A. Zone 1: Tank loading dock

Spillage of substance A in loading/unloading of tank

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Manual containment	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spill of substance A in tank loading/unloading	1,00E-03	5,00	Yes	0,0650	5,00	Yes	0,9500	6,50										SI1.E1	6,18E-05	6,50	Yes
						No	0,0500	5,00										SI1.E2	3,25E-06	5,00	Yes
			No	0,9350	5,00				Yes	0,9990	4,00	Yes	0,2000	4,00	Yes	0,9500	5,50	SI1.E3	1,77E-04	5,50	Yes
															No	0,0500	4,00	SI1.E4	9,34E-06	4,00	Yes
												No	0,8000	4,00				SI1.E5	7,47E-04	4,00	Yes
									No	0,0010	5,00	Yes	0,2000	5,00	Yes	0,9500	6,50	SI1.E6	1,78E-07	6,50	Yes
															No	0,0500	5,00	SI1.E7	9,35E-09	5,00	Yes
												No	0,8000	5,00				SI1.E8	7,48E-07	5,00	Yes

Consequence tree of initiating event 1: Spill of substance A in tank loading/unloading.

Source: Own elaboration.

Spillage of substance B in loading/unloading of tank

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Manual containment	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spill of substance B in tank loading/unloading	1,00E-03	5,00	Yes	0,0650	5,00	Yes	0,9500	6,50										SI2.E1	6,18E-05	6,50	Yes
						No	0,0500	5,00										SI2.E2	3,25E-06	5,00	Yes
			No	0,9350	5,00				Sí	0,9990	4,00	Yes	0,2000	4,00	Yes	0,9500	5,50	SI2.E3	1,77E-04	5,50	Yes
															No	0,0500	4,00	SI2.E4	9,34E-06	4,00	Yes
												No	0,8000	4,00				SI2.E5	7,47E-04	4,00	Yes
									No	0,0010	5,00	Yes	0,2000	5,00	Yes	0,9500	6,50	SI2.E6	1,78E-07	6,50	Yes
															No	0,0500	5,00	SI2.E7	9,35E-09	5,00	Yes
												No	0,8000	5,00				SI2.E8	7,48E-07	5,00	Yes

Consequence tree of initiating event 2: Spill of substance B in tank loading/unloading.

Source: Own elaboration.

B. Zone 2: Ship loading area

Spillage of substance C in loading/unloading of ships

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Manual containment	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spill of substance C in tank loading/unloading	4,05E-05	50,00	Yes	0,0650	50,00	Yes	0,9500	65,00										SI3.E1	2,50E-06	65,00	Yes
						No	0,0500	50,00										SI3.E2	1,32E-07	50,00	Yes
			No	0,9350	50,00				Yes	0,9990	40,00	Yes	0,2000	40,00	Yes	0,9500	55,00	SI3.E3	7,19E-06	55,00	Yes
															No	0,0500	40,00	SI3.E4	3,78E-07	40,00	Yes
												No	0,8000	40,00				SI3.E5	3,03E-05	40,00	Yes
									No	0,0010	50,00	Yes	0,2000	50,00	Yes	0,9500	65,00	SI3.E6	7,19E-09	65,00	Yes
															No	0,0500	50,00	SI3.E7	3,79E-10	50,00	Yes
												No	0,8000	50,00				SI3.E8	3,03E-08	50,00	Yes

Figure 4. Consequence tree of initiating event 3: Spill of substance C in ship loading/unloading.

Source: Own elaboration.

C. Zone 3: Storage Park

Substance A spill from tank

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Containment in a bucket	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spill of substance A from tank	5,00E-06	900,00	Yes	0,0650	900,00	Yes	0,9500	922,50										SI4.E1	3,09E-07	922,50	Yes
						No	0,0500	900,00										SI4.E2	1,63E-08	900,00	Yes
			No	0,9350	900,00				Yes	1,0000	900,00	Yes	0,2000	900,00	Yes	0,9500	922,50	SI4.E3	8,88E-07	922,50	Yes
															No	0,0500	0,00	SI4.E4	4,68E-08	0,00	No
												No	0,8000	0,00				SI4.E5	3,74E-06	0,00	No
									No	0,0000		Yes			Yes			SI5.E6	0,00E+00	---	No
															No			SI5.E7	0,00E+00	---	No
												No						SI5.E8	0,00E+00	---	No

Figure 5. Consequence tree of initiating event 4: Spill of substance A from tank.

Source: Own elaboration.

Substance B spill from tank

Initiating event	Prob.	Vol. (m3)	Immediate ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Containment in a bucket	Prob.	Vol. (m3)	Delayed ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Code	Prob Esc.	Vol. Esc. (m3)	Relevant
Spill of substance B from tank	5,00E-06	1.250,00	Sí	0,0650	1.250,00	Yes	0,9500	1.272,50										SI5.E1	3,09E-07	1.272,50	Yes
						No	0,0500	1.250,00										SI5.E2	1,63E-08	1.250,00	Yes
			No	0,9350	1.250,00				Yes	1,0000	1.250,00	Yes	0,2000	1.250,00	Yes	0,9500	1.272,50	SI5.E3	8,88E-07	1.272,50	Yes
															No	0,0500	0,00	SI5.E4	4,68E-08	0,00	No
												No	0,8000	0,00				SI5.E5	3,74E-06	0,00	No
									No	0,0000		Yes			Yes			SI5.E6	0,00E+00	---	No
															No			SI5.E7	0,00E+00	---	No
												No						SI5.E8	0,00E+00	---	No

Figure 6. Consequence tree of initiating event 5: Spill of substance B from tank.

Source: Own elaboration.

Substance C spill from tank

Initiating event	Prob.	Vol. (m3)	Immediate ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Containment in a bucket	Prob.	Vol. (m3)	Delayed ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Code	Prob Esc.	Vol. Esc. (m3)	Relevant
Spill of substance C from tank	5,00E-06	1.600,00	Yes	0,0650	1.600,00	Yes	0,9500	1.622,50										SI6.E1	3,09E-07	1.622,50	Sí
						No	0,0500	1.600,00										SI6.E2	1,63E-08	1.600,00	Sí
			No	0,9350	1.600,00				Yes	1,0000	1.600,00	Yes	0,2000	1.600,00	Yes	0,9500	1.622,50	SI6.E3	8,88E-07	1.622,50	Sí
															No	0,0500	0,00	SI6.E4	4,68E-08	0,00	No
												No	0,8000	0,00				SI6.E5	3,74E-06	0,00	No
									No	0,0000		Yes			Sí			SI6.E6	0,00E+00	---	No
															No			SI6.E7	0,00E+00	---	No
												No						SI6.E8	0,00E+00	---	No

Figure 7. Consequence tree of initiating event 6: Spill of substance C from tank.

Source: Own elaboration.

Substance A spill from pipeline

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Manual containment	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spillage of substance A from the pipeline	1,15E-04	15,00	Yes	0,0650	15,00	Yes	0,9500	37,50										SI7.E1	7,10E-06	37,50	Yes
						No	0,0500	15,00										SI7.E2	3,74E-07	15,00	Yes
			No	0,9350	15,00				Yes	0,9990	12,00	Yes	0,2000	12,00	Yes	0,9500	25,50	SI7.E3	2,04E-05	25,50	Yes
															No	0,0500	12,00	SI7.E4	1,07E-06	12,00	Yes
												No	0,8000	12,00				SI7.E5	8,59E-05	12,00	Yes
									No	0,0010	15,00	Yes	0,2000	15,00	Yes	0,9500	37,50	SI7.E6	2,04E-08	37,50	Yes
															No	0,0500	15,00	SI7.E7	1,08E-09	15,00	Yes
												No	0,8000	15,00				SI7.E8	8,60E-08	15,00	Yes

Consequence tree of initiating event 7: Spillage of substance A from the pipeline**.**

Source: Own elaboration.

