CONTINGENCY PLAN FOR GASOLINE AND DIESEL OIL SPILLS IN LA SAVINA PORT (FORMENTERA ISLAND)

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ABSTRACT

This study aimed to draw up a Contingency Plan in order to specify all the guidelines to be followed after a gasoline and/or diesel fuel spill in La Savina port, on Formentera Island in the Balearic Islands. Firstly, the points where the fuel is discharged are identified and the parameters to take into account when conducting the simulations determined. Starting from the simulations carried out with the ALOHA model for the diffusion of hydrocarbons in the atmosphere, the risk of explosion and poisoning is estimated. In addition, the variation of the atmospheric hydrocarbon concentration inside and outside buildings in relation to the distance from the spill point is also estimated, as well as the Maximum Average Sustained Release Rate. Once all this data has been obtained, it can be considered whether or not it is necessary to evacuate the population surrounding the spill site.

By means of the models OILMAP and GNOME, the movement of oil spilled into the sea is simulated, determining the area of shoreline that will be affected by the oil spill, the impact time, the amount of oil evaporated and the geographical extent of the spill. Therefore, a spill of 12,500 liters of petrol, which originated in the central part of the quay adjacent to the outside dyke and which is under the effect of a wind blowing in a NNW direction at a speed of 4.2 m/s, will impact on the dyke of the Formentera Sea after 21 minutes. The amount of gasoline that impacts is estimated at 6.623 liters. The length of the booms needed to prevent the spread of oil spilled through the various piers, docks and marinas of the La Savina port is also estimated. So, in order to protect the area from the right end of the pier adjacent to the outside dyke as far as the pier adjacent to the central dyke, a boom of 259 meters would be required.

The estimates made using the COSTES model for 12,500 liters of diesel fuel indicate that the losses incurred during the cleaning and the coastal repair period represent some 2,400,000 Euros. Finally, the emergency plan is included, which consists of: the organization chart, the classification and reporting of emergencies, the procedures and rules to follow after these emergencies have taken place, the evacuation procedures for the troubled area, the manner of concluding the emergency, the procedures for requests for assistance and the maintenance and revision of the plan.

INTRODUCTION

Due to its low fuel consumption, the island of Formentera does not need a supply through tankers, unlike the other islands of the Balearic archipelago. The provision is made from the CLH factory in Ibiza through tanker trucks transported by ferry to the port of La Savina. The types and quantities of oil discharged in the port of La Savina during 2007 are listed in Table 1.

Table 1. Main types and volumes of fuel unloaded in the port of La Savina in 2007.

Fuel transported	Volume unloaded (m^3)
95 octane petrol	2.954
A Diesel	3.675
B Diesel	620
C Diesel	6.092

The main points where an oil spills could originate are the discharge area of the tankers in the Sheltered Dyke (38 º 44.02 '67 "N and 01 º 25.05' 19" E) and the two fuel suppliers, located in the same port, that supply fuel to pleasure craft and fishing boats. The coordinates of these points are: 38 º 44 '51 "N, 1 º 25' 25" E and 38 º 43 '59.63 "N, 1 25' 4.50" E.

PREDOMINANT WINDS AND CURRENTS

Intensities and main directions of winds in the port of La Savina are shown in Table 2. Regarding sea currents, their intensity inside the port is minimal. In strong storms, currents may reach 0.15 m/s in the directions W, NW and SE, 0.26 m/s direction N, 0.5 m/s for NE and 0.8 m/s in a SW direction near the port of La Savina.

Table 2. Wind directions and speeds at the port of La Savina.

Wind direction	Wind speed (m/s)
NE	3.9
SE	3.8
S	2.3
NNE	4.3
N	1.6
NNW	4.2
NW	6.2

OIL TRAJECTORIES

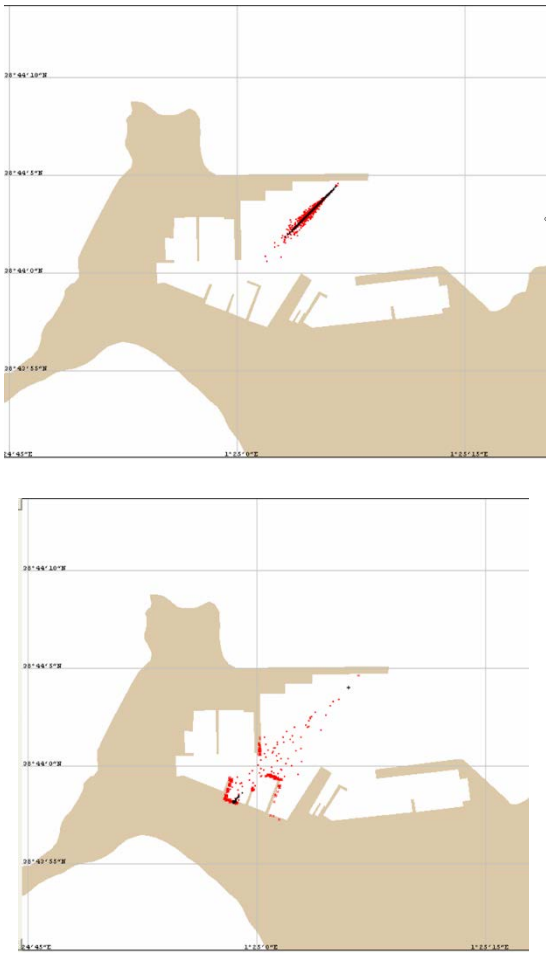
By means of the model GNOME, the different trajectories of a spill of 12,500 liters of gasoline and diesel are simulated under the effect of predominant winds in the port [1].

