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ANNEX II

Safety Assessment Grand Bahama

Risk Assessment for Pinder's Point, Lewis Yard and surrounding areas

project number 0415183.00
Draft
April 21, 2017

Understanding today.
Improving tomorrow.

Safety Assessment Grand Bahama

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Date release	Description revision	For approval	Release
April 21, 2017	Draft, revision 1.0	J. van der Schaaf	M. Pronk

2 Introduction

The environmental health risks associated with the industrial park located near the communities of Pinder's Point, Lewis Yard, Hunters and Hawksbill of Grand Bahama have long been a source of citizen, activist and leadership concern.

At the request of the Minister of Grand Bahama, the Pan American Health Organization (PAHO) engaged the Institute for Risk Assessment Sciences (IRAS) of Utrecht University in the Netherlands to conduct an environmental health risk assessment [1]. One of the recommendations of the environmental health risk assessment is:

- A professional safety assessment related to the potential threats of fires, quakes, hurricanes and explosions to people living in Pinder's Point and Lewis Yard should be performed.

As a follow-up to this recommendation, the Minister for Grand Bahama asked Antea Group to carry out the necessary safety assessment. This took place between February and May 2017. In the safety assessment, the possible threat from the activities at the Freeport Industrial Park to the residents in Pinder's Point, Lewis Yard and Hawksbill was identified. This was done by carrying out desk research (including analyzing and modelling the potential threats) and site visits. This report contains the results of the safety assessment.

This report describes the work carried out and presents the effect distances of the companies involved. This was done for ten designated company of the Freeport Industrial Park, viz., Polymers international, PharmaChem, Grand Bahama Power Company, Bahama Rock, Freeport Container Port, Bahamian Brewery & Beverage Co., Bradfort Bahamas, Grand Bahama Shipyard, FOCOL and Buckeye Bahamas Hub. Based on the modelled effect distances it was determined which homes/residents of Pinder's Point or Lewis Yard are within the safety distances if there is a major accident at the designated companies at the Freeport Industrial Park. For the homes/residents of Pinder's Point and Lewis Yard which are not within the safety distances if there is a major accident, solutions and recommendations have been given.

This report is structured as follows:
Chapter 2: Introduction to the safety assessment. This contains a description of the scope of the assessment, the executed steps, and the companies and locations involved.
Chapter 3: Criteria
Chapter 4: Necessary background information.
Chapter 5: Results of the safety assessment. These results are given for each designated company and are also combined in an overview.
Chapter 6: Conclusions based on results.
Chapter 7: Recommendations of the safety assessment.

Step 3 Analysis and modelling of potential threats; developing solutions;
Step 4 Second site visit;
Step 5 Drafting the final report.

These steps were carried out between February and April of 2017.

In the first step, preliminary research was done on the policies of Grand Bahamas regarding external safety and on the agreements and deviations of these policies from the European and Dutch policies on external safety. Furthermore, it has been investigated which stakeholders (both public and private) and which companies (including their hazardous products and substances) needed to be taken into account. The results of this step are presented in chapter 2 of this report.

During the second step, the first site visit took place. In this step Machiel Pronk and Jaap van der Schaaf visited the Grand Bahamas from February 14 till 18, 2017. During this visit each company, which had been selected as relevant in step 1, was visited on site. In addition, the mutual expectations were determined, the information from the preliminary research was checked, complemented and (if necessary) adjusted. A feasibility discussion took place on the possible recommendations and solutions coming out of this assessment. The results of this step were taken as input for the following step(s).

In the third step the potential threats, as determined in step 1 and 2, were modelled and analyzed. In assessing the threat for external safety for each separate company we used the following method:

1. Make an inventory of hazardous substances;
2. Determine the containments of the hazardous substances including the amount (m^3), the pressure (barg), the phase (solid/liquid/gas) and the temperature of the substances;
3. Make a sub-selection of the relevant installations which may cause lethal effects outside the boundaries of the corresponding company, if incidents occur at the installation;
4. Calculate the effect distance for fatalities and possible injuries, and present it on a map.

By executing a standardized sub selection method, we were able to analyze which scenario of a loss of containment (LOC) situation can cause damage outside the boundary of the company under consideration. This selection has been made for three types of hazards, namely:

- Fire radiation (kW/m^2);
- Explosion overpressure (barg);
- Exposure of toxic substances (concentration in mg/m^3).

For each hazard type, the scenario with the largest effect has been modelled in Phast (version 6.7). Phast is the world's most comprehensive process industry hazard analysis software tool for all stages of design and operation. Phast examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects. For external safety, the results of Phast are normally given in distance (meters) according to the criteria of fatality and possible injuries.

The results of some scenarios showed that residents of Pinder's Point or Lewis Yard are present within the effect distances. For these scenarios solutions have been developed and recommendations have been given. The results of step three are given in chapters 5 and 7.

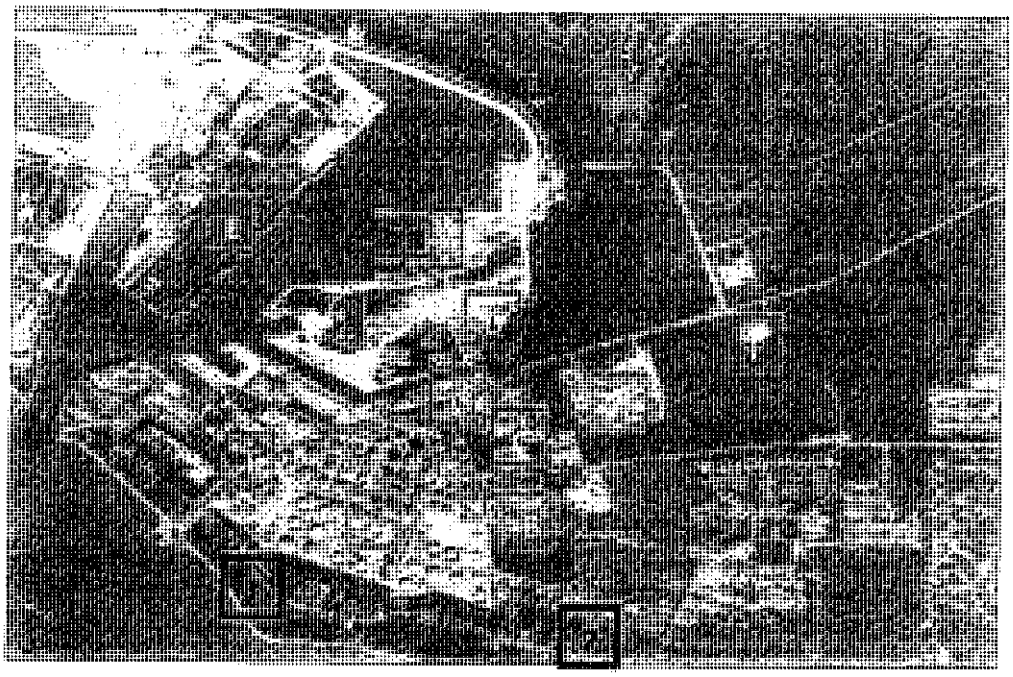

Figure 2.1 Locations of the companies and residential areas involved.

2.3.1 A. Polymers International

Description
Polymers International Limited Company (short: Polymer International) is a manufacturing and fabrication facility that produces Expanded Polystyrene (EPS). The annual production rate for the facility is estimated to be 200 million pounds of EPS per year. The facility is a 24 hours a day, 7 days a week operation.

The EPS is made from Styrene monomer that is imported by sea by product tankers. The Styrene is pumped from the dock to one of the three chilled storage tanks. The storage tanks are placed in a bund that can contain the full-tank volume.