Substance B spill from pipeline

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Manual containment	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spillage of substance B from the pipeline	7,50E-05	15,00	Yes	0,0650	15,00	Yes	0,9500	37,50										SI8.E1	4,63E-06	37,50	Yes
						No	0,0500	15,00										SI8.E2	2,44E-07	15,00	Yes
			No	0,9350	15,00				Yes	0,9990	12,00	Yes	0,2000	12,00	Yes	0,9500	25,50	SI8.E3	1,33E-05	25,50	Yes
															No	0,0500	12,00	SI8.E4	7,01E-07	12,00	Yes
												No	0,8000	12,00				SI8.E5	5,60E-05	12,00	Yes
									No	0,0010	15,00	Sí	0,2000	15,00	Sí	0,9500	37,50	SI8.E6	1,33E-08	37,50	Yes
															No	0,0500	15,00	SI8.E7	7,01E-10	15,00	Yes
												No	0,8000	15,00				SI8.E8	5,61E-08	15,00	Yes

Consequence tree of initiating event 8: Spillage of substance B from the pipeline**.**

Source: Own elaboration.

Substance C spill from pipeline

Initiating event	Prob.	Vol. (m^3)	Immediate ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Manual containment	Prob.	Vol. (m^3)	Delayed ignition	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Spillage of substance C from the pipeline	2,50E-05	150,00	Yes	0,0650	150,00	Yes	0,9500	172,50										SI9.E1	1,54E-06	172,50	Yes
						No	0,0500	150,00										SI9.E2	8,13E-08	150,00	Yes
			No	0,9350	150,00				Yes	0,9990	120,00	Yes	0,2000	120,00	Yes	0,9500	142,50	SI9.E3	4,44E-06	142,50	Yes
															No	0,0500	120,00	SI9.E4	2,34E-07	120,00	Yes
												No	0,8000	120,00				SI9.E5	1,87E-05	120,00	Yes
									No	0,0010	150,00	Sí	0,2000	150,00	Sí	0,9500	172,50	SI9.E6	4,44E-09	172,50	Yes
															No	0,0500	150,00	SI9.E7	2,34E-10	150,00	Yes
												No	0,8000	150,00				SI9.E8	1,87E-08	150,00	Yes

Consequential tree of initiating event 9: Spillage of substance C from the pipeline**.**

Source: Own elaboration.

D. Zone 4: Power substation, transformers and emergency generator

Substance C spill from tank

Initiating event	Prob.	Vol. (m3)	Immediate ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Containment in a bucket	Prob.	Vol. (m3)	Delayed ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Code	Prob Esc.	Vol. Esc. (m3)	Relevant
Spill of substance C from tank	5,00E-06	10,00	Yes	0,0650	10,00	Yes	0,9500	11,50										SI10.E1	3,09E-07	11,50	Yes
						No	0,0500	10,00										SI10.E2	1,63E-08	10,00	Yes
			No	0,9350	10,00				Yes	1,0000	10,00	Yes	0,2000	10,00	Yes	0,9500	11,50	SI10.E3	8,88E-07	11,50	Yes
															No	0,0500	0,00	SI10.E4	4,68E-08	0,00	No
												No	0,8000	0,00				SI10.E5	3,74E-06	0,00	No
									No	0,0000		Yes			Yes			SI10.E6	0,00E+00	---	No
															No			SI10.E7	0,00E+00	---	No
												No						SI10.E8	0,00E+00	---	No

Figure 11. Consequence tree of initiating event 10: Spill of substance C from tank.

Source: Own elaboration.

D-substance spill from tank

Initiating event	Prob.	Vol. (m3)	Immediate ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Containment in a bucket	Prob.	Vol. (m3)	Delayed ignition	Prob.	Vol. (m3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m3)	Code	Prob Esc.	Vol. Esc. (m3)	Relevant
Spill of substance D from tank	5,00E-06	25,00	Yes	0,0650	25,00	Yes	0,9500	26,50										SI11.E1	3,09E-07	26,50	Yes
						No	0,0500	25,00										SI11.E2	1,63E-08	25,00	Yes
			No	0,9350	25,00				Yes	1,0000	25,00	Yes	0,2000	25,00	Yes	0,9500	26,50	SI11.E3	8,88E-07	26,50	Yes
															No	0,0500	0,00	SI11.E4	4,68E-08	0,00	No
												No	0,8000	0,00				SI11.E5	3,74E-06	0,00	No
									No	0,0000		Sí			Sí			SI11.E6	0,00E+00	---	No
															No			SI11.E7	0,00E+00	---	No
												No						SI11.E8	0,00E+00	---	No

Figure 12. Consequence tree of initiating event 11: Spill of substance D from tank.

Source: Own elaboration.

Fire in electrical substation

Initiating event	Prob.	Vol. (m^3)	Flame detection and activation of the extinguishing system	Prob.	Vol. (m^3)	Containment in water and spill management system	Prob.	Vol. (m^3)	Code	Prob Esc.	Vol. Esc. (m^3)	Relevant
Fire in electrical substation	8,76E-03	0,00	Yes	0,9500	1,50	Yes	0,9500	0,00	SI12.E1	7,91E-03	0,00	No
						No	0,0500	1,50	SI12.E2	4,16E-04	1,50	Yes
			No	0,0500	25,00	Yes	0,9500	0,00	SI12.E3	4,16E-04	0,00	No
						No	0,0500	25,00	SI12.E4	2,19E-05	25,00	Yes

Figure 13. Consequential tree of initiating event 12: Fire in electrical substation.

Source: Own elaboration.

V. APPLICATION OF THE IDM

According to the current legislation, the magnitude of the environmental consequences foreseen under the hypotheses established in each accident scenario must be evaluated by calculating the Environmental Damage Index (IDM).

The procedure for calculating the IDM is specified in Royal Decree 183/2015, of 13 March, which amends the Regulation for the partial development of Law 26/2007, of 23 October, on Environmental Liability, approved by Royal Decree 2090/2008, of 22 December. In essence, the methodology of the IDM is based on a mathematical equation in which a series of input parameters are entered in order to obtain a semi-quantitative estimate of environmental damage. These input parameters are a function of the "damage-causing agent-affected natural resource" combination being assessed. Specifically, Royal Decree 183/2015 differentiates a total of twenty-one groups of agent-resource pairs.

Within the scope of the facility under study, in view of the accident scenarios identified, the following are considered for the calculation of the IDM:

1- The IDM methodology will be applied to only four types of hypothetical discharged substances: Substance A, Substance B, Substance C and Substance D.

2- These substances may potentially affect the following natural resources:

    a. Seawater. All four of the above substances are less dense than water so it is assumed that most of the hypothetical spill would float rather than sink down to the seabed.

DENSITY OF THE SUBSTANCES CONSIDERED IN THE EDX CALCULATION	
Substance	**Density (kg/m3)**
Substance A	800
Substance B	750
Substance C	843
Substance D	877

Table 15. Density of the substances considered in the EDX calculation.

Source: Prepared by the authors based on substance safety data sheets.

Note: If a range of values is given on the cards, the average density can be calculated.

It is assumed that, in the event of a spill, it would be directed towards the port since the rest of the perimeter of the facility is protected by a watertight wall. Both circumstances would allow the agents causing the damage to be contained and treated at sea.

b. Animal species. The relative geographical proximity of a natural protected area is assumed. Consequently, it is considered appropriate to include the possible impact on animal species in this analysis. Specifically, the damage assessment will include possible harm to both threatened and non-threatened seabirds. For this practical case it is assumed that the possible impact on fish would be irrelevant.