Simulation 1

Spill of 12,500 liters of automobile gasoline. NE wind direction. Wind speed of 3.9 m/s. Time of impact of gasoline on the Paseo Marina pontoons: 25.1 minutes. Volume of gasoline evaporated: 6,586 liters. Volume of gasoline remaining: 5,914 liters. Percentage evaporated: 52.7%.

The trajectory followed by the slick from the very beginning until its impact on the coast is shown in images 1a and 1b.

Images 1a and 1b. Trajectory followed by the spill from the beginning until it hits the coast.



After 32 minutes the slick will impact on the left side of the Fisheries Dock, in front of the Paseo de la Marina. At that time, 56.7% of the volume spilled will have evaporated, i.e. 7,082.5 liters, and 5,417.5 liters will remain in that area. Once the slick hits the coast, its size, shape and thickness will depend on the shape of the jetty that the gasoline reaches. If the oil were not to hit the coast, the slick would have, at that time, a radius of 102 meters and a thickness of 4.77×20^{-4} m.

Simulation 2

Spill of 12,500 liters of automobile gasoline. Wind direction SE. Wind speed of 3.8 m/s.

The slick would move along the Sheltered Dyke, impacting on the first ledge after 8 minutes. On the order of 600 liters may be retained in this area.

Volume of gasoline evaporated: 4,250 liters. Volume of gasoline remaining: 8,250 liters. Percentage evaporated: 34.0%.

Image 2 shows the trajectory followed by the slick and the point of impact on the Sheltered Dyke.

Image 2. Path followed by the slick with SE wind.

Unless the oil spill can be contained, the remaining 8,250 liters will move up to the Passengers Dyke where it will impact after 13 minutes. Some 600 liters may be retained in this area. Volume of gasoline evaporated: 5,243 liters. Volume of gasoline remaining: 7,257liters.

If, by the same token, the remaining oil cannot be contained, some 3,500 liters of gasoline will be retained from the corner of the Passengers Dyke, where it will arrive after 19 minutes. Volume of gasoline evaporated: 6,017 liters. Volume of gasoline remaining: 6,483 liters. All the oil spilled will have evaporated after eight hours.

Simulation 3

Spill of 12,500 liters of automobile gasoline. Wind direction S. Wind speed of 2.3 m/s.

The spill will be retained in the Sheltered Dyke. There will only be a process of lateral spreading of the oil, which will mean that a small part of the oil will go out to sea on the right side of the dyke while another part will be retained between the first ledge of the left side of the Sheltered Dyke and the ledge of the Passengers Dyke, displaced due to the slight marine current.

Simulation 4

Spill of 12,500 liters of automobile gasoline. Wind direction NNE. Wind speed of 4.3 m/s.

In these wind conditions, the mixture of oil will impact on the Ribera Dock of the Formentera Marina after 28 minutes. At that moment, some 9,428 liters will have impacted on the docks. In that area some 1,170 liters may be retained. Five minutes later, the oil will impact on the other side of the pier and about 865 liters may be retained in that area. The quantity of oil remaining at that moment will be around 5,353 liters.

After 8 minutes, the oil will affect the left area of the pier; where some 1,500 liters may be retained. Thereafter, some 4,910 liters could be deposited in the shore of the docks. The path followed by the slick from the beginning until it hits the coast is shown in images 3a and 3b.

Image 3a and 3b. Trajectory followed by the spill with a wind speed of 4.3 m/s NNE direction, from the beginning until it hits the coast.

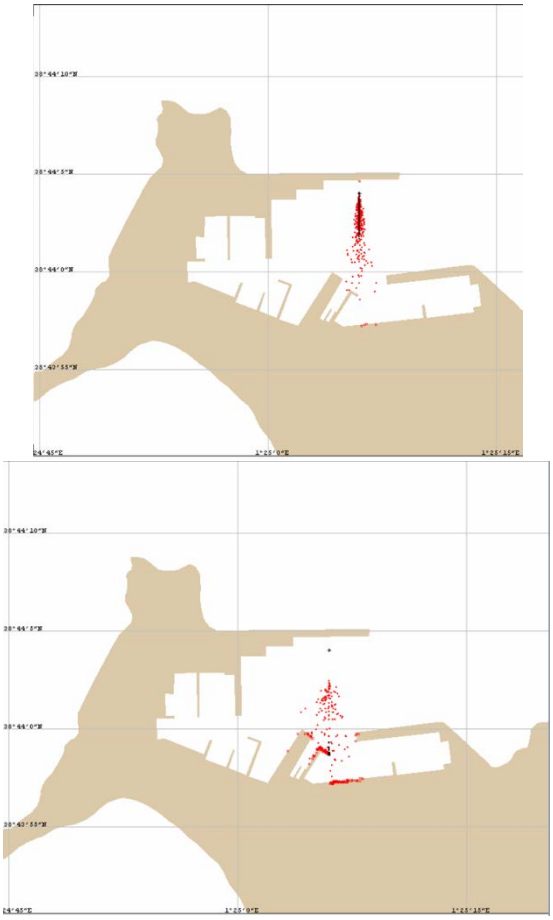
Simulation 5

Spill of 12,500 liters of automobile gasoline.
Wind direction N.
Wind speed 1.6 m/s.

In these conditions, the slick will enter the channel of Formentera Mar, then travel along the petrol pump section and finally hit the coast. The time of impact is 69 minutes. At that moment the volume of remaining oil will be 3,848 liters. Approximately 1,000 liters could be retained in the right side of Commercial Dock and the remaining 2,848 liters will move inside Formentera Mar.

After thirteen minutes, the remaining oil will have spread along the dock of Formentera Mar, which is parallel to the Paseo de la Marina. At that moment, 9,000 liters will have evaporated and around 2,500 liters will have spread along the dock. Images 4a and 4b show the path followed by the slick from the beginning until it hits the coast.

Images 4a and 4b. Trajectory followed by the slick from the beginning until it hits the coast, with a North wind at a speed of 1.6 m/s.