Maximum possible accident
The maximum possible accident that can happen is failure of a styrene storage tank (remote possibility). We have evaluated the largest tank in the largest tank-pit. This is the tank, and corresponding tank-pit, which is the nearest to Pinder's Point and Lewis Yard. The relevant hazard associated with Styrene is toxicity.
Given the amount of material and the location relative to Pinder's Point, Lewis Yard and also the Hawksbill area, the storage of Pentene is not relevant.

2.3.4 D. Bahama Rock

Description
The Bahama Rock Limited facility mines and processes more than 6 million tons of aggregate material each year. The day to day work includes land clearing, dredging materials, preparing (drill holes) for blasting and controlled blasting.

The preparation for the controlled blasting process starts with the drilling of shot holes at a depth of 80 feet, which are fitted with a 4½ inch cardboard tube to maintain the integrity of the hole in the porous limestone. The cardboard cased holes are filled with solid oxidizer, liquid ammonium nitrate to approximately 14 feet below the surface grade. The packing of the tube continues by filling it with 0 -1½ inch sized stones to stem and muffle the sound of the blast.

It operates 2-12 hour shifts, 24 hours a day, 7 days a week.
Maximum possible accident
In Appendix I the impact of the blasts by Bahama Rock on the environment is discussed. From this analysis, it is concluded that the operations of Bahama Rock do not harm the buildings of Pinder's Point/Lewis Yard and also will not cause domino effects which can affect the residents of Pinder's Point/Lewis Yard. For more details, see chapter 5 results and Appendix I.

Scenarios
No incident scenarios were evaluated for this facility.

2.3.5 E. Freeport Container Port

Description
The Freeport Container Port Limited is owned by Hutchinson Port Holdings. The facility is operated in conjunction with the Freeport Harbour Company.

Freeport Container Port (FCP) operates a computerized 24 hours a day facility with state-of-the-art security.
Freeport Container Port commenced operations in 1997. It is located on Grand Bahama Island and is situated about 100 miles from the port of Miami, Florida. It is currently the deepest container terminal in the region and serves as a major container transfer hub for the eastern seaboard of the US and the principal east/west line-haul routes through the region.
FCP is capable of handling the largest container vessels in the world. Upon completion of the US$ 250 million Phase V Development, FCP will have total quay length of 1,536 meters, a yard area of 63 hectares, a depth alongside of 15.5 meters, nine post-Panamax cranes and one super-post-Panamax quay crane.

Maximum possible accident
Given the distance between the container port and the Pinder's Point / Lewis Yard area, the small percentage of dangerous cargos that are transshipped, the relatively small packaged products (tank containers), the effects of an accident will not reach the Pinder's Point / Lewis Yard area.

Scenarios
No scenarios were evaluated for this facility.

2.3.9 I. Freeport Oil Company (FOCOL)

Description
Freeport Oil Company (FOCOL) is a fuel storage and distribution facility that manages the following products: Jet Fuel, Motor Gasoline, Diesel and LPG.

The main operation of the facility consists of nine above ground storage tanks that are located at the North-Eastern section of the main facility. The storage tanks are all located inside a tank-pit (secondary containment).

Maximum possible accident
Given the distance between the FOCOL facility and the Pinder's Point/Lewis Yard area and with the scale of the tank storage, the effects of an accident (tank fire, tank-pit fires) will not reach the Pinder's Point/Lewis Yard area.

Scenarios
No scenarios evaluated for this facility.

2.3.10 J. Buckeye Bahamas Hub

Description
Buckeye Bahamas Hub is a petroleum products terminal. Buckeye Bahamas Hub currently has over 26 million barrels of storage capacity and eight berths, including two VLCC-capable berths. Storage includes capacity for crude oil, fuel oil and VGO, diesel fuel, and gasoline and components. These products are imported from locations around the world and stored or blended at Buckeye Bahamas Hub for export, including to regional consumers, key import locations in the Americas, and long-haul markets in Asia. The facility is a 24 hours a day, 7 days a week operation.

Maximum possible accident
The maximum possible accident that can happen in the terminal near the fence is tank failure and subsequently a tank fire or a tank-pit fire. We evaluated the tanks and tank pits nearest to Pinder's Point and Lewis Yard.

Scenarios
The scenarios evaluated are:
1. Failure and fire in the largest heavy oil (floating roof) storage tank (tank-fire);
2. Pipe failure and trench fire in the pipe-trench from terminal to the jetty;
3. Failure and fire in all the tank-pits along the fence near Pinder's Point/Lewis Yard.

In case of finding protection, the following holds:

- Flight is the activity by which people try to reach a safe environment unaided;
- Evacuation is the activity in which people are helped by others to reach a safe environment;
- A 'shelter in place' is an environment in which people are sufficiently protected in order to survive for a shorter period of time;
- A 'safe haven' is an environment in which people are sufficiently protected in order to survive for a longer period of time until the environmental conditions are back to normal.

3.2 Impact criteria

As stated in chapter 2, the following incidents and accompanying hazards are considered:

- Fire: Radiation (kW/m^2);
- Explosion: Overpressure (barg);
- Toxic releases: Exposure of toxic substances (concentration in mg/m^3).

Note: Another hazard accompanying the incident of fire, is smoke. Smoke contains unhealthy/toxic combustion products and exposure to these products needs to be avoided. However, the location of smoke and the exact hazards are more difficult to predict than for radiation. The distribution and the concentration of smoke in the air is dependent of the wind (only the down-wind area is threatened by smoke), atmospheric conditions (more or less turbulence), the nature of the burning substance and the heat of the fire. For instance, a hot fire produces a lot of thermal 'lift' (i.e. plume rise). This causes smoke to rise quickly to great altitude and the environment close to the fire is in less danger. At a certain distance, the smoke will reach ground level again, but this smoke is diluted and its harmfulness is reduced. The advice from the government to close all doors and windows, and to shut down all indoor ventilation, is in this case in place. Smoke is not considered further in this assessment.

In this assessment, the impact criteria used in risk evaluations of large incidents involving hazardous substances, executed in compliance with European legislation[1], are applied.
In the following sections the impact criteria of the above stated incident types are explained.

3.2.1 Fire

The criteria for heat radiation is given in table 3.1. The heat radiation impact criteria[2] are given in both SI units and in imperial units.

Table 3.1 Heat radiation impact criteria

[1] Directive 2012/18/EU of the European Parliament and of the council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC. This is also known as the Seveso III Directive.

[2] The impact criteria levels in Europe are in SI units (i.e. kW/m^2; kilowatts per square meter). In the Bahamas the imperial units are applied (i.e. $BTU/(h*ft^2)$; British thermal unit per hour, per square foot). Therefore, the impact criteria levels for heat radiation have been conversed from kW/m^2 to $BTU/(h*ft^2)$. The conversion factor is 1 kW/m^2 = 316,9983 $BTU/(h*ft^2)$. However, the above stated levels are round down or up to fifties.

protect or shelter people against heat radiation of 10 kW/m^2 or higher. In general it is stated that in the region between 10 and 35 kW/m^2 (i.e. between approximately 3.200 and 11.100 BTU/(h*ft^2), respectively) the heat radiation is sufficient to cause escalation or transference to other buildings or constructions. Exposure to 35 kW/m^2 for people is 100% fatal. In other words, areas of constructions or houses with wooden parts are not safe environments.

3.2.2 Explosion

In the performance of step 3 of this safety assessment (see also section 2.2), it became clear that, because of the environmental storage conditions, the (flammable) hazardous substances under consideration cannot reach the region between their lower explosion levels (LEL's) and upper explosion levels (UEL's). Therefore, the incident type 'explosion' is not further considered in this report.