Thus, from all the groups of agent-resource pairs proposed in the IDM methodology, only Groups 1 (damage by chemical agents to seawater) and 16 (damage by chemical agents to animal species) are selected as relevant in the facility under study.

V.1. Parameters and modifiers in the IDM equation

In accordance with Royal Decree 183/2015, the following modifiers and parameters must be taken into account in Groups 1 and 16:

- **Parameters relating to damage-causing agents**

As indicated above, the relevant reported accident scenarios have four potentially harmful agents associated with them: substances A, B, C and D. The IDM methodology prescribes the use of four modifiers linked to these agents for Groups 1 and 16: biodegradability ($_{MB1}$), solubility ($_{MB12}$), toxicity ($_{MB15}$) and volatility ($_{MB18}$).

The following table shows the category of each modifier selected for each agent according to that listed in the corresponding safety data sheet (the value of the modifier is given in brackets).

VALUES OF THE MODIFIERS FOR EACH AGENT CAUSING DAMAGE					
Substance	IDM Agent Type	Biodegradability ($_{MB1}$)	Solubility ($_{MB12}$)	Toxicity ($_{MB15}$)	Volatility ($_{MB18}$)
Substance A	COSV	Average (0.9)	Insoluble (1)	Average (1.5)	Average (0.9)
Substance B	VOC	Average (0.9)	Insoluble (1)	Average (1.5)	High (0.8)
Substance C	CONV	Low (1)	Insoluble (1)	High (2)	Low (1)
Substance D	CONV	Low (1)	Insoluble (1)	High (2)	Low (1)

Table 16. Modifier values for each damage-causing agent.

Source: Prepared by the authors based on substance safety data sheets.

- **Parameters relating to the environment**

The IDM methodology, for Groups 1 and 16, indicates that the following modifying factors relating to the environment where the hypothetical environmental accident would occur should be used: possible effect on a natural protected area (NPA) ($_{MA2}$) and population density of the potentially affected species ($_{MB2}$). The following table shows the selected values, both qualitative and quantitative (in brackets), for each of these factors.

VALUES OF THE MODIFIERS DEPENDING ON THE ENVIRONMENT		
Modifier	**Value**	**Explanation**
Potential impact on a NPA ($_{MA2}$)	No (1)	As indicated above, it is assumed that the spill will remain in the seawater. Therefore, a direct impact on the PNA is not expected due to the distance between the origin of the hypothetical spill and this protected area.
Population density ($_{MB2}$)	Very dense (2)	There is no data available for the population density of species in the receiving area of the hypothetical spill, so the most unfavourable value is adopted in line with the precautionary principle.

Table 17. Values of the modifiers depending on the environment.

Source: Own elaboration.

- **Parameters relating to the duration of damage**

With regard to the duration of the damage caused, Royal Decree 183/2015 establishes that two modifiers must be taken into account for Groups 1 and 16. These are: "duration 1” ($_{MC1}$) and "duration 5” ($_{MC5}$). The value assigned to each of these is set out and explained below, again showing the numerical value of each modifier in brackets.

In this regard, it is worth noting that, in order to estimate the duration of the damage caused to seawater, the Environmental Liability Supply Model (MORA), accessible through the Ministry´s website, is used. This model recommends a repair technique for each accident introduced, associated with its corresponding duration.

MODIFIER VALUES DEPENDING ON THE DURATION OF DAMAGE		
Modifier	**Value**	**Explanation**
"Duration 1” ($_{MC1}$)	Low (<6 months) (1)	A simulation was carried out in the Environmental Liability Supply Model (MORA) of an accident at sea, resulting in a damage recovery time of 1 month.
"Duration 5" ($_{MC5}$)	Low (non-mammals) (1)	Only relevant damage to birds is expected.

Table 18. Modifier values as a function of damage duration.

Source: Own elaboration.

- **Parameter alpha (α)**

In discharges to seawater, the parameter α corresponds to the volume discharged (in tonnes), and in discharges affecting species to the parameter R specified in the IDM methodology.

- **Predefined parameters in the IDM methodology**

In addition to the parameters (α) and the previous modifiers ($_{MA}$, $_{MB}$ and $_{MC}$), the IDM methodology includes a series of predefined coefficients in the equation that cannot be changed by the operator. These coefficients are as follows: Ecf, Ecu, Ec, Ecr, Ecc, p and β; they are assumed as constants for each agent-resource combination.

V.2. Calculation of the IDM

Using the values described in the previous section in the IDM equation, the results shown in the table below are obtained.

Scenario	Substance	IDM Substance	IDM Resource	IDM Group	IDM Parameters						MA Modifiers		MB Modifiers						MC Modifiers			IDM Combination	IDM Scenario
					Ecf	Ecu	α	Ec	Ecr	Ecc	MA2	A	MB1	MB2	MB12	MB15	MB18	B	MC1	MC5	C		
SI1.E1	A	COSV	Seawater	1	0	866	5.20	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	5,749.04	318,451.48
			Threatened bird species	16	0	11,866	13.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	220,703.56	
			Non-threatened bird species	16	0	2,373	13.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	91,998.88	
SI1.E2	A	COSV	Seawater	1	0	866	4.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	4,882.04	248,287.52
			Threatened bird species	16	0	11,866	10.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	171,204.54	
			Non-threatened bird species	16	0	2,373	10.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	72,200.94	
SI1.E3	A	COSV	Seawater	1	0	866	4.40	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	5,171.04	271,675.50
			Threatened bird species	16	0	11,866	11.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	187,704.21	
			Non-threatened bird species	16	0	2,373	11.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	78,800.25	
SI1.E4	A	COSV	Seawater	1	0	866	3.20	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	4,304.03	201,511.54
			Threatened bird species	16	0	11,866	8.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	138,205.19	
			Non-threatened bird species	16	0	2,373	8.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	59,002.31	
SI1.E5	A	COSV	Seawater	1	0	866	3.20	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	4,304.03	201,511.54
			Threatened bird species	16	0	11,866	8.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	138,205.19	
			Non-threatened bird species	16	0	2,373	8.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	59,002.31	
SI1.E6	A	COSV	Seawater	1	0	866	5.20	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	5,749.04	318,451.48
			Threatened bird species	16	0	11,866	13.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	220,703.56	
			Non-threatened bird species	16	0	2,373	13.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	91,998.88	
SI1.E7	A	COSV	Seawater	1	0	866	4.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	4,882.04	248,287.52
			Threatened bird species	16	0	11,866	10.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	171,204.54	
			Non-threatened bird species	16	0	2,373	10.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	72,200.94	
SI1.E8	A	COSV	Seawater	1	0	866	4.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	4,882.04	248,287.52
			Threatened bird species	16	0	11,866	10.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	171,204.54	
			Non-threatened bird species	16	0	2,373	10.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	72,200.94	
SI2. E1	B	VOC	Seawater	1	0	866	4.88	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	5,122.87	317,825.31
			Threatened bird species	16	0	11,866	13.00	0,5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	220,703.56	
			Non-threatened bird species	16	0	2,373	13.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	91,998.88	
SI2. E2	B	VOC	Seawater	1	0	3,648	3.75	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	12,137.11	255,542.59
			Threatened bird species	16	0	11,866	10.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	171,204.54	
			Non-threatened bird species	16	0	2,373	10.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	72,200.94	
SI2. E3	B	VOC	Seawater	1	0	3,648	4.13	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	13,151.62	279,656.08
			Threatened bird species	16	0	11,866	11.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	187,704.21	
			Non-threatened bird species	16	0	2,373	11.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	78,800.25	
SI2. E4	B	VOC	Seawater	1	0	3,648	3.00	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	10,108.09	207,315.60
			Threatened bird species	16	0	11,866	8.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	138,205.19	
			Non-threatened bird species	16	0	2,373	8.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	59,002.31	