In order to protect the Commercial Dock and the Formentera Mar area, a 245 meter long boom would have to be deployed as shown in Image 7b.

Simulation 6

Spill of 12,500 liters of automobile gasoline. Wind direction NNW. Wind speed of 4.2 m/s.
The slick will move to impact the dyke of Formentera Mar. The time of impact is estimated at 21 minutes. At that time the oil volume that impacts on the dyke is around 6,623 liters of gasoline. In this moment, the slick will spread to the right side of the dyke.
After 9 minutes, the slick will have passed the right side of the dyke. At that time, the remaining quantity of oil is 5,549 liters. After 13 minutes, the slick will impact on the coast again. The volume of remaining oil at that instant is on the order of 4,813 liters.

The remaining oil would be held in the corner of the intersection between the end of the dyke and the land of the Paseo de la Marina.

The path followed by the slick is shown in images 5a and 5b.

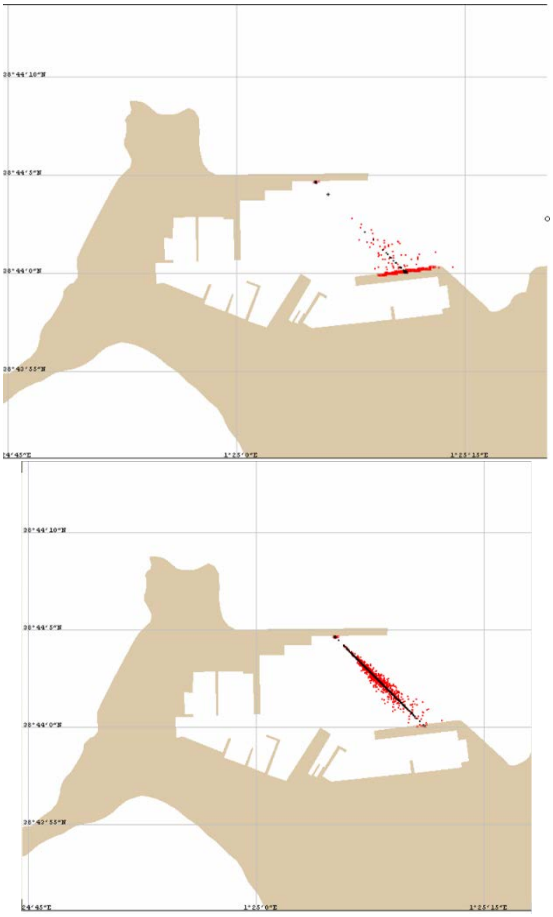
Images 5a and 5b. Path followed by the spill from the beginning until it hits the coast, with a NNW wind at a speed of 4.2 m/s

Simulation 7

Spill of 12,500 liters of automobile gasoline. Wind direction NW. Wind speed of 6.2 m/s.

In these conditions, the slick will move until it hits the end of the dyke of Formentera Mar. The impact time is estimated at 18 minutes. At that time the volume of oil that impacts the dyke is approximately 6,593 liters of gasoline. After five minutes, the slick will have moved beyond the right area of the dyke. At that time, the remaining volume of oil is 6,092 liters. After 13 minutes, the slick will impact on the coast again. The volume of remaining oil at that instant is around 5,177 liters. The remaining oil would be held in the corner of the intersection between the end of the dyke and the land of the Paseo de la Marina. The path followed by the slick is shown in the images 6a and 6b.

Images 6a and 6b. Path followed by the slick under NW wind direction and intensity of 6.2 m/s, from the beginning until it hits the coast.



Diesel oil spills

Simulation 8

Spill of 12,500 liters of diesel oil. Wind direction NE. Wind speed of 3.9 m/s.

The trajectory followed by the slick is very similar to the trajectory followed by the gasoline slick, varying only in the time of impact on the coast and the amount evaporated. The impact time on the pontoons of the Paseo de la Marina is 28 minutes. The volume of diesel oil evaporated is 355 liters. The volume of remaining diesel oil is 12,145 liters. In that area only 8,300 liters may be contained, so the slick will spread beyond the right pontoon and 2,500 liters of diesel oil could be retained. The estimated time for the remaining oil to cross the whole of the affected area is 25 minutes. The volume of remaining oil after this time is estimated at 11,880 liters. Therefore, the zone of the Marina de Formentera would be affected by the diesel oil spill in front of the La Ribera Dock at a depth of 57 meters.

Simulation 9

Spill of 12,500 liters of diesel oil. Wind direction SE. Wind speed 3.8 m/s.

As in the case of gasoline, the slick will move along the left side of the Sheltered Dyke and will impact on the first ledge after 9 minutes. In this some 600 liters may be retained. The volume of diesel oil evaporated is 122 liters. The volume of remaining oil is 12,378

liters. If the spill cannot be contained, the remaining 12,378 liters will move as far as the second ledge of the Passengers Dyke, which it will reach after 15 minutes. In this area on the order of 600 liters can be retained. The volume of oil evaporated is 200 liters. The volume of remaining oil is 12,300 liters. If the oil still cannot be contained, the remaining 700 liters of diesel will be retained in the corner of the third ledge at the terminus of the Passengers Dyke, where it will arrive after 21 minutes. The volume of evaporated oil is 274 liters. The volume of oil remaining is 12,226 liters. In the port area initially affected by the spill, some 2,400 liters could be retained. The remaining 9,826 liters will move until they reach the Dársena Deportiva, where 2,809 liters may be retained.

Simulation 10

Spill of 12,500 liters of diesel oil. Wind direction S. Wind speed of 2.3 m/s.