3.2.3 Toxic release

The criteria for toxic load is given in table 3.2. Note that each toxic substance has specific intervention values (i.e. Awareness Value (AV), Alarming Limit Value (ALV) and Life Threatening Value (LTV)). These values are determined by excessive research and are regularly updated. In this safety assessment, the intervention values are derived from [4]].

Table 3.2 Toxic load impact criteria

Toxic load		
Level	**Meaning**	**Impact on persons**
LTV	Life Threatening Value	Unsafe: **Death possible** within days after 1 hour exposure
ALV	Alarming Limit Value	Unsafe: Severe health problems possible after 1 hour exposure
AV	Awareness Value	People can get **worried** because of smell

scenarios of this assessment (see also section 3.3). These incident scenarios are further discussed for each designated company in chapter 5.

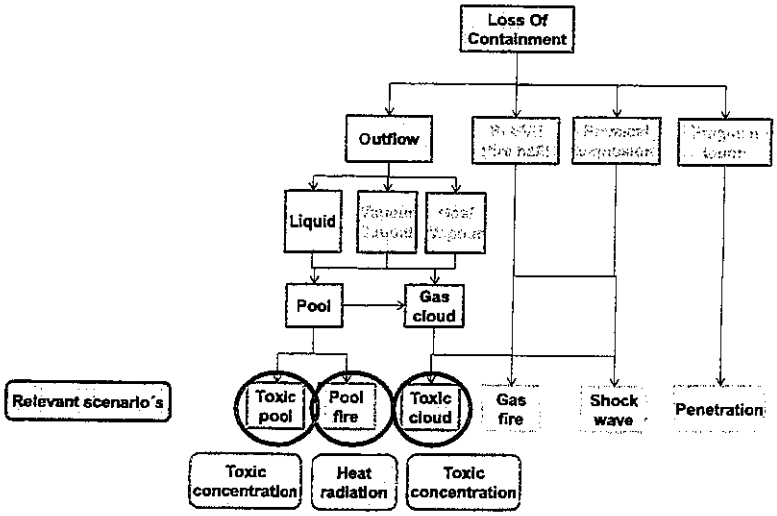

Figure 4.2 Flow diagram effect trees instantaneous outflow/BLEVE.

In figure 4.3 a schematic, simplified representation of the course of the relevant incident scenarios is given [2].

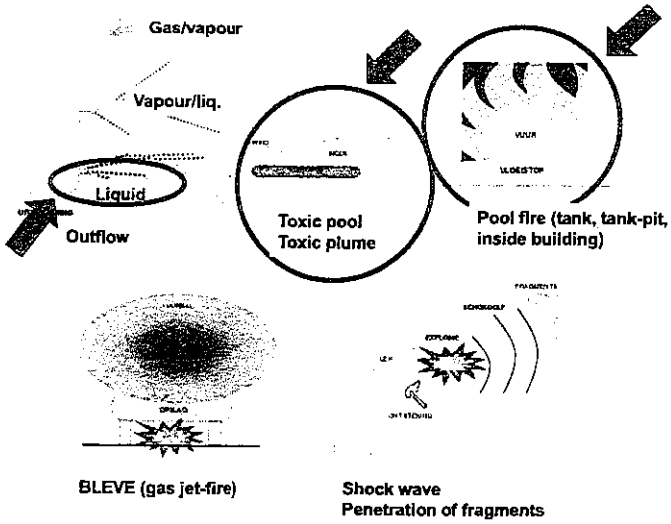

Figure 4.3 Schematic, simplified representation of the incident scenarios.

The red-circled parts of figure 4.3 indicate the relevant outflow and relevant incident scenarios of this assessment (see also section 3.3.)

and are used to set the norm of the safety management of a company. In chapter 5 the normative scenarios for the Freeport industrial park are given.

4.3 Risk situation as a system

The course of the physical part of an incident, from the source to possible victims, can be approached as a system [2]. This is represented in figure 4.4. Below figure 4.4 each element is discussed individually. This system can be used to set up an Emergency Response Plan.

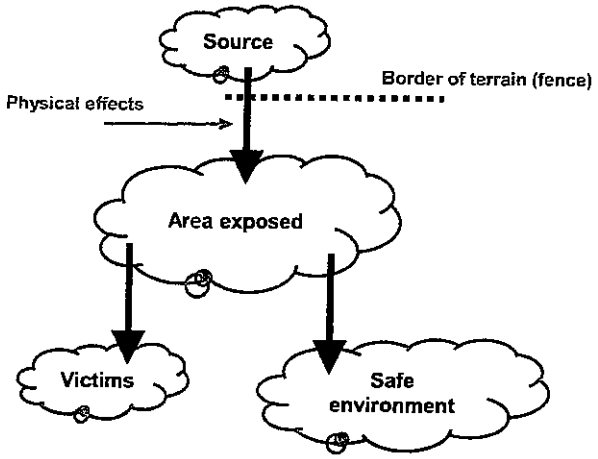

Figure 4.4 The physical part of an incident as a system.

Source
When an incident occurs, the source is considered to be the location where the incident has taken place. From this location, the unwanted physical effects of the incident arise in the surrounding area.

Area exposed
The area exposed is considered to be the study area around the source, outside the site boundary of the company, which can be exposed to physical effects. The locations within the area exposed where vulnerable people and objects are located are of most interest for external safety.

The size of the area exposed can be estimated and is determined by:

- The type of the physical effect (fire, explosion or toxic load);
- The extent of the source;
- The hazardous material involved and the amount;
- The distance from the source;
- Weather conditions (wind speed, wind direction, turbulence).

5 Results

This chapter contains the results of the analysis and modelling of the safety assessment.

5.1 Introduction

As described in chapter 2, in assessing the threat for external safety for each of the designated companies we have used the following method:

1. Make an inventory of hazardous substances;
2. Determine the containments of the hazardous substances including the amount (m^3), the pressure (barg), the phase (solid/liquid/gas) and the temperature of the substances;
3. Make a sub-selection of the relevant installations which may cause fatal effects outside the boundaries of the corresponding company, if incidents occur at the installation;
4. Calculate the effect distance for fatalities and (possible) injuries and present it on a map.

5.1.1 Relevant incident scenario's

By following the steps of this method, the relevant incident scenarios for the Freeport Industrial Park were identified and modelled. An overview of the relevant incident scenarios is given in table 5.1.

Table 5.1 Relevant incident scenarios for the safety assessment.

Relevant incident scenarios			
Company	**Hazardous substance**	**Hazard**	**Incident scenario's**
1. Polymers International	Styrene	Fire and toxic release	1. Tank fire 2. Pit fire 3. Toxic exposure from pit
2. PharmaChem Technologies	Solvent	Fire	1. Tank pit 1 fire 2. Tank pit 2 fire 3. Fire in new building
3. Grand Bahama Power Company	Heavy fuel	Fire	1. Tank pit 1 fire 2. Tank pit 2 fire
4. Buckeye Bahamas Hub	Heavy fuel	Fire	1. Tank fire 2. Tank pit (pool size 42.000 m^2) fire 3. Pipe trench fire 4. Tank pit (pool size 10.000 m^2) fire 5. Tank pit (pool size 290 m x 290 m) fire 6. Tank pit (pool size 370 m x 370 m) fire 7. Tank pit (pool size 135 m x 135 m) fire

- - - - **Dotted red line**: Life Threatening Value (LTV) contour.

Note that the toxic exposure results in this chapter, i.e. third scenario of Polymers International (scenario 1.3 of the TBD), are calculated for both standard weather types[5] D5 and F1,5. The presented results, i.e. the effect distance on the map, is given for weather type D5.

