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Ministry of Energy and Water Resources

National Outline Plan NOP 37/H

For Natural Gas Treatment Facilities

Environmental Impact Survey

Chapters 3 – 5 – Marine Environment

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Unofficial Translation

Summary

The National Outline Plan for Natural Gas Treatment Facilities – NOP 37/H – is a detailed national outline plan for planning facilities for treating natural gas from discoveries and transferring it to the transmission system. The plan relates to existing and future discoveries.

In accordance with the preparation guidelines, the plan is enabling and flexible, including the possibility of using a variety of natural gas treatment methods, combining a range of mixes for offshore and onshore treatment, in view of the fact that the plan is being promoted as an outline plan to accommodate all future offshore gas discoveries, such that they will be able to supply gas to the transmission system. This policy has been promoted and adopted by the National Board, and is expressed in its decisions. The final decision with regard to the method of developing and treating the gas will be based on the developers' development approach, and in accordance with the decision of the governing institutions by means of the Gas Authority.

In the framework of this policy, and in accordance with the decisions of the National Board, the survey relates to a number of sites that differ in character and nature, divided into three parts:

1. Survey of the Meretz wastewater treatment plant site – an onshore treatment facility with pressure reduction at sea, including an onshore gas treatment facility, and a pipeline from the landfall pipeline crossing to the facility, and from the facility to the transmission system.
2. Survey of the Hagit site – an onshore treatment facility with pressure reduction at sea, including an onshore gas treatment facility, and a pipeline from the landfall crossing to the facility, and from it to the transmission system.
3. A survey of two areas for offshore gas treatment facilities and the pipeline route detailed in this document, from the boundary of the territorial waters to the facilities, and from the facilities to the shore.

The offshore gas treatment facility presented in the survey below enables offshore processing of raw gas. The offshore processing options detailed in the survey are varied, and relate to the entire gas treatment process, on the assumption that at this stage of planning, it should be possible to choose a flexible mix of offshore and onshore processing. This mix will be decided at the building permit stage.

The offshore components of the treatment facility examined in this survey include:

- **The route of the western pipeline** – from the borders of Israel's territorial waters (to which the Planning and Building Law applies) to the exploration areas of the offshore platform. This site is intended for laying the corridor of the pipeline for transmission of the raw natural gas (and byproducts) to the gas processing platform.

- **The offshore platform exploration areas** – the platform's exploration areas stretch from a western limit 7.5 km from the shoreline, in accordance with the Ministry of Environmental Protection directive, for reasons of visibility. The western limit has a depth of 100 m – at this depth, the continental shelf begins. Two sites are planned for locating the facilities:
  - Site 1 – the northern site, in the offshore area from Dor beach in the north to Or Akiva in the south, and extending over a total area of some 43 km^2.
  - Site 2 – extending over a total area of some 55 km^2 in the offshore area between Beit Yannai beach in the north and the northern section of Netanya in the south.
- **Eastern pipeline site –** from the site of the offshore gas processing platforms to the landfall pipeline crossing at Dor or Michmoret.
- **Landfall pipeline crossing –** largely described in the onshore Environmental Impact Survey, and also surveyed in part in this document.

Since a developer has not yet been chosen to implement the plan, and at this stage there is a planning array in principle for establishing the gas treatment facilities, as with previous sections of the survey, this document will also examine and plan in principle the technological options for offshore treatment in order to examine the treatment facility's maximum impact on the marine environment and allow the future developer maximum planning flexibility in terms of the mix of offshore and onshore facilities. The representative plan for the treatment facility was drawn up by PDI Co., engineering consultants for the plan, and includes the document "Quantification of Emissions & Discharges," attached as Appendix B and which constitutes the basis for planning and assessing impacts in this document.

The aim of Chapters 3-5 is to describe the actions arising from implementation of the proposed plan and to detail the assessed environmental impact from this implementation, and means of reducing them.

The information below includes an explanation of the gas treatment method and supplements the information detailed in the two sections of the survey already circulated for the Meretz wastewater treatment facility and the Hagit site. Accordingly, the survey relates to the gas treatment process carried out onshore, and explains the principles of the process, but focuses on and goes into detail with regard to the offshore activity and its effects on the environment and population. Since the survey relates to the maximum impacts, it does relate to all types of partial offshore processing, including developing a platform for pressure reduction only.

Chapter 3 - Description of Actions Resulting from Implementation of the Proposed Plan

This chapter includes a review of the main components of the offshore treatment facility, and a description of the gas treatment process from the drilling well until the treated gas is transmitted to the onshore facility. The description of the treatment process and description of the facility will incorporate the basic assumptions regarding the facility's operation, characterization of its components, the operating regime, and remarks on hazardous materials, monitoring devices, energy sources, and auxiliary infrastructures. The information presented in this chapter is a summarized review of the engineering report on the offshore treatment facility and the engineering-operational report on the pipeline, presented in full in Appendices B and C.

The gas comes from the wellhead in raw form, at high pressure, and needs to be treated before it can pass through the transmission system, in accordance with the requirements of INGL. Treatment of the gas is unique to each discovery, and may even change from one well to another in the same discovery, because the treatment depends on the characteristics of the gas: its type and composition, the pressure at which it comes out, the percentage of hydrocarbons it contains, and especially the quantity of gas condensate, the percentage and composition of the water in it, and also the quantity of antifreeze. Below is a general description of the processing chain, from the wellhead until entry into the transmission system, based on the assumption that there is a high percentage of methane in the gas discoveries (on the basis of the percentage that is common in discoveries in Israel). The description of the processing chain includes attention to the main elements that exist in most discoveries around the world:

1. Adjust the gas pressure to the pressure required for natural gas processing if part of the treatment is carried out onshore, in accordance with the guidelines of the Ministry of Energy and Water Resources, by which flow pressures in the pipeline at landfall will be no greater than 110 bar.
2. Reduce the pressure of the gas coming from the well, or compression of the raw gas where the gas in the reservoir is becoming depleted.
3. Initial separation of liquids from the raw gas in a separator, including:
   - Removal of steam from the gas flow (water dew-pointing)
   - Removal of hydrocarbons, such as condensate, which are liable to condense in liquid form in the pipeline (hydrocarbon dew-pointing)
   - Removal of other substances found in the gas that are liable to be toxic.
4. Removal of antifreezes (MEG/TEG).
5. In the future, with changes in pressure in the well, an additional compression process will be added after this stage.
6. Fine separation – the gas goes through an additional cleaning and drying process (gas conditioning) that includes pressure reduction (to around 80 bar, the pressure required on entry to the transmission system), and cooling the gas (and additional

heating later on), aimed at separating other fuels from the gas, by turning them into dissolved liquids. In this process, antifreeze is sometimes added to the gas in order to prevent additional formation of liquids and/or damage in processes later on along the chain (inlet gas separation).

7. Diverting a small part (usually around 2%) of the gas flow for use as fuel in the facility itself (fuel gas) in the offshore facility, and to the onshore facility if it is not connected to the electricity grid and produces its energy independently.
8. A safety disposal system (venting at high pressure and low pressure) for surplus gas volumes, in the event of a malfunction, maintenance, and emergency only, by means of a ventilation pipe that includes a flare system.
9. Treatment of liquids and solids separated from the gas, separating them from the water and treating them, including stabilizing condensate for storage, separating antifreeze from the water, and treating the water (hereinafter; product water).
10. Treating the additional materials – other substances that sometimes come with the gas will also be separated and treated, and if they are considered to be hazardous or toxic in concentrations above that permitted in the accepted standards, they will be treated offshore only.
11. Systems for treating and removing hazardous materials (mercury, NORM, trimethylamine, BTEX, and others) that are liable to accumulate in the different treatment facilities, and ensuring that they are not emitted into the air or soil.
12. Treating gases, liquids and solids that have been separated from the gas and are considered to be toxic. If toxic matter is found in the natural gas extracted from the discoveries, beyond those substances whose treatment is detailed in the survey, in concentrations that are considered hazardous by the standards, separation from the gas, storage, and treatment <u>will be carried out only offshore</u>, in accordance with the environmental management and monitoring plan (EMMP) for building and operating the project. For this reason, the survey for the onshore sites (Hagit and Meretz wastewater treatment plant) does not go into details on the manner of their treatment.
13. A flare recovery system for returning the methane emissions back into the treatment process, intended for collecting the gas emitted in the treatment process so as to avoid emission into the air.
14. Treatment of the water to bring it to a level that can be discharged into the sea at a designated point representing part of this plan.
15. Treatment, storage, and transportation of anti-corrosives, if required.
16. Storage of condensate for marketing to refineries in a pipeline, or in ship-borne tanks (FSO – floating storage and offloading), in floating tanks (storage buy), or in storage tanks on the seabed.

17. Storage of antifreeze (TEG/MEG – usually glycol) for return to the wellhead in a designated pipeline.
18. Adjusting pressures and temperature to the INGL requirements for transfer to the transmission system.
19. Metering the quantity of gas and testing its quality is implemented before the gas enters the INGL national grid.
20. Sending the treated natural gas to the INGL receiving station. At the station, the flows of treated gas come together in a single pipe, and are transferred through it to the INGL transmission system.

Chapter 4 – Details and Assessment of the Environmental Impacts

This chapter deals with a description in principle of the potential environmental impacts of implementing the plan, and means for reducing negative impacts.

Since there is a lack of information affecting the planning of the treatment facility (such as the composition of the gas in the reservoir, and the planned technology), the review of the best available technological means (BAT – Best Available Technology) for reducing the impact on the environment and the examination of possible environmental impacts that are not included in this document will be drawn up at the building permit stage, in accordance with the principles described in the documents of the EMMP (which also relate to the BAT) and the ENVID, attached as Appendices G and I, drawn up by Royal Haskoning DHV.

In this chapter, the impact of the facility is reviewed in the following aspects:

Air quality – The impact of facilities operating on natural gas and operation of the gas engine (in terms of all pollutants examined: particles, nitrogen oxide, and sulfur dioxide) in the area of the northern and southern site on the environment is very low to negligible.

It is important to note that in a number of cases examined, methods of reduction enabling compliance with theTA Luft 2002 standards were taken into account. Additionally, when implementing the plan the implementing contractor will have to comply with the emission standards, or any other up-to-date emission standards accepted by the Ministry of Environmental Protection, and make use of the best available reduction technology (BAT).

Zoning, uses and activities – The marine environment does not abound with uses and purposes with respect to the plan's onshore environment. In addition, at this stage the plan includes corridors and exploration sites for the precise location of platforms and pipeline routes, and it is not possible to determine whether and which uses and purposes will be limited as a result of the plan's implementation. At the same time, there are a number of uses and purposes at sea that are liable to be affected by the plan's implementation, such as fishing and sailing, and it may be necessary to coordinate with the offshore desalination and communication infrastructures.

Appearance – It may be said with certainty that the offshore platforms constitute a new landscape disruption in an area of high visual value and sensitivity, and that they change the skyline from a near view, but this is not always true of the far views. From the analysis performed, it appears that the facilities are highly visible from the direction of the shoreline. The closer one is to the facilities, from a distance of 7.5 km and in the center of the field of vision, the greater the significance. On the other hand, visibility from areas further away from the facilities to the north and south, or from areas further from the shore to the west, is distant, raised above the horizon, at the end of the field of vision, and is not of great significance. The number and density of the facilities has a different effect on the appearance obtained.

Antiquities and heritage – Antiquity and heritage values that are liable to be affected by the plan's implementation in the offshore area include declared antiquity and heritage sites within the work area for laying the pipeline, or close to it, and antiquity sites in the area of the landfall pipeline crossing.

In each of the landfall sites archaeological investigation will be required: surveys and, as necessary, investigation or rescue excavations in the area of the marine corridor, and if necessary, diversion of the pipeline in the area of the blue line of the marine corridor. The archaeological investigations will be required at the planning stage before receipt of a building permit.

In addition, the HDD method will be used for implementing the landfall crossing. With this method it is possible to reduce the impact on offshore antiquity sites and the shore environment, by passing beneath areas of declared antiquity sites. All work will be performed under the direction of the Antiquities Authority, and naturally requires compliance with the Antiquities Law 5738-1978.

Seismology –During an earthquake, multi-system, simultaneous damage may be caused to the different facilities, and pollutants may be released into the air and the sea. It is important to state that the seismic design should take into account the stability of all engineering installations (non-structural components), and not only the structures themselves. In addition, this section details the means for preventing and minimizing these risks.

Noise – The stage of establishing the gas processing system – which includes laying a pipeline and erecting four platforms for treating gas from the wells and transferring it to the onshore facility – will undoubtedly be the noisiest stage in the life of the system.

It is clear that the dominant source of noise will be that caused by inserting the pilings that support the platforms. Noise can also be expected from the lively traffic of the various sailing vessels involved in the construction project.

At the operational stage, the characteristics of sources of noise will be completely different – both in terms of their nature and in terms of their intensity – from the noise sources during the construction process. These include noise from the gas flowing through the pipeline, and the noise of equipment installed on the platform for treating the gas.

Inserting the pilings involves strong pulses of noise created by repeated blows to the top of the piling, occurring a great many times throughout the working day. Because of the importance of this noise source and its potential negative impact on marine life, the main part of this section will deal with this source and its impact.

Pollution of the offshore or onshore environment due to leaks – this section describes the conditions for leaks of natural gas and liquids (such as product water, oils, condensate) from the system components in the offshore environment: the pipeline and the processing platform.

In addition, using a representative dispersion model, the spill of operating fuel from the platform into the sea was examined, and details are given of means and procedures for monitoring leaks of natural gas and liquids, and protecting the environment in these cases.

Attention is also given to plans of action and measures to be taken in the event of a leak. The plan of action, to be prepared by the developer, will include, among other things, a definition of the forces and tasks, and details of the methods of action and means, by stages of dealing with an incident, according to the nature of the incident, communication and reporting procedures, and coordination with other plans of action. The plan for dealing with different scenarios of spills of condensate and operating fuel into the sea will relate, among other things, to the outcomes of models for predicting the fate of these substances in different media-oceanographic conditions.

Handling product water and condensate – this section examines the effects of a flow of product water or spill of condensate into the sea, by dispersion models.

According to a conservative environmental assessment based on the results of a dispersion model of product water, the environmental effects of a flow of product water into the sea will be very slight. It is reasonable to assume that any impact on marine life will be limited to the immediate area around the gas treatment platform, within a radius of 250 m at the most.

From an analysis of a condensate spill, it is hard to accurately assess the degree of harm to different organisms, which is dependent on a number of variable factors. Condensate solution can be expected to harm various organisms (as detailed above) along the entire route of its progress and when it reaches the shore. It is also important to emphasize that at this stage, the exact composition of the condensate is not known and therefore the means to be taken to deal with it are also not known. Because of the anticipated effects resulting from a condensate spill into the sea, in our professional assessment priority should be given to taking decisions with regard to treating the condensate and its onshore storage, in any offshore-onshore mix to be decided upon.

Impact on habitats and natural values – this section reviews the anticipated effects on the natural environment as a result of the plan's implementation, and includes an examination of the effects of constructing an offshore platform on birds and a marine survey. The description of the marine environment has been made by means of a marine survey performed in January - May 2013. The survey was carried out in the two offshore sites intended for constructing gas treatment platforms, and three corridors in the exploration area for pipeline routes from the eastern border of the offshore sites to the shore, and includes an assessment in principle of the impact of the plan's implementation on habitats and natural values at sea.

Chapter 5 – Proposed Plan Instructions

This chapter details the proposed plan instructions for the environmental issues examined in this document, relating to all of the plan's implementation stages in the issues detailed:

- Stages of implementing the project
- Preventing marine pollution and handling pollution incidents
- Preventing air pollution
- Preventing damage to natural values, landscape, and continuum of open areas
- Control and handling of leaks
- Visual treatment of the site
- Instructions for collecting, treating and removing wastewater, brine and product water
- Seismic safety of structures and installations, relating to each of the possible elements of damage
- Instructions for reducing noise, both at the construction stage and at the stage of regular operation
- Rehabilitation of the seabed environment
- Sealing and monitoring leaks from the pipeline (gas and fuel)
- Handling auxiliary infrastructures
- Dismantling the facilities and restoring the former condition at the end of the project's life
- Antiquities and heritage sites

Instructions and guidelines are also detailed for issuing building permits. Since the plan is a detailed plan, but because of the fact that certain aspects relating to operation of the specific facility are not known, and there are still various issues in which there is a lack of information affecting the planning (such as the composition of gas in the reservoir, location of the offshore platforms and pipeline, and plans technology), a framework document has been drawn up for preparing an environmental management and monitoring plan (EMMP) detailing the issues to which the developer will be required to relate at the building permit stage for implementation of the plan. The framework document is submitted as part of this plan, and attached as Appendix I to the survey.

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Table of Contents

3. Chapter 3 – Description of Actions Resulting From Implementation of the Proposed Plan 26

3.0 General 30

3.1 Structures and installations at the site 46

3.1.1 Maps of sites 46

3.1.2 Set-up work 49

3.1.3 Changes to the existing situation 49

3.1.4 Characterization of facilities 50

3.1.5 Characterization of products 81

3.1.6 Fuels 82

3.2 Structures and facilities in the pipeline corridor and accompanying infrastructures 84

3.2.1 Mapping and cross sections 94

3.2.2 Description of the work area 97

3.3 Operating regime 97

3.3.1 Description of the operating principles 97

3.3.2 Description of the operating regime 98

3.3.3 Monitoring devices 99

3.3.4 Malfunction situations 100

3.4 Infrastructures 100

3.4.1 Description of the accompanying infrastructures 100

3.4.2 Wastewater 101

3.4.3 Produced water 102

3.4.4 Preventing penetration of surface runoff into the facility 106

3.4.5 Flooding 106

3.4.6 Monitoring systems 106

3.4.7 Emissions or gas flaring system 107

3.4.8 Signs and fencing 108

3.4.9 Protection of groundwater 108

3.5 Hazardous materials 108

3.6 Energy 109

3.6.1 Energy facilities ... 109
3.6.2 Fuels ... 110
4. Chapter 4 – Details and Evaluation of the Environmental Impact ... 112
4.0 General ... 112
4.1 Air quality ... 112
4.1.1 Details of emissions ... 113
4.1.2 Emissions impact ... 123
4.1.3 Planned measures for reducing emissions ... 123
4.1.4 Calculating pollutant dispersion ... 124
4.1.5 Model results ... 152
4.1.6 Malfunction or system failure ... 157
4.1.7 Description of air quality status in case of malfunction ... 158
4.1.8 Control systems and means of preventing leaks ... 180
4.1.9 Gas flaring system ... 180
4.1.10 Magnetic media ... 181
4.2 Assigned land-use, land-use, and activities ... 181
4.2.1 Compromising land-use and assigned land-use ... 181
4.2.2 Changing assigned uses and establishing restrictions ... 183
4.2.3 Charts ... 183
4.3 Visuals ... 183
4.3.1 Visual analysis ... 183
4.3.2 Description of findings ... 185
4.3.3 Landscape description ... 190
4.3.4 Means of reducing visual impact ... 190
4.3.5 Means of reducing harm to the environment/landscape ... 190
4.4 Antiquities and heritage ... 191
4.4.1 Antiquity and heritage values ... 191
4.4.2 Means of minimizing the ramifications of implementing the plan ... 191
4.5 Seismology ... 192
4.5.1 Expected ramifications of seismic events ... 193
4.5.2 Preventive and treatment measures for contamination incidents ... 195
4.6 Noise ... 203

4.6.0 General – basic hydroacoustics ... 203
4.6.0.1 Noise sources ... 207
4.6.1 Expected noise level ... 207
4.6.1.1 Pile-driving noise ... 207
4.6.1.2 Noise from other sources ... 209
4.6.2 Impact of noise on marine mammals and turtles ... 210
4.6.2.1 General ... 210
4.6.2.2 Acute injury and discomfort or displacement versus long-term cumulative injury ... 211
4.6.2.3 Data pertinent to noise impact from both plan sites ... 211
4.6.2.4 Influences of noise on marine mammals ... 217
4.6.2.5 Sea turtles ... 220
4.6.2.6 Means of reducing the impact of pile-driving noise on marine animals 221
4.6.2.7 Addressing noise impact in Regional Zoning Plan 37-H ... 222
4.6.2.8 Means of preventing harm to marine mammals and sea turtles during pile work 224
4.6.3 Acoustic protection ... 225
4.7 Leaks contaminating the marine or terrestrial environment ... 225
4.7.1 Describing leak conditions ... 225
4.7.2 Monitoring leaks – means and procedures ... 229
4.7.3 Preventing environmental pollution – means and procedures ... 230
4.7.4 Plan of operation and means in case of a leak ... 230
4.8 Handling produced water and condensate ... 230
4.8.1 Expected impact of produced water under the onshore treatment alternative ... 230
4.8.2 Dispersion model ... 230
4.8.3 Estimating impact of produced water on the marine environment ... 233
4.8.4 Removal via an existing outlet ... 246
4.8.5 Removal via a new outlet ... 246
4.8.6 Failure in condensate storage ... 247
4.9 Impact on habitats and nature values ... 257
4.9.1 Onshore environment ... 257

4.9.2 Marine Environment ... 266
4.10 Drainage and hydrogeology ... 318
4.11 Hazardous materials ... 318
5. Chapter 5 – Proposal for Plan Provisions ... 321
5.0 General ... 321
5.1 Proposal for Plan Provisions ... 321
5.2 Provisions and conditions for issuing building permits ... 330
5.2.1 Buildout reduction ... 330
5.2.2 Separation distances and restriction update ... 330
5.2.3 Emission permit ... 330
5.2.4 Environmental management and monitoring plan ... 330
5.2.5 Reducing fuel storage ... 331
5.2.6 Supplementary requirements for the building-permit stage ... 331
5.3 Restrictions and conditions regarding zoning, uses and activities ... 332

List of Figures

Figure 3.1: Onshore and offshore sites examined in Chapters 3-5 of the Environmental Impact Survey, against a general background 29

Figure 3.2: The onshore and offshore sites examined in Chapters 3-5 of the Environmental Impact Survey, against the background of a map of Israel's drilling licenses 30

Figure 3.0-1: Natural gas treatment chain 36

Figure 3.0-2: Simulation of the York platform in the North Sea 37

Figure 2.0-3: Example of planning a storage facility in a tanker alongside a treatment facility (Thailand) 42

Figure 3.1.1-1: The sites, against a background of a bathymetric map, marine cover, land uses and zoning 46

Figure 3.1.1-2: Components of the generic offshore facility 47

Figure 3.1.1-3:Typical sections of the components of the generic offshore facility 48

Figure 3.1.4-1: Illustration of the distribution of offshore facilities 51

Figure 3.1.4-2: Simulation of the offshore facility 52

Figure 3.1.4-3: The natural gas treatment chain – offshore treatment process 54

Figure 3.1.4-4: Generic planning of the main offshore natural gas treatment facility 56

Figure 3.1.4-5: Generic planning of the main offshore natural gas treatment facility 58

Figure 3.1.4-6: Generic planning of the main offshore natural gas treatment facility 60

Figure 3.2-1: Trenching area for pipelines between the offshore platforms and the landfall crossing 86

Figure 3.2-2: Different methods of pipeline burial 87

Figure 3.2-3: Cross-section of the pipeline 88

Figure 3.2-4: Terminology for pipeline trenches 90

Figure 3.2-5: Typical "mattress" profile 91

Figure 3.2.1-1: Typical cross-section of the western offshore pipeline corridor 94

Figure 3.2.1-2: Typical cross-section of the eastern offshore pipeline corridor 95

Figure 3.2.1-3: Overview of the cross-section representing HDD drilling relative to the shoreline at Dor and Michmoret 96

Figure 3.2.1-4: Representative cross-section of HDD drilling relative to the shoreline at Dor 96

Figure 3.2.1-5: Representative cross-section of HDD drilling relative to the shoreline at Michmoret....96

Figure 4.1.4-1: Location of receptor grids in the northern and southern compounds..126

Figure 4.3.1-1: Visual analysis....184

Figure 4.3.2-1: Impact of facility contour on the horizon – view from the coastline (top) and from higher elevations (bottom)....186

Figure 4.3.2-2: Impact on the horizon of a number of installations – view from the coastline (top) and from higher elevations (bottom)....187

Figure 4.4.2-1 : Schematic illustration of HDD....192

Figure 4.5.2-1: Description of harmonization process between ISO and API standards for platform design (DNV, 2011)....198

Figure 4.6.0-1: Schematic illustration of noise levels in the open sea according to Wenz....204

Figure 4.6.0-2: Noise propagation from a hammer striking a pile....205

Figure 4.6.0-3: Determining flow noise criterion....206

Figure 4.6.2.3-1: Distribution map of *Tursiops truncatus* schools during 2003-2011 normalized for search effort (sea hours)....215

Figure 4.6.2.3-2: Locations of natural sea turtle nests along the Israeli coast during 1993-2008....216

Figure 4.6.2.4-1: Spectral weighting function for sea turtles....221

Figure 4.6.2.7-1: Unweighted attenuation curves of source pressure level, with distance from pile-driving point....223

Figure 4.7.1-1: Dispersion of operational diesel accumulated on the beach (ton/km) in an extreme winter storm scenario for dumping 31 tons....228

Figure 4.8.2-1: Currents and tracer concentration (percent relative to the concentration at the discharge lattice point) at a depth of 6.5m for a calm sea scenario....232

Figure 4.8.2-2: Vertical section of tracer concentration (percent relative to concentration at the discharge lattice point) with the current for a calm sea scenario. 232

Figure 4.8.3: Compounds that may fall under the definitions of Oil and Dispersed Oil in produced water, depending on the testing method (according to Yang, 2011)....234

Figure 4.8.6: Distribution of condensate accumulated on the shore (barrels/km) under the extreme winter storm scenario (1 barrel=0.16m3)....249

Figure 4.9.2-1: Survey and habitat boundaries....268

Figure 4.9.2-2: Multi- Dimensional Scaling of the sampling results at Dor 271
Figure 4.9.2-3 Cluster analysis of the Dor sampling results 273
Figure 4.9.2-4: Average taxa diversity at depths of 10-100m at Dor 273
Figure 4.9.2-5 Average richness of taxa at depth of 100m, Dor 274
Figure 4.9.2-6: Dor, depth 10-20m 275
Figure 4.9.2-7: Dor, depth 30-40m 276
Figure 4.9.2-8: Dor, depth 50-60m 277
Figure 4.9.2-9: Dor, depth 70-90m 278
Figure 4.9.2-10: Multi-dimensional scaling of the sampling results at Havazelet Hasharon 280
Figure 4.9.2-11: Cluster ordination of the sample results collected across from Havazelet Hasharon 280
Figure 4.9.2-12: Average taxon diversity at sampling stations 1-10 at Havazelet Hasharon 282
Figure 4.9.2-13: Average taxon abundance at sampling stations 1 to 10 at Havazelet Hasharon 282
Figure 4.9.2-14: Havazelet Hasharon, depth 10-30m 283
Figure 4.9.2-15: Havazelet Hasharon, depth 40-70m 284
Figure 4.9.2-16: Havazelet Hasharon, depth 80-100m 285
Figure 4.9.2-17: Trawling routes along the Mediterranean coast of Israel (Edelist, 2013) 307

List of Tables

Table 3.1.4-1: Description of the main installations in the treatment facility 62

Table 3.1.5-1: Composition of gas typical of finds off Israel's shores 82

Table 3.3.1-1: Main planning principles of the offshore treatment facility 97

Table 3.4.3-1: Examples of typical chemicals in produced water 103

Table 3.4.3-2: Specification of equipment for treatment of produced water in an onshore facility 105

Table 3.4.6: Composition and flow data 106

Table 3.5: Hazardous materials 109

Table 4.1.1-1: Emissions from power plants (power generation) 116

Table 4.1.1-2: Power plant stack data 117

Table 4.1.1-3: Fired heater emissions 117

Table 4.1.1-4: Fired heater data 117

Table 4.1.1-5: Diesel engine emissions 117

Table 4.1.1-6: Diesel engine data 118

Table 4.1.1-7: Emissions during the years after 2025 118

Table 4.1.1-8: Emission-source data during future years (after 2025) 119

Table 4.1.1-9: Emission data for HP and LP flares in case of malfunction 120

Table 4.1.1-10: Emission data for HP flare in cases of compressor blowdown after 2025 121

Table 4.1.1-11: HP and LP flare data according to type of malfunction 122

Table 4.1.4-1: Model results for particulate pollutants (PM) – background (point emissions and vehicles) 129

Table 4.1.4-2: Model results for particulate pollutants (PM) – background (point emissions) 130

Table 4.1.4-3: Model results for nitrogen oxides NO_X (emissions from natural gas treatment facilities and diesel engines) 131