The slick will be retained in the Sheltered Dyke. There will only be a process of lateral spreading of the oil, which will mean that a very small volume of the oil goes out to sea following the right side of the dyke while the rest of the volume will be held both in the first ledge of the left side of that dyke and in the ledge of the Passengers Dyke, due to a marine current of low intensity. The slick must be contained by booms, as stated in the last section, and recovered using skimmers.

Simulation 11

Spill of 12,500 liters of diesel oil. Wind direction NNE. Wind speed of 4.3 m/s.

In these wind conditions, the mixture of oil will impact on La Ribera Dock of the Formentera Marina after 31 minutes. At that moment 12,110 liters will have reached the docks. In that area 1,170 liters may be retained. After about 6 minutes, the oil will impact on the other side of the dock, where 865 liters may be retained. The quantity of oil remaining at that moment will be 12.00 liters. After 9 minutes, the oil will affect the left area of the dock, where around 1,500 liters may be retained. After that time, 11,950 liters of oil will be deposited on the edge of the docks. The path followed by the spill is similar to that of the gasoline spill.

Simulation 12

Spill of 12,500 liters of diesel oil. Wind direction N. Wind speed of 1.6 m/s.

In these conditions, the slick will enter the channel of Formentera Mar, then move along the petrol pump section and finally hit the coast. The time of impact is 76 minutes. At that moment the volume of remaining oil is 11,675 liters. Approximately 1,000 liters could be retained in the right side of Commercial Dock and the remaining 10,675 liters will move inside Formentera Mar. After fifteen minutes, the remaining oil will have spread along the dock of Formentera Mar, which is parallel to the Paseo de la Marina. At that moment, 952 liters will have evaporated and around 11,548 liters will have spread along the dock.

Simulation 13

Spill of 12,500 liters of diesel oil. Wind direction NNW. Wind speed of 4.2 m/s.

The slick will move to impact on the dyke of Formentera Mar. The time of impact is estimated at 23 minutes. At that time, the oil volume that will impact on the dyke is approximately 12,202 liters of gasoline. At this moment, the slick will spread to the right

side of the dyke. After 10 minutes, the slick will have passed the right side of the dyke. At that time, the remaining quantity of oil is 12,087 liters. After 15 minutes, the slick will impact on the coast again. The volume of remaining oil at that instant is around 1,928 liters.

The remaining oil will be held in the corner of the intersection between the end of the dyke and the land of the Paseo de la Marina.

Simulation 14

Spill of 12,500 liters of diesel fuel. NW wind direction. Wind speed of 6.2 m / s.

In these conditions, the slick will move until it hits the end of the dyke of Formentera Mar. The impact time is estimated at 20 minutes. At that time the volume of oil that impacts the dyke is approximately 12,000 liters of gasoline. After six minutes, the slick will have moved beyond the right area of the dyke. At that time, the remaining volume of oil is 11,950 liters. After 15 minutes, the slick will impact on the coast again. The volume of remaining oil at that instant is around 11,950 liters. The remaining oil would be held in the corner of the intersection between the end of the dyke and the land of the Paseo de la Marina.

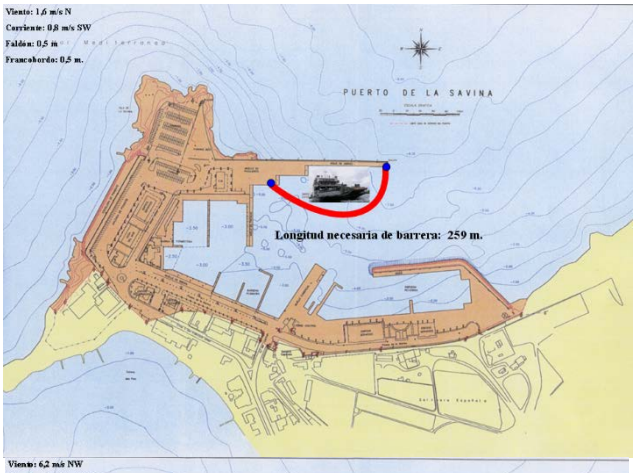
GASOLINE AND DIESEL OIL SPILL AND GAS FUEL AT THE PETROL PUMPS

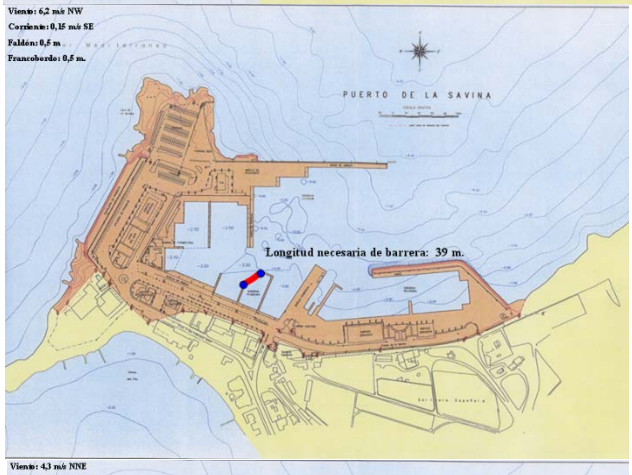
The main sources of gasoline and diesel oil spills are the process of unloading fuel from the tank trucks which transport fuel from Ibiza, the processes of supplying oil from petrol pumps to vessels and finally any problems that may occur with the petrol pumps themselves. The volumes of gasoline and diesel oil that may be spilled while unloading the tanks or during fuel supplying from petrol pumps to vessels or fishing boats are often minimal. CLH internal communications show that these volumes could be 50 liters at the most. In the case of a gasoline spill, it will evaporate in a very short period of time and in the case of a diesel oil spill it could be recovered with adsorbent blankets, without generating any environmental problems.