5.2 Overview results

In figure 5.1 an overview of the results, i.e. the effect distances presented on a map, is given. The overview is an indication of what the results of the modelled incident scenarios look like. Note that not all the results are contained in the overview figure. This is done in order to keep the figure clear and transparent.

In the overview of figure 5.1 scenarios 1.2, 1.3, 2.2, 2.3, 3.1, 4.2 and 4.3 are presented.

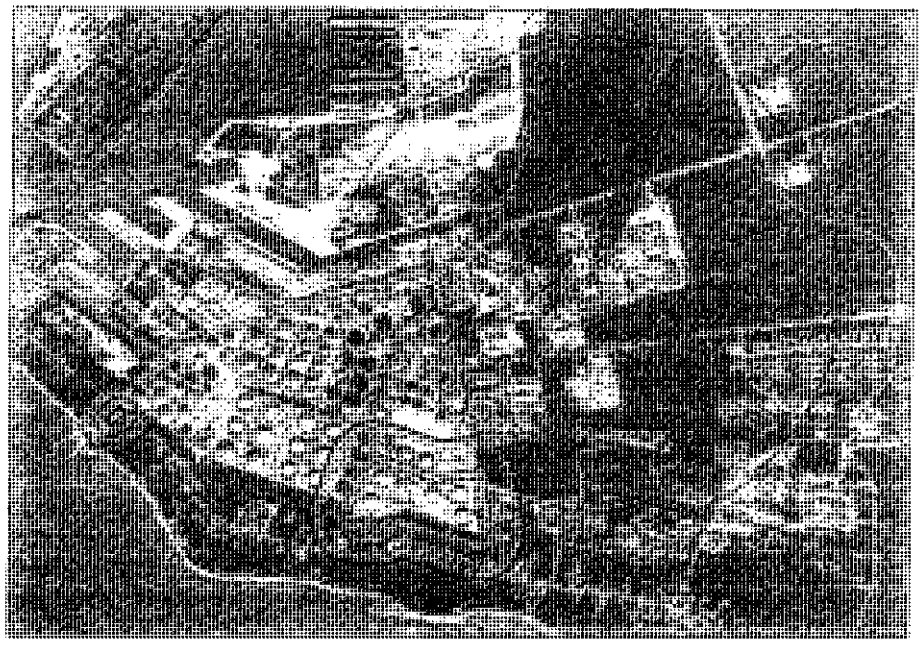

Figure 5.1 Overview of the safety assessment results.

This overview already shows that residents of Pinder's Point or Lewis Yard are present within the effect distances of some scenarios. This is further discussed in chapter 6.

[5] F1,5 is a stable weather type with wind speed of 1,5 m/s (i.e. approximately 5 ft/s).

Conclusions for Polymer International:

- In the case of a fire (tank or pit), there is no impact on the residents of Pinder's Point or Lewis Yard.
- In the case of a toxic release of styrene, no toxic loads with dangerous levels for human health reach Pinder's Point, Lewis Yard or the Hawksbill area.
- Additionally, it is not possible for the Awareness Value (AV; i.e. lowest impact criteria for toxic load) to reach the residential areas of Pinder's Point, Lewis Yard or Hawksbill under the most common weather conditions (D5). Only under exceptional weather conditions (F1,5) it might be possible that residents smell styrene, in the case of an incident with a pool of styrene in the tank pit at Polymers International. Nevertheless, in that exceptional case it is only the smell of styrene, which may result in public concern, but the concentration is not hazardous to human health. Note that it will be most noticeable (in smell, no health effects) in the Hawksbill area when the wind direction is coming from the West or North-West.

5.4 PharmaChem Technologies

For PharmaChem Technologies the relevant incident scenarios, which are normative (with maximum impact) from the external safety point of view, are:

1. A tank pit fire with solvent (scenario 2.1 in the TBD);
2. A tank pit fire with solvent (scenario 2.2 in the TBD) and
3. Fire in the new building with solvent (scenario 2.3 in the TBD).

The calculated effect distances of the fire incident scenarios of are given in table 5.4. For more details of the scenarios and the presentation of the effect distances on the map for each single scenario, please see the TBD of this Safety Assessment, sections 2.1 till 2.3.

Table 5.4 Effect distances of fire incident scenario's PharmaChem Technologies.

PharmaChem Technologies

Scenario	Nature of effect	Effect criterion		Effect distance at ground level	
		kW/m²	BTU/(h*ft²)	Meters	Feet
2.1 Solvent - tank pit 1	Liquid pool fire	35	11.100	3	10
fire		10	3.200	20	66
		3	950	45	148
		1	300	80	262
2.2 Solvent - tank pit 2	Liquid pool fire	35	11.100	7	23
fire		10	3.200	25	82
		3	950	45	148
		1	300	75	246

Conclusions for Grand Bahama Power Company:

- In the case of a tank pit fire, there is no impact on the residents of Pinder's Point or Lewis Yard.

5.6 Bahama Rock

As described in section 2.3.4, no incident scenarios were evaluated for this facility.

5.7 Freeport container port

As described in section 2.3.5, no incident scenarios were evaluated for this facility.

5.8 Bahamian Brewery & Beverage Co.

As described in section 2.3.6, no incident scenarios were evaluated for this facility.

5.9 Bradfort Bahamas

As described in section 2.3.7, no incident scenarios were evaluated for this facility.

5.10 Grand Bahama Shipyard

As described in section 2.3.8, no incident scenarios were evaluated for this facility.

5.11 FOCOL

As described in section 2.3.9, no incident scenarios were evaluated for this facility.

5.12 Buckeye Bahamas Hub

For Buckeye Bahamas Hub the relevant incident scenarios, which are normative (with maximum impact) from the external safety point of view, are:

1. A tank fire with heavy fuel (scenario 4.1 in the TBD);
2. A tank pit (pool size 42.000 m^2, i.e. 137.795 ft^2) fire with heavy fuel (scenario 4.2 in the TBD);
3. A pipe trench fire with heavy fuel (scenario 4.3 in the TBD);
4. A tank pit (pool size 10.000 m^2, i.e. 32.808 ft^2) fire with heavy fuel (scenario 4.4 in the TBD);
5. A tank pit (pool size 290 m x 290 m, i.e. 951 ft x 951 ft) fire with heavy fuel (scenario 4.5 in the TBD);

4.3 Heavy fuel - pipe	Liquid pool fire -	35	11.100	Not reached	Not reached
trench fire	down-wind	10	3.200	12	39
		3	950	73	240
		1	300	125	410
	Liquid pool fire -	35	11.100	Not reached	Not reached
	up-wind	10	3.200	2	7
		3	950	16	52
		1	300	60	197
4.4 Heavy fuel - tank	Liquid pool fire -	35	11.100	Not reached	Not reached
pit fire	down-wind	10	3.200	20	66
(pool size 10.000 m^2,		3	950	110	361
i.e. 32.808 ft^2)		1	300	192	630
	Liquid pool fire -	35	11.100	Not reached	Not reached
	up-wind	10	3.200	2	7
		3	950	44	144
		1	300	124	407
4.5 Heavy fuel - tank	Liquid pool fire -	35	11.100	Not reached	Not reached
pit fire (pool size	down-wind	10	3.200	25	82
290 m x 290 m,		3	950	190	623
i.e. 951ft x 951ft)		1	300	345	1.132
	Liquid pool fire -	35	11.100	Not reached	Not reached
	up-wind	10	3.200	2	7
		3	950	65	213
		1	300	220	722
4.6 Heavy fuel - tank	Liquid pool fire -	35	11.100	Not reached	Not reached
pit fire (pool size	down-wind	10	3.200	25	82
370 m x 370 m,		3	950	190	623
i.e. 1.214 ft x 1.214 ft)		1	300	345	1.132
	Liquid pool fire -	35	11.100	Not reached	Not reached
	up-wind	10	3.200	2	7

- A low-hanging cloud of smoke (down-wind), in the case of insufficient thermal rise, will be an important threat to the residents.