Scenario	Substance	IDM Substance	IDM Resource	IDM Group	IDM Parameters						MA Modifiers		MB Modifiers						MC Modifiers			IDM Combination	IDM Scenario
					Ecf	Ecu	α	Ec	Ecr	Ecc	MA2	A	MB1	MB2	MB12	MB15	MB18	B	MC1	MC5	C		
			Seawater	1	0	3,648	3.00	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	10,108.09	
SI2. E5	B	VOC	Threatened bird species	16	0	11,866	8.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	138,205.19	207,315.60
			Non-threatened bird species	16	0	2,373	8.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	59,002.31	
			Seawater	1	0	3,648	4.88	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	15,180.63	
SI2. E6	B	VOC	Threatened bird species	16	0	11,866	13.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	220,703.56	327,883.07
			Non-threatened bird species	16	0	2,373	13.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	91,998.88	
			Seawater	1	0	3,648	3.75	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	12,137.11	
SI2. E7	B	VOC	Threatened bird species	16	0	11,866	10.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	171,204.54	255,542.59
			Non-threatened bird species	16	0	2,373	10.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	72,200.94	
			Seawater	1	0	3,648	3.75	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	12,137.11	
SI2. E8	B	VOC	Threatened bird species	16	0	11,866	10.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	171,204.54	255,542.59
			Non-threatened bird species	16	0	2,373	10.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	72,200.94	
			Seawater	1	0	3,648	54.76	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	207,758.83	
SI3.E1	C	CONV	Threatened bird species	16	0	11,866	130.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	3,183,922.61	4,668,868.05
			Non-threatened bird species	16	0	2,373	130.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,277,186.61	
			Seawater	1	0	3,648	42.13	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	160,274.18	
SI3.E2	C	CONV	Threatened bird species	16	0	11,866	100.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,450,603.81	3,594,761.80
			Non-threatened bird species	16	0	2,373	100.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	983,883.81	
			Seawater	1	0	3,648	46.34	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	176,102.40	
SI3.E3	C	CONV	Threatened bird species	16	0	11,866	110.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,695,043.41	3,952,797.22
			Non-threatened bird species	16	0	2,373	110.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,081,651.41	
			Seawater	1	0	3,648	33.70	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	128,617.75	
SI3.E4	C	CONV	Threatened bird species	16	0	11,866	80.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,961,724.61	2,878,690.97
			Non-threatened bird species	16	0	2,373	80.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	788,348.61	
			Seawater	1	0	3,648	33.70	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	128,617.75	
SI3.E5	C	CONV	Threatened bird species	16	0	11,866	80.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,961,724.61	2,878,690.97
			Non-threatened bird species	16	0	2,373	80.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	788,348.61	
			Seawater	1	0	3,648	54.76	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	207,758.83	
SI3.E6	C	CONV	Threatened bird species	16	0	11,866	130.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	3,183,922.61	4,668,868.05
			Non-threatened bird species	16	0	2,373	130.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,277,186.61	
			Seawater	1	0	3,648	42.13	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	160,274.18	
SI3.E7	C	CONV	Threatened bird species	16	0	11,866	100.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,450,603.81	3,594,761.80
			Non-threatened bird species	16	0	2,373	100.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	983,883.81	
			Seawater	1	0	3,648	42.13	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	160,274.18	
SI3.E8	C	CONV	Threatened bird species	16	0	11,866	100.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,450,603.81	3,594,761.80
			Non-threatened bird species	16	0	2,373	100.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	983,883.81	

Scenario	Substance	IDM Substance	IDM Resource	IDM Group	IDM Parameters						MA Modifiers		MB Modifiers						MC Modifiers			IDM Combination	IDM Scenario
					Ecf	Ecu	α	Ec	Ecr	Ecc	MA2	A	MB1	MB2	MB12	MB15	MB18	B	MC1	MC5	C		
SI4.E1	A	COSV	Seawater	1	0	866	922.50	1	1,934	0.03		0.00	0.9		1		0.9	0.81	1		1.00	1,992.02	42,632,036.81
			Threatened bird species	16	0	11,866	1,845.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,650,715,993.10	
			Non-threatened bird species	16	0	2,373	1,845.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	660,234,476.90	
SI4.E2	A	COSV	Seawater	1	0	866	900.00	1	1,934	0.03		0.00	0.9		1		0.9	0.81	1		1.00	1,992.02	41,592,582.44
			Threatened bird species	16	0	11,866	1,800.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,649,973,507.81	
			Non-threatened bird species	16	0	2,373	1,800.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	659,937,507.81	
SI4.E3	A	COSV	Seawater	1	0	866	922.50	1	1,934	0.03		0.00	0.9		1		0.9	0.81	1		1.00	1,992.02	42,632,036.81
			Threatened bird species	16	0	11,866	1,845.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,650,715,993.10	
			Non-threatened bird species	16	0	2,373	1,845.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	660,234,476.90	
SI5.E1	B	VOC	Seawater	1	0	866	1,272.50	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	36,138,019.58	59,618,559.09
			Threatened bird species	16	0	11,866	2,545.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	2,475,699,643.10	
			Non-threatened bird species	16	0	2,373	2,545.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	990,200,126.90	
SI5.E2	B	VOC	Seawater	1	0	866	1,250.00	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	36,127,182.02	58,564,654.64
			Threatened bird species	16	0	11,866	2,500.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	2,474,957,157.81	
			Non-threatened bird species	16	0	2,373	2,500.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	989,903,157.81	
SI5.E3	B	VOC	Seawater	1	0	866	1,272.50	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	36,138,019.58	59,618,559.09
			Threatened bird species	16	0	11,866	2,545.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	2,475,699,643.10	
			Non-threatened bird species	16	0	2,373	2,545.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	990,200,126.90	
SI6.E1	C	CONV	Seawater	1	0	866	1,622.50	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	75,168,215.62	112,507,881.59
			Threatened bird species	16	0	11,866	3,245.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	4,889,898,186.01	
			Non-threatened bird species	16	0	2,373	3,245.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,955,798,162.01	
SI6.E2	C	CONV	Seawater	1	0	866	1,600.00	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	75,151,307.02	110,947,879.64
			Threatened bird species	16	0	11,866	3,200.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	4,888,798,207.81	
			Non-threatened bird species	16	0	2,373	3,200.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,955,358,207.81	
SI6.E3	C	CONV	Seawater	1	0	866	1,622.50	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	75,168,215.62	112,507,881.59
			Threatened bird species	16	0	11,866	3,245.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	4,889,898,186.01	
			Non-threatened bird species	16	0	2,373	3,245.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,955,798,162.01	
SI7.E1	A	COSV	Seawater	1	0	866	30.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	23,667.13	**1,768,506.70**
			Threatened bird species	16	0	11,866	75.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,243,683.29	
			Non-threatened bird species	16	0	2,373	75.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,156.29	
SI7.E2	A	COSV	Seawater	1	0	866	12.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	10,662.07	**716,047.27**
			Threatened bird species	16	0	11,866	30.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,198.00	
			Non-threatened bird species	16	0	2,373	30.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	204,187.20	
SI7.E3	A	COSV	Seawater	1	0	866	20.40	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	16,731.10	**1,207,195.00**
			Threatened bird species	16	0	11,866	51.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	847,691.13	
			Non-threatened bird species	16	0	2,373	51.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	342,772.77	