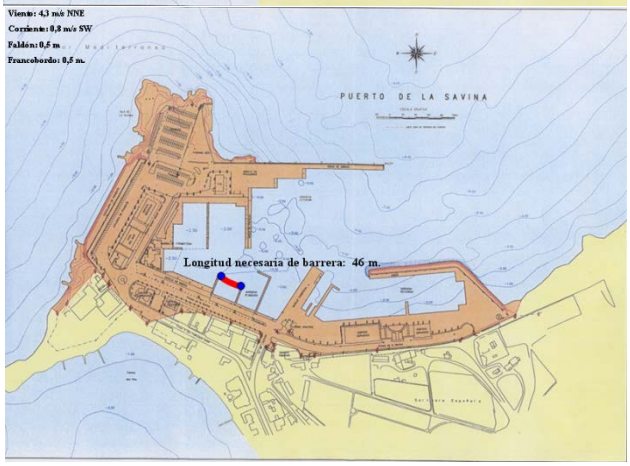
PROTECTION BY MEANS OF CONTAINMENT BOOMS

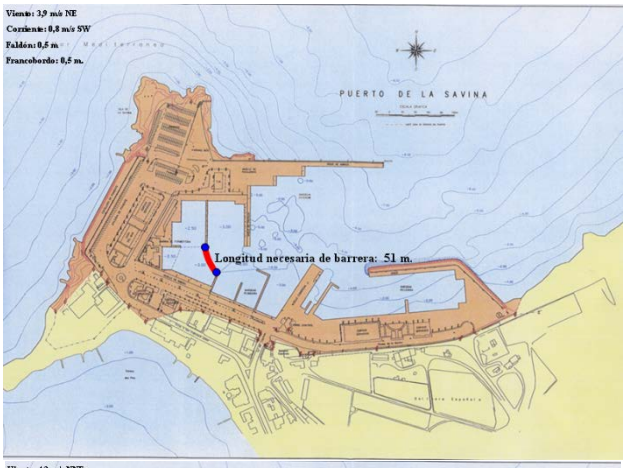
By means of the simulation model ALFONSO, the lengths of boom required were estimated. These booms are necessary to avoid further spreading of oil and contamination of other port facilities, as shown in images 7a, 7b, 7c, 7d, 7e, 7f and 7h.

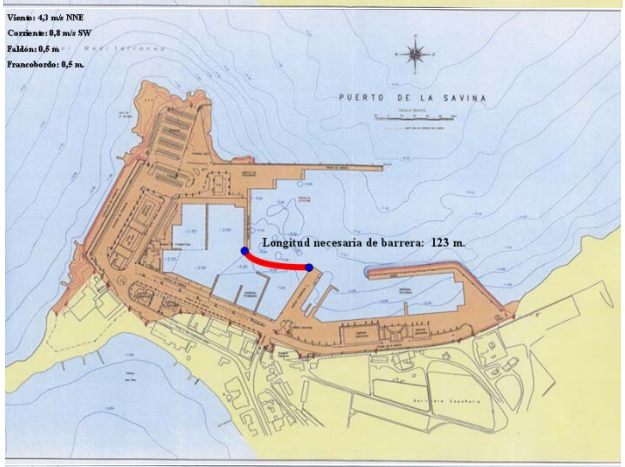
Images 7a, 7b, 7c, 7d, 7e, 7f, 7g and 7h. Lengths of booms needed for the protection of the different areas of La Savina port

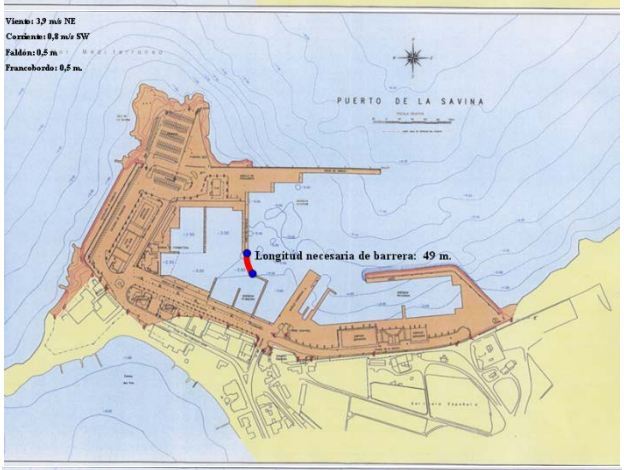

Viento: 1,6 m/s N
Corriente: 0,8 m/s SW
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 259 m.

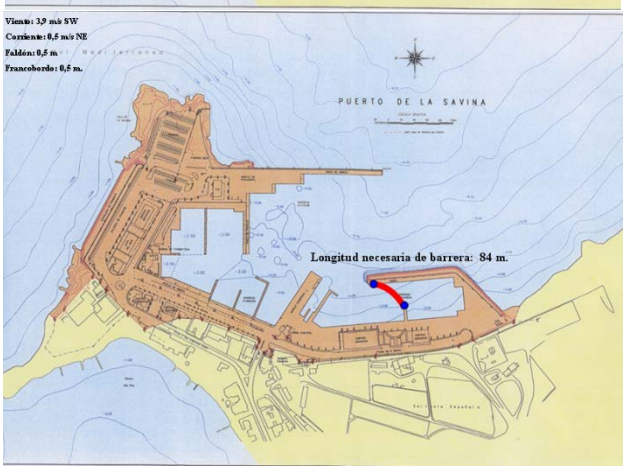

Viento: 6,2 m/s NW
Corriente: 0,15 m/s SE
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 39 m.


Viento: 4,3 m/s NNE
Corriente: 0,8 m/s SW
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 46 m.


Viento: 3,9 m/s NE
Corriente: 0,8 m/s SW
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 51 m.