Table 4.1.4-4: Model results for sulfur dioxide SO_2 (emissions from natural gas treatment facilities and diesel engines) 132

Table 4.1.4-5: Model results for particulate pollutants PM (diesel engine emissions only) 133

Table 4.1.4-6: Model results for nitrogen oxides NO_X (background emissions (point sources) from natural gas treatment facilities and diesel engines) 135

Table 4.1.4-7: Model results for sulfur dioxide SO_2 (background emissions (point sources) from natural gas treatment facilities and diesel engines) 137

Table 4.1.4-8: Model results for particulate pollutants PM (background emissions (point sources) and diesel engines) 138

Table 4.1.4-9: Model results for particulate pollutants PM (background emissions (point sources and vehicles) and diesel engines) 139

Table 4.1.4-10: Model results for nitrogen oxide NO_X (emissions from natural gas operated facilities and diesel engines) after 2025 140

Table 4.1.4-11: Model results for sulfur dioxide SO_2 (emissions from natural gas operated facilities and diesel engines) after 2025 141

Table 4.1.4-12: Model results for nitrogen oxide NO_X (emissions from natural gas treatment facilities and diesel engines 143

Table 4.1.4-13: Model results for sulfur dioxide SO_2 (emissions from natural gas treatment facilities and diesel engines) 144

Table 4.1.4-14: Model results for particulate pollutants PM (emissions from diesel engines only) 145

Table 4.1.4-15: Model results for nitrogen oxides NO_X (background emissions (point sources) and natural gas treatment facilities and diesel engines) 146

Table 4.1.4-16: Model results for sulfur dioxide SO_2 (background emissions (point sources) and emissions from natural gas treatment facilities and diesel engines) 146

Table 4.1.4-17: Model results for particulate pollutants PM (emissions from the background (point sources) and diesel engines) 148

Table 4.1.4-18: Model results for particulate pollutants PM (emissions from background (point sources and vehicles) and diesel engines) 149

Table 4.1.4-19: Model results for nitrogen oxides NO_X (emissions from natural gas operated facilities and diesel engines) after 2025 150

Table 4.1.4-20: Model results for sulfur dioxide SO_2 (emissions from natural gas operated facilities and diesel engines) – after 2025 151

Table 4.1.7-1: Model results for nitrogen oxide NO_X in case of operational malfunction – from flare and diesel engines only 160

Table 4.1.7-2: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources) 162

Table 4.1.7-3: Model results for nitrogen oxide NO_X in case of operational malfunction – from flare and diesel engines ... 163

Table 4.1.7-4: Model results for sulfur dioxide SO_2 in case of operational malfunction – from flare and diesel engines, and background (point sources only) ... 164

Table 4.1.7-5: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines only ... 165

Table 4.1.7-6: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources only) ... 166

Table 4.1.7-7: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines only ... 167

Table 4.1.7-8: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines, and background (point sources) ... 168

Table 4.1.7-9: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines only ... 169

Table 4.1.7-10: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources) ... 170

Table 4.1.7-11: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines ... 171

Table 4.1.7-12: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines, and background (point sources only) ... 172

Table 4.1.7-13: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines only ... 173

Table 4.1.7-14: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources) ... 174

Table 4.1.7-15: Model results for sulfur dioxide SO_2 in case of malfunction – from flare and diesel engines only ... 175

Table 4.1.7-16: Model results for sulfur dioxide SO_2 in case of malfunction – from flare and diesel engines, and from the background (point sources) ... 176

Table 4.2.1-1: Plan's impact on land uses and assigned uses ... 182

Table 4.6.2.3-1: Cetaceans and turtles whose presence in the Sharon area is known or assumed ... 213

Table 4.6.2.7-1: Noise exposure level calculated for a stationary marine mammal exposed to 4 hours of pile-driving ... 224

Table 4.7.1-1: Summary of operational diesel dispersion scenarios when dumping 6 cubic meters – landfall arrival times and most impacted areas ... 228

Table 4.7.1-2 : Summary of operational diesel dispersion scenarios when dumping 31 tons – landfall arrival times and most impacted areas 229

Table 4.8.2: Dilution factors obtained from the produced water dispersion model under various sea conditions and at different distances from the discharge point of produced water to the sea 233

Table 4.8.3-1: Heavy metal concentrations in produced water on gas treatment platforms worldwide, in microgram/liter..... 237

Table 4.8.3-2: Concentrations of selected organic components of produced water on gas treatment platforms worldwide, in microgram/liter 237

Table 4.8.3-3: EU sea water quality standards and Israeli Mediterranean Sea water quality proposed standards by the Ministry for Environmental Protection, microgram/liter..... 240

Table 4.8.3-4: Dilution factors obtained from the produced water dispersion model, under different sea conditions and at varying distances from the point of discharge of produced water..... 241

Table 4.8.3-5: Critical dilution factors (dilution necessary to ensure compliance with stringent sea water quality standards) for average and maximum produced water concentrations, and the least dilution (quiet sea) expected at a distance of 250m from the gas treatment platform 242

Table 4.8.3-6: Calculated maximum concentrations of produced water components around the gas treatment platform (for naphthalene and anthracene the average calculated concentrations are shown)..... 243

Table 4.8.3-7: Calculated average and maximum concentrations of dispersed oil around the gas treatment rig 243

Table 4.8.6-1: Summary of condensate dispersion scenarios –landfall arrival times and most impacted areas..... 250

Table 4.8.6-2 : Sensitivity of shores to oil spills..... 256

Table 4.9.1: Guidelines for preliminary monitoring program..... 265

Table 4.9.2-1: Dominant grain size results from Perimeter 1 (Dor) and Perimeter 2 (Havazelet) and pipeline corridors..... 269

Table 4.9.2-2: Table 3: Data for grain size and concentrations of organic material for sampling stations in the depth range of 40-85m (TAHAL, 2011)..... 269

Table 4.9.2-3: List of biota on the bed and background data for the Dor perimeter..... 287

Table 4.9.2-4: Findings from biota on the bed sampling conducted at the Dor perimeter 288

Table 4.9.2-5: List of biota on the bed and background data for the Havazelet Hasharon perimeter 289

Table 4.9.2-6: Biota on the bed findings, in the Havazelet Hasharon perimeter 290

Table 4.9.2-7: Distribution range (average depth +/- SD) of trawled fish on the Israeli coast, with an emphasis on the 50-100m depth range (Edelist, 2013) 301

Table 4.9.2-8: Platform construction stages 315

Chapter 3

Description of Actions Resulting from Implementation of the Proposed Plan

3. Chapter 3 – Description of Actions Resulting From Implementation of the Proposed Plan

The outline plan for treatment facilities for natural gas from discoveries – TAMA 37/8 – is a detailed national outline plan for planning facilities for treating natural gas from offshore finds and transferring it to the transmission system. The plan relates to existing and future finds.

In accordance with the guidelines for its preparation, the plan is facilitating and flexible, including the possibility of using a variety of natural gas treatment methods, combining a range of mixes for offshore and onshore treatment. This is in view of the fact that the plan is being promoted as an outline plan that will address all future offshore gas finds, such that they will be able to supply gas to the transmission system continuously and over time. This policy has been promoted and adopted by the National Board, and is expressed in its decisions. The final decision with regard to the method of developing and treating the gas will be based on the approach of the developers, and in accordance with the decision of the governing institutions by means of the Gas Authority.

In the framework of this policy, and in accordance with the decisions of the National Board, the survey relates to a number of sites that differ in character and nature, divided into three parts:

1. Survey of the Meretz wastewater treatment plant site – an onshore treatment facility with pressure reduction at sea, including an onshore gas treatment facility for treating the gas, and a pipeline from the landfall pipeline crossing to the facility, and from the facility to the transmission system.
2. Survey of the Hagit site – an onshore treatment facility with pressure reduction at sea, including an onshore gas treatment facility, and a pipeline from the landfall crossing to the facility, and from it to the transmission system.
3. A survey of two sites for offshore gas treatment facilities and the pipeline route detailed in this document, from the boundary of the territorial waters to the facilities, and from the facilities to the shore.

Figure 3.1 shows the onshore and offshore sites examined in Chapters 3-5 of the Environmental Impact Survey, against a general background.

Figure 3.2 shows the onshore and offshore sites examined in Chapters 3-5 of the Environmental Impact Survey, against the background of a map of Israel's drilling licenses.

The offshore facility for treating gas at sea presented in the survey below enables offshore processing of raw gas. The offshore processing options detailed in the survey are varied, and relate to the entire gas treatment process, on the assumption that at this stage of planning, it should be possible to choose a flexible mix of offshore and onshore processing. This mix will be decided at the building permit stage.

Based on the National Board's decision[1]of January 1, 2013, the offshore components of the treatment facility examined in this survey include:

- **The route of the western pipeline** – from the borders of Israel's territorial waters (in which the Planning and Building Law applies) to the exploration areas of the offshore platform. This site is intended for laying the pipeline corridor for transmission of the raw natural gas (and byproducts) to the gas processing platform.
- **The offshore platform exploration areas –** the platform's exploration areas extend from an eastern boundary 7.5 km from the coastline, in accordance with the Ministry of Environmental Protection directive, for reasons of visibility. The western boundary has a depth of 100 m – at this depth, the continental shelf begins.

  Two sites are planned for locating the platform:

  - Site 1 – Northern site, in the offshore area from Dor beach in the north to Or Akiva in the south, and extending over a total area of some 43 km^2.
  - Site 2 – Extending over a total area of some 55 km^2 in the offshore area between Beit Yannai beach in the north and the northern section of Netanya in the south.
- **Eastern pipeline site –** from the site of the offshore gas process platforms to the landfall pipeline crossing at Dor or Michmoret.
- **Landfall pipeline crossing –** largely described in the onshore Environmental Impact Survey, and also surveyed in part in this document.

Since no developer has yet been chosen to implement the plan, and at this stage there is a planning array in principle for establishing the gas treatment facilities, in this document too, as with previous sections of the survey, the technological options for offshore treatment will be examined and planned in principle in order to examine the treatment facility's maximum impact on the marine environment, and allow the future developer maximum planning flexibility in the plan in terms of the mix of offshore and onshore facilities. The representative plan for the treatment facility was drawn up by PDI Co., the engineering consultants for the plan, and includes the document "Quantification of Emissions & Discharges," attached as Appendix B and forming the basis for planning and assessing impacts in this document.

Bibliographic references are attached at the end of the document and as footnotes at the

[1]http://mavat.moin.gov.il/MavatPS/Forms/SV4.aspx?tid=4&pid=99007844

bottom of the relevant pages. DWG format files of the location of the facilities and pipelines are attached in the digital file attached to the survey. The consultants' affidavits attached to this document relate to both the onshore and offshore Environmental Impact Surveys. In addition, it should be noted that the proposed plan, including instructions and diagrams, will be submitted separately at a later stage.

The aim of Chapters 3-5 is to describe the actions arising from implementation of the proposed plan and to detail the assessed environmental impacts of implementation, and means of reducing them.

The information below includes an explanation of the method of treating gas, and supplements the information detailed in the two sections of the survey already circulated for the Meretz wastewater treatment facility and the Hagit site. Accordingly, the survey relates to the gas treatment process carried out onshore, and explains the principles of the process, but focuses on and goes into detail with regard to the offshore activity and its effects on the environment and population. Since the survey relates to the maximum impacts, it does relate to all types of partial offshore processing, including developing a platform for pressure reduction only.

Figure 3.1: Onshore and offshore sites examined in Chapters 3-5 of the Environmental Impact Survey, against a general background

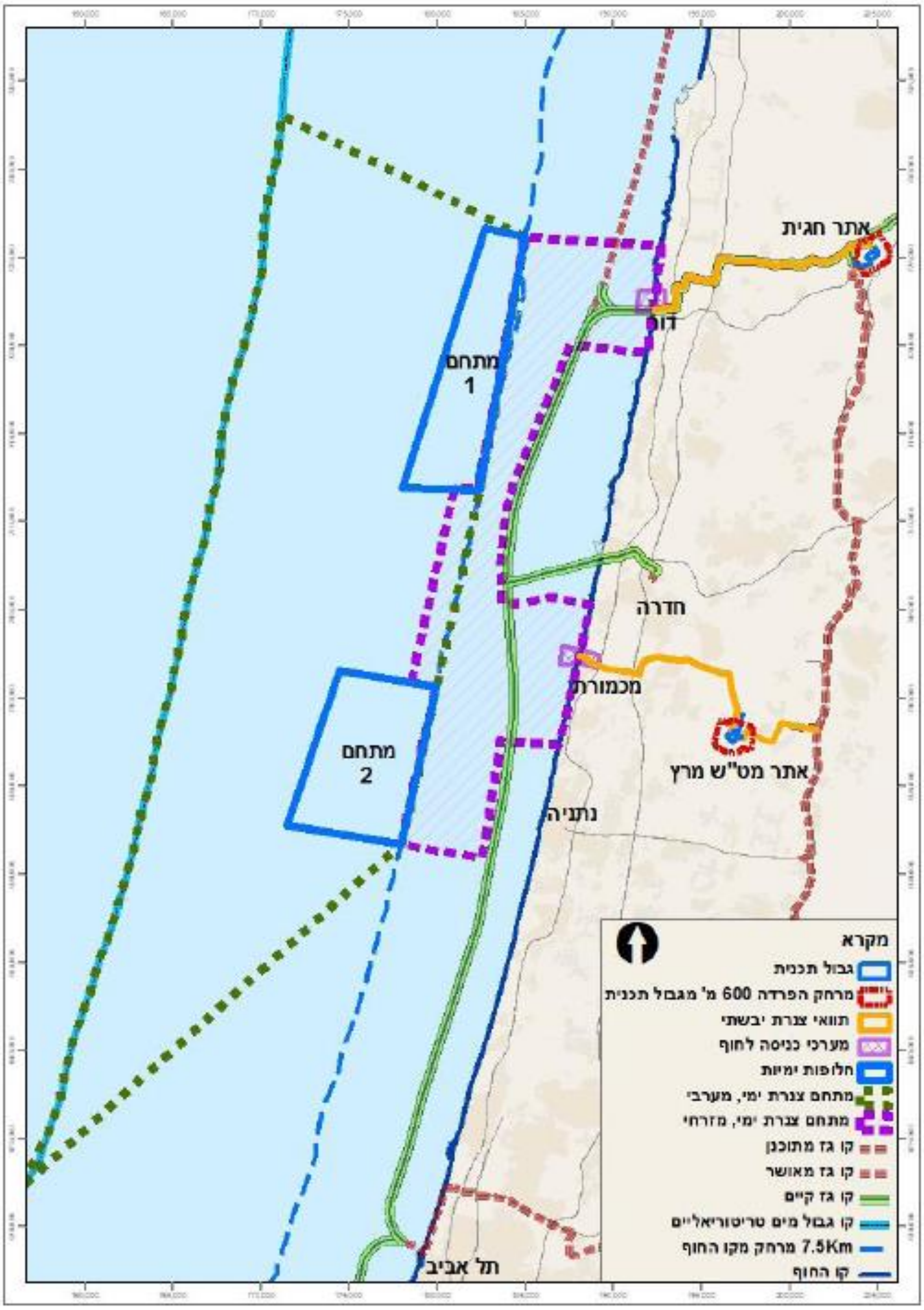
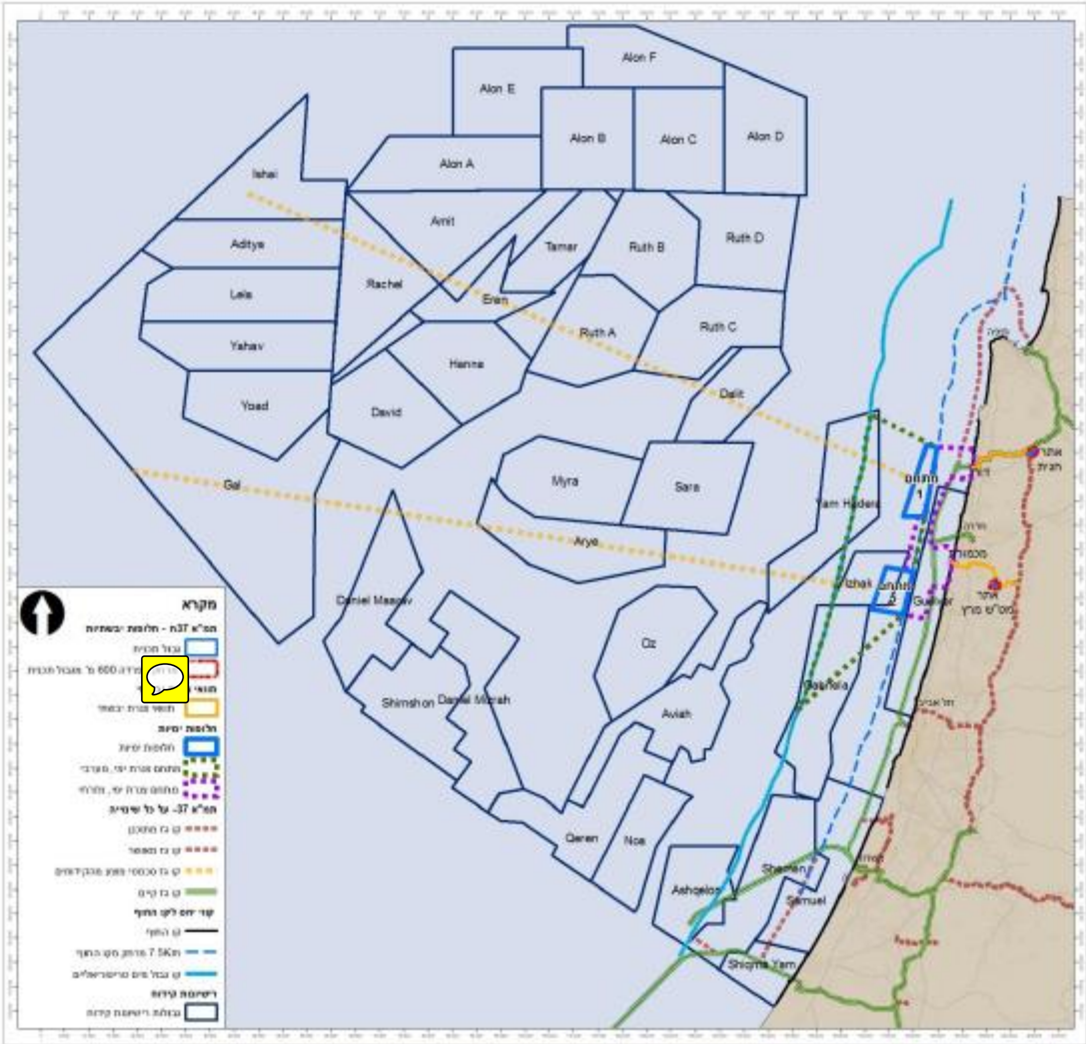


Figure 3.2: The onshore and offshore sites examined in Chapters 3-5 of the Environmental Impact Survey, against the background of a map of Israel's drilling licenses



3.0 General

This chapter includes a review of the main components of the offshore treatment facility, and a description of the gas treatment process from the drilling well until the treated gas is transmitted to the onshore facility. The description of the treatment process and description of the facility will incorporate the basic assumptions of operation of the engineering facility.

The information presented in Chapter 3 below is a summarized review of the engineering report on the offshore treatment facility and the engineering-operational report on the pipeline, presented in full in Appendices B and C, and also includes a description in principle of the gas treatment and extraction process from its source in the offshore discoveries.

In accordance with the engineering survey, the conditions and requirements for building permits for the facilities detailed below will be formulated as part of the Environmental Impact Survey. Due to the requirement to prepare a facilitating and flexible plan, the survey instructions will represent a planning framework by which it will be possible to issue building permits, and will include instructions for drawing up an environmental management and monitoring plan (EMMP), in accordance with the guidelines to be detailed in the Environmental Impact Survey and assimilated in the plan instructions. The guideline document for drawing up the EMMP is attached to this document as Appendix I, and submitted as part of this plan.

As a rule, there are two stages of development for gas treatment facilities:

1. The stage at which utilization of gas from deep sea discoveries begins, in which the pressure of flow from the wellhead is high and therefore gas treatment is relatively cheap and easy.
2. The stage at which utilization of the gas takes place as the pressure in the wells producing gas from the discoveries becomes low and the gas coming from the reservoirs is accompanied by increasing quantities of produced water, up to the stage that the well is abandoned. Upon abandonment of all the wells, the discovery itself is abandoned (it should be noted that there is still natural gas in the reservoir, but it is not financially worthwhile to exploit it), or the reservoir from this discovery serves for storage of natural gas (and in certain cases, also other substances). At this stage of reduced pressure, it is necessary to develop compressors intended to increase the pressure in the wells, thus reducing the quantity of produced water coming with the gas that is extracted, and increase the percentage of gas utilized from the discovery. This stage is a relatively costly development stage, with many operational malfunctions mainly arising from the increased quantity of produced water that comes with the gas. The scale of development included in this stage depends on the method of developing the reservoir, and the scale of exploitation. In light of the fact that the plan relates to a variety of deep sea discoveries, it is not possible to give a timeframe for development at this stage.

After this, the facilities are dismantled, or used for other discoveries or other purposes.

Generic description of the gas treatment chain

Figure 3.0-1 below is a flow diagram showing the natural gas treatment chain for a scenario in which most of the processing takes place at an offshore treatment facility: from its beginnings as raw gas (untreated gas) pumped from an offshore drilling well, until the end of the process, in which the treated gas is transferred (at the delivery station) to the INGL transmission system, including treating the main additional byproducts that are obtained / added in.

The process of treating natural gas at sea starts with pumping the gas from the seabed (accompanied mainly by water, antifreeze coolant and condensate).

The gas comes from the wellhead in raw form, at high pressure, and needs to be treated before it can be passed through the transmission system, in accordance with INGL requirements. Treatment of the gas is unique to each find, and may even change from one well to another in the same discovery, because the treatment depends on the characteristics of the gas: type and composition, the pressure at which it comes out, the percentage of hydrocarbons it contains, and especially the quantity of gas condensate, the percentage and composition of the water in it, and also the quantity of antifreeze coolant. Below is a general description of the processing chain, from the wellhead until entry into the transmission system, based on the assumption that there is a high percentage of methane in the gas (on the basis of the percentage that is common in discoveries in Israel). The description of the processing chain includes attention to the main elements that exist in most discoveries around the world:

1. Adjusting the gas pressure to the pressure required for natural gas processing if all or part of the treatment is carried out onshore, in accordance with the guidelines of the Ministry of Energy and Water Resources, by which flow pressures in the pipeline at landfall will be no greater than 110 bar.
2. Reducing the pressure of the gas coming from the well, or compression of the raw gas where the gas in the reservoir is becoming depleted.
3. Initial separation of liquids from the raw gas in a separator, including:
    - Removal of steam from the gas flow (water dew-pointing)
    - Removal of hydrocarbons, such as condensate, which are liable to condense in liquid form in the pipeline (hydrocarbon dew-pointing)
    - Removal of other substances found in the gas that are liable to be toxic.
4. Removal of antifreeze coolants (MEG/TEG).
5. In the future, with the changes of pressure in the well, an additional compression process will be added after this stage.
6. Fine separation – the gas goes through an additional cleaning and drying process (gas conditioning) that includes pressure reduction (to around 80 bar, the pressure required for entry to the transmission system), and cooling the gas (and additional heating later on), aimed at separating other fuels from the gas, by turning them into dissolved liquids. In this process, antifreeze coolant is sometimes added to the gas in order to prevent additional formation of liquids and/or damage in processes further on along the chain (inlet gas separation).
7. Diverting a small part (usually around 2%) of the gas flow for use as fuel in the facility itself (fuel gas) in the offshore facility, and for the onshore facility if it is

not connected to the electricity grid and produces its energy independently.

8. A safety disposal system (venting at high pressure and low pressure) for excess gas volumes, only in the event of a malfunction, maintenance, and emergency, by means of a ventilation pipe that includes a flare system.
9. Treatment of liquids and solids separated from the gas, separating them from the water and treating them, including stabilizing condensate for storage, separating antifreeze coolant from the water, and treating the water (hereinafter, produced water).
10. Treating the additional matter – other substances that sometimes come with the gas will also be separated and treated, and if they are considered to be hazardous or toxic in concentrations above that permitted in the accepted standards, they will be treated only at sea.
11. Systems for treating and removing hazardous materials (mercury, NORM, trimethyl, BTEX, and others) that are liable to accumulate in the different treatment facilities, and ensuring that they are not emitted into the air or the soil.
12. Treating the gases, liquids and the solids that have been separated from the gas and are considered to be toxic. If toxic matter is found in the natural gas extracted from the finds beyond those substances whose treatment is detailed in the survey, in concentrations that are considered hazardous by the standards, separation from the gas, storage, and treatment will be carried out only at sea, in accordance with the environmental management and monitoring plan (EMMP) for building and operating the project. For this reason, the survey for the onshore sites (Hagit and Meretz wastewater treatment plant) does not go into detail on the manner of treating them.
13. A flare recovery system for returning the methane emissions back into the treatment process, intended for collecting the gas emitted in the treatment process so as to avoid emission into the air.
14. Treatment of the water to bring it to a level that can be discharged into the sea at a designated point representing part of this plan.
15. Treatment, storage, and transportation of anti-corrosives if required.
16. Storage of condensate for marketing to refineries, in a pipeline, or in ship-borne tanks (FSO – floating storage and offloading), in floating tanks (storage buy), or in storage tanks on the seabed.
17. Storage of antifreeze coolant (TEG/MEG – usually glycol) for return to the wellhead in a designated pipeline.
18. Adjusting pressures and temperature to the INGL requirements for transfer to the transmission system.

19. Metering the quantity of gas and testing its quality is implemented before the gas enters the INGL national grid.
20. Sending the treated natural gas to the INGL receiving station. At the station, the flows of treated gas come together in a single pipe, and are transferred through it to the INGL transmission system.

Below is a detailed explanation of the liquids that are separated during the treatment process:

The main liquids separated from the raw gas in the treatment process (condensate, MEG and water) are passed through liquid separators. These devices produce a physical separation between the liquids (based on the difference in specific gravity at different temperatures), which can be transferred to designated installations. The separated liquids pass through the following processes:

- **Fuel - condensate:** The fuel passes through a process of stabilization in order to separate the remaining gas components from the fuel and enable it to be stored and/or transported in a pipeline, truck, or tanker liner. After stabilization, the fuel is moved to designated storage tanks before being transferred, in a separate pipeline, for processing at the refineries or at a designated facility to be established adjacent to the offshore site. The gas obtained in the stabilization process is returned to the gas stream.
- **Antifreeze coolants – TEG/MEG (mono / tri ethylene glycol)**: Antifreeze coolants are injected into the wellhead to help in the process of producing gas from the reservoir, and then this material flows into the treatment facility together with the gas and the other liquids and solids for separation and recycling, and from there is returned to the wellhead, such that a closed system is formed. There are two main types of antifreeze coolant separation:
    - **Offshore TEG/MEG** – a mix of TEG/MEG and produced water without salt, received in a liquid separation tank, undergoes a process of treatment and recycling of the MEG in a designated facility. The water in the mixture is boiled to obtain relatively clean MEG and produced water. The clean TEG/MEG is transferred to designated tanks before passing through a designated pipeline to the offshore facility, and from there to the well.
    - **Onshore TEG/MEG –** a mixture of TEG/MEG with a relatively large quantity of produced water originating in the reservoir (and therefore likely to contain a certain concentration of salt) is added to the gas in the cleaning and drying process in the gas conditioning system (stage 2). The TEG/MEG that it contains undergoes a treatment process that includes separation from the salt and recycling in a separate, designated system in the treatment facility, and returns to the offshore facility in a designated

pipeline. Since this facility emits toxic gases in the separation process, a closed system will be required, transferring the vapor formed in the process into the internal combustion system and burning it, thus completely preventing its emission into the air. In addition, salt will be stored and removed to a toxic waste site.

- **Produced water:** Produced water is the water occurring in the geological strata in which the gas is found, or formed during the extraction process or pumping process, or as a result of injection into the reservoir for increasing pressure. In addition, water is formed in gas as a result of changes in pressure or temperature, etc. Produced water is separated from the natural gas and the other liquids and solids that come with it, and undergoes treatment in a designated facility intended to separate the remaining fuel components from the water before it is dispersed into the sea.