Note: The chance of a full surface pit fire is very small. Around the world there are only a few examples known of such fires. If a full surface pit fire occurs at Buckeye Bahamas Hub, at one of the tank pits near the boundary of the company and close to Pinder's Point and Lewis Yard, it will not develop rapidly. The reason for the slow development is the lack of oil which can rapidly develop into a full surface pit fire. In chapter 7 recommendations are made to enhance slow development by intervening in the fire quickly and adequately, and at the same time protecting the residents of Pinder's Point and Lewis Yard.

7 Recommendations

The conclusion of the safety assessment is that in the case of a full surface tank pit fire at Buckeye Bahamas Hub, parts of Pinder's Point and Lewis Yard are unsafe. In these parts, several houses are located. For these houses, there is a direct danger, in the sense that the houses do not offer sufficient protection to people. In addition, escalation or transfer of the fire to the houses is a real hazard, in the case of a full surface tank pit fire. This is also true in the case of a pipe trench fire in the down-wind situation, but on a smaller scale. Therefore, the aforementioned houses do not satisfy the minimal safety needs.

> **Minimal safety needs**
> The inhabited environment of the Freeport Industrial Park needs, at least, shelters to protect people from heat radiation of fires at the industry. Therefore, the houses need to be resistant to the remaining heat radiation from the fire. This is needed in order to provide shelter for fleeing or evacuated people and to prevent escalation or transfer of the fire to the houses.

Since the minimal safety needs are not satisfied, recommendations for protecting the residents of Pinder's Point and Lewis Yard are given in the following sections. Two types of recommendations are provided: The first type is a safety buffer zone and the second type is Lines of Defence (LODs; see also section 4.1). The LODs are recommended to control and combat incidents in order to prevent fatalities and possible injuries among the residents of Pinder's Point and Lewis Yard, while the safety buffer zone is meant as a direct measure to prevent fatalities and possible injuries.

7.1 Safety buffer zone

In order to (directly) prevent fatalities and possible injuries among the residents of Pinder's Point and Lewis Yard in the case of an incident at Buckeye Bahamas Hub, a safety buffer zone between the boundary of Buckeye Bahamas Hub and Pinder's Point and Lewis Yard is advised. The safety buffer zone is determined as stated in tenet 1 and tenet 2.

> **Tenet 1:**
> The radiation contour of 10 kW/m^2 (i.e. 3.200 BTU/(h*ft^2)), which is the maximum in the case of down-wind weather conditions, determines the boundary of the safety buffer zone around the industrial locations with a fire scenario. Houses do not offer a shelter, nor a safe haven, within this radiation contour.

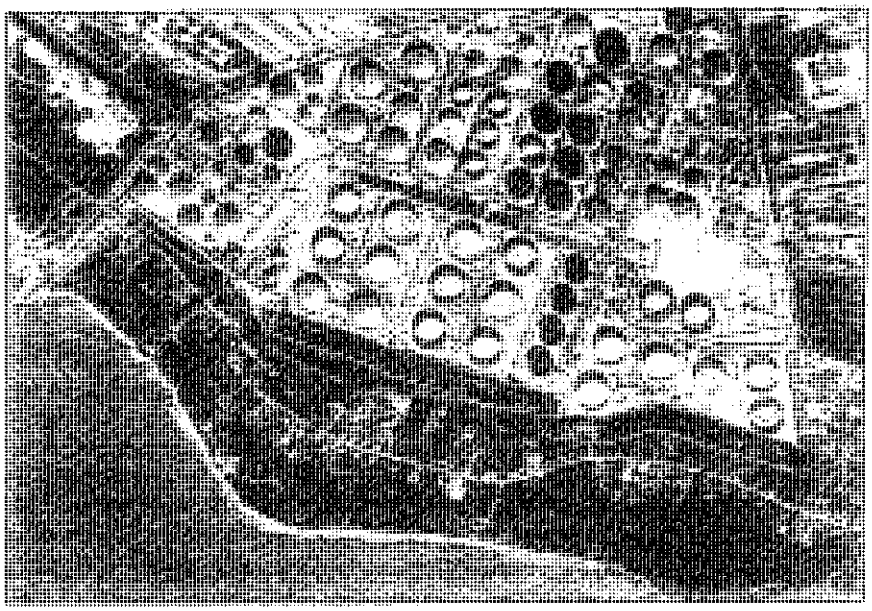

Figure 7.1 Map with the determined safety buffer zone of Buckeye Bahamas Hub.

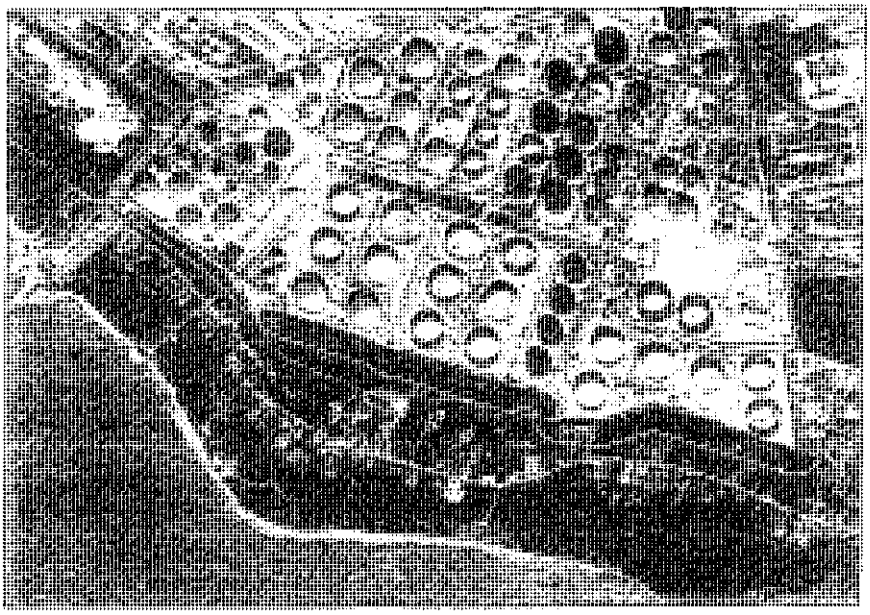

Figure 7.2 The safety buffer zone border at the south-side of Buckeye Bahamas Hub, smoothened.

References

[1] M. Lumens, M.T.O. Jonker, 'Environmental Health Risk Assessment for Pinder's Point, Lewis Yard, and Surrounding Areas', final report, December 7, 2015.

[2] Handreiking Rampbestrijdingsplan Veiligheidsrapportplichtige Bedrijven, Ingenieurs/adviesbureau SAVE, januari 2002.

[3] Publicatiereeks gevaarlijke stoffen 6, http://www.publicatiereeksgevaarlijkestoffen.nl/publicaties/PG56.html (visited on March 30, 2017).

[4] Publicatie Interventiewaarden, Rijksinstituut voor de Volksgezondheid en Milieu, december 2016. http://www.rivm.nl/rvs/ (visited on April 5, 2017).

[5] Fires in large atmospheric tanks and their effect on adjacent tanks, Loughborough University Institutional Repository, Doctoral thesis by Khalid Mansour, 2012.