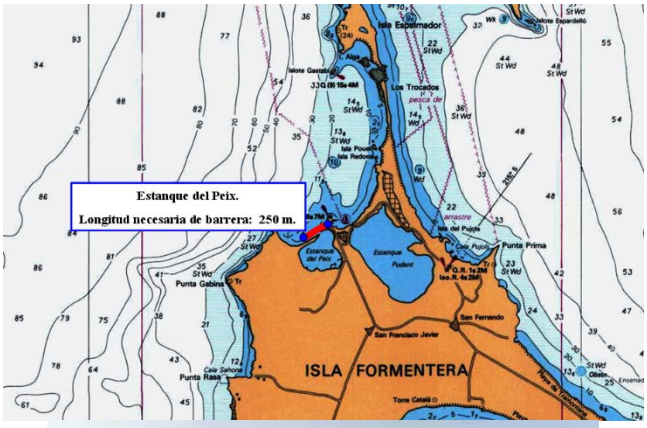

Viento: 4,3 m/s NNE
Corriente: 0,8 m/s SW
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 123 m.


Viento: 3,9 m/s NE
Corriente: 0,8 m/s SW
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 49 m.


Viento: 3,9 m/s SW
Corriente: 0,5 m/s NE
Faldón: 0,5 m
Francobordo: 0,5 m.
PUERTO DE LA SAVINA
Longitud necesaria de barrera: 84 m.

In case of a risk of the slick leaving La Savina port, the lengths of boom needed to protect the Estanque des Peix and the salt marshes were calculated using the model ALFONSO. The calculated lengths are 250 and 1,800 meters respectively (Images 8a and 8b).

Images 8a and 8b. Length of boom needed to protect the Estanque des Peix and the salt marshes



BURNING OF OIL SPILLED

Due to the proximity of inhabited areas in the whole area of La Savina port, the burning of oil spilled is not advisable as a disposal method because the damage it could cause to the surrounding population is considered as a high risk.

OIL TREATMENT WITH DISPERSANTS

In view of the shallow waters at the various spill spots and their the proximity to the coast, spraying dispersants is not advisable as a disposal method. Moreover, in the case of gasoline the efficacy of treatment would be minimal.

Likewise, spraying dispersants is totally unadvisable due to the presence of a pond connected to the sea (Estanque des Peix) and a water inlet header in the salt marshes.

RECOVERY OF OIL SPILLED

In the case of a gasoline spill, the recovery possibilities are minimal, given its high volatility. It should simply be left to evaporate by itself, taking the necessary precautions for the population of La Savina port, due to the risk of poisoning and explosion of gasoline vapours formed. All information concerning the risk of poisoning and explosion is shown in the section on diffusion in the atmosphere.
In the case of a diesel oil spill, its recovery on the sea surface can be achieved using sorbents and skimmers. Of all the products tested by CEDRE and Environment Canada (Environmental Technology Center), we can highlight ABSORBPAL bulk, which has an adsorbent capacity of 64.1 g diesel oil / g sorbent, and Black Green, which has an adsorbent capacity of 56.1 g diesel oil / g sorbent. According to these results, at the most 166 kg of adsorbent ABSORBPAL bulk or 190 Kg of Black Green would be required in order to recover all the oil spilled.

If the absorbent material is in powder form it can be sprayed using a cannon with an average spraying capacity of 300 Kg/minute and a range of 10 meters wind on tail.

A spill of diesel oil can be recovered at sea using skimmers. Most commercial skimmers can be used to recover diesel oil efficiently and rapidly. In this way, oleophilic disc skimmers can be used to recover 12,500 liters of diesel oil in less than 3 hours, including deployment time and its subsequent recovery.

For the correct operation of the skimmer, it should be surrounded by a containment boom with an estimated length of 600 meters of boom per skimmer.

ATMOSPHERIC OIL DIFFUSION

By means of the simulation model ALOHA, the variation in the concentration of gasoline vapors in the air (inside and outside of buildings) is estimated over time at a point located 30 meters downwind. The model input parameters are shown in Table 3 [1].

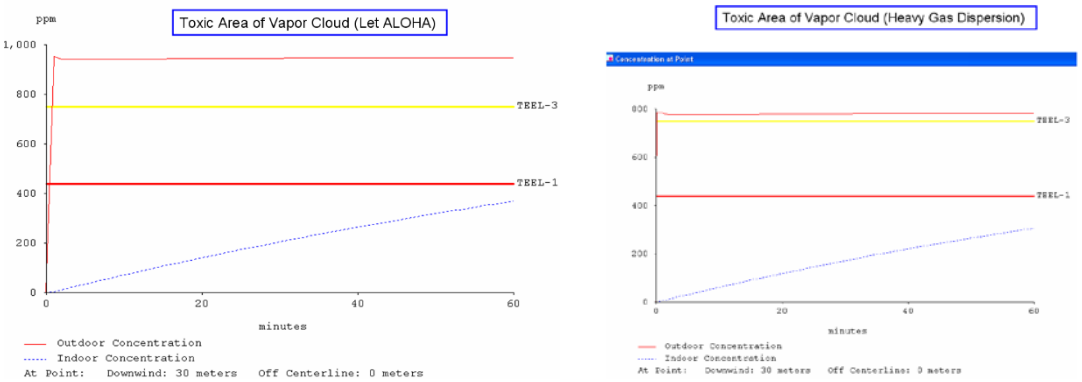
Table 3. Input parameters for model "ALOHA" in order to estimate the diffusion values of gasoline in the air surrounding the spill.

Type of fuel spilled	Automobile gasoline 95 Octanes
Spilled quantity	12.500 Liters
Substrate on which oil is spilled	Water
Slick shape	Pond shape
Air temperature	20ºC
Water temperature	15ºC
Atmosphere stability	D (neutral)
Air speed	10 m/s
Focus distance	30 m.