Scenario	Substance	IDM Substance	IDM Resource	IDM Group	IDM Parameters						MA Modifiers		MB Modifiers						MC Modifiers			IDM Combination	IDM Scenario
					Ecf	Ecu	α	Ec	Ecr	Ecc	MA2	A	MB1	MB2	MB12	MB15	MB18	B	MC1	MC5	C		
SI7.E4	A	COSV	Seawater	1	0	866	9.60	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	8,928.06	575,719.34
			Threatened bird species	16	0	11,866	24.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	402,199.96	
			Non-threatened bird species	16	0	2,373	24.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	164,591.32	
SI7.E5	A	COSV	Seawater	1	0	866	9.60	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	8,928.06	575,719.34
			Threatened bird species	16	0	11,866	24.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	402,199.96	
			Non-threatened bird species	16	0	2,373	24.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	164,591.32	
SI7.E6	A	COSV	Seawater	1	0	866	30.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	23,667.13	1,768,506.70
			Threatened bird species	16	0	11,866	75.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,243,683.29	
			Non-threatened bird species	16	0	2,373	75.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,156.29	
SI7.E7	A	COSV	Seawater	1	0	866	12.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	10,662.07	716,047.27
			Threatened bird species	16	0	11,866	30.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,198.00	
			Non-threatened bird species	16	0	2,373	30.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	204,187.20	
SI7.E8	A	COSV	Seawater	1	0	866	12.00	1	1,934	0.03		1.00	0.9		1		0.9	0.81	1		1.00	10,662.07	716,047.27
			Threatened bird species	16	0	11,866	30.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,198.00	
			Non-threatened bird species	16	0	2,373	30.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	204,187.20	
SI8.E1	B	VOC	Seawater	1	0	866	28.13	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	20,054.62	1,764,894.19
			Threatened bird species	16	0	11,866	75.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,243,683.29	
			Non-threatened bird species	16	0	2,373	75.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,156.29	
SI8.E2	B	VOC	Seawater	1	0	866	11.25	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	9,217.06	714,602.26
			Threatened bird species	16	0	11,866	30.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,198.00	
			Non-threatened bird species	16	0	2,373	30.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	204,187.20	
SI8.E3	B	VOC	Seawater	1	0	866	19.13	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	14,274.58	1,204,738.49
			Threatened bird species	16	0	11,866	51.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	847,691.13	
			Non-threatened bird species	16	0	2,373	51.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	342,772.77	
SI8.E4	B	VOC	Seawater	1	0	866	9.00	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	7,772.05	574,563.33
			Threatened bird species	16	0	11,866	24.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	402,199.96	
			Non-threatened bird species	16	0	2,373	24.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	164,591.32	
SI8.E5	B	VOC	Seawater	1	0	866	9.00	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	7,772.05	574,563.33
			Threatened bird species	16	0	11,866	24.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	402,199.96	
			Non-threatened bird species	16	0	2,373	24.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	164,591.32	
SI8.E6	B	VOC	Seawater	1	0	866	28.13	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	20,054.62	1,764,894.19
			Threatened bird species	16	0	11,866	75.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	1,243,683.29	
			Non-threatened bird species	16	0	2,373	75.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,156.29	
SI8.E7	B	VOC	Seawater	1	0	866	11.25	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	9,217.06	714,602.26
			Threatened bird species	16	0	11,866	30.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,198.00	
			Non-threatened bird species	16	0	2,373	30.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	204,187.20	

Scenario	Substance	IDM Substance	IDM Resource	IDM Group	IDM Parameters						MA Modifiers		MB Modifiers						MC Modifiers			IDM Combination	IDM Scenario
					Ecf	Ecu	α	Ec	Ecr	Ecc	MA2	A	MB1	MB2	MB12	MB15	MB18	B	MC1	MC5	C		
SI8.E8	B	VOC	Seawater	1	0	866	11.25	1	1,934	0.03		1.00	0.9		1		0.8	0.72	1		1.00	9,217.06	714,602.26
			Threatened bird species	16	0	11,866	30.00	0.5	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	501,198.00	
			Non-threatened bird species	16	0	2,373	30.00	1	6,027	0.03	1	1.00	0.9	2		1.5		2.70		1	1.00	204,187.20	
SI9.E1	C	CONV	Seawater	1	0	866	145.33	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	131,624.59	11,950,188.61
			Threatened bird species	16	0	11,866	345.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	8,439,374.01	
			Non-threatened bird species	16	0	2,373	345.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	3,379,190.01	
SI9.E2	C	CONV	Seawater	1	0	866	126.38	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	114,715.99	10,393,347.61
			Threatened bird species	16	0	11,866	300.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	7,339,395.81	
			Non-threatened bird species	16	0	2,373	300.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,939,235.81	
SI9.E3	C	CONV	Seawater	1	0	866	120.06	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	109,079.79	9,874,400.61
			Threatened bird species	16	0	11,866	285.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	6,972,736.41	
			Non-threatened bird species	16	0	2,373	285.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,792,584.41	
SI9.E4	C	CONV	Seawater	1	0	866	101.10	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	92,171.20	8,317,559.62
			Threatened bird species	16	0	11,866	240.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	5,872,758.21	
			Non-threatened bird species	16	0	2,373	240.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,352,630.21	
SI9.E5	C	CONV	Seawater	1	0	866	101.10	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	92,171.20	8,317,559.62
			Threatened bird species	16	0	11,866	240.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	5,872,758.21	
			Non-threatened bird species	16	0	2,373	240.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,352,630.21	
SI9.E6	C	CONV	Seawater	1	0	866	145.33	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	131,624.59	11,950,188.61
			Threatened bird species	16	0	11,866	345.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	8,439,374.01	
			Non-threatened bird species	16	0	2,373	345.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	3,379,190.01	
SI9.E7	C	CONV	Seawater	1	0	866	126.38	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	114,715.99	10,393,347.61
			Threatened bird species	16	0	11,866	300.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	7,339,395.81	
			Non-threatened bird species	16	0	2,373	300.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,939,235.81	
SI9.E8	C	CONV	Seawater	1	0	866	126.38	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	114,715.99	10,393,347.61
			Threatened bird species	16	0	11,866	300.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	7,339,395.81	
			Non-threatened bird species	16	0	2,373	300.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	2,939,235.81	
SI10.E1	C	CONV	Seawater	1	0	866	9.69	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	10,634.19	810,126.37
			Threatened bird species	16	0	11,866	23.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	568,418.89	
			Non-threatened bird species	16	0	2,373	23.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	231,073.29	
SI10.E2	C	CONV	Seawater	1	0	866	8.43	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	9,506.95	706,336.97
			Threatened bird species	16	0	11,866	20.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	495,087.01	
			Non-threatened bird species	16	0	2,373	20.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	201,743.01	
SI10.E3	C	CONV	Seawater	1	0	866	9.69	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	10,634.19	810,126.37
			Threatened bird species	16	0	11,866	23.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	568,418.89	
			Non-threatened bird species	16	0	2,373	23.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	231,073.29	