[6] Brandveiligheid opslagtanks, The atmospheric storage tank, technical frame of reference (CIV02), Centrum Industriële Veiligheid.

design, they are typically over-engineered to provide a safety factor. In some cases, limits are expressed as a single value, for example 2S mm/sec (i.e. 1.0 in/sec). However, it is more likely that the limits will vary based on frequency (see also figure A1.1 for an example).

A very common set of recommended limits is derived from research conducted by the United States Bureau of Mines (USBM). Part of this research has resulted in a report entitled *USBM RI 8507, "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting"*. Based on this report the USBM recommended the frequency-based limiting criteria.

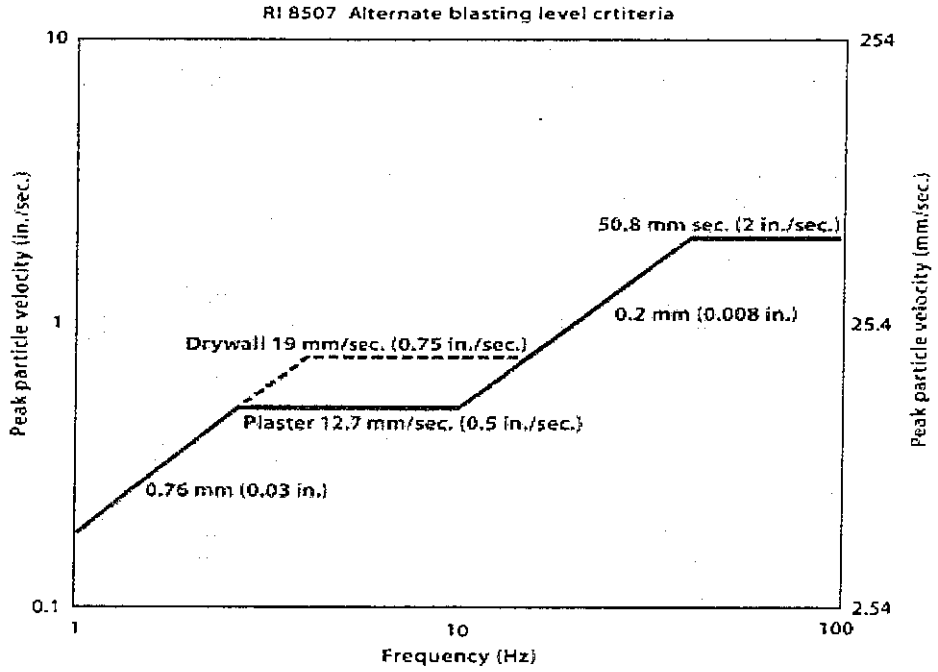

Figure A1.1 Alternate blasting level criteria.

Basis

The basis for the frequency-based limits is the concept of structure response. The recommended limits in the USBM report RI 8507 are thresholds in order to prevent cosmetic damage to the most susceptible materials such as plaster and sheetrock. Other materials, including masonry, concrete block and mass concrete, can withstand much higher levels of vibration without damage.

Limits valid for and used by Bahama Rock

In the permit of The Port Authority Bahama Rock it is stated that Bahama Rock is limited to a Peak Particle Velocity (PPV) of 1.5 inch/sec for all frequencies (red line in figure A1.2). This is above the limits of the Z-curve of USBM RI 8507 (less strict) for most frequencies.
Bahama Rock uses an internal limit if 0.5 inch/sec. for all frequencies (orange line in diagram). This is stricter than the USBM Z-curve.

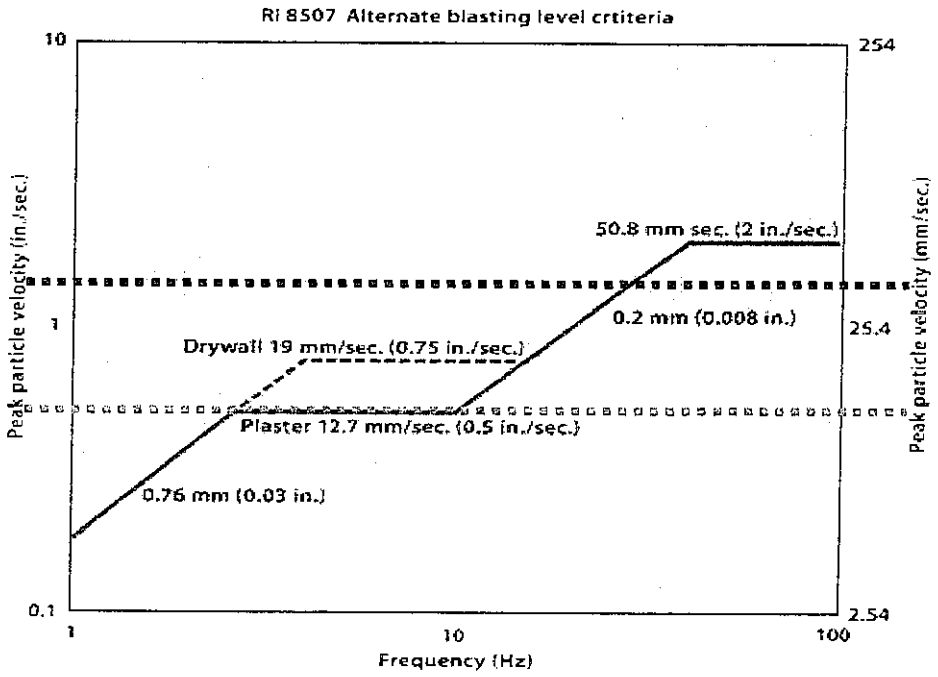

Figure A1.2 Alternate blasting level criteria including limits of Bahama Rock (red line: permitted limit, orange: internal limit of Bahama Rock).

Actual vibration levels

The Bahama Rock blasting operations are overseen by a third-party consultant (GeoSonics, FL). A blasting seismograph is set up prior to a blast. The seismographs are placed at five different locations, including the residential area of Hawksbill. These are continuous monitoring stations. A seismograph is normally also placed at the residential structure closest to a blast. Continuous monitoring stations might be used at quarries, mines and long-term projects.

Appendix II – Results Buckeye Bahamas Hub

This appendix contains the effect distances on the map for scenario's 4.1 to 4.7 of Buckeye Bahamas Hub. Please see the Technical Background Document (TBD) of this Safety Assessment, sections 4.1 till 4.7, as well.

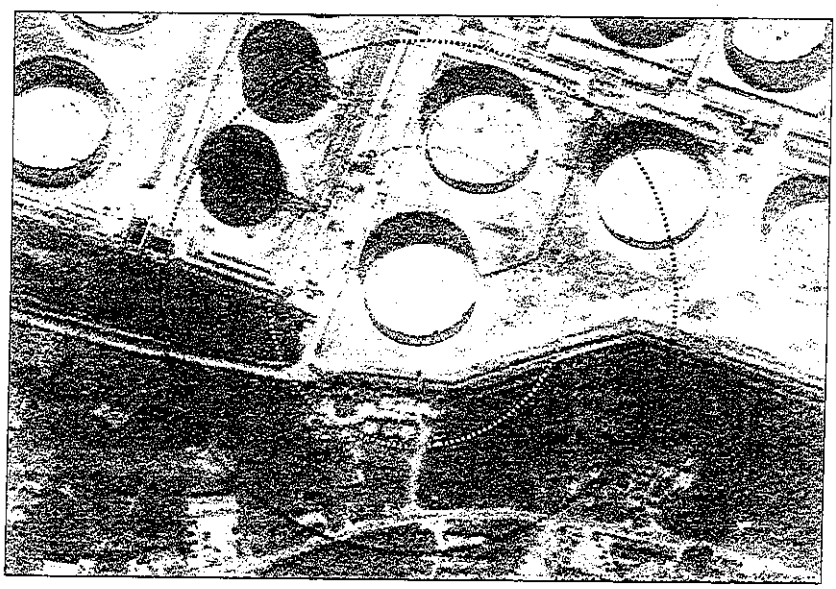

Figure A3.1: Effect distance of scenario 4.1 'Heavy fuel - tank fire'.