Simulation Method	“Gaussian Dispersion” and “Heavy Gas Dispersion”

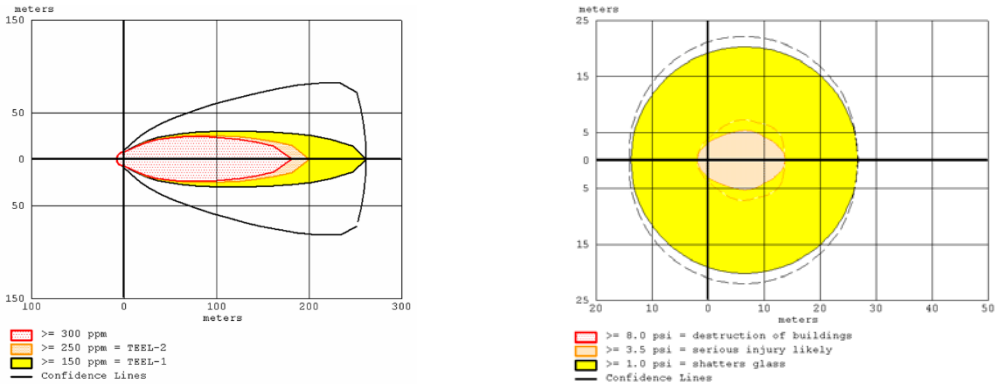
The values of the variation in concentration obtained by the “Gaussian Dispersion” and “Heavy Gas Dispersion” methods are shown in Graphs 1a and 1b. These charts also include the TEEL values (Temporary Emergency Exposure Limits), which represent the main public response to different concentrations of a chemical product during an incident.

Graphs 1a and 1b. - Variation in the concentration of gasoline vapors in the air over time at a point located 30 meters downwind.



Likewise, areas where the concentration of gasoline vapours is greater than or equal to 300, 250 and 150 ppm (graph 2a) were identified and the damages caused by a gasoline vapor explosion, spilled in a pond shape slick, according to the distance (graph 2b) (ALOHA 2007) were also determined.

Graphs 2a and 2b. Variation in concentration and pressure variation according to distance.



FOAM FLOW IN ORDER TO ENXTINGUISH A BURNING TRUCK

In the case of a fire in a tanker truck carrying gasoline, the simulation model "ESPUMAS" estimates the flow of foam which is necessary to be sprayed, depending on the length and the width of the largest tank. We can therefore calculate that a flow of 1,800 liters/minute of foam, for 5 minutes, is required using the total area of the vessel. The cost of the foam to be used is estimated at 45,000 €.

TOXICITY OF GASOLINE AND DIESEL OIL

Using the simulation model E. V. A. (Extension Vapor Assessment), the toxicity of the water-soluble fraction of gasoline and diesel oil was estimated in different species. Thus, for a gasoline spill the average effective concentration (EC_{50}) after 48 h is 25 mg/L for *artemia spp* and 5 mg/L for *daphnia magna*. The average lethal concentration (48 h LC_{50}) is 51 mg/L for *artemia spp*, 5 mg/L for *daphnia magna* and 7 mg/L for *rainbow trout larvae*. In the case of a spill of diesel, the average tolerance limit (24h TL_m) for *American shad juveniles* is 91 mg/L.

OIL IMPACT ON THE COAST

The characteristics of the two coastal areas affected by gasoline were estimated. Using the simulation model "V. I. C. EN. C." (intrinsic vulnerability of coast and polluted environments), the vulnerability, the resilience and the induced recovery were estimated. The values of these parameters for the port of La Savina are shown in Table 4.

Table 4. Vulnerability, Resilience, and Induced Recovery in the port of La Savina.

Vulnerability		Resilience			Induced recovery		
Index	Level	Index	Level	Time (years)	By mechanical means	By chemical means	By biological means
2	Slightly vulnerable	9	Very high	A few months	7	9	6

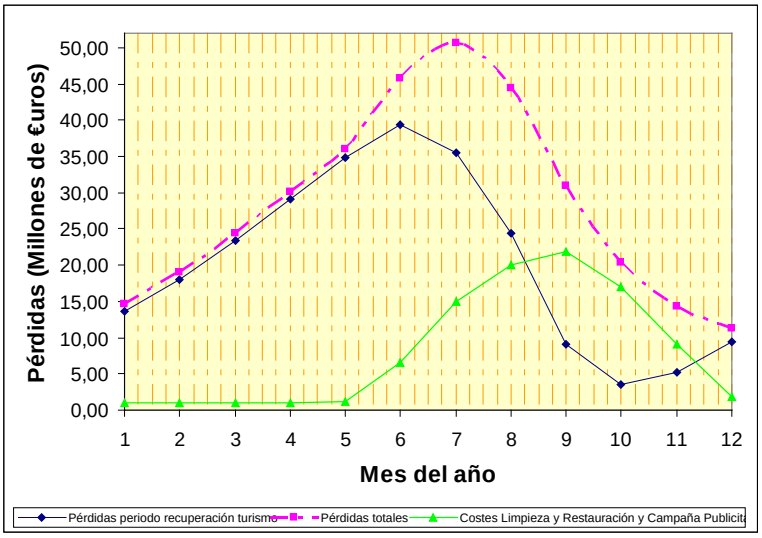
TREATMENT COSTS

Using the simulation model COSTS, the time, the number of operators and the cost of cleaning and restoration of the docks and piers of the port of La Savina were estimated for a spill of 12,500 liters of diesel oil. The estimated time for clean-up is approximately 34 days, needing some 868 people as workers, supervisors, technicians, medical personnel, etc. The total cost is estimated at about 2,380,000 €. Using the simulation model of Texas A & M University, the average cost of treatment is approximately 2,350,000 €. By means of the simulation model CO.PER, the total cost of cleanup and restoration of the coastal environment polluted by diesel oil is estimated at around 2,442,998 €.