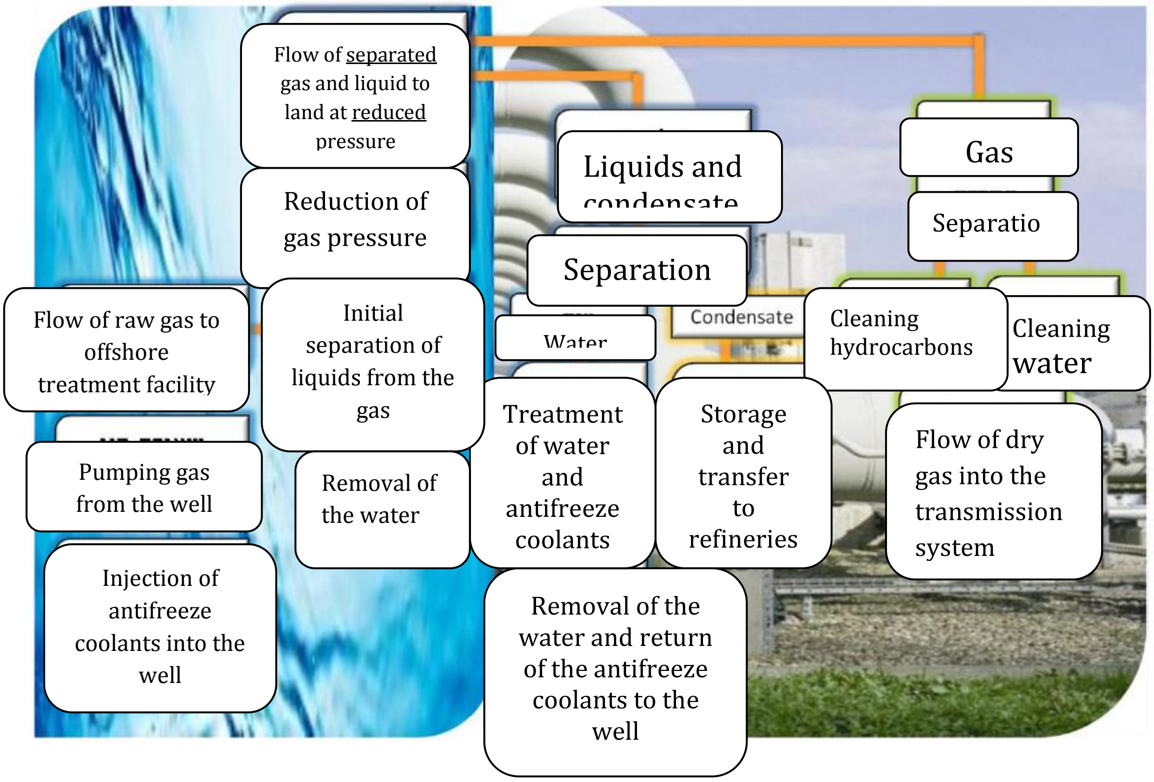
It should be noted that there are both offshore and onshore options for separating liquids and solids from the gas, and therefore:

- There are solutions for both offshore and onshore storage and transportation of concentrate, and the offshore and onshore facilities are connected by means of a pipeline that can serve both the offshore facility and the onshore facility, and enable treatment and storage solutions both at sea and on land. In this connection, it should be noted that from an environmental and safety viewpoint, onshore storage is preferable to offshore storage, and therefore this is our recommendation in any mix of offshore-onshore treatment that is decided upon.
- There are collection, storage and transportation solutions for antifreeze coolants (see explanation below), both offshore and onshore, and a pipeline transporting the antifreeze coolants back to the wellheads and connecting the offshore and onshore facilities. Here too, it should be noted that from an environmental and safety viewpoint, onshore storage is preferable to offshore storage. There is another type of treatment for future antifreeze coolants (for example, antifreeze coolants that are similar in composition, should the need arise, if the produced water is particularly saline), for which an area is set aside in the facility.
- There are treatment solutions for produced water and condensation water, both offshore and onshore, and solutions for transporting the produced water for discharge back into the sea from the offshore platform. In this connection it should be noted that from an environmental viewpoint, it is preferable to separate the greater part of the produced water at sea, so that it will not be necessary to store and transport the produced water from the onshore facility back to sea. It should be emphasized that in any event, it is necessary to have the ability to treat water at the onshore treatment facility, since some of the water in the gas condenses in the pipeline (due to changes in temperature, pressure, etc.)

or in the process undergone by the gas after the initial separation processes, and therefore it is necessary to ensure the ability to separate water from the gas on land, and to deal with problems arising from the quantity of water coming onshore with the gas.

- There are communication cables accompanying the pipeline, and these will connect the offshore and offshore facilities.

Figure 3.0-1: Natural gas treatment chain



Construction for support of the offshore gas process platform

There are different types of support constructions for gas process platforms (topside):

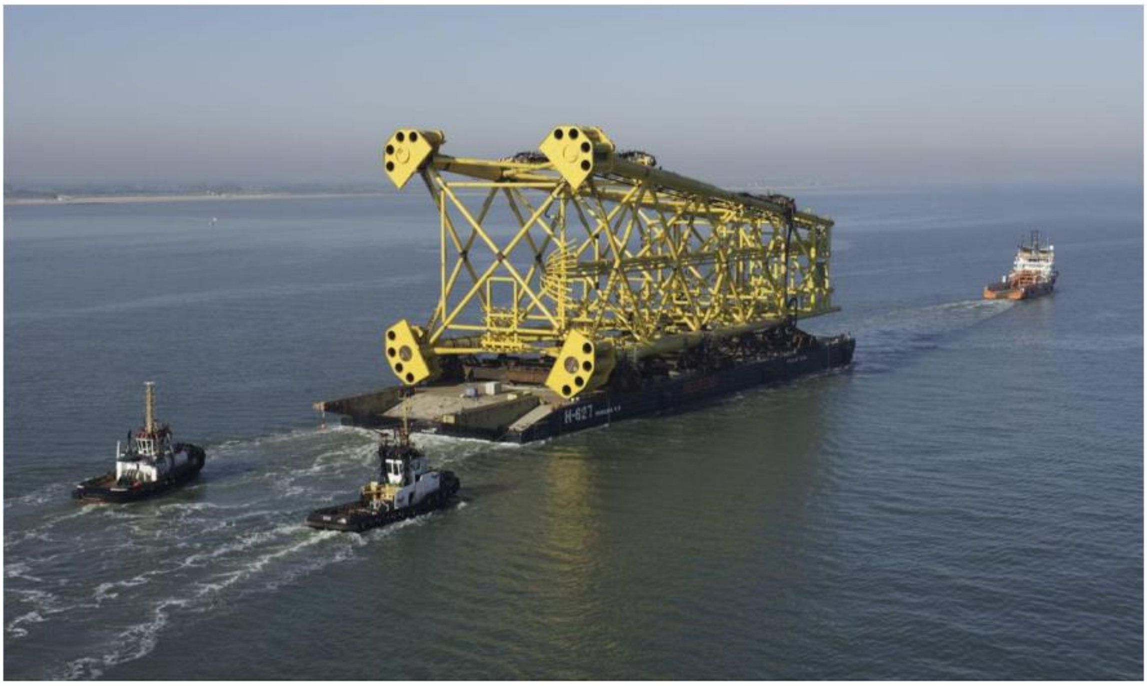
- Jacket

Fixed platform – supported by foundations on the seabed. The jacket platform is the most common type of offshore infrastructure in the world, and it also exists in Israel. Jacket platforms are used for gas/oil processing, accommodation, and helicopter landing, interconnected by transit bridges. Platforms of this type are most common in shallow water, because of the lower construction costs. In Israel, the Mari B jacket is situated at a water depth of 280 m, and the total weight of the jacket and the topside is 35,000 tons. The jacket in question in the current projects will be located in Israeli territorial waters, with depths of between 60 and 100 m, and the estimated weight of the jacket and the topside is around 20,000 tons (see Appendices B and C).

Figure 3.0-2: Simulation of the York platform in the North Sea

The platform is manufactured at a special shipyard and transported to the site, as illustrated in Photograph 3.0-1.

Photograph 3.0-1: Transporting a jacket in the North Sea in Norway



- **Concrete construction**

There are concrete constructions, some of which have been developed with liquid storage tanks as gravity-based structures (GBS).

Photograph 3.0-2 shows the transportation of a gas treatment facility on a concrete construction to the offshore treatment site in Norway.

Photograph 3.0-3 shows a concrete construction with liquid storage tanks, in Norway.

Photograph 3.0-2: Transportation of a gas treatment facility on a concrete construction to the offshore treatment site in Norway

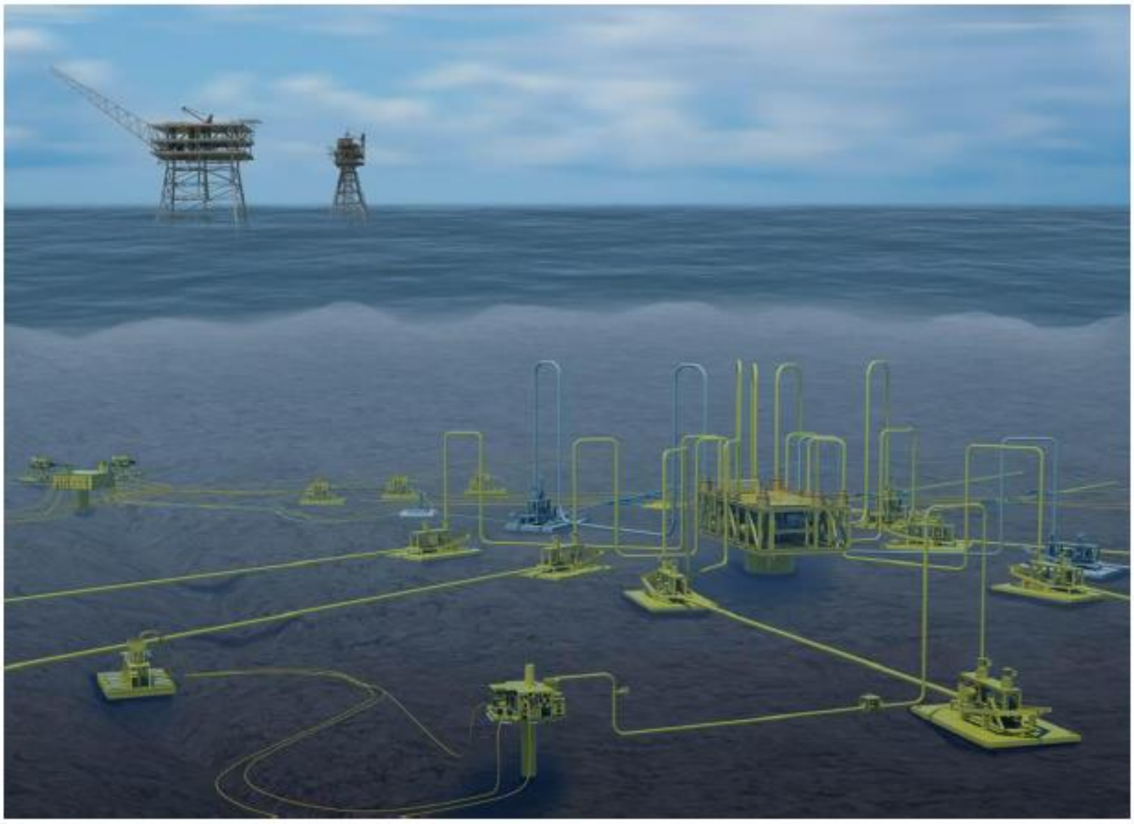
Photograph 3.0-3: Concrete construction with liquid storage tanks in Norway

Offshore infrastructures are built on land, in stages, and taking into account the weight, method of installation at sea, and constraints of equipment for lifting and transporting the parts.

Unique characteristics of offshore treatment in the Israeli case

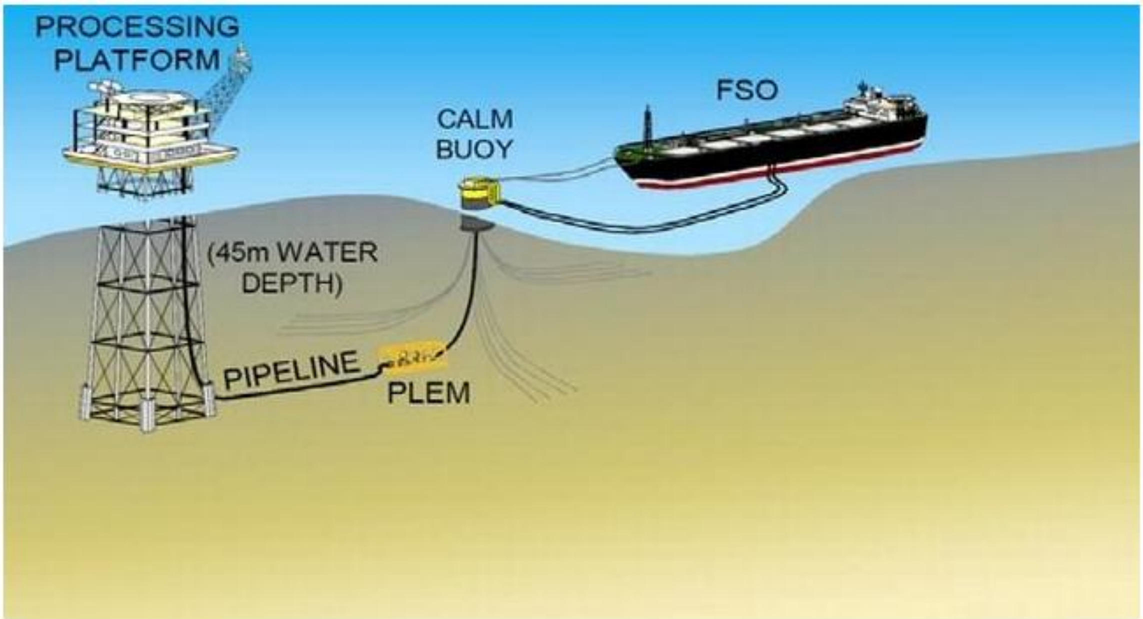
In Israel, the majority of finds are in very deep water, where access to the wells is exclusively by robot. It should be noted that no country in the world plans to rely so significantly on deep water gas finds as a source of energy for electricity production and other industrial and transport purposes. As a rule, gas production from ultra-deep-water finds examined in the framework of this plan is implemented by the tieback method, in which the wells are on the deep seabed (usually outside the territorial waters), and are put down there by robots (see Figure 3.0-2 below), while the gas treatment facilities are at a distance from the wells and are connected to them by a high-pressure natural gas pipeline (in the test case described in the appendix, this involves three high-pressure 16” diameter pipelines, 110 km in length). In addition, there is a pipeline to return the antifreeze coolants to the wellhead (the antifreeze pipeline has a 10” diameter), and communication cables connecting the treatment facility to the wellhead (umbilical). Space is set aside for the pipeline corridors, marked in Figure 3.1.1-1, the area in which it is possible to locate routes for pipes of this kind.

Figure 3.0.2: Simulation of a collection of seabed drilling wells against the background of the Tamar platform



A condensate storage facility should be positioned alongside the natural gas treatment facilities, from which, as stated above, it is possible to transport the product to land by a pipeline, or store it in a tank, whether permanent and allowing offloading to other tankers (this is also true for cases where storage is in a buoy or on the seabed), or by FSO (see diagrams below), which can sail independently to an offloading point in port or connector.

Figure 2.0-3: Example of planning a storage facility in a tanker alongside a treatment facility (Thailand)



Photograph 3.0-4: Example of a device connecting a storage container with a tanker (West Africa)

Photograph 3.0-5: The Tamar process platform during construction work

Photograph 3.0-6: Deployment of processing facilities in the Gulf of Thailand

Photograph 3.0-7: Deployment of processing facilities in Norway

In the framework of TAMA 37/8, two sites are planned for offshore treatment facilities as marked in Figure 3.1.1-1. At these sites, it will be possible to develop the offshore facilities for treating the gas, and the auxiliary facilities. In addition, the plan includes an area for pipeline corridors, connecting the boundary of the territorial waters to the sites for the offshore treatment facilities. As a rule, there are two main methods of gas processing in offshore facilities:

a. In a special facility built for the discovery – a facility adapted to the find. For the most part this kind of facility is developed to serve large discoveries, like Leviathan and Tamar, where the large quantity of gas makes it possible to finance and develop it. An example of this kind of facility for the partial treatment of gas is the Tamar platform, to which the natural gas is brought for part of the treatment, at high pressure, in 16” pipes, from wellheads 150 km from the treatment facilities, while the rest of the treatment is carried out onshore at the Ashdod receiving station.

b. In a joint facility at which it is possible to treat gas from a number of smaller discoveries. A joint facility is usually intended to serve small discoveries – apparently the quantity of gas in small fields such as Karish and Dalit will not enable the financing of gas treatment facilities, and therefore a joint treatment facility will be required, sometimes even an abandoned facility of a well that has already been exploited. Planning a single facility that can receive gas from a number of fields at the same time presents engineers with technical challenges, since a “joint” facility of this kind has to deal with differences in a number of parameters:

   - **Disparities in pressure and deliverability** – between the different reservoirs. These differences are likely to create an advantage in deliverability (and therefore in quantity) for one field over another. In this case it will be necessary to run a simulation of the entire 'system' of gas fields as a single unit before it will be possible to give a detailed description of the technological alternatives.

- **Differences in timing of extraction** – extraction is possible from a number of reservoirs in a single facility one after the other (consecutively), by controlling the timing and by bringing the second reservoir to production as the gas produced from the first field is decreasing. However, this method will affect production from the first reservoir, and will result in the need to increase the pressure of the gas extracted from it. As will be mentioned below, gas compression is one of the more complex and costly of the processes that are likely to be part of the treatment chain, and therefore the need for compression is likely to have a considerable effect on its planning and characteristics. In light of the great complexity, any general description of a gas treatment facility for multiple but undefined reservoirs should be treated only as a general guideline.
- **Ability to respond to treatment of gas of different compositions from different discoveries** – each well has a different gas composition requiring a different treatment method, which affects planning accordingly, and hence also the facilities.

As noted above, an offshore gas treatment facility is connected by a pipeline corridor approximately 1 km in width (up to a distance of around 1 km from the shore), intended to serve two different suppliers. The corridor contains:

- 2 natural gas pipes with a 36" diameter, at a pressure that will not exceed 110 bar at the landfall crossing, and an output of up to 2 million m^3 per hour.
- 2 condensate pipes allowing the product to flow between the offshore and onshore facility.
- 2 water pipes allowing produced water to be removed from the onshore to the offshore facility, should it be decided to separate the water at the onshore treatment facility.
- 2 pipes allowing the flow of antifreeze coolant to the wellheads from the onshore treatment facilities.
- 2 communication cables.

An area is set aside for the pipeline corridors as marked in Figure 3.1.1-1 , through which they can be passed.

The pipeline corridors between the facilities and the shore are for pipes buried in the seabed (at depths of over 60 m), reaching a distance of around 1 km from the coastline at a depth of around 10 m. From this point and eastwards, the pipe continues through horizontal drilling, using the HDD method or a similar method for drilling beneath the surface in a manner that will not harm the shallow seabed between this point and the coastline, and does not damage the coastal kurkar cliff. TAMA 37/8 includes two horizontal drilling corridors, as marked on Figure 3.1.1-1 and Figures 3.2-1 and 3.2-4 below. From the exit point of the horizontal drilling on land, there is an onshore pipeline corridor to the onshore treatment facility, and from there to the transmission system.

In summary, the description above is a generic explanation of a gas treatment facility that provides an optimal answer to the range of technological and commercial possibilities for offshore treatment of natural gas, in a manner describing the maximum impacts of the facility on the environment and population. The description relates to all components of gas treatment, and is intended:

1. To explain, in very general terms, the characteristics of the main operations of the natural gas treatment facility;
2. To describe the maximum environmental impacts of offshore gas treatment;
3. To clarify the uncertainty that exists at this stage with regard to commercial and operational aspects, due to the fact that this plan is not intended for a specific discovery, and therefore there are many aspects requiring further detail and examination of impacts at the stage of the building permit.

It should be emphasized that this description is not intended to replace the detailed description in Appendices B and C, which describe the installations and infrastructures in the plan, but to summarize the information in general terms, thus making it easier to read the survey.

A description and details of the structures, installations and their characteristics are included later in Chapter 3.

3.1 Structures and installations at the site

3.1.1 Maps of sites

Figure 3.1.1-1 shows the sites against the background of a bathymetric map, marine cover, land uses and zoning.

Figure 3.1.1-2 shows the components of the generic offshore facility.

Figure 3.1.1-3 shows typical sections of the components of the generic offshore facility (detailed data can be seen in the engineering document, in Appendix B).

Figure 3.1.1-1: The sites, against a background of a bathymetric map, marine cover, land uses and zoning

[no diagram]

Figure 3.1.1-2: Components of the generic offshore facility

[no diagram]

Figure 3.1.1-3:Typical sections of the components of the generic offshore facility

[no diagram]

3.1.2 Set-up work

General

As noted, a description of the set-up work at this stage is in principle only. Planning will include details of the work of setting up the pipeline and platform in the marine environment (the landfall pipeline crossing array and its establishment have been reviewed in the framework of the onshore Environmental Impact Surveys for the Meretz wastewater treatment plant and Hagit sites submitted as part of this plan).

As a rule, the objective is for the set-up stage for the pipeline and the facility to be as efficient as possible, both in terms of the time taken, and in terms of disturbance to residents and the environment. Accordingly, at the building permit stage there will be an individual examination to identify the areas in which the contractor's staging areas and camps can be established, an effort will be made to avoid disturbing areas of environmental and ecological sensitivity and/or impact on populations, a series of measures will be taken to moderate and reduce the impacts resulting from the set-up work, and a work plan will be drawn up for streamlining the work process itself. Principles for this matter are included in the document of principles for drawing up the EMMP, attached in Appendix I.

- **The marine pipeline**

For a description of the work of laying the marine pipeline, see details in Section 2.2 – Construction and installation of pipelines, in Appendix C – *Report on Operational and Engineering Aspects in the Marine Environment* by Bipol Energy Ltd.

- **The process platform**

For a description of the set-up of the process platform, see details in Section 2.1 in Appendix C – *Report on Operational and Engineering Aspects in the Marine Environment*.

Building the process platform, which includes the contractor's camps and staging areas, is expected to be implemented outside Israel. The platform will be transported to the selected location site.

3.1.3 Changes to the existing situation

Setting up an offshore gas treatment facility will lead to changes relative to the existing situation. These changes will take place within the area of the site chosen for the gas process platform, along the pipeline route, in the staging areas, and in all the areas required for setting up the facility, during the set-up stages and at the permanent stage. It should be noted that in areas that are identified for set-up and staging purposes (and not for the permanent facilities), the main changes will be at the set-up stage only, and an effort will be made to restore the area to its original function as far as possible, other than cases where there are restrictions requiring safety distances to be maintained from the facilities and/or the infrastructures, in which case these uses / activities will have to be moved away throughout the facility's period of operation.

As noted, at this stage there is no exact location for the marine components. This subject will be examined in the framework of the building permit, after selection of the pipeline route and site of the process platform.

3.1.4 Characterization of facilities

This section includes a summary review of the main components of the offshore treatment facility, and their characteristics. A full characterization of the facility is detailed in the engineering document – Appendix B. The characterization appearing below is of an offshore gas treatment facility, where the pressure of the gas in the pipes leading the facility in the direction of the shore is no greater than 110 bar. The assumption is that at least one offshore pressure reduction facility will be constructed.

The offshore site includes room for four different treatment facilities, each offshore treatment facility comprising four different platforms.

Figure 3.1.4-1 illustrates the distribution of the offshore facilities.

Figure 3.1.4-2 shows a simulation of the offshore facility.

Figure 3.1.4-1: Illustration of the distribution of offshore facilities

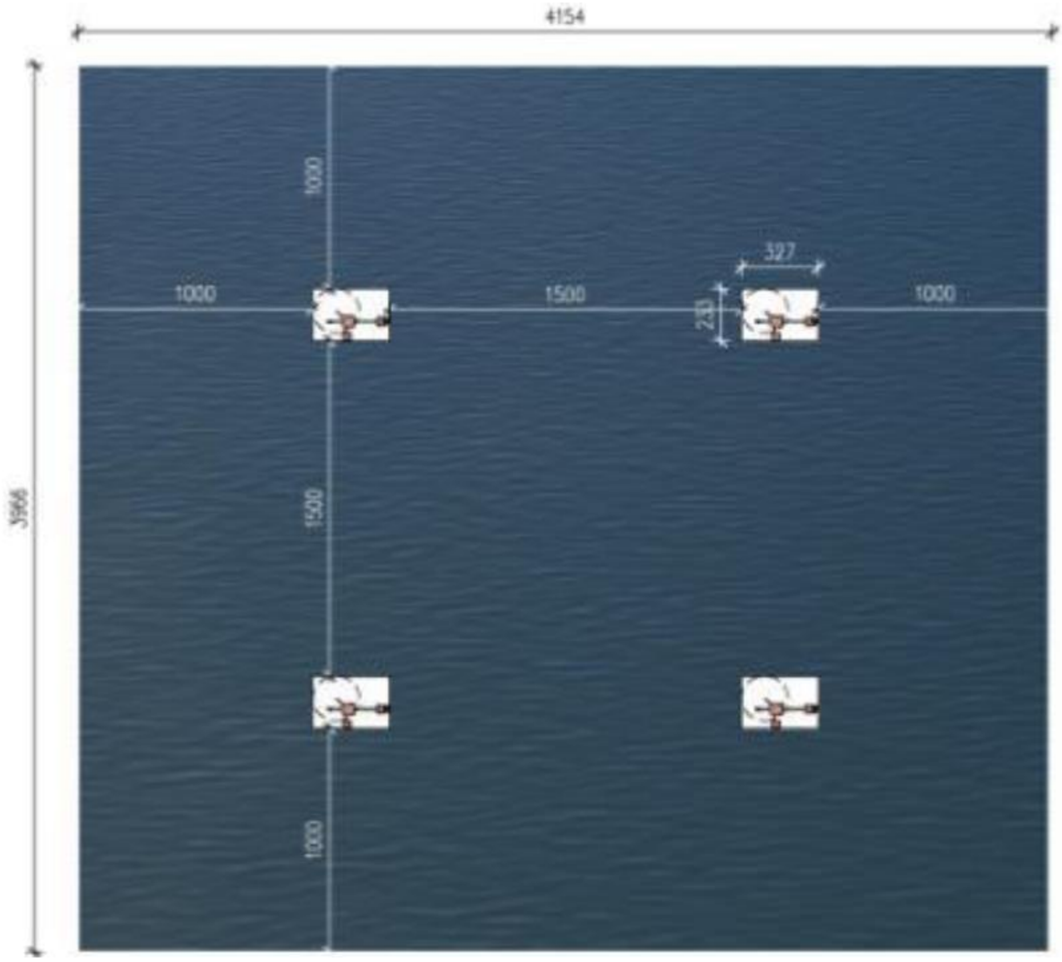
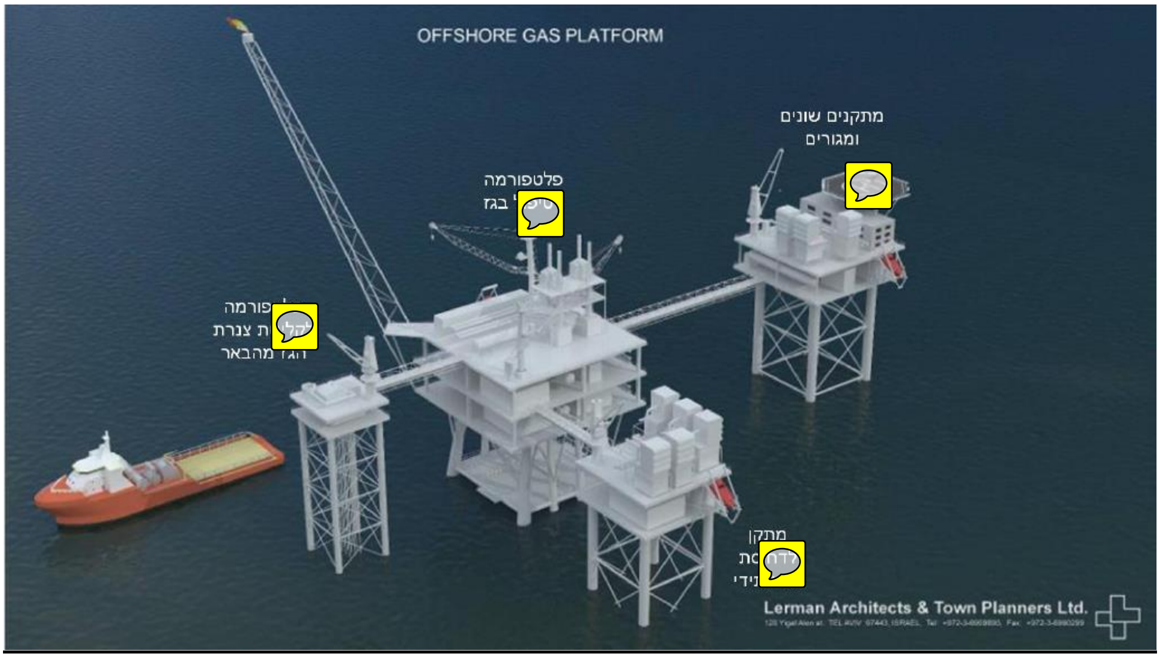


Figure 3.1.4-2: Simulation of the offshore facility



Gas from the drilling, including the untreated gas, will pass, at the least, through an offshore pressure reduction facility to the onshore treatment facility by means of an onshore pipeline corridor as will be described in Section 3.2 below. Below are details of the main operations taking place in each of the components of the gas treatment facility.