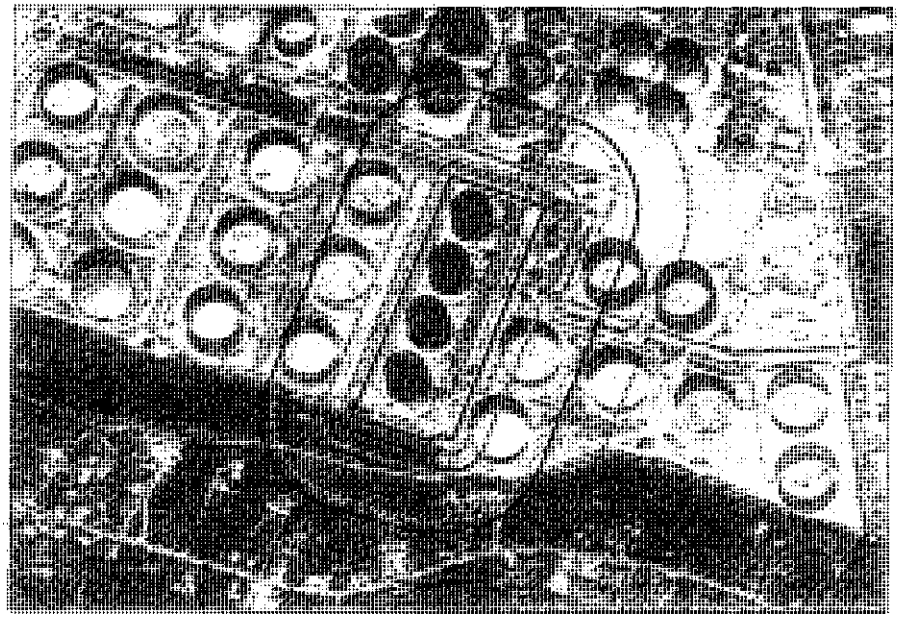

Figure A3.4 Effect distance of scenario 4.4 'Heavy fuel – tank pit (pool size 10.000 m^2) fire'.

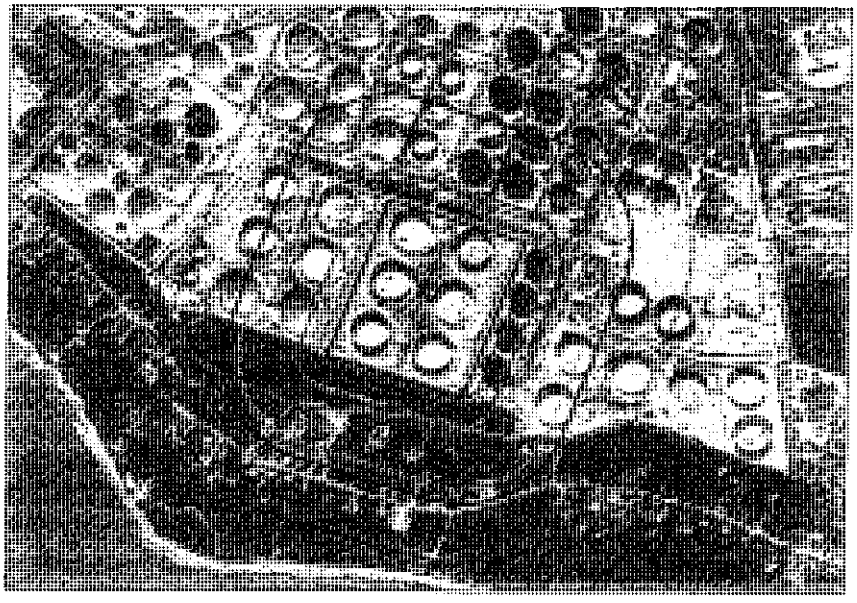

Figure A3.5 Effect distance of scenario 4.5 'Heavy fuel – tank pit (pool size 290 m x 290 m) fire'.

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Appendix III – Safety buffer zone zoomed-in

In this attachment the safety buffer zone, as presented in figure 7.2 (see also figure A4.1), is zoomed-in such that the individual objects are more recognizable. Figures A4.2 till A4. 6 show the safety buffer zone, zoomed-in, from East to West.

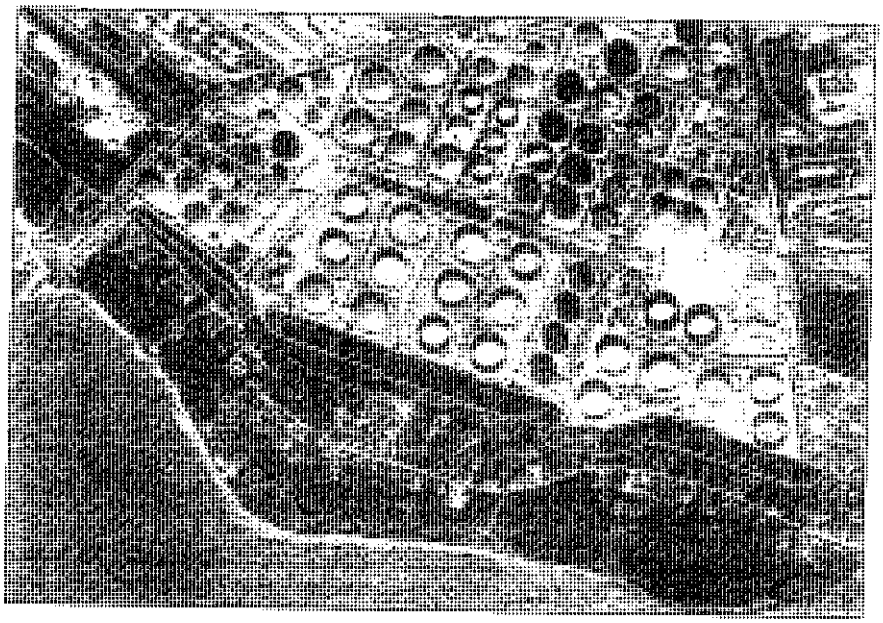

Figure A4.1 The safety buffer zone border at the south-side of Buckeye Bahamas Hub, smoothened.