Scenario	Substance	IDM Substance	IDM Resource	IDM Group	IDM Parameters						MA Modifiers		MB Modifiers						MC Modifiers			IDM Combination	IDM Scenario
					Ecf	Ecu	α	Ec	Ecr	Ecc	MA2	A	MB1	MB2	MB12	MB15	MB18	B	MC1	MC5	C		
SI11.E1	D	CONV	Seawater	1	0	866	23.23	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	22,710.26	1,848,824.04
			Threatened bird species	16	0	11,866	53.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,301,737.69	
			Non-threatened bird species	16	0	2,373	53.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	524,376.09	
SI11.E2	D	CONV	Seawater	1	0	866	21.91	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	21,537.53	1,744,989.15
			Threatened bird species	16	0	11,866	50.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,228,405.81	
			Non-threatened bird species	16	0	2,373	50.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	495,045.81	
SI11.E3	D	CONV	Seawater	1	0	866	23.23	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	22,710.26	1,848,824.04
			Threatened bird species	16	0	11,866	53.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,301,737.69	
			Non-threatened bird species	16	0	2,373	53.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	524,376.09	
SI12.E2	D	CONV	Seawater	1	0	866	23.23	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	22,710.26	1,848,824.04
			Threatened bird species	16	0	11,866	53.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,301,737.69	
			Non-threatened bird species	16	0	2,373	53.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	524,376.09	
SI12.E4	D	CONV	Seawater	1	0	866	21.91	1	1,934	0.03		1.00	1		1		1	1.00	1		1.00	21,537.53	1,744,989.15
			Threatened bird species	16	0	11,866	50.00	0.5	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	1,228,405.81	
			Non-threatened bird species	16	0	2,373	50.00	1	6,027	0.03	1	1.00	1	2		2		4.00		1	1.00	495,045.81	

Notes

1- The parameter α in discharges to seawater corresponds to the volume discharged (in tonnes) and in discharges to species to the parameter R specified in the IDM methodology.

2- In all the identified scenarios the following parameters of the IDM equation take the same values, namely: p = 0 and β = 0.

Table 19. IDM value for each accident scenario.

Source: Own elaboration.

VI. Reference Scenario Selection

The procedure for determining the amount of the financial security to be provided by the operator, where applicable, is specified in Article 33 of the Regulation for partial development of Law 26/2007, of 23 October, on Environmental Liability. This procedure comprises the following phases:

1. Identification of the accident scenarios and establishment of the probability of occurrence of each scenario.

In this risk analysis, the identification of accident scenarios and the allocation of probabilities of occurrence is addressed in section IV.5 of the report.

2. Estimation of an Environmental Damage Index associated with each accident scenario following the +steps set out in Annex III of Royal Decree 183/2015, amending the Regulations for the Partial Development of Law 26/2007, of 23 October, on Environmental Liability, approved by Royal Decree 2090/2008, of 22 December.

The calculation of the Environmental Damage Index (IDM) for each of the scenarios identified is carried out in section V of this report. This index provides an estimate of the magnitude of the environmental consequences associated with each scenario.

3. Calculation of the risk associated with each accident scenario as the product of the probability of occurrence of the scenario and the Environmental Damage Index.

Therefore, the risk of each scenario is the result of multiplying its probability by the magnitude of the hypothetical damage it would trigger. This operation is shown in Table 20.

4. Selection of the scenarios with the lowest associated Environmental Damage Index which account for 95% of the total risk.

This phase first requires the relevant scenarios to be ordered in decreasing order of the IDM (as shown in Table 20), to subsequently select only those that represent 95% of the total risk of the installation. In equal IDM values, it was decided to rank those scenarios with the highest probability of occurrence first.

5. Establishment of the amount of the financial security as the value of the environmental damage of the scenario with the highest Environmental Damage Index from among the selected accident scenarios. This scenario is generally referred to as the "reference scenario" and is the only one considered in order to carry out the subsequent phases indicated in article 33 of the Regulation for the partial development of Law 26/2007, of 23 October.

Code	EDX	Probability	Risk	Relative risk	Cumulative risk
SI6.E3	112.507.882	8.88E-07	99.94	4.98%	100.00%
SI6.E1	**112,507,882**	**3.09E-07**	**34.74**	**1.73%**	**95.02%**
SI6.E2	110,947,880	1.63E-08	1.80	0.09%	93.30%
SI5.E3	59,618,559	8.88E-07	52.96	2.64%	93.21%
SI5.E1	41,592,582	3.09E-07	12.84	0.64%	90.57%
SI5.E2	58,564,655	1.63E-08	0.95	0.05%	89.93%
SI4.E3	42,632,037	8.88E-07	37.87	1.89%	89.88%
SI4.E1	42,632,037	3.09E-07	13.16	0.66%	88.00%
SI4.E2	41,592,582	1.63E-08	0.68	0.03%	87.34%
SI9.E1	11,950,189	1.54E-06	18.45	0.92%	87.31%
SI9.E6	11,950,189	4.44E-09	0.05	0.00%	86.39%
SI9.E2	10,393,348	8.13E-08	0.84	0.04%	86.39%
SI9.E8	10,393,348	1.87E-08	0.19	0.01%	86.34%
SI9.E7	10,393,348	2.34E-10	0.00	0.00%	86.33%
SI9.E3	9,874,401	4.44E-06	43.81	2.18%	86.33%
SI9.E5	8,317,560	1.87E-05	155.38	7.74%	84.15%
SI9.E4	8,317,560	2.34E-07	1.94	0.10%	76.42%
SI3.E1	4,668,868	2.50E-06	11.68	0.58%	76.32%
SI3.E6	4.668.868	7.19E-09	0.03	0.00%	75.74%
SI3.E3	3.952.797	7.19E-06	28.41	1.41%	75.74%
SI3.E2	3.594.762	1.32E-07	0.47	0.02%	74.32%
SI3.E8	3.594.762	3.03E-08	0.11	0.01%	74.30%
SI3.E7	3.594.762	3.79E-10	0.00	0.00%	74.29%
SI3.E5	2.878.691	3.03E-05	87.12	4.34%	74.29%
SI3.E4	2.878.691	3.78E-07	1.09	0.05%	69.96%
SI12.E2	1.848.824	4.16E-04	769.30	38.30%	69.90%
SI11.E3	1.848.824	8.88E-07	1.64	0.08%	31.60%
SI11.E1	1.848.824	3.09E-07	0.57	0.03%	31.52%
SI7.E1	1.768.507	7.10E-06	12.56	0.63%	31.49%
SI7.E6	1,768,507	2.04E-08	0.04	0.00%	30.87%
SI8,E1	1,764,894	4.63E-06	8.17	0.41%	30.86%
SI8,E6	1,764,894	1.33E-08	0.02	0.00%	30.46%
SI12,E4	1,744,989	2.19E-05	38.22	1.90%	30.46%
SI11,E2	1,744,989	1.63E-08	0.03	0.00%	28.55%
SI7,E3	1,207,195	2.04E-05	24.64	1.23%	28.55%
SI8,E3	1,204,738	1.33E-05	16.04	0.80%	27.33%
SI10,E3	810,126	8.88E-07	0.72	0.04%	26.53%
SI10,E1	810,126	3.09E-07	0.25	0.01%	26.49%
SI7,E2	716,047	3.74E-07	0.27	0.01%	26.48%
SI7,E8	716,047	8.60E-08	0.06	0.00%	26.47%
SI7,E7	716,047	1.08E-09	0.00	0.00%	26.46%
SI8,E2	714,602	2.44E-07	0.17	0.01%	26.46%
SI8,E8	714,602	5.61E-08	0.04	0.00%	26.45%
SI8,E7	714,602	7.01E-10	0.00	0.00%	26.45%
SI10,E2	706,337	1.63E-08	0.01	0.00%	26.45%
SI7,E5	575,719	8.59E-05	49.47	2.46%	26.45%
SI7,E4	575,719	1.07E-06	0.62	0.03%	23.99%
SI8,E5	574,563	5.60E-05	32.20	1.60%	23.96%
SI8,E4	574,563	7.01E-07	0.40	0.02%	22.35%
SI2, E6	327,883	1.78E-07	0.06	0.00%	22.33%
SI1,E1	318,451	6.18E-05	19.66	0.98%	22.33%
SI1,E6	318,451	1.78E-07	0.06	0.00%	21.35%
SI2, E1	317,825	6.18E-05	19.63	0.98%	21.35%
SI2, E3	279,656	1.77E-04	49.63	2.47%	20.37%
SI1,E3	271,676	1.77E-04	48.21	2.40%	17.90%
SI2, E2	255,543	3.25E-06	0.83	0.04%	15.50%
SI2, E8	255,543	7.48E-07	0.19	0.01%	15.46%
SI2, E7	255,543	9.35E-09	0.00	0.00%	15.45%
SI1,E2	248,288	3.25E-06	0.81	0.04%	15.45%
SI1,E8	248,288	7.48E-07	0.19	0.01%	15.41%
SI1,E7	248,288	9.35E-09	0.00	0.00%	15.40%
SI2, E5	207,316	7.47E-04	154.92	7.71%	15.40%
SI2, E4	207,316	9.34E-06	1.94	0.10%	7.69%
SI1,E5	201,512	7.47E-04	150.58	7.50%	7.59%
SI1,E4	201,512	9.34E-06	1.88	0.09%	0.09%

Table 20. Selection of the reference scenario.