Maximum operations taking place on the main offshore treatment facility are described in detail in Section 3.0 above, and are presented below in brief:

- Initial separation of gas and liquids
- Drying the gas
- Stabilizing and storing condensate
- Treating and separating the remaining liquids
- Storing antifreeze coolants
- Recycling system for methane emissions, systems for treating and removing hazardous materials
- High-pressure and low-pressure venting system with flare
- Transfer of the gas for final treatment on land, before the treated gas is passed on to the holder of the transmission license
- Metering the gas for sale and analyzing it at the transmission license holder's designated station.

All these operations will be carried out on the gas process platform. In addition, the offshore facility will include three other platforms:

1. A platform for receiving the gas pipeline from the well, including gate valves for shutting off the flow of gas in case of need.
2. A gas pressure regulation platform – including a facility for gas compression (in the future).
3. A residential platform and auxiliary facilities – including residential structures, workshops, offices, electricity and control rooms, and so on.

Most of the gas treatment processes described above exist on every gas treatment facility, and some of them are specific to different types of reservoir, but possible in future scenarios of discoveries off the Israeli coast.

A pipeline infrastructure will pass between the offshore facilities and offshore facilities, including pipes for raw gas, condensate, MEG, produced water, and an umbilical for each of the suppliers.

Figure 3.1.4-3 shows the natural gas treatment chain – the offshore treatment process.

Figures 3.1.4-4 – 6 (included in the engineering document – Appendix B) show the generic planning of the main treatment facility, with all its components. Generic planning of the adjacent platforms is also described in the engineering document – Appendix B. Table 3.1.4-1, attached, includes details of all the components of the main facility, according to the numbering appearing in the figure.

Figure 3.1.4-3: The natural gas treatment chain – offshore treatment process

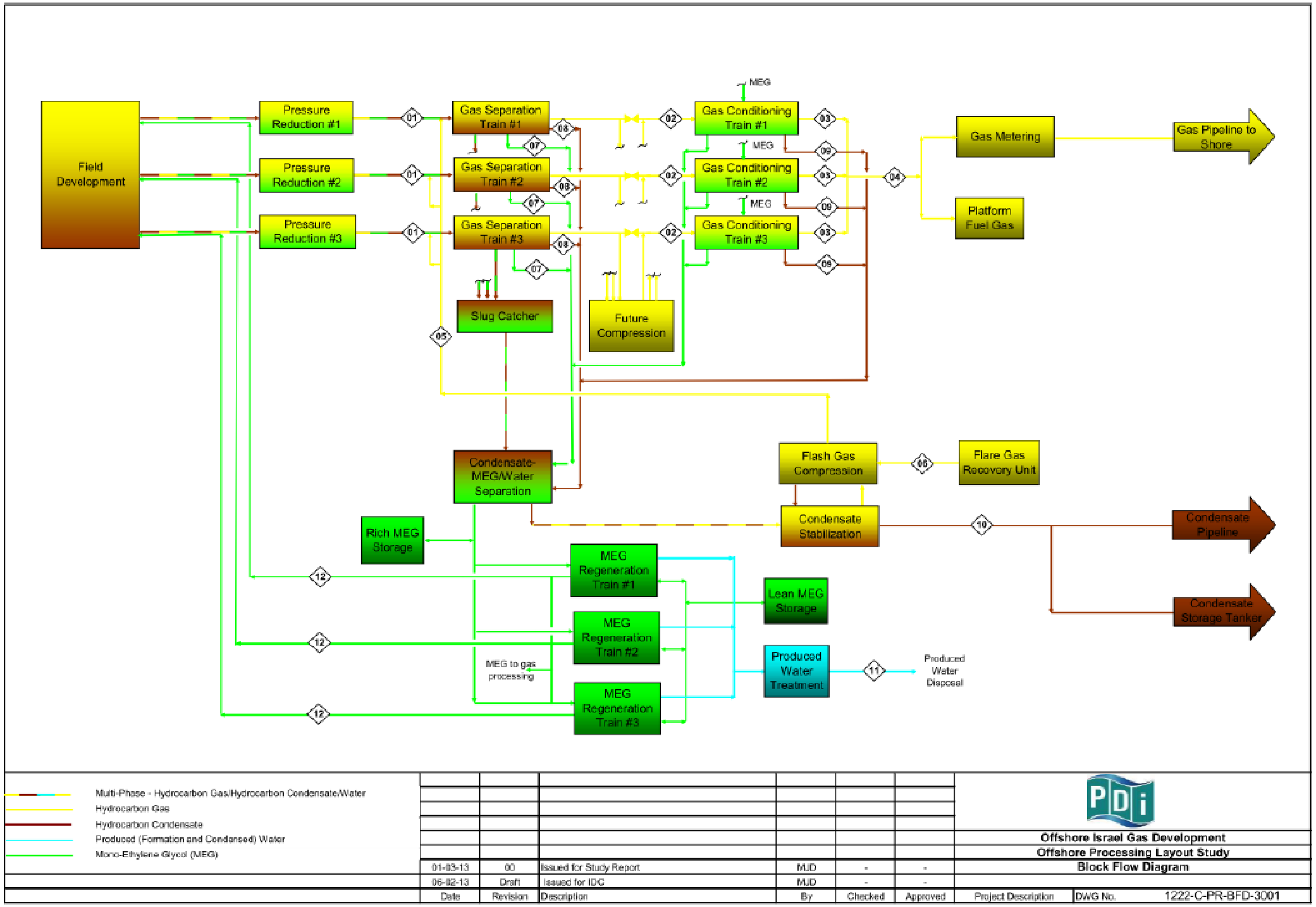
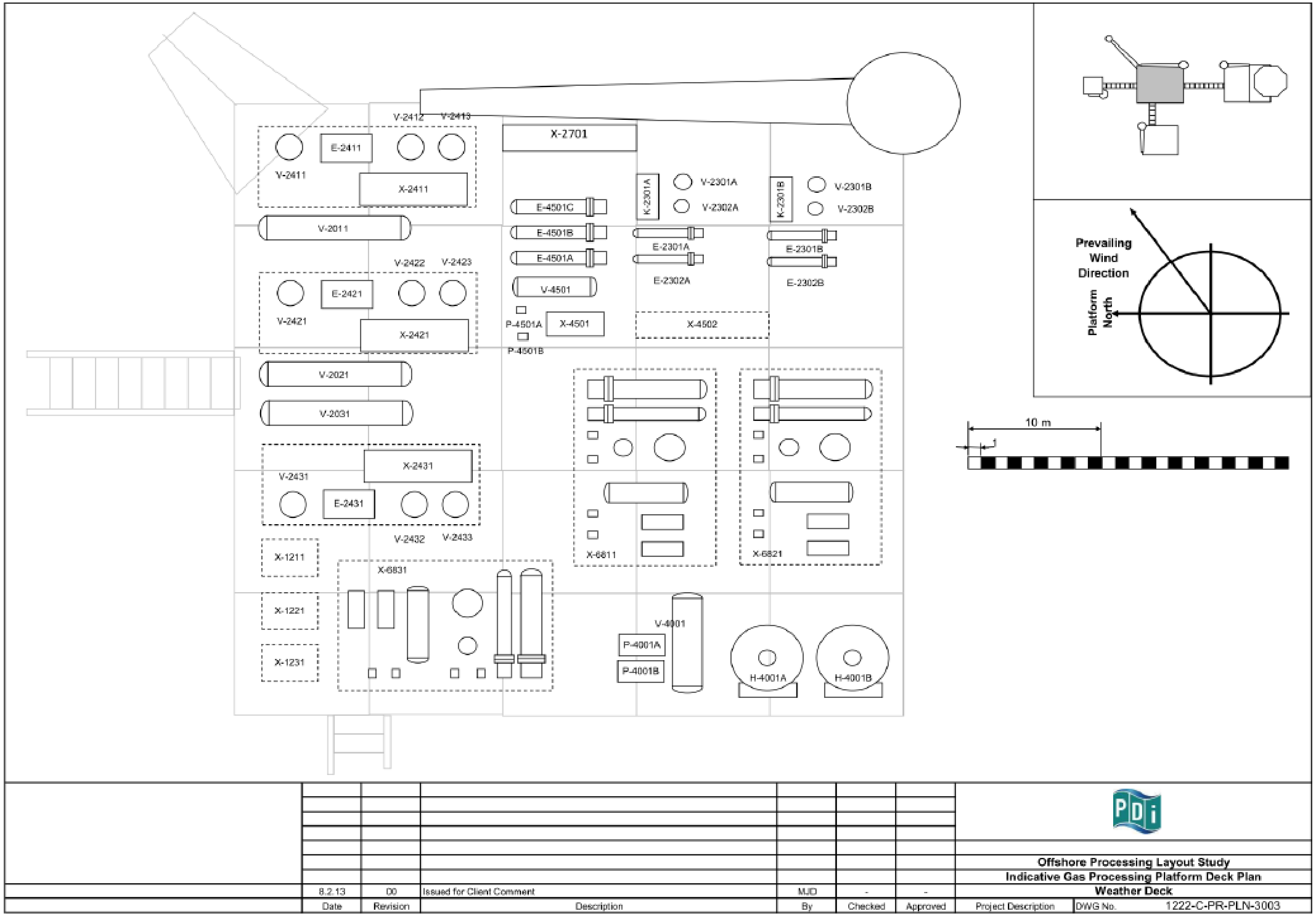

Field Development
Pressure Reduction #1
Pressure Reduction #2
Pressure Reduction #3
Gas Separation Train #1
Gas Separation Train #2
Gas Separation Train #3
Gas Conditioning Train #1
Gas Conditioning Train #2
Gas Conditioning Train #3
MEG
Gas Metering
Gas Pipeline to Shore
Platform Fuel Gas
Slug Catcher
Future Compression
Condensate-MEG/Water Separation
Flash Gas Compression
Flare Gas Recovery Unit
Condensate Stabilization
Condensate Pipeline
Condensate Storage Tanker
Rich MEG Storage
MEG Regeneration Train #1
MEG Regeneration Train #2
MEG Regeneration Train #3
Lean MEG Storage
Produced Water Treatment
Produced Water Disposal
MEG to gas processing
Multi-Phase - Hydrocarbon Gas/Hydrocarbon Condensate/Water
Hydrocarbon Gas
Hydrocarbon Condensate
Produced (Formation and Condensed) Water
Mono-Ethylene Glycol (MEG)
01-03-13 00 Issued for Study Report MJD - -
06-02-13 Draft Issued for IDC MJD - -
Date Revision Description By Checked Approved
Offshore Israel Gas Development
Offshore Processing Layout Study
Block Flow Diagram
Project Description DWG No. 1222-C-PR-BFD-3001

Figure 3.1.4-4: Generic planning of the main offshore natural gas treatment facility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V-2302A
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V-2301B
V-2302B
E-4501C
E-4501B
E-4501A
V-4501
P-4501A
X-4501
P-4501B
E-2301A
E-2302A
E-2301B
E-2302B
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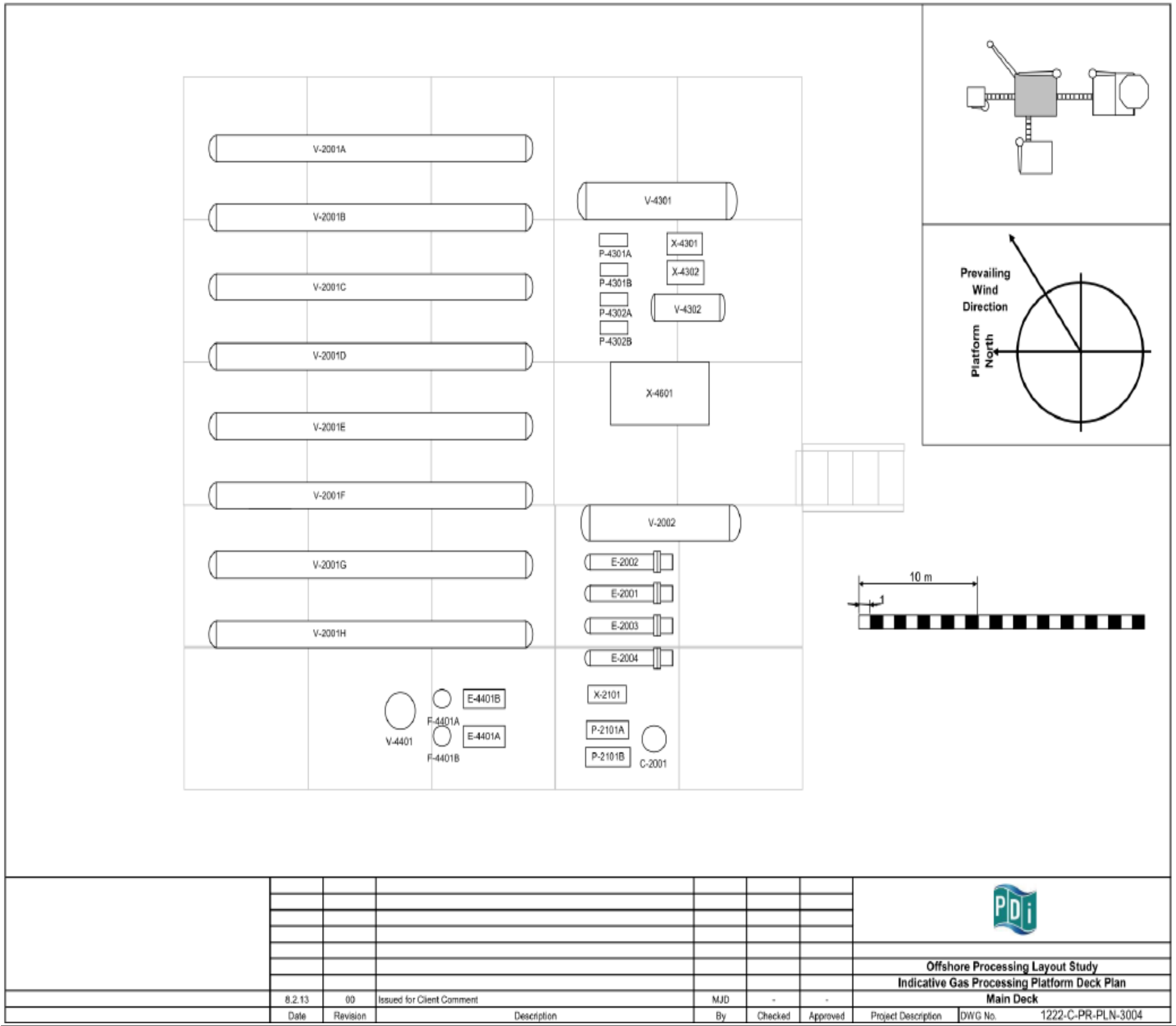
Project Description
DWG No.
1222-C-PR-PLN-3003

Figure 3.1.4-5: Generic planning of the main offshore natural gas treatment facility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E-2004
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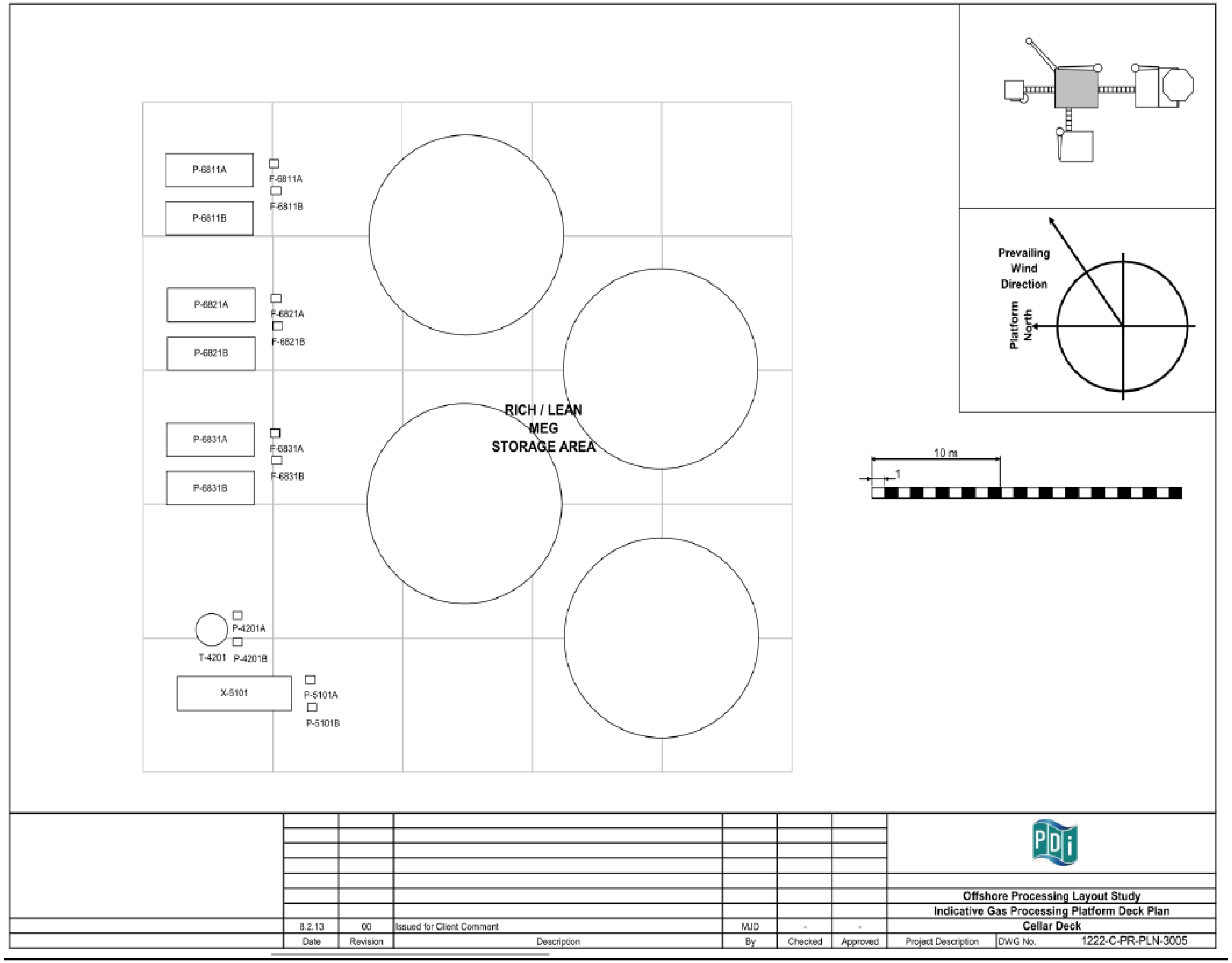
1222-C-PR-PLN-3004

Figure 3.1.4-6: Generic planning of the main offshore natural gas treatment facility



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P-6821B
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F-6821B
P-6831A
P-6831B
F-6831A
F-6831B
RICH / LEAN
MEG
STORAGE AREA
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P-4201A
P-4201B
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Indicative Gas Processing Platform Deck Plan
Cellar Deck
Project Description
DWG No.
1222-C-PR-PLN-3005

Table 3.1.4-1 below contains a description of the main installations and components of the main treatment facility, with a comparison between offshore and onshore. It also includes additional installations and important components in the treatment facility area.

Table 3.1.4-1: Description of the main installations in the treatment facility

Facility	Component	Offshore installations	Onshore installations
		Description	Description
Platform receiving the gas pipeline from the well	Riser platform	The riser platform receives the gas from the wells at high pressure, in 16” pipes, and transfers it to the main process platform. This platform also includes valves for shutting off the flow of gas from the well in the event of a malfunction.	See Valve/shutter for shutting off the gas flow
	Valve/shutter for shutting off the gas flow	See riser platform	The onshore installation has a valve for stopping the flow of gas if necessary. In addition to the valve at the entrance to the onshore facility, there is also a valve at the landfall crossing and at the interim valve station along the route of the onshore pipeline.
Compression platform / pressure reduction	Pressure regulators for reducing the gas pressure to 110 bar if the rest of	Facilities to which the gas arrives at high pressure from the finds, in which the pressure is reduced, and it is then heated to the appropriate temperature for flow of the gas, which includes solids, and delivered to	Not relevant

Facility	Component	Offshore installations	Onshore installations
		Description	Description
platform	the processing is carried out on land	land in a pipeline. In the pressure reduction process, antifreeze coolants are injected into the gas to deal with the cooling that results from the process. All processes on the platform for regulating pressure from the wells so that it can flow at a pressure of no more than 110 bar in the landfall crossing are part of the processes that take place in the offshore gas treatment facility and are detailed in Appendix B. These regulators will be positioned on a separate platform only in the event that the rest of the treatment is carried out on land. In any other scenario, it is possible that pressure reduction will be carried out in another way on the process platform and/or on the riser.	
	Increasing gas pressure	This component will be established at a later stage of the project and is intended for a future stage in which the gas pressure in the drilling well is reduced, and it becomes necessary to add pressure to the system in order to pump gas from the well to the offshore / onshore treatment facility (in	This component will be established at a later stage of the project and is intended for a future stage in which the gas pressure in the drilling well is reduced, and it becomes necessary to add pressure to the system in order to pump gas from the well to the onshore treatment facility (in order to meet

Facility	Component	Offshore installations	Onshore installations
		Description	Description
		order to meet the specification of pressure required in the INGL transmission system). At this stage, before the gas enters the cleaning and drying process in the gas conditioning system, it will undergo compression.	the specification of pressure required in the INGL transmission system). At this stage, before the gas enters the cleaning and drying process in the gas conditioning system, it will undergo compression. For each gas flow there are two compressors, and a total of 4 compressors is planned. At first the compressors will be driven by gas turbines and motors. In later stages it is possible that multi-stage compressors will be required. The compressors will apparently be covered, in order to reduce the noise and provide protection for the equipment. The gas obtained in the separation process passes through another facility in which all the remaining liquids in the gas are trapped. In the compression process, the gas is warmed, and therefore before it enters the gas conditioning system it is cooled by fans. The equipment included at this site will apparently not be installed in the first years, other than the gas conditioning system and the fuel it includes.

<table>
<tr><th rowspan="2">Facility</th><th rowspan="2">Component</th><th>Offshore installations</th><th>Onshore installations</th></tr>
<tr><th>Description</th><th>Description</th></tr>
<tr><td></td><td></td><td></td><td>Note: In the onshore surveys the installations for increasing pressure are described in the main treatment facility (Feed Gas Compression Area).</td></tr>
<tr><td rowspan="3">Central treatment facility</td><td>Slug catcher</td><td colspan="2">The slug catcher is an installation with a large capacity for initial reception of liquids that can appear in the offshore pipeline, as a result of non-continuous flow of gas due to obstructions and malfunctions. The purpose of the installation is to trap liquids obtained (if any) in the pipeline, in order to prevent a situation in which a large quantity of liquids comes into the gas treatment system all at once. In this installation, gas is separated from liquids and transferred directly to the gas processing facility.</td></tr>
<tr><td>Gas processing area</td><td colspan="2">An installation for the continuous and complete separation of liquid from gas. The gas that comes from the slug catcher is transferred to 2 separation installations. In this process, all liquids that may still remain in the gas after separation in the slug catcher are removed. Separation is carried out by physical heating and cooling systems. In the future, when an additional compression process is required, the gas will first undergo this separation process, before the compression process.</td></tr>
<tr><td>Condensate handling and flash gas compression</td><td colspan="2">Liquids (condensate, MEG, and water) coming from the slug catchers pass through heating systems and are then mixed before being transferred to a liquid separation tank. The condensate obtained in the separation process undergoes stabilization (so that in the event that gas remains, it is emitted). The fuel is cooled after stabilization (and can safely be transported by pipeline or ship), and then transferred to designated storage reservoirs. The gas emitted as a result of the stabilization process is compressed again into the system. This</td></tr>
</table>

Facility	Component	Offshore installations	Onshore installations
		Description	Description
		installation also contains the recycling facility for onshore MEG, helping to prevent the formation of liquids in the cleaning and drying process in the gas conditioning system.	
	Flare gas handling and produced water	Flare recovery system - this unit helps reduce gas emissions by enabling a process of compression of the gases (which would otherwise pass to the flare system, to the head of the high and low pressure chimneys, and burn), and their return to the gas processing system. The liquids obtained in the flare system are also pumped back into the liquid processing system. When it is necessary to get rid of gas, when it reaches amounts in excess of the emission reduction unit, the gas is directed to the flare system, to high and low pressure chimneys. Produced water processing system - the produced water obtained from the onshore and offshore MEG recycling facilities is transferred to a designated treatment facility for produced water. In this facility, there is an additional process of separating all the remains of the fuel left in the water. After this, the water (according to the defined level) is transferred to the offshore facility from which it is discharged into the sea.	
	MEG regeneration and reclamation	A specific system for regeneration of the "offshore" MEG (which is mixed with produced water). The MEG reaches the offshore facility after undergoing liquid separation processing. In this facility, the MEG is separated from the water by boiling the water. The water undergoes a process of condensation before being transferred to any	In addition, MEG reclamation will be possible in the future in the onshore facility, if the produced water reaching the facility is more saline, requiring additional treatment of the MEG for reclamation, including separation of the salt. An area of the installation is set aside for this activity, should it be necessary in the

Facility	Component	Offshore installations	Onshore installations
		Description	Description
		designated treatment facility. The reclamation system includes heating systems, similar to other facilities at the site	future.
	MEG storage	Storage of the MEG (onshore and offshore) in four designated tanks before transferred to the offshore installation. As far as possible, the tanks will be buried in the seabed.	
	Feed gas compression area	This component exists on a separate offshore platform, see above under increasing gas pressure.	See details above for increasing gas pressure
	Utilities, firewater, workshops	A quarters and utilities platform including a workshop building, offices, an area for a power station for operation of the facility and emergency generators, safety systems, fire detection systems, nitrogen tanks, rescue boats, control	This facility is the most part intended for supplementary equipment and for the firefighting array, as well as workshops, equipment storage, and general storage. The supplementary equipment includes: nitrogen tanks, compressed air system, methanol tanks, pumps, and corrosion retardant stores. The firefighting array includes water tanks for four hours of fire extinguishing, pumps, foam, and more.
	Power generation and building	room, electricity room, gym and accommodations for the crew operating the offshore facility. On this platform there is a	This area includes the power station building together with offices and the control room. It also contains emergency power station units,

Facility	Component	Offshore installations	Onshore installations
		Description	Description
		helipad to serve the facility.	and a system for the storage and transfer of diesel for the fire extinguishing pumps and for the emergency generator. The electricity supply may involve connecting the facility to the local electricity grid, but there is also the possibility of setting up a power station in the facility in case of emergency, by means of 2 10 MW turbines. For this purpose it is also necessary to have a diesel engine with a 1 MW capacity. The diesel is stored in designated tanks.
Condensate storage		Offshore, the condensate will be stored in an FSO (floating storage and offloading) ship. FSO ships have different capacities. In the framework of the plan, it was examined whether the tankers on an FSO would crack if loaded with some 100,000 barrels.	The condensate storage tanks include three tanks with a total capacity of 20,000 m, a quantity enabling fuel storage for seven days of continuous production process. The tanks are intended to provide a temporary storage solution in the event that it is not possible to transfer the fuel through the designated pipeline (another solution for a problem in the fuel pipeline is removal by means of trucks). The tanks are located at a relative distance from the other components of the

Facility	Component	Offshore installations	Onshore installations
		Description	Description
			facility. Fuel storage in three separate tanks allows a better quality of control in order to identify the type of fuel and its continued handling. Since the fuel is a hazardous material, a spill containment pallet is positioned alongside the tanks, intended to handle cases where there are leaks or problems with the storage tanks.
Emergency flare		Safety system for removal of excess gas volumes by means of gas release ventilation pipe with a flare. The flare system is located on the central process platform, and the height of the chimney will be 90 m. Around the flare there will be an area with no sources of ignition (a sterile area), with a minimum radius of 100 m for a heat radiation force of 4.73 kW/m2.	Safety system for removal of excess gas volumes by means of gas release ventilation pipe with / without a flare, in the event of problems. During a serious malfunction in the gas treatment facility, in a situation in which the best solution is to release the gas, it will be necessary to vent while burning all the gas in the gas pipeline (in the range between the nearest valve station to the facility and the treatment facility itself) and in the treatment facility. The flare system includes two types of chimney, one for high pressure (over 10 barg) and the other for low pressure (less than 10 barg). These can be alongside each other, or in the same apparatus itself with