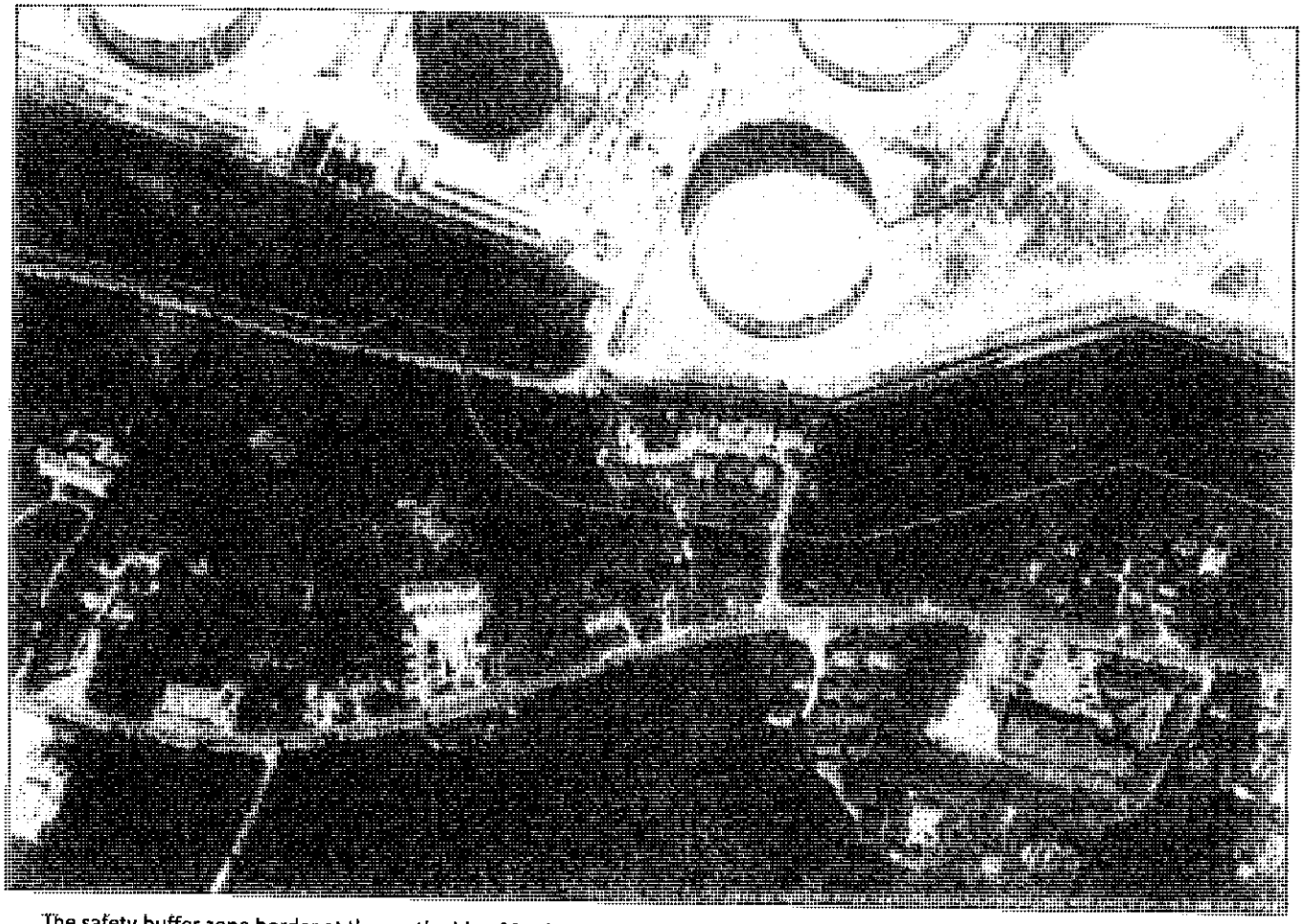

Figure A4.3 The safety buffer zone border at the south-side of Buckeye Bahamas Hub, zoomed in part 2 of 5.

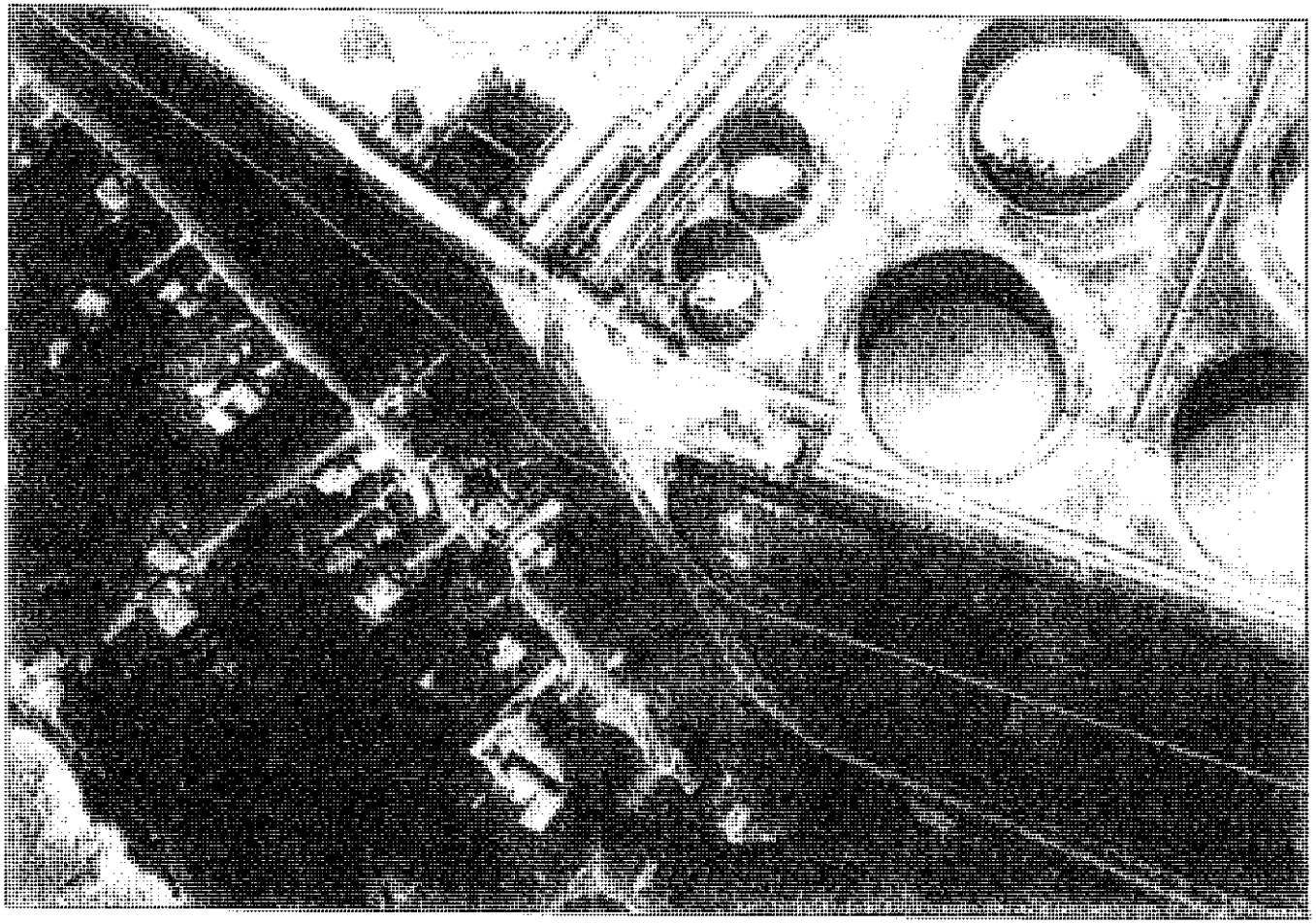

Figure A4.5 The safety buffer zone border at the south-side of Buckeye Bahamas Hub, zoomed in part 4 of 5.

About Antea Group

From city to countryside, from air to water: Antea Group's engineers and consultants have been contributing to our living environment in the Netherlands for years now. We design bridges and roadways, and create residential neighborhoods and water structures. But we are also involved in areas such as the environment, safety, asset management and energy. Under the name Oranjewoud, we expanded into an all-round, independent partner for companies and government bodies. As the Antea Group, we also apply this knowledge at a global level. By combining valuable knowledge, including on technical matters, with a pragmatic approach, we make solutions attainable and workable. Goal-oriented, with an eye for sustainability. In this way, we anticipate today's questions and tomorrow's answers. Just as we have been for over 60 years now.

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