Source: Own elaboration.

Table 20 shows the scenario selected as the reference scenario at the facility under study (shaded in light blue), this being **SI6.E1**, corresponding to **"Fire with release to the sea of 1,622.50 m3 of substance C mixed with 1% of the extinguishing waters"**.

VII. DAMAGE QUANTIFICATION AND ASSESSMENT

As indicated above, the quantification of the environmental damage must only be carried out for the reference scenario selected. Therefore, in the case under study, this procedure focuses on the hypothetical **discharge into the sea of 1,622.50 m3 of substance C mixed with 1% of the extinguishing water** (scenario SI6.E1).

In accordance with the definition of environmental damage included in Law 26/2007, of 23 October, the regulation excludes damage that does not cause significant adverse effects on natural resources within its scope. For this reason, it is particularly relevant to assess the significance of the damage that would be caused under the hypotheses established in the accidental reference scenario, using, among other data, the information obtained during the quantification process.

The first section of this section describes the study of damage quantification, followed by an assessment of the significance of this damage.

VII.1. Quantification of environmental damage

Under the term "quantification of the damage" the regulation includes three different aspects:

a) Extent of damage. The extent of damage refers to the amount of resource or service that would be affected and is therefore expressed in biophysical units of the affected resource such as surface area, mass, volume or population size.

b) Intensity of the damage. Intensity is used to evaluate the degree of severity of the effects caused by the agent causing the damage to the natural resources or services affected. The regulations provide for three degrees of intensity: acute, chronic and potential, which respectively imply an impact on at least 50%, between 10 and 50% or at least 1% of the population, respectively. However, it is usual to consider an additional degree of intensity called lethal, which assumes the loss of 100% of the population affected.

c) The temporal scale of the damage. The evaluation of the temporal scale of the damage includes the study of its duration, frequency and the reversibility of the effects that the agent causes on the receiving environment.

In the following points, the study carried out on each of these aspects for the reference scenario, which considers damage by substance C to Seawater and birds, is set out specifically.

A. Extent of Damage

a) Seawater

The extent of the damage to seawater is assessed through the amount of the resource that would be affected under the hypotheses established in scenario SI6.E1. Given the high uncertainty about the evolution of discharges of substance C, the precautionary principle has been observed in this study. Thus, it is assumed that in case of a spill the most unfavourable circumstances would occur.

The maximum surface area that a spill of substance C would have been calculated, taking the available bibliography on spills of this type into the sea as reference. In this sense, an average equilibrium thickness of a slick of this substance of 2.54E1 cm was adopted as a reference (USEPA, 2001).

Therefore, given that the simulated accident would have an associated volume of water contaminated with substance C of 1,622.50 m3, its maximum extension would reach 64 ha, which is a valid value when defining the extent of the damage. However, in order to complete the information required by the Environmental Liability Supply Model (MORA) -a tool for the economic valuation of environmental damage recommended by the Technical Commission for the Prevention and Remediation of Environmental Damage-, it is necessary to express this surface area in terms of the volume of water affected. For this purpose, an average depth of the water column affected by the spill is estimated. Specifically, in the scope of this study, given the relatively thin film of the spill, a reference value of 1 mm was used.

The final result provides an estimated volume of contaminated water equal to 639 m3. The following table summarises the calculations made.

VALUES OF THE PARAMETERS USED FOR THE QUANTIFICATION OF DAMAGE TO SEAWATER		
Parameter	**Value**	**Unit**
Discharged volume	1,622.50	m3
Average thickness	0.1	in
Conversion	2.54	cm/in
Average thickness	2.54E-01	cm
Average thickness	0.00254	m
Affected area	6.39E+05	m2
Affected area	64	ha
Depth affected	0.001	m
Volume of seawater	639	m3

Table 21. Values of the parameters used for the quantification of damage to seawater.

Source: Own elaboration.

b) Species (birds)

With regard to the impact on birds, initially the species present in the vicinity of the facility were identified in order to select those that, at least *a priori*, might be affected by the hypothetical spill.

Environmental Liability Supply Model (MORA)

The MORA tool facilitates the calculation of the value of the damage caused and, additionally, provides a series of data on the natural environment. In this sense, the information provided on the species present in each area is of particular interest. Specifically, the following table shows these species for the coordinates of the hypothetical spill (randomly selected among the port areas of Spain).

SPECIES IDENTIFIED IN MORA	
Accipiter nisus	*Sus scrofa*
Aythya nyroca	*Ardea cinerea*
Circus pygargus	*Ardea purpurea*
Fulica cristata	*Athene noctua*
Marmaronetta angustirostris	*Buteo*
Tyto alba	*Falco peregrinus*
	Falco tinnunculus
	Podiceps cristatus

Table 22. Species identified in MORA.

Source: MORA.

In the present study it has been decided not to select any of the species identified in MORA as possible receptors of the damage. This is because the species listed are not typical of the marine environment, affected by the hypothetical damage (wild boar, herons, grebes, birds of prey, etc.).

It is assumed that the species likely to be affected by the spill could be identified on the basis of a detailed inventory of existing species for that area[11]. In this case, only seabirds will be considered, given that they are the most likely to come into contact with the spill. Specifically, a Special Protection Area for Birds in the vicinity is considered. The species potentially affected are the common tern, the little tern, the white-faced tern and the black-footed tern.

In this analysis, in addition to the possible impact of the spill on non-endangered seabirds (as mentioned above), a precautionary approach has been adopted, assuming a certain impact on endangered species that may occasionally be present in the area (brown teal or white-headed duck). This is intended to ensure that the operator has sufficient financial coverage for any possible eventualities that may arise after the occurrence of a spill. Again, in this section it is worth remembering the inevitable degree of uncertainty associated with this type of study. Consequently, it is always advisable to take a precautionary approach.

Once the bird species expected to be affected by a hypothetical spill have been selected, the next phase involves the estimation of the number of individuals which would perish as a result of the spill. To calculate this, the number of individuals that would come into contact with the agent causing the damage is estimated (this operation is carried out in this section based on the calculation of the extent of the spill). Then it is necessary to determine how many of these would perish as a result (this aspect is addressed in the study of intensity). In this regard, two points are made:

[11] As indicated in the introduction to this case study, as with other data used in this case study, this hypothetical inventory has been created *ad hoc* for the purposes of this example.

1- Although the MORA tools allows the introduction of two types of damage to the species (death or injury), in this study it is assumed that the damage caused will always be death. Again, this is due to the high level of uncertainty in selecting one or other type of damage. Therefore, the least favourable option is selected.