Facility	Component	Offshore installations	Onshore installations
		Description	Description
			two separate chimneys. There is flexibility in deciding chimney height, and accordingly the radiation radius that must be maintained. The flare will rise to a height of at least 25 m, and up to 100 m, according to the limitations existing at the facility site and surrounding area. Around the flare an area must be kept free of sources of ignition (sterile area) with a minimum radius of 111 m, for a heat radiation force of 4.73 kW/m2 [2] which is attributed to the area of operation of the facility crew, including in emergency scenarios when they are equipped with appropriate equipment. A fence will be set up around this area, which will be included in the site area. Another safety area to be calculated according to a heat radiation force of 1.6 kW/m2 dictates a radius of 200 m around the flare. In this area, in the event of a gas release, a PA system will warn passers-by

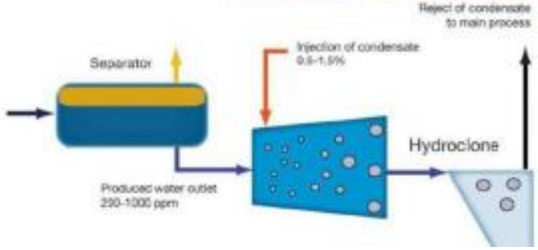
[2] According to API standard. 521

Facility	Component	Offshore installations	Onshore installations
		Description	Description
			not to enter the area, which is signed but not fenced off. In this area, agricultural work and the passage of passers-by will be permitted.
Loading area		This component does not exist offshore	In order to load and unload the byproducts of the treatment process (which do not pass through designated pipelines), among other things the surplus condensate, there has to be a designated area for loading and unloading trucks. This site covers an area of around 4 dunams.
INGL station		This component does not exist offshore	**INGL station – gas transmission and reception system** including assembly no. 8 – monitoring at the entry point to the transmission system – connection point and fiscal or custody transfer to NGTS, whose role is to control and measure the quality of the gas and its characteristics before it enters the national transmission system at a pressure of 80 bar. This system is set up by INGL in accordance with its accepted planning procedures. The area of the INGL receiving station will be planned as close as possible to

Facility	Component	Offshore installations	Onshore installations
		Description	Description
			the receiving and supplementary treatment facility, and will allow separate entry for two different suppliers to the transmission system. **In accordance with INGL requirements and the specification given by it with regard to the installations required at the monitoring and control station, an area of some 15 dunams must be set aside**. The installation includes the following components: – Pipeline from the gas receiving and processing facility – Valve station – Command and control room – Pipeline from the INGL receiving station to the national transmission system – Vent for venting the gas – Boiler room and PRMS + possibility of

Facility	Component	Offshore installations	Onshore installations
		Description	Description
			connecting to a future pipeline to consumers – Area for compressors Area for operation and maintenance

Component	Offshore facility	Onshore facility
Slug catcher		
	http://www.hsm.nl/index.php?category0=hsm_offshore&category1=en&category2=projects&category3=oil_gas&category4=compression_modules&category5=k8_fa_1	December 12, 2011 Noble Energy facility in Ashdod

Component	Offshore facility	Onshore facility
Produced water system		 
	http://www.epmag.com/Production-Drilling/New-Water-Treatment-Technoogy-Minimizes-Offshore-Footprint-Costs_82184	* http://canadiansatwork.ca/2011/ctour-produced-water-treatment-system – April 8, 2013 ** http://www.alderlygroup.com/product_category.asp - April 8, 2013

Component	Offshore facility	Onshore facility
MEG regeneration and reclamation		 
	http://www.akersolutions.com/en/Global-menu/Products-and-Services/technology-segment/Wellstream-processing/Process-systems-technologies/Hydrate-inhibition/	http://www.prosernat.com – April 4, 2013 http://www.akersolutions.com/Documents - April 20, 2013
MEG/TEG Storage		

Component	Offshore facility	Onshore facility
	http://www.harpspringdesigns.co.uk/projects/	http://reports.shell.com/investors-handbook/2011/downstream/chemicals.html – April 8, 2013
Feed gas compression area		 
	http://wwww.khi.co.jp/english/pressrelease/detail/2010 1206_1.html	http://www.greenstreamby.com/en/pages/photo-gallery/photo - April 8, 2013

Component	Offshore facility	Onshore facility
Flare recovery system + Flare		 

Component	Offshore facility	Onshore facility
		
		

Component	Offshore facility	Onshore facility
	http://www.google.co.il/imgres?q=offshore+Flare+recovery+system&start=133&um=1&rlz=1T4ADFA_nIL464IL464&hl=iw&tbm=isch&tbnid=xmWJlhwb-BGqM:&imgrefurl=http://www.dynapumps.com.au/news/vent-flare-gas recovery.aspx&docid=nuBBEHROernQBM&imgurl=http://www.dynapumps.com.au/sites/dynapumpscc mau/assets/public/Image/northey%252520article.jpg&w=670&h=249&ei=FcS1UbT8KsSN4AS0moGAA w&zoom=1&iact=hc&vpx=704&vpy=190&dur=203&hovh=137&hovw=369&tx=213&ty=77&page=7&tb nh=95&tbnw=222&ndsp=25&ved=1t:429,r:52,s:100,i:160&biw=1115&bih=535	http://www.zeeco.com/ - April 20, 2013 http://www.mh21japan.gr.jp/english/mh21-1/2-2/
Condensate storage		
	http://www.intellasoa.net/rang-dong-mv17-to-arrive-in-vietnam-in-august-82056	http://www.123rf.com/photo_10694016_treatment-and-storage-tanks-for -separating-water-from-condensate-at-a-gas-and-oil-well-location.html

3.1.5 Characterization of products

All domestic and industrial processes and activities create emissions and waste. This is also true with regard to natural gas processing and treatment. The following products are obtained from this process: natural gas, fuels – condensate obtained from condensation of the gas flow, combustion products obtained in the processes of generating heat and electricity, chemical additives helping the production process (at the wellhead or in the treatment facilities), chemicals supporting the process of treating emissions and waste, additional chemicals for maintenance of the equipment and machinery in the facilities, and produced water.

This section will include a summary review of the main products in the treatment facility, and their characteristics. A full characterization of the products is detailed in the engineering document, Appendix B. In addition, a description of the substances obtained in the emissions and waste will be included in the sections on air and waste quality below. A general explanation with regard to the products of the process is included in the description of the gas treatment chain, in Section 3.0 above.

Main products in the gas treatment process:

- **Natural gas:** the maximum rate of supply of the gas will be 48 MSm^3/d (millions of standard cubic meters per day) in the two pipelines. The characteristics of the gas, based on characteristics of existing offshore wells within Israeli borders, are of a sweet gas with a very high concentration of methane. Two important principles assumed in estimating the composition of the gas and characterization of the products are:
    - A concentration of 8 ppm (mole) H_2S was assumed in the untreated gas flow, which is the maximum permitted concentration in the INGL transmission network. All various sulfur compounds above this concentration will be treated before entering the gas treatment facilities.
    - A very low concentration of CO2 is found in the composition of the gas, at a concentration that is also permitted for use in the ING are national transmission network (of up to 3% mole), and therefore additional designated facilities for treating it will not be required.

Table 3.1.5-1 below gives details of the natural gas composition characteristic of discoveries obtained off Israel's coastline:

Table 3.1.5-1: Composition of gas typical of finds off Israel's shores

Component	Mole %
Carbon Dioxide	0.1192
Nitrogen	0.2146
Methane	98.9021
Ethane	0.3365
Propane	0.1631
i-Butane	0.0412
n-Butane	0.0421
i-Pentane	0.0245
n-Pentane	0.0096
C6+ 47/35/17	0.1471
Total	100.0000

- **Fuel - condensate**: as noted above, the fuels are obtained from condensation of the gas flow. At this stage, there is no information with regard to the composition of the condensate, and therefore a typical composition of C2, C5 and C6 was assumed for estimating the condensate. According to the rate of treatment of the gas, the rate of fuel supply is expected to be 7630 barrels per day.
- **Produced water**: produced water includes all water obtained at the surface originating in the drilling well together with the natural gas. For the most part, underneath the gas strata in the reservoir is a stratum of water blocking it. At the point of equilibrium of the gas strata and the water phase, the water mixes with the gas. Produced water obtained from the gas fields is comprised mainly from two sources: condensed water (water originating in the stratum of gas that is saturated with water, which is condensed in facilities on the surface), and formation water – water that is found beneath the gas stratum, coming into the well when pressure in the bore is reduced. The composition of the water according to the water sources detailed above varies over the life project. Additional details with regard to produced water can be found in Section 3.4.3 below.

As noted above, details of the above products and other materials are included in the engineering documents, in Appendix 3. As stated, the treatment solution for produced water includes: treating the water in the treatment facility (offshore or offshore) and discharging into the sea in a designated pipeline. Situating the flow of the produced water is decided at the pressure reduction installation or offshore gas treatment facility, and a model was performed for this situation, which will be presented and explained at length in Section 4.8 below.

3.1.6 Fuels

The fuel (condensate) reaches the offshore treatment facility as a byproduct of the offshore treatment of gas, or through the onshore pipeline corridor in a designated infrastructure, according to the chosen treatment solution. There are two main treatment options:

1. Treating fuels at the offshore site by means of a designated treatment facility – FSO, which is a tanker situated alongside the treatment facility and storing the condensate. The tanker will be able to sail to port to offload, or float to a ship anchoring alongside it. In addition, in the event that the GBS method is chosen for construction of the platform, it is possible to store it in this installation, and offload it through a ship anchoring alongside the platform.
2. Onshore treatment of fuels in refineries – the preferred solution in environmental terms. This solution requires arranging a designated pipeline for fuel, taking it from the treatment facility to the refineries in Haifa. In this framework, as first preference the condensate will be directed to the Hagit / Meretz wastewater treatment plant site, where it can be stored temporarily as a substitute for storage at sea. From there, it will continue in a designated pipeline alongside the route of the existing PEI pipeline – Hagit – Alroi - Haifa refineries, along the INGL statutory strip or the gas pipeline strip of the Hagit – ORL line (according to TAMA 37/2)– in coordination with the relevant infrastructure owners, where it will undergo treatment.

In emergencies, the fuel will be removed directly from the facility by trucks to a chosen treatment facility, in accordance with the two options described above. This solution requires a loading and unloading area that will be included in the onshore treatment facility site.

For additional details on the subject of the fuel, see Section 3.1.5 above, and Sections 3.2.8, 3.7, 4.3, 6.4.4 in the engineering document in Appendix B.

3.2 Structures and facilities in the pipeline corridor and accompanying infrastructures

This section will review all the aspects relating to the offshore pipeline corridor, from the drilling wellhead, through the offshore facility, up to the landfall pipeline crossing setup. Landfall crossings by HDD drilling were presented at length in the Environmental Impact Surveys for the onshore sites at Hagit and Meretz wastewater treatment plant presented in the framework of this plan.

Below is a description of the main components along the pipeline corridor and accompanying infrastructures:

Western offshore pipeline corridor – the pipeline corridor from the drilling wellhead to the offshore treatment facility is a strip of variable width according to the number of wells, through which several pipelines will pass, as follows:

- A number of 16” diameter pipelines, through which raw gas will pass at high pressure.
- Pipeline for returning antifreeze coolants to the wellhead, up to 10” diameter.
- Communication cables (umbilical) connecting the treatment facility to the wellhead with a diameter of up to 4”.

Figure 3.2.1-1 below shows a typical cross-section of the Western offshore pipeline corridor.

Eastern offshore pipeline corridor – from the offshore treatment facility to the landfall pipeline crossing, forming a strip some 500 m wide, through which a number of pipelines will pass, as follows:

- Raw gas line coming from the sea (from the pressure reduction facility) for final treatment at the receiving facility, up to 36” diameter.
- Pipeline for removing surplus water, up to 10” diameter.
- Pipeline for removing surplus condensate, up to 8” diameter.
- MEG recycling pipeline with a diameter of up to 6”.
- Maintenance and control line, between the offshore and onshore facilities – umbilical control cable, with a diameter of up to 4”.

Figure 3.2.1-2 below shows a typical cross-section of the eastern offshore pipeline corridor.

Landfall pipeline crossing – HDD drilling: at the point of landfall from the sea to the shore, there will be horizontal underground drilling of lengths that may be as much as 1.5 km, enabling the gas pipeline to make landfall at a distance of between 300 and 400 m from the coastline, and up to 800 to 900 m into the sea.

The HDD technique offers a method by which it is possible to install a pipe at landfall (between land and sea) quickly, and with greater depth coverage, thus reducing disturbance to the environment, existing pipelines, and future pipelines that will need the same part of the shore.

See further details in Appendix C.

At the Michmoret landfall crossing the exit point of the HDD drilling at sea has been extended to a depth of 11 m, and not 8-10 m, because there are kurkar ridges at a distance of 10 – 780 m from the coastline, approximately up to a depth of 10 m beneath the sea.

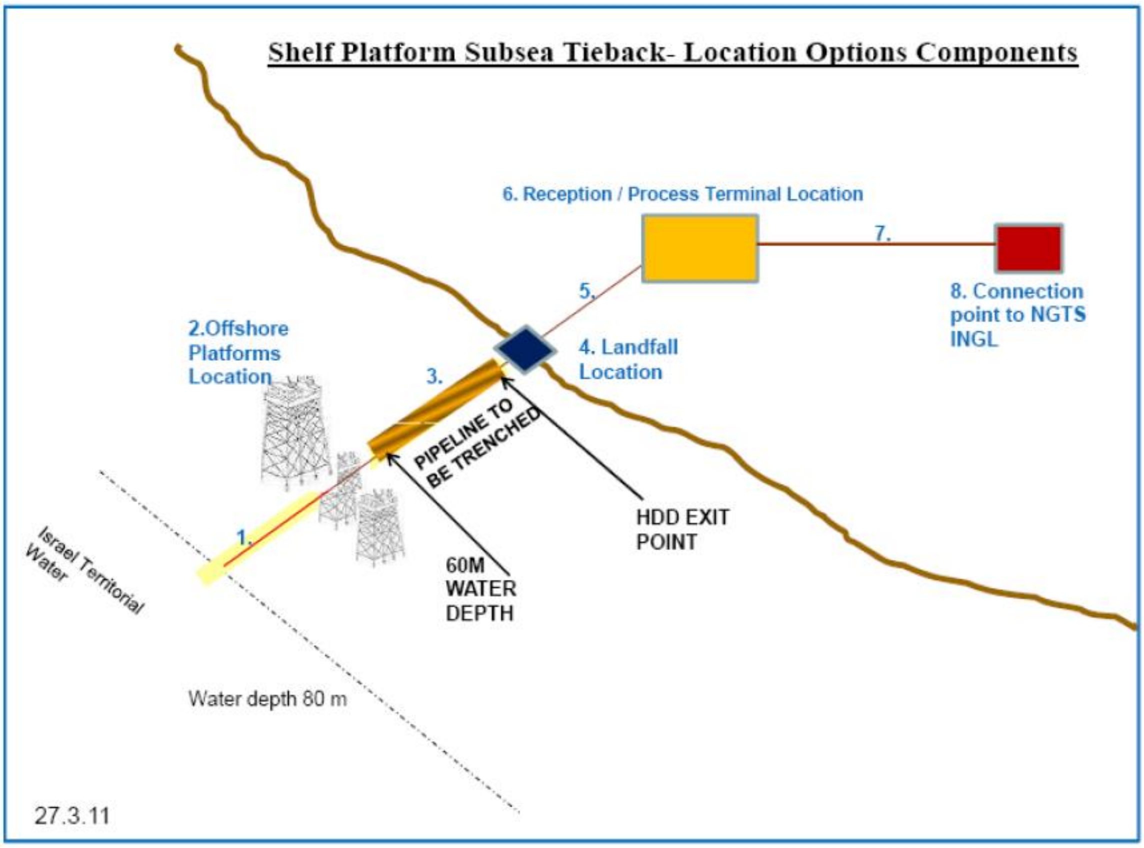
Figs. 3.2.1-3 – 3.2.1-6 show representative overviews and cross-sections of the landfall crossings at Dor Beach and Michmoret Beach.

Pipeline infrastructures at the treatment site: at this stage of planning, the assumption is that in each area of the offshore treatment facility, pipeline infrastructures pass across bridges connecting the platforms and in designated pipeline trenches that will be used for the gas treatment process and for connecting the system between the different installations. In addition, a pipeline to the seabed is planned to connect the offshore facility to the condensate storage ship, and a pipe to connect the facility and the shore power station. All these infrastructures are an integral part of the designated pipeline to and from the facility.

Requirements for trenching the pipe –

It is necessary to trench the pipelines connecting the offshore platforms to the landfall crossing area in the section between the horizontal-diagonal drilling (HDD)exit point to a water depth of 60 m. The diagram below shows the area in which it is necessary to perform the trenching (representing part of assembly no. 3).

Figure 3.2-1: Trenching area for pipelines between the offshore platforms and the landfall crossing



Below is a general description of the requirements for safeguarding the underwater transmission pipelines for the processed gas, and a description of special cases in which the pipeline is at high risk, such as anchoring areas.

Pipelines are planned in such a way as to ensure that they do not move as a result of the effect of waves and currents, and to prevent damage resulting from the use of fishing equipment.

Underwater pipelines are usually laid on the seabed, and are only trenched or protected if there is a particular reason to do so. For the most part, underwater pipes are not trenched and are not laid beneath the seabed.

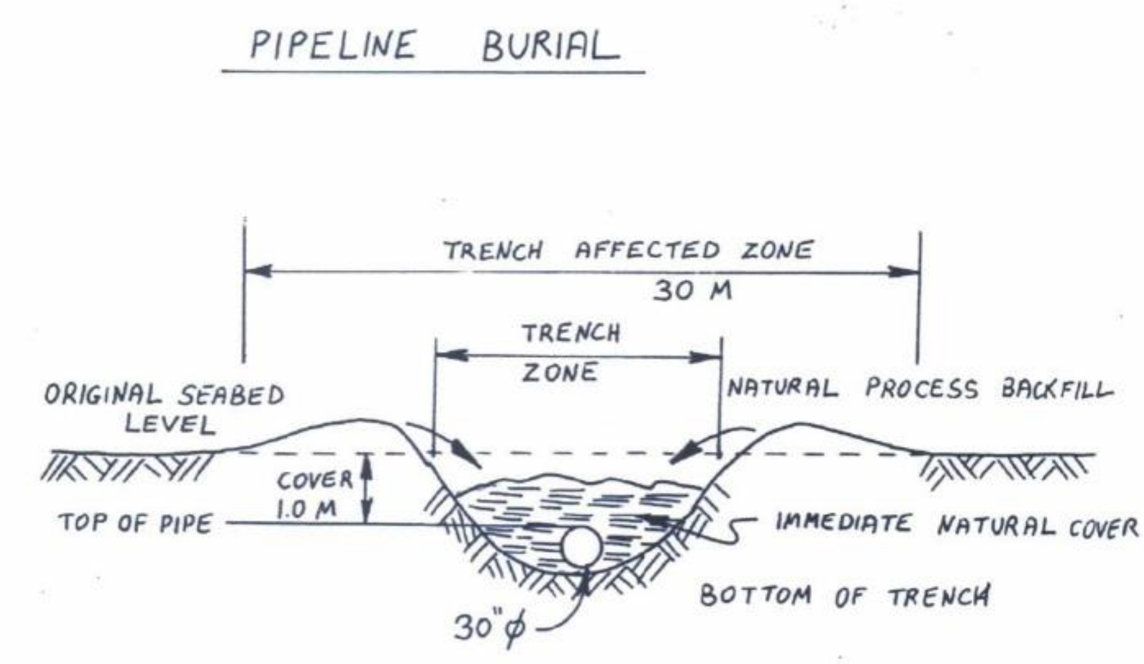
In order to lay the pipeline, an operational radius of sailing vessels in a radius of 2 km is required, in order to maintain the integrity and stability of the pipeline when it is laid.

The diagram below shows two possibilities for trenching:

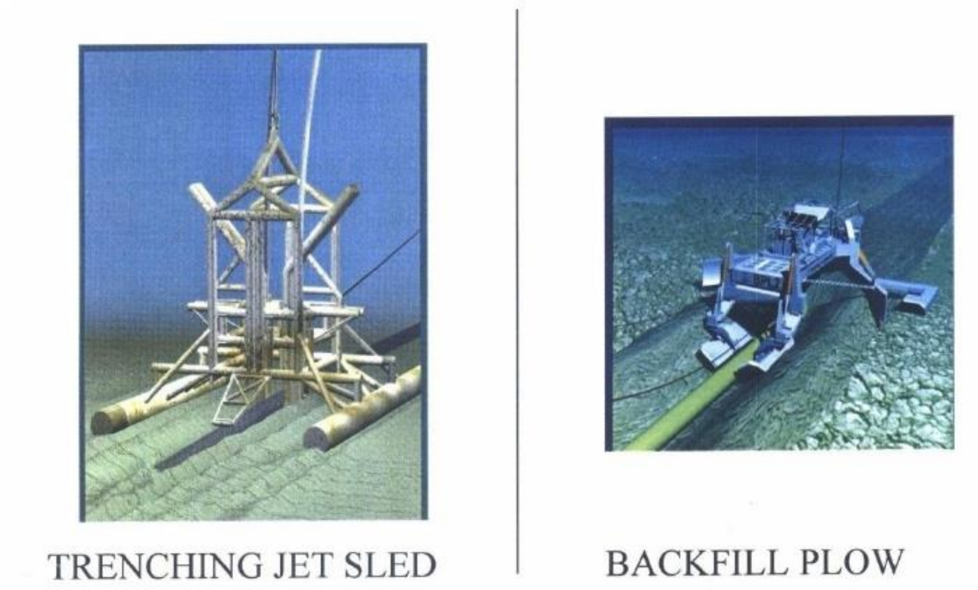
1. A typical trench channel.
2. Laying rocks over the pipeline in order to protect it (a technology called rock dumping), if this is necessary and the area is affected by the pipeline trenching

activity.

Figure 3.2-2: Different methods of pipeline burial



Photograph 3.2-1: Simulation of tools used for pipeline burial



Impact of pipeline burial activities on seabed conditions and the environment

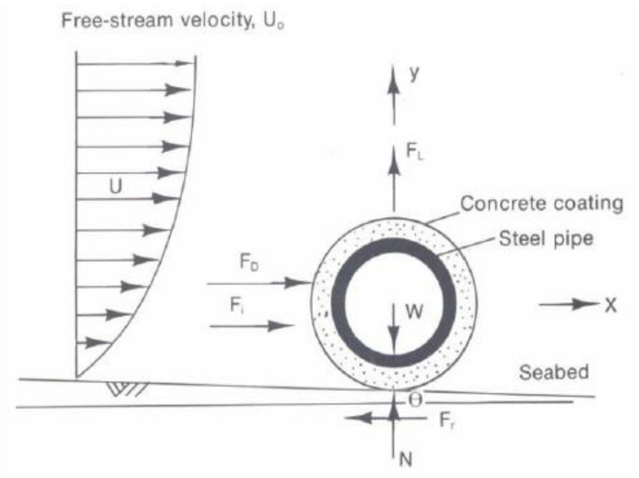
In the proposed pipeline burial area, the communication cable will also be buried in order to protect it from waves, currents, fishing equipment and tourism activities. Burying the pipe will allow sufficient cover and protection and the operation will be carried out in a controlled manner, without causing any kind of environmental disturbances.

I. General planning of a marine pipeline

Pipelines are affected by hydro-dynamic forces formed as a result of waves and currents. Only minimal movement of the pipe is possible in these loads. In addition, damage caused to the pipeline is rare and the risk involved in transmission of the gas in underwater pipelines is reasonable. Burial of the pipes is a planning requirement that will enable stability and maintain the pipe's integrity.

The following diagram depicts the forces affecting the pipeline on the seabed.

Figure 3.2-3: Cross-section of the pipeline



W = Total submerged weight of pipe, including concrete coating and wrap, steel pipe, and contents, lb/ft

F_D = Drag force, lb

F_i = Inertia force, lb

F_L = Lift force, lb

N = Normal force, lb

F_r = Friction resistance, lb

U = Flow velocity in boundary layer, ft/sec

Θ = Slope of seabed, °

$$F_D + F_i + \mu\,(F_L - W\cos\Theta) = W\sin\Theta$$

II. Pipeline stability, typical protection requirements and methods

Pipelines are designed to be stable on the seabed, safe from fishing equipment, and buried at the landfall crossing (in order to avoid negative visual impacts). In very special cases, the lines are also designed to be safe from the effects of anchorage or mishaps.

Problems of stability and protection are solved by wrapping the pipe in a concrete jacket, and by burying the pipelines. The following explanation includes the basic aspects of pipeline design.

<u>Pipeline stability</u>

First of all, the most basic requirement is that the pipeline' weight will be correct, in order to ensure that the pipe does not float up to the surface, and does not move significantly as a result of the effect of environmental conditions (waves and currents).

The height of waves on Israel's Mediterranean coast causes strong forces, so that it is not possible to plan the pipeline in shallow water in a manner that will ensure stability while it is lying on the seabed. Therefore, in order to ensure stability, the pipeline must be buried under the seabed.

Laying the pipe in an open trench will reduce the force of the waves, but will not cancel it out altogether. However, in relatively shallow water, it is likely that even the reduction in wave force produced by an open trench will not suffice, and then the pipeline will have to be buried under the seabed (trenched, with rock dumping).

Pipes are sometimes designed without a concrete jacket in order to suit certain laying methods, and in this case the thickness of the pipe wall is selected in order to give it the necessary weight.

<u>Interaction as a result of fishing equipment</u>

In places where pipelines come in contact with modern fishing equipment (especially fishing nets operating along the seabed), there is a risk that damage will be caused to the pipe by the equipment used by the net fishing sailing vessels.

The risk to pipelines as a result of fishing equipment includes damage from direct contact, and apparently excess pressure and twisting of small-diameter pipes as a result of mishaps with the fishing equipment underneath the pipeline. However, the risk in both these cases is low.

<u>Burial / excavation techniques</u>

Pipes can be lowered beneath the seabed either pre-lay or post-lay. The exact method used depends on the soil of the seabed and the excavation equipment that is available.

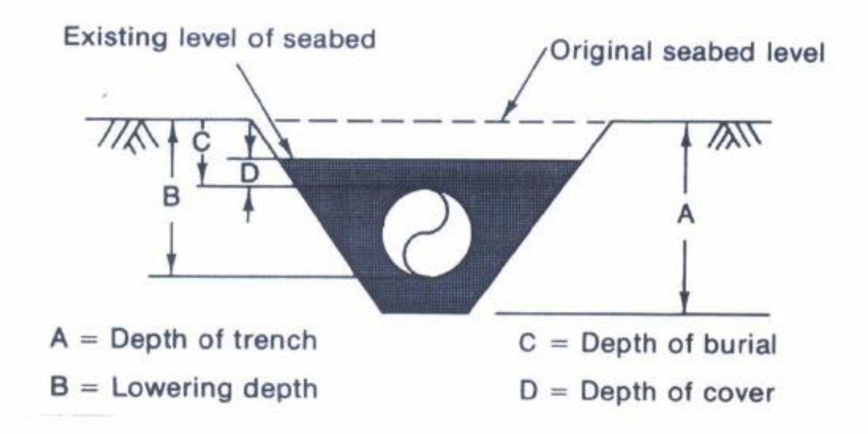
Pre-lay –A trench can be dug for the pipe. This is usually the preferred method for short areas that are close to the coastline. This method will also be used in other places if greater excavation depths are required.

Post-lay –The pipe can be buried under the seabed after it is laid.

Based on the soil and on the selected equipment, trenches that can be achieved are usually at a depth of 3 m for the section near the coast, and between 1 - 2 m for longer sections that are excavated after laying.

The diagram below details the terminology for pipeline trenches:

Figure 3.2-4: Terminology for pipeline trenches



III. Special requirements for protecting the pipeline

In areas where there are special risks to pipelines, there is usually an individual risk assessment. Examples of this include:

- Designated ship anchorage areas
- Crowded shipping lanes in which there is a high risk of collision between ships
- Areas in which there is a higher risk of falling objects

In places where there is an unacceptable risk, the preference is to remove the hazard, and if this is not possible steps are taken to ensure that the implications and impact on the pipeline are acceptable.