INFLUENCE OF POLLUTION ON TOURISM

The island of Formentera has 119 hotels which can accommodate up to 7,668 people. The average expenditure per person per day is estimated at 87.59 € (including tourist packages and on destination expenses). The estimated time needed to recover the levels of tourism is estimated at 1 year and the cost of promotional campaigns is estimated at 1,000,000 €. The simulation model IN.CO.TUR is used to estimate the time needed for cleaning and restoring the various port areas affected by a spill of 12,500 liters of diesel oil. Similarly the number of operators, technicians and specialists needed and the total cost of their performance can be estimated (Graph 3) [2].

Graph 3. Economic losses that a diesel oil spill of 12,500 liters may cause for the tourism sector, depending on the impact date.



EMERGENCY PLAN

The Emergency Plan includes everything related to emergency classification, alarm signals, emergency notification, the first actions to be taken to respond to an emergency, accident notification criteria or significant event criteria and notification channels and related criteria. With regard to emergencies, three categories can be distinguished. The first category includes small spills that can be treated without having to activate the Contingency Plan. However, the evolution of such a spill must be monitored in case it could become a major accident. Category 2 refers to medium-sized spills that require the activation of Contingency Plans and category 3 refers to major accidents that cannot be controlled with the port's own pollution response means and need the activation of the External Emergency Plan [3]. Regarding alarm signs, the plan indicates that the general alarm must begin by operating a siren continuously for one minute with intervals of 15 seconds between sirens. To mark the end of the emergency, the alarm must sound with short, intermittent rings for half a minute.

Regarding the notification of the communications room of the ferry bridge in the event of an emergency, it is necessary that all communications from accidents/incidents

converge at the bridge. When faced with an emergency, the truck driver will inform the captain of the ferry of the type of emergency that has occurred, the place where it has occurred, the possible causes of the spill and the possible consequences. The mission of the captain of the ferry is to assume the command of all the response operations and ensure that all personnel obey the behavior protocol. Likewise, the captain must inform by loudspeaker of all the instructions to be followed by all the staff on the unload pontoon. He will also have all the telephone numbers of external aid ready, will keep a phone line with the outside and will prevent interferences from external lines. Likewise, he must also cooperate in all operations that are necessary to minimize the spill. The person in charge of fire-prevention services should monitor their correct work and will keep the leadership of the emergency informed. The remaining staff will come to the ferry bridge ready to obey the captain's orders. Likewise, the plan deals with the procedures to evacuate the damaged area, the rules to follow during the initial proceedings, the operations of all the leaderships and the objectives to achieve and techniques to implement in order to mitigate the spill's impact. Finally, the Emergency Plan includes information on equipment and materials that may be needed, emergency telephone numbers, information transmission and assistance requests to CECOPI and Protección Civil, maintenance and review methods of the Emergency Plan and the practices and drills required.

RESULTS AND CONCLUSIONS

[1] The paths followed by a spill of 12,500 liters of automobile gasoline and diesel oil were simulated in seven different meteorological conditions of winds, and the time of impact on the coast and the percentage evaporated were identified.

[2] The lengths of containment boom to protect the different areas of the port of La Savina, the Estanque des Peix and the salt marshes of Formentera were calculated. These lengths are 250 and 1800 meters respectively.

[3] The amount required of the two best absorbents on the market to treat a spill of 12,500 liters of diesel oil was calculated. These quantities are 148 and 166 kg respectively.

[4] The time needed to recover the spilled diesel oil by means of conventional skimmers was estimated. This time is approximately three hours, including skimmer deployment and recovery time.

[5] The diffusion in the atmosphere of gasoline vapors was analyzed. The area where the concentration of vapors is greater than or equal to 300, 250 and 150 ppm, as well as the limits of the security zone where there are no risks, were also estimated.

[6] The damage caused by an explosion of gasoline vapors was estimated according to the distance in the case of overpressure greater than or equal to 8, 3.5 and 1 Psi. The safety limits were also estimated.

[7] Using the simulation model ESPUMAS, the flow of foam needed to spray on a ferry on fire transporting a tanker truck loaded with 12,500 liters of automobile gasoline was calculated. This flow corresponds to 1,800 L / minute.

[8] Using the simulation model E. V. A. (Extension Vapor Assessment) the toxicity of the fraction of gasoline and diesel oil soluble in water was estimated in different species. Thus, in a gasoline spill the average effective concentration (EC_{50}) after 48 h is 25 mg/L for *artemia spp* and 5 mg/L for *daphnia magna*. The average lethal concentration (48 h LC_{50}) is 51 mg/L for *artemia spp*, 5 mg/L for *daphnia magna* and 7 mg/L for *rainbow trout larvae*. In case of a diesel oil spill, the average tolerance limit (24h TL_m) for *American shad juveniles* is 91 mg/L.

[9] Using the simulation model "V. I. C. EN. C.", the Vulnerability, Resilience and induced Recovery were estimated at the docks and piers of the port of La Savina, with a value of 2 for Vulnerability (slightly vulnerable), with a value of 9 for Resilience (very high resilience), and values of 7; 9 and 6 for Recovery Induced by mechanical, chemical and biological means.

[10] By several simulation models, the number of operators and the cost of cleaning and restoration of the docks and piers of the port of La Savina were estimated in the case of a diesel oil spill. The number of employees needed is 868 and the period of time for cleaning and restoration is 34 days.

[11] By means of the simulation model IN.CO.TUR, the economical impact on tourism that a diesel oil spill may cause both inside and outside the port of La Savina was estimated and its maximum value is fifty millions euros.

[12] An emergency plan has been elaborated including all the information related to emergency classification, notification, first actions when faced with an emergency and notification criteria when reporting accidents. Likewise, the evacuation procedures, rules to be followed during the first proceedings, objectives to be met and intervention techniques to mitigate the spill impact were described.

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