2- The determination of the number of individuals that would perish as a result of the spill is technically very complex. Not only must a certain population that could be affected be taken as a reference, but it is also necessary to establish the number of members of that population that would come into contact with the spill, and which of these would suffer relevant effects. Therefore, the decision taken regarding the number of individuals is also associated with a high degree of uncertainty and is even somewhat subjective. Again, a precautionary approach to the assessment of damage is advised.

In the calculation of the number of affected individuals, the classification of animal species carried out in MORA was taken into consideration. Specifically, according to this tool, the non-threatened species considered in the study are treated as "other birds"; while the threatened species (marbled teal and duckling) are assimilated to the marbled teal, since it is the only species of the two that has differentiated data of costs in MORA.

The census of breeding pairs in the natural area was taken as the source data for the quantification. Given that this data is assumed to be a range, it has been converted into number of individuals (multiplying it by two) and, subsequently, the average of this range was calculated in order to obtain a single reference value.

The estimation of the number of individuals that would come into contact with the spill was carried out separately for each category of species (threatened and non-threatened):

- For endangered species, given the considerable uncertainty about the number of individuals of endangered species that would come into contact with the spill, and their high sensitivity to the damage caused, a precautionary approach was adopted, assuming that the entire population would come into contact with the spill.
- For non-endangered species, 25% of the population were assumed to come into contact with the damaging agent.

The results of this estimation are shown in the table below:

Species	Reference population (p)		Reference population (i)		Average (i)	Populationa affected (i)
	Minimum	Maximum	Minimum	Maximun		
gray teal (*Marmaronetta angustirostris*)	0	2	0	4	2	**2**
White-headed Malvasia (*Oxyura leucocephala*)	0	2	0	4	2	**2**
Total individuals of threatenead species afectated, similar to Cerceta pardilla (Marmaronetta angustirostris)						**4**
White-faced smoke (*Chlidonias hybrida*)	40	200	80	400	240	**60**
Little tern (*Sternula albifrons*)	60	163	120	326	223	**56**
Common tern (*Sterna hirundo*)	50	200	100	400	250	**63**
Total individuals of non threateaned species , classified as "Other birds"						**178**

p: couples. i: individuals

Table 23. Estimated number of affected individuals.

Source: Own elaboration.

To sum up, note that the main purpose of including the above data in the study is to incorporate and foresee the possibility that, in the event of an accident, a certain number of birds (both endangered and non-endangered species) may have to be recovered. In this respect, the key aspect is the introduction of these natural resources in the valuation, in order to illustrate the methodology, rather than provide an accurate estimate of the specific number of individuals.

B. Intensity of damage

As in the estimation of the extent, a precautionary approach was adopted in the assessment of the intensity of the damage, assuming a lethal impact. It was assumed that all the individuals that came into contact with the agent causing the damage would perish (4 individuals assimilated to marbled teal and 178 assimilated to other birds).

This decision is based on the following arguments:

- On the one hand, the high degree of uncertainty associated with estimating the extent of the damage must be taken into account. That is, not knowing with sufficient certainty the surface area and volume of water that would be affected makes it difficult to estimate key parameters for determining the intensity of the damage, such as the concentration reached by the pollutants in the water.
- An additional difficulty lies in the scarcity or absence of sufficient data to declare a degree of intensity lower than lethal. In this sense, the uncertainty that exists when specifying the species and individuals that would come into contact with the spill and their toxicity thresholds with respect to the agent causing the damage is of note.

Therefore, as indicated, following a precautionary approach, a lethal impact is assumed.

C. Time scale of the damage

The study of the time scale of the damage includes the estimation of three aspects: the duration of the damage, the frequency with which it may occur and the reversibility of the damage.

a) Duration of the damage

In order to estimate the duration of the hypothetical damage, the Environmental Liability Supply Model is used.

This tool indicates that the average time needed to remedy a spill of non-volatile organic compounds into the sea is one month. On the other hand, for the remediation of a damage to birds, a 6 month period is indicated.

b) Frequency of damage

The frequency with which the hypothetical accident is expected to occur is analysed in Chapter IV of this report. Specifically, for the reference scenario (SI6.E1) the frequency is established at 3.09E-7 times per year.

c) Reversibility of the damage

Taking into account the agent causing the damage (CONV) and the receptors (seawater and birds), remediation could be carried out using currently available techniques within a reasonable period of time and at a proportionate cost. In this regard, it is worth noting that remediation techniques for all of the agent-resource combinations identified in the reference scenario are available in MORA.

In this way, the damage is declared reversible and the measures to be applied will be primary and compensatory.

VII.2. Assessment of the significance of the environmental damage

In view of the above and, once again, prioritising the precautionary approach in the assessment, the damage predicted under the hypotheses established in the reference scenario is considered to be significant. Therefore, it would have the status of environmental damage in accordance with Law 26/2007, of 23 October, and would require repair if it were to occur.

VIII. MONETISATION OF DAMAGE

The economic evaluation of the remediation that should be carried out for the damage predicted in the reference scenario (SI6.E1) is evaluated using the Environmental Liability Supply Model (MORA), available on the Ministry´s environmental liability website(https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/responsabilidad-mediambiental/modelo-de-oferta-de-responsabilidad-ambiental/).

Note that, in the application of MORA, all the default values given in MORA have been maintained except for the waiting time necessary to start the remediation, which is6 months in accordance with the new wording of article 45 of Law 26/2007, of 23 October, given that this is the period of time that the Administration has to finish the administrative procedures of environmental liability.

The following table shows the economic valuation of damages offered by MORA, including both the primary remediation measures and the corresponding compensatory measures.

VALUE OF PRIMARY AND COMPENSATORY REPAIR			
Agent-resource combination	Primary remediation (€)	Compensatory remediation (€)	Total (€)
CONV non-biodegradable-Marmaronetta angustirostris (Death)	38,046.35	25,747.69	63,794.04
CONV non-biodegradable-Other Birds (Death)	27,891.51	25,519.02	53,410.53
CONV non-biodegradable-Seawater	16,083,542.39	269,096.98	16,352,639.37
Total repairs	**16,149,480.25**	**320,363.69**	**16,469,843.94**

Table 24. Value of primary and compensatory repair.

Source: Prepared by the authors using MORA.

IX. ESTABLISHING THE FINANCIAL SECURITY

As provided for in the regulations, the amount of the financial security corresponds to the cost of the primary remediation measures, amounting in this case to 16,149,480.25 €. This amount must be increased in order to take into account the costs of damage prevention and avoidance. In this sense, the minimum percentage proposed in the Regulation for the partial development of the law (10%) is applied. Therefore, the amount of the prevention and avoidance measures is set at: 1,614,948.03 €.

Despite the fact that the facility has the environmental management system UNE-EN ISO 14001 in force and EMAS, as the primary remediation cost exceeds Eur 2,000,000, it would be obliged to provide the corresponding financial security, in accordance with article 28 of Law 26/2007, of 23 October.

Therefore, in the present study the operator should cover its risks for a total amount of 17,764,428.28 €.

The breakdown of the costs is shown in the following table, differentiating, on the one hand, the reference amount in order to assess the need to provide the compulsory financial security and, on the other, the total value of the damage that would be caused under the hypotheses established in the reference scenario.

BREAKDOWN OF THE VALUE OF THE ENVIRONMENTAL DAMAGE AND AMOUNT OF FINANCIAL SECURITY	
Measure	Amount (€)
Prevention and avoidance	1,614,948.03
Primary Remediation	16,149,480.25
Amount of financial security	**17,764,428.28**
Compensatory Remediation	320,363.69
Total cost of hypothetical damage	**18,084,791.97**

Table 25. Breakdown of the value of the environmental damage and amount of the financial security.

Source: Own elaboration.

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