Anchors

Most types of anchors move both horizontally and vertically, and so they represent a risk to a pipeline on the seabed. There is a minimum instruction in the planning code for these cases, and therefore the pipeline designers will often be required to prove that the proposed pipeline design is safe against anchors.

Impact of the anchor on an unprotected pipeline

In designated anchorage areas and in a number of particularly crowded shipping lanes there are also similar problems. If an anchor that has fallen or is being dragged comes into contact with an unprotected pipeline, there is a considerable risk of serious damage to the pipe. This damage may be extensive because of the heavy loads and high speed resulting from an anchor falling through the water. In addition, when ships drag their anchor during a storm, the anchor can be dragged for a distance of many meters under the seabed, and a very large protective structure is required in order to stop the drift of such a vessel, or to ensure that the anchor bypasses the pipeline or is diverted.

The exact load depends first of all on the size of the sailing vessel and the environmental conditions. In soft soil, anchors can be dragged for a distance of 6 m or deeper beneath the seabed, and in these conditions, it would appear to be impossible to bury the pipe at a depth at which dragged anchors will not reach.

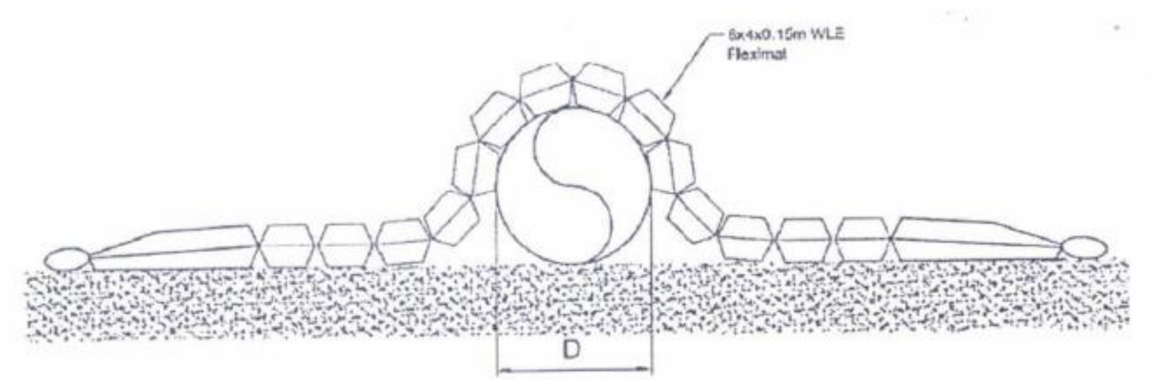
<u>The preferred approach – danger of separate pipeline</u>

With regard to pipelines that have to cross particularly crowded shipping lanes, it is not possible to protect them. In other areas, before considering how to protect the pipeline from anchor damage, it is necessary to examine all the possibilities for protection. In many cases it may be possible to divert the pipeline so as to bypass the hazardous area. In other cases, it may be possible to keep the pipeline's position but to decide whether to reduce the area of the anchor or to transfer the anchor area in order to form a safety distance between the anchor area and the pipeline route. If this is possible, it would be the preferred solution because it can be implemented at the lowest cost.

IV Safeguarding the pipeline in areas where burial is not possible

In areas where burial is not practical, such as areas of sandstone ridges, it is possible to protect the pipeline by means of the customary method of laying a number of flexible "mattresses" over the pipeline in order to alleviate the effects and provide greater stability for the pipe. Mattresses are usually made up of concrete blocks with a thickness of 0.2 m, bound together by strong synthetic ropes.

<u>Figure 3.2-5: Typical "mattress" profile</u>



The diagram above is a depiction of a typical mattress profile.

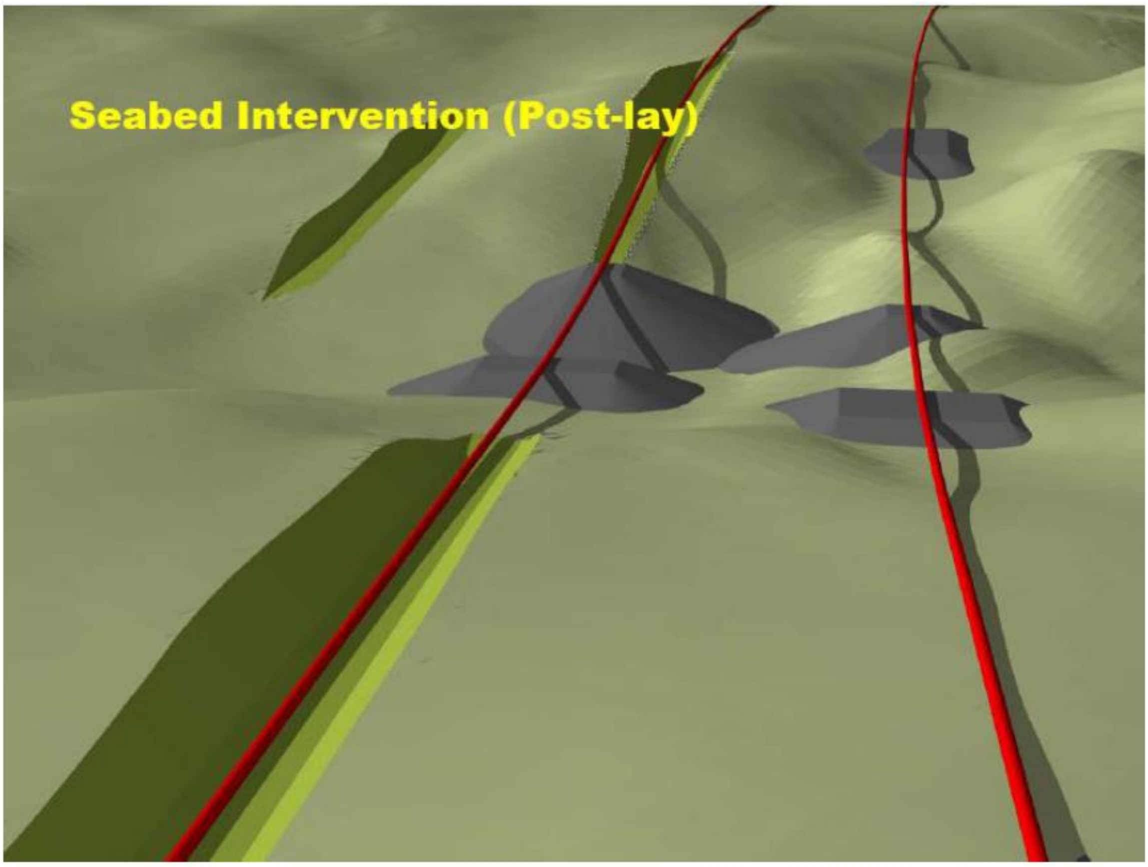
The specific gravity of concrete for the concrete mattresses is 3600 kg / m^3.

<u>Photograph 3.2-2: Installation of a concrete "mattress"</u>

Deep sea pipelines

Deep sea pipelines will rest on the seabed, as far as possible on clay or sandy soil, in a manner that bypasses exposed kurkar ridges on the seabed and sensitive habitats as far as possible. In an area in which there are slopes and canyons, there will be a support system for the pipeline, using an infill in order to avoid the effect of a span or pipe that is suspended in the water rather than laid on the seabed. Preventing span includes periodic monitoring of the pipeline route, and dealing with deviations.

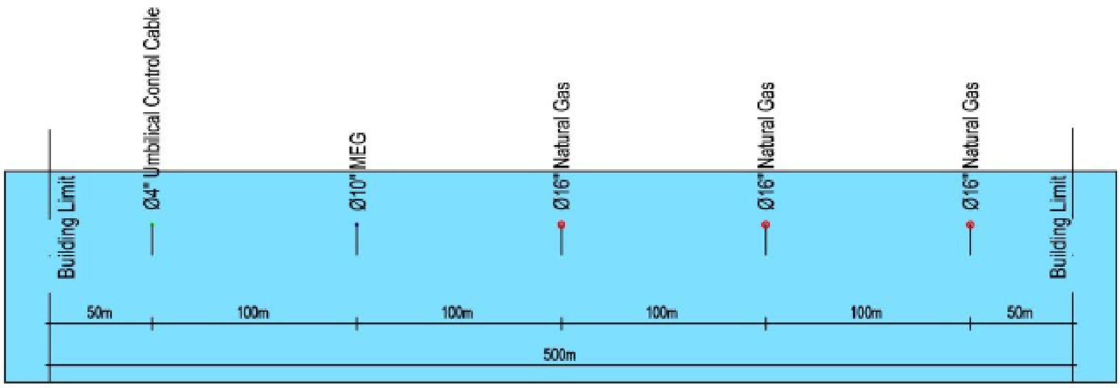
Photograph 3.2-3: Simulation of a pipeline along a canyon route with slides in the seabed, in Norway



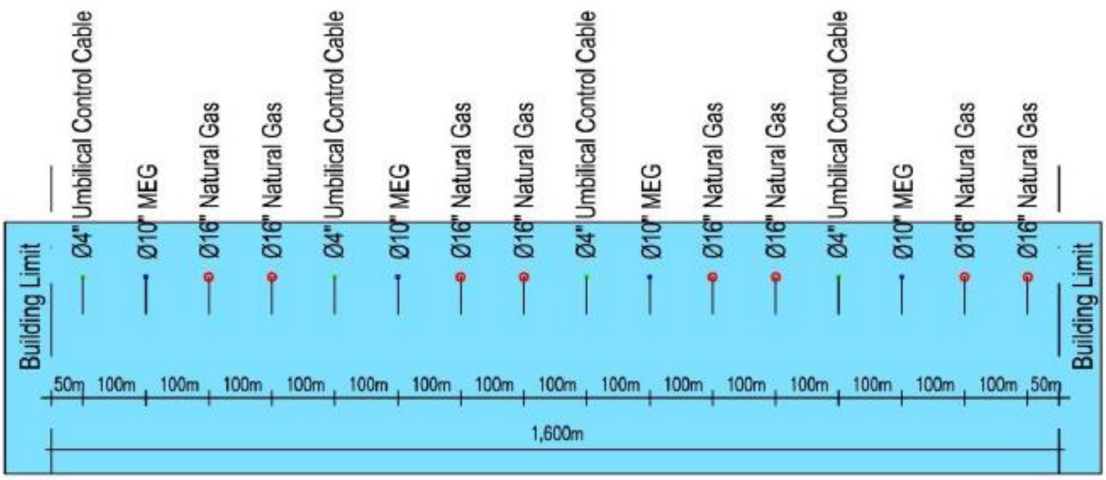
3.2.1 Mapping and cross sections

Mapping the offshore pipeline on the background of a bathymetric map, marine cover, and land uses and zoning is presented in Figure 3.1.1-1 above. Typical cross sections of laying the pipeline are presented in Figures 3.2.1-1 and 3.2.1-3 below.

Figure 3.2.1-1: Typical cross-section of the western offshore pipeline corridor

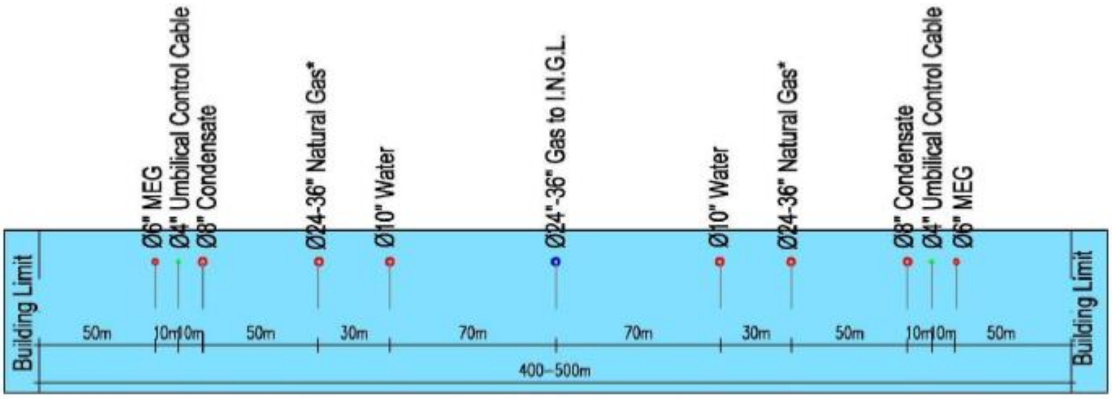


Western offshore pipeline array (to one drilling well)



Western offshore pipeline array (to four drilling wells)

Figure 3.2.1-2: Typical cross-section of the eastern offshore pipeline corridor



Eastern offshore pipeline setup (from the offshore facility to the landfall crossing, for two different suppliers)

Figure 3.2.1-3: Overview of the cross-section representing HDD drilling relative to the shoreline at Dor and Michmoret

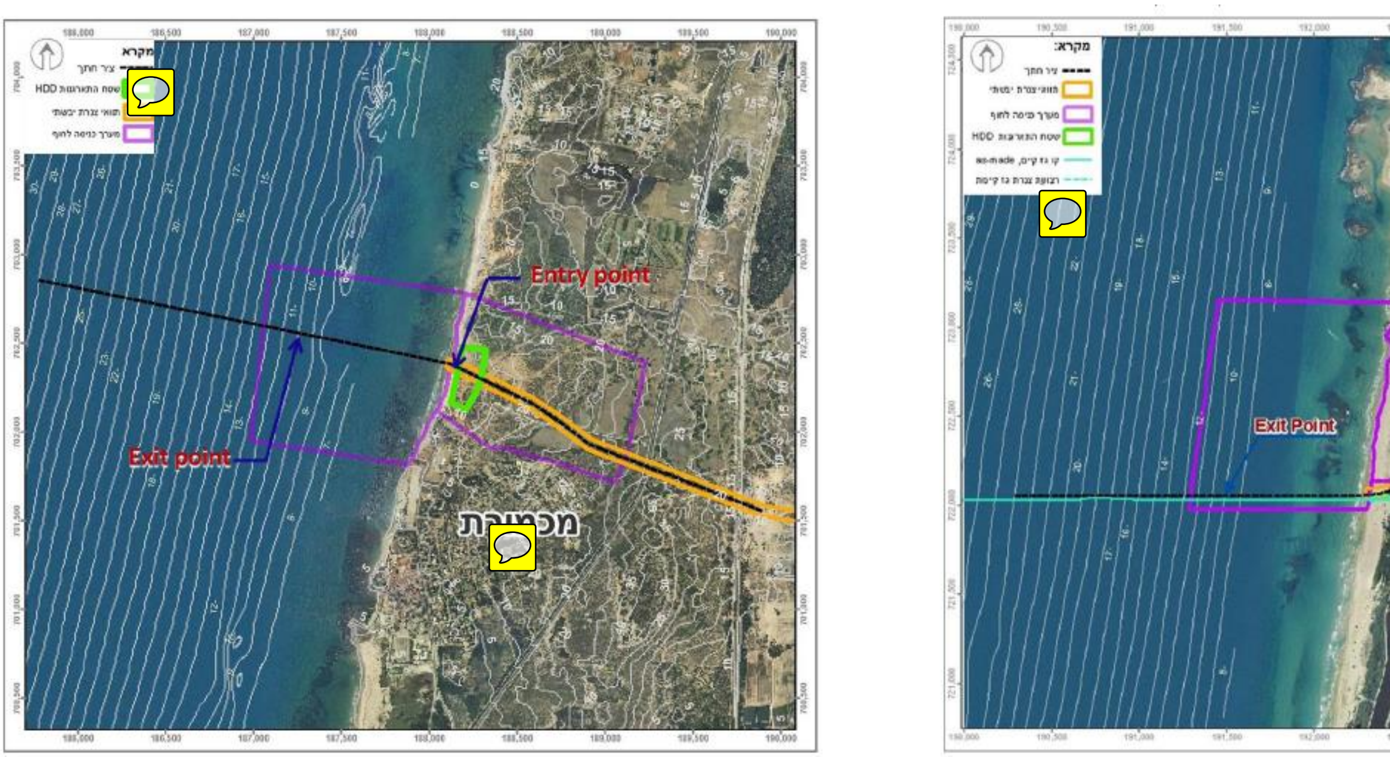


Figure 3.2.1-4: Representative cross-section of HDD drilling relative to the shoreline at Dor

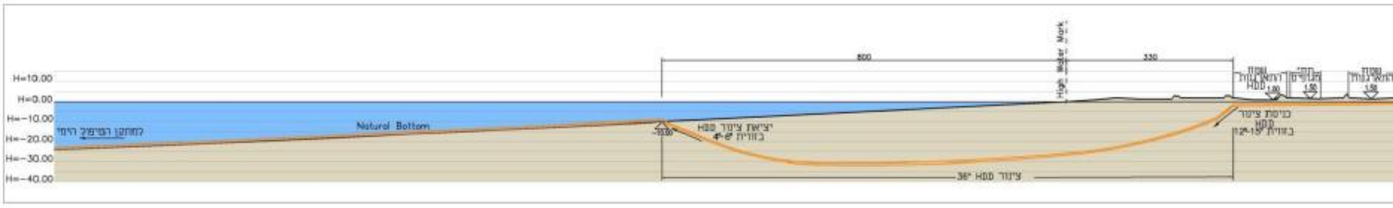
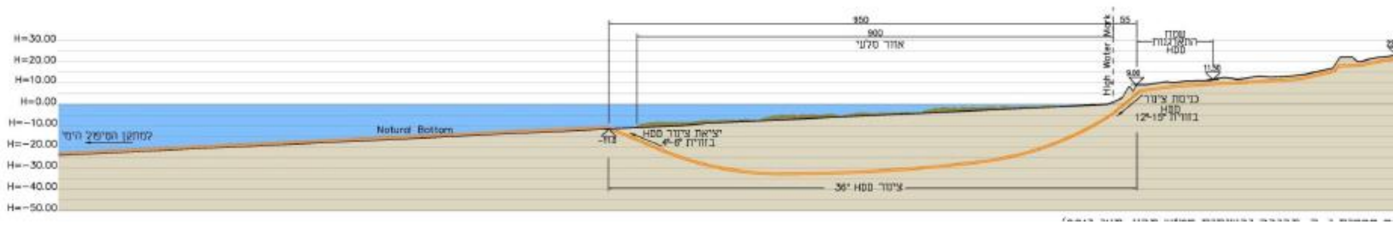


Figure 3.2.1-5: Representative cross-section of HDD drilling relative to the shoreline at Michmoret



Note: up-to-date cross-section (updated to the Environmental Impact Survey, Chapters 3-5, Meretz Wastewater Treatment Plant survey, May 2013)

3.2.2 Description of the work area

A description of the work strip and staging areas for laying the offshore pipeline is given in Section 2.2 of the document on Operational and Engineering Aspects in the Marine Environment, attached as Appendix C.

The staging area for offshore construction work will be within the port (Haifa, Ashdod or Ashkelon), in disturbed areas that do not require landscape and environmental rehabilitation.

3.3 Operating regime

3.3.1 Description of the operating principles

A detailed description of the operating principles of the gas facilities is included in the engineering document, in Appendix B, Sections 5, 9.2, 9.5, and others. The engineering document includes details according to the different components, and in accordance with the different materials and products. In addition, a description of the operating principles of the onshore components is included in the framework of the Environmental Impact Survey for the onshore facilities.

In Table 3.3.1-1 below, the main planning principles of the offshore treatment facility are detailed, on the basis of the engineering document.

Table 3.3.1-1: Main planning principles of the offshore treatment facility

Item	Value
Manning	Manned – up to 35 personnel (no allowance made for security personnel).
Helideck	Assumed to be required for crew transfer and rescue
Incoming Risers	3 x 16" pipeline risers 1 x 6" MEG transfer riser (for possible MEG reclamation)
Outgoing Risers	1 x 36" gas pipeline Riser 1 x 8" condensate riser to onshore 1x 8" condensate riser to storage vessel 1 x 6" MEG transfer riser (for possible MEG reclamation) 3 x MEG lines to the wellheads 3 x umbilical J-tube risers
HP: LP interface	At the incoming riser ESVs on the RP
J-Tube Risers	Required for umbilicals (detail not required for indicative design)
Wellhead Control	MCS and HPU included with control from the onshore DCS.
Water Depth	80 m suitable for jacket sub-structure
Flare Radiation	1.9 kW/m^2 for Helideck - 6.3 kW/m^2 for personnel exposure: **limiting value** - 15.8 kW/m^2 for equipment exposure -

In addition, an expanded description of the operating principles of the gas platform and offshore pipeline is included in the document on operational and engineering aspects in the marine environment, attached as Appendix C, in Sections 1 and 7.

3.3.2 Description of the operating regime

At sea, unlike on land, there is a broad expanse for setting up offshore facilities, where the internal area that they occupy is significantly smaller than the internal area of the onshore facility.

A supplier entering the site will be required to check and prove the geological feasibility of establishing the facilities as a condition for the building permit. The offshore facility will have an output of up to 2 million m^3 an hour.

It is important to recognize the fact that at this stage, there is considerable uncertainty with regard to gas suppliers, offshore reservoirs, and the circumstances in which the facility will operate.

In order to promote and determine the discussion of operating principles, a number of basic assumptions have been made:

- It is assumed that there will be a separate riser platform to which the supplier will connect with gas from finds, so that in the event of a malfunction it will be possible to shut off the valves and disconnect the connection between the treatment platform and the pipe to the wellhead.
- It is assumed that the accommodation platform will be separate from the gas treatment platform, to allow the workers a degree of safety and hygiene, as is common around the world.
- The company responsible for design, construction and operation will be a qualified organization with knowledge and experience in designing, constructing and operating similar facilities. These parties can be the developers or work contractors on behalf of the developer, but it is assumed that the developers will have legal responsibility for all the work taking place throughout the lifetime of the project.
- All personnel related to the facility's design and operation will themselves be qualified to do so.
- The entity responsible for managing and supervising the facility's operation will be an experienced body.
- All personnel without experience in operating facilities of this kind will undergo the appropriate training and will be under the supervision of a person with knowledge and experience.
- The designer / operator will provide a comprehensive library of operating procedures and designated manuals.

The facility will operate year-round and will be staffed all the time, and in particular the control room will be permanently manned. The facility crew will work in shifts enabling the facility to be staffed throughout the day. It can be assumed that staffing the facility will be on a larger scale during the day than at night or at weekends, and therefore routine maintenance and other non-critical work will be performed during the day. In addition, the facility will be staffed by security guards in accordance with the requirements as may exist from time to time.

In addition, it was assumed that the equipment manufacturers will have an agency in Israel and other experts will have immediate access to Israel.

The facility will have an emergency shut-off system (apparently in three stages), together with procedures for emergency shutdown. Personnel on the facility must be skilled in these procedures. Emergency planning should include coordination with the emergency services and with operators of nearby facilities. Facility operators will work in coordination with the relevant local authorities with regard to the facility's operation, and will give warning of any action that is liable to create a disturbance, such as release of gas in the event of a malfunction, or movement of massive components.

In accordance with the above, consideration of the method of treatment facility component control will be included in the framework of the building permits.

For **emergency procedures** and means of minimizing risks, see comments in Sections 4.7 and 4.11 below.

Emergency plans and detailed guidelines for action in the event of environmental contamination will be drawn up for the facility, and will be detailed in the environmental management and monitoring plan to be formulated for the facility's operational stage.

Safety restrictions – consideration of safety restrictions for the facility is included in the engineering document, Appendix B. In addition, the aspect of safety restrictions in the facility will be expanded and detailed in the framework of the building permits.

On platforms, safety restrictions for workers and the immediate environment will be determined in accordance with the findings of the detailed risk survey to be conducted at the stage of the building permits.

In addition, a detailed description of the operating regime according to the operating principles of the gas platform and the offshore pipeline is included in the Operational and Engineering Aspects in the Marine Environment document, attached as Appendix C, in Section 7.

3.3.3 Monitoring devices

Offshore facilities will be controlled by an automatic system based on Supervisory Control and Data Acquisition (SCADA). The safety system will include an emergency shutdown system (ESD), and a monitoring and control system for gas leaks and fire

(F&G). The ESD and F&G systems on the facility will be connected to the control rooms.

There will be a large number of automatic valves that can be closed from the control room. In addition, there are a numerous sensors on the facility, measuring parameters such as pressure and temperature. This information goes to the main control room.

In the main control room, the process operation computer is programmed for the High-High (HH) and/or Low-Low (LL) alarm and emergency disconnection functions in the event of abnormal pressure, temperature, level and outputs. The system receives signals from all parts of the system.

The origin of the signals from the gas and fire sensors will operate alarms, systems for isolation of areas, and/or pressure blowdown, according to the incident.

Devices for monitoring and preventing malfunctions at sea from the pipeline and the process platform are detailed in the document on Operational and Engineering Aspects in the marine environment, attached as Appendix C, in Section 7.4.

3.3.4 Malfunction situations

Malfunction situations in the pipeline and the facilities, and means of protecting the environment from these incidents, will be examined in the framework of Chapter 4 below.

3.4 Infrastructures

3.4.1 Description of the accompanying infrastructures

This section will include a review of the main accompanying infrastructures in the project – supply lines and pipelines for removal of products from the facility. Additional details of the accompanying infrastructures for the offshore treatment facility are included in the engineering document, in Appendix B.

<u>Gas lines</u> – As detailed in Section 3.2, the area of the western offshore pipeline corridor will include high-pressure gas pipes, and the area of the eastern offshore pipeline will include gas at a pressure of 110 bar. In addition, there will be other pipes as detailed in Section 3.2 above.

<u>Fuel – condensate lines</u>– Fuel from the offshore treatment facility will be treated by two solutions (see details in Section 3.1.6 above):

1. Treatment of fuels in the offshore site by means of a designated treatment facility (FSO).
2. Treatment of fuels onshore, at the refineries.

<u>Produced water</u> – Because of the fact that the produced water is contaminated (see details in Section 3.4.3 below), treatment is required to purify the water to an agreed quality before its dispersal, in such a way as to minimize the environmental impact. Among the existing solutions, and in order to prevent any pollution in the facility area,

the planning in principle assumes that all produced water that has been treated and cleaned on a designated facility and will be dispersed in the sea at an outlet at the feet of the pressure reduction facility.

TEG/MEG lines – In a gas transmission system with characteristics of high pressure and long pipes, there is usually a reduction in temperature in order to change the balance of the water, and so it is necessary to use thermodynamic retardants such as MEG or methanol. In this facility, it is assumed that MEG will be used because it is commonly used in similar facilities in the Mediterranean region. The corridor includes a dedicated pipe for the flow of MEG from the natural gas well to the pressure reduction facility and returning it to the well.

Umbilical control cable line – A maintenance and control line between the drilling well and the offshore facility. In addition, the line will also include an energy supply line to the drilling well head.

Treatment of flows coming from the facility – All fluid systems on the facility are closed systems, meeting construction and production standards, and operation and monitoring of the systems in accordance with the provisions the law will prevent any contaminating fluids from components of the system into the environment. At the same time, in order to relate to certain scenarios of failure or faulty maintenance that are liable to cause the emission of contaminating fluids from the facility's systems into the sea, a number of dispersion models were run, detailed below in Sections 4.7 and 4.8.

3.4.2 Wastewater

Details of the quantities and types of wastewater expected to be formed in each part of the project, the manner of their preliminary treatment and that of the byproducts from the gas treatment system, and the manner of connecting the facility to an approved end solution is included in the engineering document, in Appendix B. This excludes wastewater treated in the offshore site, which will be related to the framework of the survey impact on the current environment for offshore facilities.

The main wastewater received at the treatment site will be:

- Sanitary waste –wastewater originating in activities of the personnel at the site. Will be treated on the platform to accepted standards before discharge into the sea.
- Industrial waste –produced water obtained during the natural gas treatment process will be treated as necessary on the offshore treatment facility to accepted standards before discharge into the sea.
- In addition, during initial operation of the system (start-up) it is necessary to remove a one-time volume of pressure testing water (approximately 2900 m^3 for each kilometer of gas pipe). The source of the water is likely to be sea water or system water and it is possible that this water will contain various contaminants

originating in installation of the pipe (metals, oils, etc.). During planning, it will be necessary to detail the anticipated composition of the water and obtain a permit to discharge it into the sea, in accordance with the Prevention of Sea Pollution from Land-Based Sources Law and its regulations.

3.4.3 Produced water

Produced water originates in three components in the gas production process: 1. Formation water coming from the reservoir rocks together with the natural gas; 2. Condensed water condensing on the surface from the phase of gas saturated with water; and 3. Rift water, whose pressure increases as a result of decreased pressure in the reservoir in the course of production. Salinity of the produced water is not known at this stage, and it is estimated as the salinity of sea water[3]. In addition, the produced water may contain condensed hydrocarbons at a concentration of up to 100 ppm, and glycol at a concentration of up to 10 – 50 ppm.

- Quantities: according to the planning in principle, the estimated quantity of produced water per day is 1,640 m^3. See details in Section 14.8 of Appendix B.
- Composition of produced water and additives: the composition of the produced water is specific to the gas field and cannot be estimated without specific information. At the same time, there are substances that can be characterized as typical / common substances in produced water, and these are detailed in Table 3.4.3-1 below (the table is taken from the engineering document, presented in Appendix B). The produced water coming to the treatment facility will include various components of natural gas, as well as the chemicals used in the drilling well and in the pipes. Some of the substances are also used for the pressure reduction facility and for the produced water treatment facility. It should be noted that it is not always possible to mix produced water from different sources, and therefore it may become necessary to create separate transmission and treatment systems.

[3] As a stringent scenario for examining the impact on the onshore environment.

Table 3.4.3-1: Examples of typical chemicals in produced water

Component	Source
Natural Gas	
Trace hydrocarbons and gases	Gaseous hydrocarbons with low solubility in water – e.g. methane, ethane, propane, butanes, nitrogen
Soluble Hydrocarbons and Volatile Organic Compounds (VOCs)	Hydrocarbons soluble in water – e.g. BTEX, PAH, NPD and hydrocarbon components that are soluble in water at pressure but vaporize at low (atmospheric) pressure
Dispersed Hydrocarbons	Hydrocarbons insoluble in water but mixed with the produced water stream
Hydrogen Sulphide (H_2S)	Gaseous component soluble in water
Sulphur Compounds	Gaseous components soluble in water
Carbon Dioxide	Gaseous component soluble in water
Produced Water	
Sand	Fine sand particles
Dissolved solids and ions	Soluble salts, rare metal ions
Heavy metals	Can be present in produced water
Wellhead and Facilities Production Chemicals	
MEG	Used for hydrate inhibition, sales gas water and hydrocarbon dew-point control, carrying corrosion inhibitor
TEG	Used for sales gas water dew-point control
Methanol	Used for hydrate inhibition and pressure balancing at well start-up
Kinetic Hydrate Inhibitors	Used for hydrate inhibition
Corrosion inhibitors	Used to prevent corrosion in pipelines
Corrosion and Erosion Products	For example: due to CO_2 in the gas stream and sand particles
Scale Inhibitors	Sometimes used to prevent scale formation in process equipment from the produced water
Antifoaming agents	Sometimes used to prevent/reduce foaming in gas-liquid/water separators
Demulsifier	Sometimes used to enhance separation of produced water from hydrocarbon condensate
Reverse Emulsion Breakers	Sometimes used to enhance separation of hydrocarbon condensate from produced water

- **Treatment** – There are a number of options for treating produced water, as detailed below:
  1. Initial treatment in the gas treatment facility and discharge into the sea – the produced water obtained at the treatment facility (onshore and/or offshore) undergoes treatment in a designated facility, aimed at separating the remaining fuel components from the water, before it is transferred to a designated pipeline for discharge into the sea in the area of the offshore facility.
  2. Reinjection of the produced water into an underwater bore / reservoir – this case is reviewed by Royal Haskoning DHV, and found to be less suitable for this plan in a number of aspects:
     – Injection of produced water is suitable for bores in shallow water (up to a

depth of 100 m), while the assessment is that the gas reservoirs relevant to this plan will be at greater depths.

- The environmental impact in the option of discharge into the sea after treatment is low. See details in Section 4.8.3 below.
- Re-injection of produced water has a high energy cost.

In addition, the option of re-injection into the sea is inferior in planning and economic terms as detailed in Appendix K, which details the examination of options for treatment of the produced water.

Details of facilities:

- The location of the outlet in the water will be close to the treatment rig, at a depth of a few meters.
- Transmission method – this section presents the method of transmitting the produced water from the onshore facilities (at the Meretz and Hagit site) and from the offshore facilities:

  According to the planning in principle of the onshore facility, the transmission method will be pushing through by pumps, as detailed in the engineering document drawn up by PDI for the onshore facilities, and attached as Appendix B to the Environmental Impact Surveys for the Meretz wastewater treatment plant and Hagit sites, submitted in the framework of this plan – see details in table 3.4.3-2 below. Pumps will be located at the onshore treatment facility at Hagit and/or the Meretz wastewater treatment plant.

  In the offshore facilities the process is simpler. After treatment of the produced water to the required level of cleanliness, the produced water will be transferred to a separate liquids tank (for produced water and oils and lighter liquids), and from there discharged into the sea.
- Discharge pipe structure – the pipeline for removing surplus water will be up to 10” in diameter, without diffuser.
- Outlets existing in practice in the offshore environment are presented in Figure 3.1.1-1 above. The planned outlet in this plan is a new outlet for the planned facility and there is no connection between it and the outlets existing in different plans.

Table 3.4.3-2: Specification of equipment for treatment of produced water in an onshore facility

Onshore Processing Layout Study
Hagit and Meretz Facilities - Major Equipment List
2 x 24 MSm³/d (847 MMscfd) Process Streams
1222-C-PR-LST-2001

Date	Rev.	By	Rev'd	App'd	Description
19/02/13	01	MJD	HF	HF	Issued for Study Report
18/12/12	00	MJD	HF	HF	Issued for Client Comment
14/12/12	Draft	MJD	-	-	Issued for PDi Review

Tag No.	Item	Basis	Duty	Power		Pressure		Temperature		Dimensions			Weights		Design Information
				Draw	Installed	Oper	Design	Oper	Design	i.d. / W	t/t - L	H	Dry	Oper.	
		-	kW	kW	kW	bara	barg	°C	°C	m	m	m			
System 45: Produced Water Handling															
E-4501A	Produced Water Condenser		16500	104	120					16.00	9.75	1.00	102.4	112.6	Air cooler bare CS tube area = 800 m^2, extended surface = 16000 m^2.
E-4501B	Produced Water Condenser		16500	104	120					16.00	9.75	1.00	102.4	112.6	Air cooler bare CS tube area = 800 m^2, extended surface = 16000 m^2.
P-4501A	Produced Water Booster Pump	25 m^3/h		5	10					0.80	1.70	0.80	0.7	0.8	100% duty stainless steel (SS) pump with nominal ΔP = 5 bar.
P-4501B	Produced Water Booster Pump	25 m^3/h			10					0.80	1.70	0.80	0.7	0.8	100% standby SS pump with nominal ΔP = 5 bar.
P-4502A	Produced Water Injection Pump	25 m^3/h		50	60					2.00	5.00	2.00	12.9	14.2	100% duty SS pump with nominal ΔP = 50 bar.
P-4502B	Produced Water Injection Pump	25 m^3/h			60					2.00	5.00	2.00	12.9	14.2	100% standby SS pump with nominal ΔP = 50 bar.
P-4503A	Produced Water Transfer Pump	25 m^3/h		5	10					0.80	1.70	0.80	0.7	0.8	100% duty SS pump with nominal ΔP = 5 bar.
P-4503B	Produced Water Transfer Pump	25 m^3/h			10					0.80	1.70	0.80	0.7	0.8	100% standby SS pump with nominal ΔP = 5 bar.
P-4504A	Skimmed Oil Pump	5 m^3/h		2	3					0.40	1.20	0.40	0.4	0.5	100% duty CS pump with nominal ΔP = 5 bar.
P-4504B	Skimmed Oil Pump	5 m^3/h			3					0.40	1.20	0.40	0.4	0.5	100% standby CS pump with nominal ΔP = 5 bar.
T-4501	Produced Water Tank	8000 bbl					atm		75	13.41		9.75	34.0	634.0	CS Tank sized for 2 days of full production (50% full for op. weight).
V-4501	Produced Water Degassing Drum	120 m^3/h				atm	10			3.00	12.00	4.50	15.0	35.0	Horizontal CS vessel.
X-4501	Produced Water Separator									1.48	3.70	2.10	1.4	7.3	Tilted plate separator.
X-4502	Produced Water Sump									10.00	30.00	5.00			Sump in ground sized for 1500 m^3.
X-4503	Produced Water Chemicals Package			5	10					3.00	6.00	3.00	2.6	3.9	Complete produced water treatment chemicals package.

3.4.4 Preventing penetration of surface runoff into the facility

Preventing the penetration of surface runoff is only relevant to the plan's onshore components and has been presented in the onshore Environmental Impact Surveys at the Meretz wastewater treatment plant and Hagit, presented in the framework of this plan.

3.4.5 Flooding

Damage to the facility and the environment due to flooding is relevant to the onshore components of the plan and has been presented in the onshore Environmental Impact Surveys at Meretz wastewater treatment plant and Hagit, presented in the framework of this plan.

3.4.6 Monitoring systems

This section relates to systems monitoring leaks of condensed hydrocarbons and glycol in the pipeline and in the tanks. For details with regard to gas leaks, see Sections 3.3.3 and 4.1.8 in this document.

- Condensed hydrocarbons – containers and pipelines in the treatment facility will be protected and monitored for leaks. Additional recommendations for the monitoring system will be obtained in the framework of the survey assessing the potential pollution of the sea by fuels, to be attached by applicants for a sea spillage permit.
- Mono-ethylene glycol – since glycol is defined in the Hazardous Materials Law as a toxin, it will be necessary to obtain a toxins permit for its use. In order to define the standards for building the pipeline and tanks, and the protection and monitoring instructions , it is recommended to make use of the US Department of Transport (DoT) standard for pipes carrying hazardous materials.

Table 3.4.6: Composition and flow data[4]

	Output (m^3/day)	Estimated composition	Length of line (km)	Diameter (inches)	No. lines	Flow regime in pipe	Overall volume (m^3)
Condensate – condensed hydrocarbons	2802 - 2159	Over 90% decanes, hexanes, heptanes & octanes	12	8	1	Full	389
MEG – Mono-ethyleneglycol	437	72% glycol, 28% water	12	4	2	Full	195

[4] The data are based on the engineering report attached in Appendix B.

3.4.7 Emissions or gas flaring system

As part of the natural gas treatment process, in certain cases it will be necessary to remove the excess gas from the over pressure protection system. For this purpose, it is necessary to set up a gas removal system in the area of the plan. In the framework of TAMA 37/8, this excess gas will be removed by means of a flare (see greater detail in Section 13 of Appendix B).

The flare system comprises the following facilities:

- HP flare

- LP flare

- Flare gas recovery unit (FGRU)

Details and reasons for each of the facilities can be seen in sections 13.5 to 13.7 of Appendix B.

In a routine state of operation, the emission gases from the flare will be returned to the system using flare gas recovery unit (FGRU) technology as detailed in Sections 6.4.8 and 9.4 of Appendix B. Accordingly, in a routine state of operation there are hardly expected to be any emissions from the flare (emissions that are liable to be emitted in routine state are considered to be negligible). However in the event of a malfunction, excess emission gases will be emitted through the HP flare and/or the LP flare, depending on the type of malfunction (at the site there will be one flare that will serve both the HP and the LP flare).

Anticipated types of malfunction from the HP flare are:

– Operational mishap

– Release of gas from the upper structure of the platform (blowdown gas platform topsides)

– Release of gas from the separation skid at low temperatures (blowdown LTS train)

– Release of gas from a high pressure pipe and from a low pressure pipe (planned blowdown of high pressure and low pressure pipelines)

– Release of gas from the pressure relief (PSV lift)

– During future operation (2025 +), there is liable to be a malfunction requiring release of the gas within the compressor (blowdown compressor)

Anticipated type of malfunction from the low pressure flare:

– Release of gas from the pressure relief (PSV lift)

For details of the emissions from the flare and from other sources of emission in the plan area, and data on the emissions and facilities (height, etc.), see Section 4.1.1 below.

3.4.8 Signs and fencing

The lighting on the offshore treatment facility will be decided at the building permits stage, taking into account landscape and ecological aspects (with the emphasis on bird migration), to reduce the use and strength of the light, according to a number of principles, among them:

a. Maximum reduction of the use of light, both in terms of time and in terms of strength.

b. Use of light with short wavelength and narrow spectrum – avoiding the use of white light.

c. The lighting plan should be backed up with photometric mapping, presenting the spread of light around the facility and showing that there is no deviation of lighting beyond the essential area.

d. Accompanying monitoring to examine the impact of the lighting.

The subject of the lighting, its impact on the environment and the means of reducing it are detailed in Sections 4.3 and 4.9 below.

Signs in the offshore area of the plan will be in accordance with the guidelines of the Shipping and Ports Authority in the Transport Ministry, and as is customary.

3.4.9 Protection of groundwater

The subject of groundwater protection is only relevant to the onshore components of the plan and has been presented in the onshore Environmental Impact Surveys at the Meretz wastewater treatment plant and Hagit, presented in the framework of this plan.

3.5 Hazardous materials

Below is a forecast of typical hazardous materials used in a gas treatment plant. This forecast is based on the PDI report – Offshore Processing Scheme Facilities Description & Quantification of Emissions & Discharges – for the planning in principle, attached as Appendix B.

The processes of production and treatment of natural gas and service systems make use of a wide range of chemicals for: separation of gas – condensed gas – water; gas processing; stabilizing condensed gases; recompression of the gas; treatment of the produced water; heating and cooling systems; re-production of MEG; treating seawater, water from the fire extinguishing system, freshwater, and the sewage system. Other chemicals include a range of painting and coating materials, lubricants, cleaning fluids for the equipment, and diesel oil.

On the drilling platform there will mainly be MEG – mono-ethylene glycol, used as antifreeze, and flammable chemicals – methanol, oils, paints, solvents. There will also be chemicals for treating water: preventing scale, chemicals to prevent corrosion (which can be different types of materials, such as oxygen repellent amines – hexamine, phenylenediamine, dimethyl ethanolamine, or zinc dithiophosphates or benzalkonium chloride - and chemicals for treating wastewater (for example, oxidants such as sodium hypochlorite).

Although MEG does not have a UN number, its steam pressure is very low, and it is not considered a flammable material (flash point 111°C), it is included in the list of hazardous materials in the Hazardous Materials (Classification and Exemption)Regulations 5756 – 1996, in concentrations of above 70% in a quantity of over 250 kg, and therefore should be related to as a hazardous material. Methanol is also a hazardous material whose risk is flammability and toxicity.

Below are details of the main chemicals on the processing platform:

Table 3.5: Hazardous materials

Name of material	Anticipated quantity at the site
Natural gas	Throughput of 2 million standard m^3 per hour passing through the site
Condensate	100,000 m^3 of hydrocarbons[5]
Mono-ethylene glycol - MEG	6,400 m^3
Corrosion inhibitor	10 m^3
Methanol	30 m^3
Nitrogen	5 m^3

3.6 Energy

3.6.1 Energy facilities

Energy production facilities at the initial operating stage include:

- Two gas turbines with a total output of 20 MW – one in continuous operation, and the other for emergencies
- 1 MW diesel engine for emergency use – to back up basic operations in

[5] To be transported and stored in a tanker at sea and not on the gas processing rig

the event of a malfunction.

A detailed description of sources of energy can be found in Section 6.5.11 and in Section 14.6.1, in Appendix B.

3.6.2 Fuels

The main fuels found at the treatment site are diesel oil and condensate. Beyond this, at this stage it is not possible to assess which other types of fuel will be obtained in the gas treatment process. At the same time, Section 12 in the engineering document (Appendix B) presents a list of typical materials that are liable to be found in this type of facility.

Most of the materials obtained on the facility will be oils and lubricants in quantities that are not large, and they will be stored in designated containers.

Additional details on the subject of types and quantities of fuel is to be used for the different processes on the facility are included in the engineering document, in Appendix B.

Chapter 4

Details and Evaluation of the Environmental Impact

4. Chapter 4 – Details and Evaluation of the Environmental Impact

4.0 General

The goal of this chapter is to outline the potential environmental impact of implementing the plan and the means of reducing negative effects. Technical data specifications are based on the engineering document Offshore Processing Scheme Facilities Description & Quantification of Emissions & Discharge prepared by PDI (attached as Appendix B).

As noted in Chapter 3 above, the program has no developer at this point and information is absent that influences planning (such as gas composition in the reservoir and the technology that is planned for the treatment plant). This means that the review of best available technology (BAT) to reduce the environmental impact, as well as the examination of possible environmental impacts that are not included in this document, will be conducted at the building permit stage and will be based on the principles described in the ENVID documents and the document of principles for preparing an EMMP (Environmental Management and Monitoring Plan), which also refers to examining and selecting the BAT during the next stages. These documents were prepared by Royal Haskoning DHV and are attached as Appendices G and I of this document.

4.1 Air quality

Operating a natural gas treatment plant consumes energy that is used to operate auxiliary equipment such as gas turbines, fired heater installations, etc. The consumed energy creates air pollution emissions. Expected emissions include point sources and nonpoint sources. The point sources do not include emissions from the flare stack under normal operating conditions (explanation below). During normal operation, installations operated with diesel engines may potentially be used, such as the emergency generator and water pumps. When calculating the environmental impact of operating the facility, a worst case assumption was applied in which there are emissions both from installations operated by natural gas and from installations operated by diesel engines (total emissions from the facility – hereinafter referred to as "the Plan").

During the first years of its operation (approximately 8 years) gas will reach the facility at peak pressures. After the initial operating period, gas will arrive onshore at lower pressures (see Table 3-3, Appendix B). Therefore, starting around 2025, an increase in pressure will be needed to accelerate the rate of gas delivery to the shore. This additional gas compression involves additional energy and emissions. Total emissions under normal operations, normal future operations (after 2025), and in cases of malfunction are listed in this section. All information shown below has been taken from the engineering appendices attached to this document (Appendices B and C), except for the pollutant dispersion calculations which were conducted using the AERMOD[6] and CALPUFF models.

The application for an emissions permit, as required by the Clean Air Law – 2008 and by any revisions at the time of application, will be submitted at the building-permit application phase.

4.1.1 Details of emissions

This section details the sources of emissions and pollutants emitted by all sources during normal operations, future normal operations (after 2025), and malfunction.

These are the sources of emissions into the air:

1. Two gas turbines, 20 MW each (2X power generation)
2. Two fired heaters
3. Diesel engines
    - One 1 MW emergency power generator
    - Two fire water pumps, 0.6 MW each
4. Flare – the treatment facility will have one flare to release and burn gas at high pressure (HP) and at low pressure (LP) (see details in Appendix B).

Following is a list of all emission sources with their emissions according to operating status (normal, future normal, after 2025, and malfunction). A detailed explanation for each source of emissions is available in Appendix B, Section 9.2.

1. Sources of emissions during normal operation (during the first years, approximately 8 years) include:

[6]Due to limitations of the AERMOD model, the highest emission velocities that can be entered into the model is 50 m/s, with the result that any velocity over this threshold was entered as 50m/s.

1.1 **Two gas turbines, 20 MW each** (power generation)

When examining the impact of emissions from the treatment facility on the environment, we assumed there would be emissions from these two turbines. This is a stringent assumption made according to Ministry for Environmental Protection guidelines. In practice, one turbine will be operated and the other will be in reserve; in rare cases both will be operated at the same time, for instance when switching between the two turbines during maintenance. However, we note that periods in which both turbines will operate simultaneously will be very limited.

1.2 **Fired heating**

Two fired heaters will be operated and run on natural gas.

1.3 **Non-point emissions (fugitive emissions)**

Fugitive emissions are to be expected at a natural gas treatment facility, as described in Appendix B. These are undesirable emissions and necessary steps must be taken to minimize them. These fugitive emissions are expected as a result of valve and flange leaks. Based on Appendix B, sources of non-point emissions are:

- Estimated number of valves: 100
- Estimated number of flanges: 1500
- Estimated number of pumps: 20

Total emissions amount to approximately 10-100 kg/year. The main gas released into the atmosphere is methane.

4.1 1.4 Diesel emissions

Additional sources of emissions that will occur in special cases include the emergency generator and water pumps that run on diesel fuel.

In certain cases, during the natural gas treatment process, the emergency generator will be needed as well as the firewater pumps. These have diesel engines which consume diesel fuel. The emergency generator will mostly be used when the supply of natural gas to the gas turbine is shut off. The firewater pump is used to pump water from the fire-extinguishing tanks and will be used mainly in cases of fire (see Appendix B, Section 14.6.5).

The facility will have two firewater pumps each with a capacity of 0.6 MW and one emergency generator with a capacity of 1MW. Based on Appendix B, the emergency generator is expected to run 15 days a year, and the fire-extinguishing pumps can be expected to run approximately 4.5 days a year.

2. Future emissions (after 2025) (see Appendix B, Section 6.6.2):

In the future, approximately eight years after the gas treatment facility has been in operation, gas delivery rate to the treatment facility is expected to slow down. It will therefore be necessary to add compressors that will boost gas delivery rate during these years. This means that starting at 2025 (estimated date) energy consumption by the facility is expected to change as will pollutant emission rates. Nevertheless, no change in diesel engine emission rates has been reported.

2.1 Feed gas compression

In future years (after 2025) three compressors are expected to be added to the current emission rates and they will run on natural gas. The gas compression process produces emissions from all three trains[7] (see Appendix B, Section 6.6.2).

3. Emissions during malfunction:

Under normal operating conditions, gas emissions from the flare are returned to the system using a flare gas recovery unit (FGRU) as listed in the plan documents in Sections 6.4.8. and 9.4 (Appendix B). Therefore, under normal conditions almost no emissions are expected from the flare (any emissions that occur normally are considered negligible). However, in case of malfunction, excess gas emissions will be released through the flare, depending on the malfunction.

The following are types of malfunctions expected at the HP flare:

- Operational malfunction
- Gas blowdown from the platform topsides
- Gas blowdown from the low temperature separation train (LTS)
- Planned blowdown from high pressure and low pressure pipelines
- Pressure safety valve (PSV) lift
- During future operation (after 2025) a malfunction may occur that will require blowdown of gas in the compressor

The following are types of malfunctions expected at the LP flare:

[7] One segment of the gas treatment process.

- Blowdown from the pressure safety valve (PSV lift)

Tables 4.1.1-1 to 4.1.1-11 below are based on Appendix B and they list the pollutants emitted from the emission sources by operational status (normal, future, after 2025, and malfunction). In cases where emission rates exceed TA Luft 2002 recommended rates, emission rates appearing in TA Luft 2002 were used. Note that the entire compound is located 20m above sea level. This elevation was taken into account when calculating pollutant dispersal using the model.

- Tables 4.1.1-1 to 4.1.1-6 describe emission sources and their expected pollutants for the years 2016-2025 under normal operating conditions. Under these conditions diesel engine emissions are included (emergency generator and fire-extinguishing water pumps).
- Tables 4.1.1-7 to 4.1.1-8 describe emissions and their expected pollutants during future years (after 2025).
- Tables 4.1.1-9 to 4.1.1-10 describe emissions and their expected pollutants when various malfunctions occur.

The following tables contain data and emission rates for each source:

➢ **<u>Expected emissions during 2016-2024 under normal operating conditions</u>**

Point emissions:

<u>Table 4.1.1-1: Emissions from power plants (power generation)</u>

Pollutant	Power plant 1 (kg/hour)	Power plant 2 (kg/hour)
NO_x	0.74	0.74
SO_2	0.03	0.03
UHC (as C)	0.01	0.01
Methane	0.01	0.01
VOC	0.01	0.01
CO	0.04	0.04
N_2O	0.01	0.01
CO_2	7833	7833

Table4.1.1-2: Power plant stack data

Parameter	Units	Power plant 1	Power plant 2
Temperature	°C	478.0	478.0
Stack height	m	20	20
Stack diameter	m	1.1	1.1
Emission rate	m/s	140.3	140.3

Table4.1.1-3: Fired heater emissions

Pollutant	Fire heater 1 (kg/hour)	Fire heater 2 (kg/hour)
NOx[8]	1.8	1.8
SO_2	0.07	0.07
CO_2	6120	6120

Table 4.1.1-4: Fired heater data

Parameter	Units	Fire heater 1	Fire heater 2
Temperature	°C	213.8	213.8
Stack height	m	40	40
Stack diameter	m	0.7	0.7
Emission rate	m/s	41.8	41.8

Table4.1.1-5: Diesel engine emissions

Pollutant	Emergency generator (kg/hour)	Fire pump 1 (kg/hour)	Fire pump 2 (kg/hour)
NOx[9]	1.8	1.8	1.8
SO_2	0.02	0.01	0.01
UHC (as C)	1.0	0.34	0.34
V0C	0.38	0.23	0.23
C0	3.3	2.0	2.0
N_20	7.90	4.74	4.74
Particulates[10]	0.2	0.2	0.2
CO_2	698.5	419.1	419.1

[8] According to TA Luft 2002 guidelines – fourth category of general guidelines for limiting emissions of non-organic gases (Section 5.2.4).
[9]According to TA Luft 2002 guidelines – fourth category of general guidelines for limiting emissions of non-organic gases (Section 5.2.4).
[10]According to TA Luft 2002 guidelines – general guidelines for limiting emissions particulates in emission gases (Section 5.2.1).

Table4.1.1-6: Diesel engine data

Parameter	Units	Emergency generator	Fire pump 1	Fire pump 2
Capacity	kW	1000	600	600
Workdays per year	days	15	4.5	4.5
Temperature[11]	°C	405.5	412.4	412.4
Stack height	m	3	6	6
Stack diameter	m	0.1	0.2	0.2
Emission rate	m/s	25	25	25

Fugitive emissions:

Expected fugitive emissions under normal operating conditions are:

27 kg/hour of methane from the gas treatment facility.

➢ **Expected emissions in the future after 2025 under normal operating conditions**

Point emissions:

Table 4.1.1-7: Emissions during the years after 2025

Pollutant	Heating process		Gas compressions process			Power plant 1 (kg/hour)	Power plant 2 (kg/hour)
	Heater 2 (kg/hour)	Heater 1 (kg/hour)	Train 1 (kg/hour)	Train 2 (kg/hour)	Train 3 (kg/hour)		
NOx	1.8	1.8[12]	1.19	1.19	1.19	0.94	0.94
SO_2	0.07	0.07	0.05	0.05	0.05	0.04	0.04
UHC (as C)	0	0	0.02	0.02	0.02	0.02	0.02
Methane	0	0	0.01	0.01	0.01	0.01	0.01
VOC	0	0	0.01	0.01	0.01	0.01	0.01
CO	0	0	0.06	0.06	0.06	0.05	0.05
N2O	0	0	0.02	0.02	0.02	0.02	0.02
Particulates	0	0	0	0	0	0	0
CO_2	5185	5185	3332	3332	3332	8175	8175

[11] Estimated values.

[12] According to TA Luft 2002 guidelines – general guidelines for limiting emissions particulates in emission gases (Section 5.2.1).

Table 4.1.1-8: Emission-source data during future years (after 2025)

Parameter	Heater 2	Heater 1	Train 3	Train 2	Train 1	Power plant 1	Power plant 2
Stack height (m)	40	40	20	20	20	20	20
Stack diameter (m)	0.7	0.7	0.9	0.9	0.9	1.1	1.1
Emission rate (m/s)	36.6	36.6	123.1	123.1	123.1	142.7	142.7
Temperature (°C)	203.0	203.0	480.5	480.5	480.5	480.5	490.5

Fugitive emissions:

37 kg/hour methane.

➢ Expected emissions during malfunctions

Table 4.1.1-9: Emission data for HP and LP flares in case of malfunction

	LP Flare	HP Flare								
Malfunction type	PSV lift	PSV lift	Blowdown from high-pressure pipeline Blowdown from low-pressure pipeline		Low temperature blowdown from train		Blowdown from platform topside		Operational malfunction
No. occurrences per year	3	6	4		3		2		3
Emission rate	regular emissions	regular emissions	varying emissions		varying emissions		varying emissions		regular emissions
Point in time			3 days	up to 3 days	15 minutes	up to 15 minutes	15 minutes	up to 15 minutes	up to 10 days
Emission duration (days)	0.08	0.08							10
CO_2 (kg/hour)	48413	1291020	38127	46009	8069	125068	80689	1347502	258204
CO (kg/hour)	116	3089	19	110	19	299	193	3224	618
NO_x (kg/hour)	21	553	16	20	3	54	35	578	111
N_2O (kg/hour)	1	37	1	1	0	4	2	39	7
SO_2 (kg/hour)	0	6	0	0	0	1	0	6	1
CH_4 (kg/hour)	173	4611	136	164	29	447	288	4813	922
VOC ((kg/hour)	173	4611	136	164	29	447	288	4813	922

- During the years following 2025, in addition to the malfunction cases listed in Table 4.1.1-9, a malfunction may also occur that will require compressor blowdown via the HP flare, as listed in Table 4.1.1-10.

Table 4.1.1-10: Emission data for HP flare in cases of compressor blowdown after 2025

Type of malfunction	Blowdown Compressor	
No. occurrences a year	2	
Emission rate	Varying	
Point in time	15 minutes	up to 15 minutes
CO_2 (kg/hour)	8069	165418
CO (kg/hour)	19	396
NO_x (kg/hour)	3	71
N_2O (kg/hour)	0	5
SO_2 (kg/hour)	0	1
CH_4 (kg/hour)	29	591
VOC (kg/hour)	29	591

Table 4.1.1-11: HP and LP flare data according to type of malfunction

	LP Flare	HP Flare								
Parameter	Blowdown from PSV	Blowdown from PSV	Blowdown from high-pressure pipeline and blowdown from low-pressure pipeline		Compressor blowdown	Blowdown from train at low temperatures		Blowdown from platform topside		Operational malfunction
Flare diameter (m)	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Emission rate (m/s)	90	225.0	6.6	8	28.5	1.4	21.8	14.1	234.8	45.0
Temperature (°C)	1600	1200	1200	1200	1200	1200	1200	1200	1200	1200
Stack height (m)	90	90	90	90	90	90	90	90	90	90

Figure 4.1.1-1 describes emission sources according to the operation types of gas treatment facility. Extreme cases of malfunction appearing in the illustration are the most extreme cases of malfunction of all cases described in Table 4.1.1-9. These are the only cases that were taken into account when examining the impact of malfunction conditions on the environment. This examination was conducted using pollutant dispersion models and results are provided later in this report.

4.1.2 Emissions impact

Impact of emissions on air quality in the vicinity of the northern and southern compounds under normal operating conditions and normal future conditions (2025 and later), as well as results of the model, are described in Section 4.1.4, below.

4.1.3 Planned measures for reducing emissions

At this stage of the Plan we cannot recommend best available technologies to reduce environmental emissions because it is impossible to predict which technologies will be available in 3 to 4 years from now; optimal technologies available today may be obsolete in the future. Nevertheless, it is possible to recommend principles for emissions reduction rather than specific technologies for implementing it.

These are the fundamental guidelines for reducing emissions in a natural gas treatment facility:

– *Flare emissions reduction technology*

Use a technology that recovers emission gases and returns them into the system (FGRU) described in Sections 6.4.8 and 9.4 in Appendix B. This technology can almost completely prevent flare emissions. Although some emissions are possible when using FGRU technology they are considered negligible.

– *Technologies for reducing emissions from installations that burn liquid or gaseous fuel*

Emission rates from all installations that emit combustion gases must be compatible with the emission rates listed in TA Luft 2002 or any other current standard that will be adopted by the Ministry for Environmental Protection. In addition to the requirement for complying with the standards, these installations must be installed with the best available emission-reducing technologies (BAT).

– *Technologies for reducing fugitive emissions*

During normal operations of a gas treatment facility fugitive emissions may be expected from the equipment and from connections in the pipelines, as described in Section 4.1.8, below. To minimize these emissions, the following measures must be implemented:

- Reduce as far as possible the number or flanges (for example, by welding).
- Ongoing maintenance of flanges and valves.
- Operate control systems to identify leaks. Control system activation and

their frequency must comply with the guidelines appearing in the relevant BREF[18] documents.

4.1.4 Calculating pollutant dispersion

Pollutant dispersion is calculated for routine emissions in coordination with the Ministry for Environmental Protection using AERMOD software within a 10km range around the emission source (the Plan), which is the approximate impact range of the Plan on the environment.

The area examined for pollutant concentrations is onshore only (which is a populated area).

Emission sources are the northern and southern compounds. For this report the environmental impact was examined separately for each compound.

<u>Defining Receptors</u>

For this model, 1155 receptors were defined, as listed below (Figure 4.1.4-1):

Dimensions of the receptor grid were 13.5km from north to south and 5km from east to west (the sea was not considered a part of the receptor grid). The distance between receptors was 250m.

Additionally, several individual receptors were selected in each of the compounds, as follows:

List of receptors in the northern compound:

Locality	Coordinates
Caesarea	191050 / 713305
Sdot Yam	190120 / 710965
Jissr a-Zarka	191834 / 715699
Neveh Haim	191372 / 705984
Hadera	192574 / 704836
Givat Olga	189431 / 704942
Or Akiva	192645 / 712884
Beit Hanania	193160 / 714975

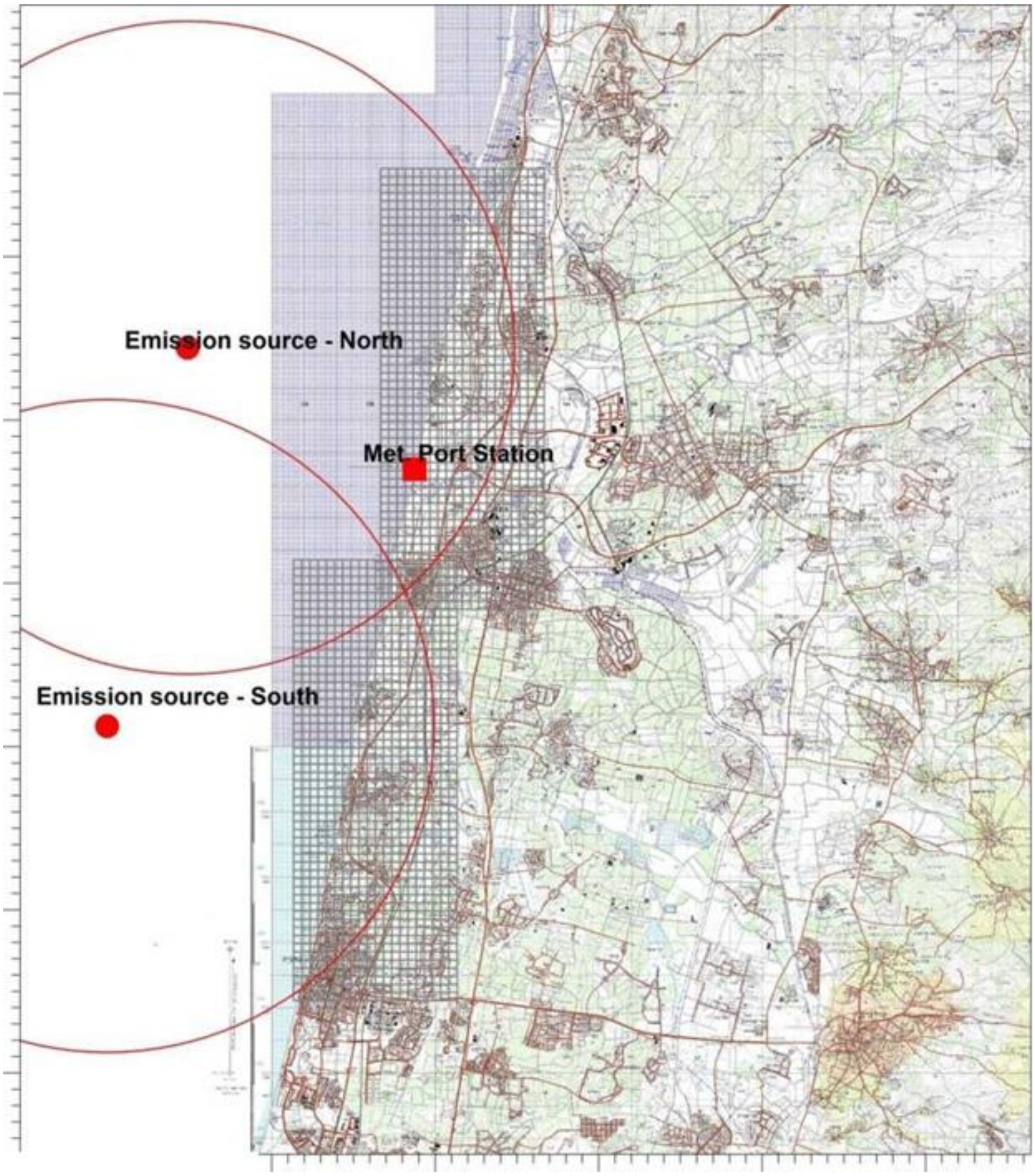
18 Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries, February, 2003

List of receptors in the southern compound:

Locality	Coordinates
Netanya north	187200 / 694800
Netanya south	187601 / 693984
Havazelet Hasharon	187004 / 696464
Beit Herut	187810 / 698504
Kfar Vitkin	188855 / 698743
Givat Shapira	188450 / 696114
Mikhmoret	188068 / 701509

The meteorological data used in the model were those from the Hadera Port meteorological station. The meteorological data file was supplied by Dr. Ilan Starr, a meteorologist by profession. The meteorological data were entered into the model according to the configuration listed in Appendix E.

Figure 4.1.4-1: Location of receptor grids in the northern and southern compounds



The pollutant dispersion model was applied to the following pollutants:

- Nitrogen oxides, NO_X
- Sulfur dioxide, SO_2
- Particulate material, PM

The model was run only for the listed pollutants because there are no air quality regulations for the other emitted pollutants.

Modeling methodology:

The goal of running the model was to examine the impact of emissions on the environment from operating a natural gas treatment facility. To do this, the model was applied to several scenarios, separately for each pollutant; once from the natural gas treatment facility and the diesel-operated installations (the Plan) and once from the Plan and the background (background = pollutant emissions from the environment when the facility is not in operation) together.

Background conditions in the areas associated with the marine compounds have already been presented in the environmental impact reports for this Plan (Chapters 1 and 2 for onshore environment and Chapters 3-5 for the Meretz WWTP), except the background conditions for the particulate pollutant that are presented later in this document.

As noted, the model was applied to the worst case scenario in which both the gas treatment installations and the diesel engines are in operation.

Background emissions

There were two scenarios for background emissions:

- Emissions from factories and vehicles within a 10km radius of the Plan
- Emissions from factories only (point emissions)

When the model was applied to background emissions from factories (point emissions) and vehicles, in the case of NO_X, vehicles were found to have a large impact on pollutant concentrations. Therefore, to compare model results for Plan emissions with and without background emissions, when applying the model to NO_X, no vehicular emissions were entered into the model. In the other cases (modeling particulate pollutants), emissions from the Plan and background were calculated for two scenarios: one for Plan and background emissions with vehicles, and a second scenario for Plan and background emissions without vehicles.

For the future situation (after 2025) gas compressors were added to the gas treatment facilities, adding to the total emissions. To examine the effect of this increase the model was applied to scenarios for emissions from natural gas operated facilities after 2025. Also for this mode of operation, the most stringent case was used in which both gas treatment facilities and diesel engines are in operation.

Model results shown in the tables below list the maximum values for that cycle and, for each receptor, maximum values of several averaging times and their percentage of threshold values from the 2011 Air Quality Regulations. Values that exceed the thresholds and their percent over the threshold are highlighted in red.

Scenario definitions

The model was applied to the following scenarios:

Current conditions (background) – Scenario 1

- Emissions from factories and vehicles within a 10km radius of the plan
- Emissions from factories only (point emissions)

Normal scenario (2016-2024) – Scenario 2

- Emissions from natural gas treatment facilities and diesel engines
- Background (point emissions) and emissions from natural gas operated facilities and diesel engines

Future normal scenario for after 2025 – Scenario 3

- Emissions from natural gas operated facilities and diesel engines

Tables 4.1.4-1 to 4.1.4-11 show model results for the <u>northern compound</u>.

Tables 4.1.4-12 to 4.1.4-22 show model results for the <u>northern compound</u>.

<u>Model results for the northern compound</u>

<u>Scenario 1: current conditions – background</u>

Model results for NO_X – see Section 1.4.4 in Tables 1.4.4-17 and 1.4.4-18.

Model results for SO_2 – see Section 1.4.4 in Table 1.4.4-20.

Emissions from factories (excluding the natural gas treatment facility) and vehicles within a 10km radius of the Plan

Table 4.1.4-1: Model results for particulate pollutants (PM) – background (point emissions and vehicles)

				Target / Environment 300		Target / Environment 300		Target / Environment 200		Target / Environment 200		Target / Environment 75
	X	Y	3-hour concentration mcg/m3	Percent of 3-hour value - %	3-hour concentration - 2nd concentration mcg/m3	Percent of 3-hour value - %	Highest daily value mcg/m3	Percent of daily value - %	Second daily environment value mcg/m3	Percent of daily environment value - %	Highest annual concentration mcg/m3	% annual environment value
of alues g	192585	717697	582.4	194.1	563.9	188.0	86.4	43.2	81.0	40.5	10.3	13.8
	191050	713305	27.6	9.2	17.6	5.9	3.8	1.9	3.4	1.7	0.3	0.4
a	190120	710965	25.0	8.3	23.8	7.9	7.4	3.7	7.2	3.6	0.9	1.2
rka	191834	715699	31.5	10.5	22.8	7.6	4.1	2.1	3.4	1.7	0.3	0.4
aim	191372	705984	29.1	9.7	25.5	8.5	6.1	3.0	4.8	2.4	0.6	0.8
	192574	704836	19.6	6.5	17.7	5.9	3.8	1.9	2.6	1.3	0.4	0.5
a	189431	704942	33.8	11.3	33.6	11.2	4.8	2.4	4.5	2.3	0.4	0.6
	192645	712884	30.9	10.3	28.2	9.4	5.2	2.6	4.3	2.1	0.8	1.0
ania	193160	714975	20.3	6.8	19.7	6.6	3.4	1.7	3.2	1.6	0.5	0.7

Emissions from factories only (excluding the natural gas facility) – point emissions

Table 4.1.4-2: Model results for particulate pollutants (PM) – background (point emissions)

				Target / Environment 300		Target / Environment 300		Target / Environment 200		Target / Environment 200		Target / Environment 75
	X	Y	3-hour concentration mcg/m^3	Percent of 3-hour value - %	3-hour concentration - 2nd concentration mcg/m3	Percent of 3-hour value - %	Highest daily value mcg/m3	Percent of daily value - %	Second daily environment value mcg/m3	Percent of daily environment value - %	Highest annual concentration mcg/m3	% annual environment value
ighest ily lues	190835	711447					43.9	21.9	43.3	21.7	4.0	5.3
ighest hour lues	191335	711697	156.9	52.3	129.8	43.3						
	191050	713305	13.1	4.4	12.4	4.1	3.0	1.5	2.0	1.0	0.1	0.2
	190120	710965	24.7	8.2	23.6	7.9	7.4	3.7	7.1	3.6	0.7	1.0
	191834	715699	9.1	3.0	6.4	2.1	1.3	0.7	1.3	0.7	0.1	0.1
	191372	705984	8.6	2.9	8.3	2.8	2.1	1.1	1.7	0.8	0.1	0.2
	192574	704836	19.0	6.3	16.5	5.5	3.4	1.7	2.1	1.1	0.2	0.2
	189431	704942	6.3	2.1	5.4	1.8	1.3	0.7	1.2	0.6	0.1	0.1
	192645	712884	16.4	5.5	13.3	4.4	3.7	1.9	3.5	1.7	0.3	0.3
	193160	714975	12.4	4.1	8.5	2.8	2.2	1.1	2.2	1.1	0.1	0.1

Scenario 2: Normal scenario (2016-2024) emissions from natural gas treatment facilities and diesel engines

Emissions from natural gas treatment facilities and diesel engines

Table 4.1.4-3: Model results for nitrogen oxides NO_X (emissions from natural gas treatment facilities and diesel engines)

				Environment 940		Environment 940		Environment 560		Environment 560		Target 30
	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value - %	Second highest half hour concentration (mcg/m³)	Percent of half hour value - %	Highest daily concentration (mcg/m³)	Percent of daily environment value - %	Highest daily concentration (mcg/m³)	Percent of daily environment. value - %	Highest annual concentration (mcg/m³)	Percent of annual target - %
es for aging	191335	711197									0.1	0.3
es for d ging	191085	710197	47.4	5.0	47.0	5.0	3.2	0.6	3.1	0.5		
	191050	713305	8.4	0.9	8.0	0.8	1.0	0.2	1.0	0.2	0.0	0.2
	190120	710965	8.4	0.9	8.0	0.9	1.0	0.2	1.0	0.2	0.0	0.1
a	191834	715699	10.5	1.1	9.1	1.0	1.1	0.2	1.0	0.2	0.0	0.1
n	191372	705984	7.6	0.8	7.5	0.8	0.9	0.2	0.7	0.1	0.0	0.1
	192574	704836	25.9	2.8	25.9	2.8	1.6	0.3	1.6	0.3	0.0	0.2
	189431	704942	8.6	0.9	8.5	0.9	0.8	0.1	0.7	0.1	0.0	0.1
	192645	712884	7.4	0.8	7.4	0.8	0.8	0.1	0.8	0.1	0.0	0.1
a	193160	714975	9.7	1.0	7.7	0.8	0.9	0.2	0.8	0.1	0.0	0.1

Table 4.1.4-4: Model results for sulfur dioxide SO_2 (emissions from natural gas treatment facilities and diesel engines)

Standard					Target 500		Target 500		Env. 350		Env. 350		Env. 350		Env. 125	Target 20		Env. 125	Target 20		Target 60
No.	Location	X	Y	Highest 10-minute concentration (mcg/m^3)	Percent of 10-minute target value - %	Highest 10-minute concentration – second concentration (mcg/m^3)	Percent of 10-minute environment. value - %	Highest hourly concentration (mcg/m^3)	Percent of hourly environment. value - %	Second Highest hourly concentration (mcg/m^3)	Percent of environment value	Hourly 99.9 percentile (mcg/m^3)	Percent of hourly environment. value - %	Highest daily concentration (mcg/m^3)	Percent of daily environment. value - %	Percent of daily target. value	Second daily concentration (mcg/m^3)	Percent of daily environment. value - %	Percent of daily target. value	Highest annual concentration (mcg/m^3)	Percent of annual target - %
	Location of highest values for 99.9 percentile averaging values	191085	710197									0.1	0.0								
	Location of highest values for daily averaging values	188335	709697											0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
	Location of highest values for hourly and 2nd 10-minute averaging values	192335	710697			0.5	0.1			0.3	0.1										
	Location of highest values for hourly and 10-minute averaging values	188335	714447	0.7	0.1			0.5	0.1												
1.	Caesarea	191050	713305	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
2.	Sdot Yam	190120	710965	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
3.	Jissr a-Zarka	191834	715699	0.5	0.1	0.2	0.0	0.3	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
4.	Neveh Haim	191372	705984	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
5.	Hadera	192574	704836	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
6.	Givat Olga	189431	704942	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
7.	Or Akiva	192645	712884	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
8.	Beit Hanania	193160	714975	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0

Table 4.1.4-5: Model results for particulate pollutants PM (diesel engine emissions only[19])

Standard					Target/ env. 300		Target/ env. 300		Target/ env. 200		Target/ env. 200		Target/ env. 75
No.	Location	X	Y	3-hour concentration mcg/m³	Percent of 3-hour value	3-hour concentration - 2nd concentration mcg/m³	Percent of 3-hour value	Highest daily value mcg/m³	Percent of daily value	Second daily env. value mcg/m³	Percent of daily value	Highest annual[20] concentration mcg/m³	% annual env. value
	Location of highest values for 3-hour and daily averaging values	191085	710197	1.8	0.6	1.6	0.5	0.3	0.2	0.3	0.2		
	Location of highest values for annual averaging values											0.0	0.0
1.	Caesarea	191050	713305	0.5	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0
2.	Sdot Yam	190120	710965	0.5	0.2	0.5	0.2	0.1	0.1	0.1	0.1	0.0	0.0
3.	Jissr a-Zarka	191834	715699	0.5	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0
4.	Neveh Haim	191372	705984	0.5	0.2	0.4	0.1	0.1	0.0	0.1	0.0	0.0	0.0
5.	Hadera	192574	704836	1.4	0.5	1.4	0.5	0.2	0.1	0.2	0.1	0.0	0.0
6.	Givat Olga	189431	704942	0.5	0.2	0.5	0.2	0.1	0.0	0.1	0.0	0.0	0.0
7.	Or Akiva	192645	712884	0.5	0.2	0.4	0.1	0.1	0.0	0.1	0.0	0.0	0.0
8.	Beit Hanania	193160	714975	0.4	0.1	0.4	0.1	0.1	0.0	0.1	0.0	0.0	0.0

[19] Diesel engines are the only source of particulates emissions at a natural gas treatment facility
[20] Annual averaging values that were calculated were negligible and were therefore recorded as 0

Normal scenario (2016-2024) – Background emissions and emissions from natural gas treatment facilities and diesel engines

Table 4.1.4-6: Model results for nitrogen oxides NO_X (background emissions (point sources) from natural gas treatment facilities and diesel engines)

Standard					Environment 940		Environment 940		Environment 560		Environment 560		Targe
o.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percen annual ta
	Location of highest values for annual and daily averaging values	192585	707447					62.8	11.2	58.3	10.4	8.2	27.3
	Location of highest values for 2nd half hour averaging values	193335	708947			**976.0**	**103.8**						
	Location of highest values for highest half hour averaging values	193335	708697	**1042.7**	**110.9**								
	Caesarea	191050	713305	45.9	4.9	36.2	3.9	4.6	0.8	4.5	0.8	0.5	1.5
	Sdot Yam	190120	710965	56.3	6.0	55.5	5.9	4.0	0.7	3.7	0.7	0.7	2.3
	Jissr a-Zarka	191834	715699	29.2	3.1	27.7	2.9	2.6	0.5	2.3	0.4	0.3	1.1
	Neveh Haim	191372	705984	82.5	8.8	70.8	7.5	9.8	1.7	8.1	1.4	0.7	2.2
	Hadera	192574	704836	415.8	44.2	385.6	41.0	17.6	3.1	15.4	2.7	0.7	2.5

	Givat Olga	189431	704942	54.5	5.8	47.7	5.1	4.3	0.8	4.3	0.8	0.4	1.3
	Or Akiva	192645	712884	43.0	4.6	40.9	4.3	2.8	0.5	2.8	0.5	0.4	1.5
	Beit Hanania	193160	714975	34.2	3.6	31.1	3.3	2.8	0.5	2.7	0.5	0.3	1.2

Table 4.1.4-7: Model results for sulfur dioxide SO_2 (background emissions (point sources) from natural gas treatment facilities and diesel engines)

Standard					Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Target 60
No.	Location	X	Y	Highest 10-minute concentration (mcg/m³)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest 2nd hourly concentration (mcg/m³)	Percent of env. value	Hourly 99.9 percentile (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for daily and annual averaging values	192585	707447											**150.7**	**120.6**	**753.5**	**138.4**	**110.8**	**692.2**	18.4	30.7
	Location of highest values for 2nd hourly and 10-minute averaging values	193335	708947			**2821.7**	**564.3**			**1971.9**	**563.4**										0.0
	Location of highest values for highest hourly and 10-minute averaging values	193335	708697	**3014.3**	**602.9**			**2106.5**	**601.8**			**355.5**	**101.6**								0.0
1.	Caesarea	191050	713305	132.9	26.6	94.9	19.0	92.9	26.5	66.3	19.0	36.4	10.4	9.1	7.3	45.6	6.9	5.5	34.3	0.5	0.8
2.	Sdot Yam	190120	710965	162.7	32.5	160.3	32.1	113.7	32.5	112.0	32.0	50.8	14.5	8.4	6.7	41.8	8.0	6.4	40.0	0.8	1.4
3.	Jissr a-Zarka	191834	715699	86.0	17.2	80.6	16.1	60.1	17.2	56.4	16.1	18.1	5.2	4.9	3.9	24.5	3.3	2.7	16.7	0.3	0.5
4.	Neveh Haim	191372	705984	238.4	47.7	176.3	35.3	166.6	47.6	123.2	35.2	93.3	26.7	22.8	18.3	114.2	17.8	14.3	89.1	1.1	1.8
5.	Hadera	192574	704836	1202.2	240.4	1115.0	223.0	840.1	240.0	779.2	222.6	112.5	32.1	40.2	32.2	201.0	35.2	28.2	176.1	1.1	1.8
6.	Givat Olga	189431	704942	137.8	27.6	121.6	24.3	96.3	27.5	85.0	24.3	57.2	16.4	9.2	7.4	46.2	8.7	7.0	43.7	0.6	1.0
7.	Or Akiva	192645	712884	105.8	21.2	95.4	19.1	73.9	21.1	66.7	19.1	26.8	7.7	5.0	4.0	24.8	4.2	3.4	21.2	0.4	0.7
8.	Beit Hanania	193160	714975	100.2	20.0	83.1	16.6	70.0	20.0	58.1	16.6	20.8	5.9	4.5	3.6	22.6	4.4	3.6	22.2	0.3	0.5

Table 4.1.4-8: Model results for particulate pollutants PM (background emissions (point sources) and diesel engines)

Standard					Target/ env. 300		Target/ env. 300		Target/ env. 200		Target/ env. 200		Target/ env. 75
No.	Location	X	Y	3-hour concentration mcg/m³	Percent of 3-hour value	3-hour concentration - 2nd concentration mcg/m³	Percent of 3-hour value	Highest daily value mcg/m³	Percent of daily value	Second daily env. value mcg/m³	Percent of daily value	Highest annual concentration mcg/m³	% annual env. value
	Location of highest values for annual and daily averaging values	190835	711447					43.9	21.9	43.3	21.7	4.0	5.3
	Location of highest values for 3-hour averaging values	191335	711697	156.9	52.3	130.1	43.4						
1.	Caesarea	191050	713305	13.1	4.4	12.4	4.1	3.0	1.5	2.0	1.0	0.1	0.2
2.	Sdot Yam	190120	710965	24.7	8.2	23.6	7.9	7.4	3.7	7.1	3.6	0.7	1.0
3.	Jissr a-Zarka	191834	715699	9.1	3.0	6.4	2.1	1.3	0.7	1.3	0.7	0.1	0.1
4.	Neveh Haim	191372	705984	8.6	2.9	8.3	2.8	2.1	1.1	1.7	0.8	0.2	0.2
5.	Hadera	192574	704836	19.0	6.3	16.6	5.5	3.4	1.7	2.1	1.1	0.2	0.2
6.	Givat Olga	189431	704942	6.3	2.1	5.5	1.8	1.3	0.7	1.2	0.6	0.1	0.1
7.	Or Akiva	192645	712884	16.4	5.5	13.3	4.4	3.7	1.9	3.5	1.7	0.3	0.3
8.	Beit Hanania	193160	714975	12.4	4.1	8.5	2.8	2.2	1.1	2.2	1.1	0.1	0.1

Table 4.1.4-9: Model results for particulate pollutants PM (background emissions (point sources and vehicles) and diesel engines)

Standard					Target/ env. 300		Target/ env. 300		Target/ env. 200	env	Target/ env. 200		Target/ env. 75
No.	Location	X	Y	3-hour concentration mcg/m3	Percent of 3-hour value	3-hour concentration - 2nd concentration mcg/m3	Percent of 3-hour value	Highest daily value mcg/m3	Percent of daily value	Second daily. value mcg/m3	Percent of env. daily value	Highest annual concentration mcg/m3	% annual env. value
	Location of highest values for all averaging values	192585	717697	**582.4**	**194.1**	**563.9**	**188.0**	86.4	43.2	81.0	40.5	10.3	13.8
1.	Caesarea	191050	713305	27.6	9.2	17.6	5.9	3.8	1.9	3.4	1.7	0.3	0.4
2.	Sdot Yam	190120	710965	25.0	8.3	23.8	7.9	7.4	3.7	7.2	3.6	0.9	1.2
3.	Jissr a-Zarka	191834	715699	31.5	10.5	22.8	7.6	4.2	2.1	3.4	1.7	0.3	0.4
4.	Neveh Haim	191372	705984	29.1	9.7	25.5	8.5	6.1	3.0	4.8	2.4	0.6	0.8
5.	Hadera	192574	704836	19.6	6.5	17.7	5.9	3.8	1.9	2.6	1.3	0.4	0.5
6.	Givat Olga	189431	704942	33.8	11.3	33.6	11.2	4.8	2.4	4.5	2.3	0.4	0.6
7.	Or Akiva	192645	712884	30.9	10.3	28.2	9.4	5.2	2.6	4.3	2.1	0.8	1.0
8.	Beit Hanania	193160	714975	20.3	6.8	19.65228	6.6	3.4	1.7	3.2	1.6	0.5	0.7

Scenario 3: Future normal scenario (after 2025)

Emissions from natural gas operated facilities and diesel engines

Table 4.1.4-10: Model results for nitrogen oxide NO_X (emissions from natural gas operated facilities and diesel engines) after 2025

Standard					Environment 940		Environment 940		Environment 560		Environ ment 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for annual averaging values	191335	711197									0.1	0.3
	Location of highest values for 2nd half hour and daily averaging values	191085	710197	47.4	5.0	47.0	5.0	3.3	0.6	3.1	0.5		
1.	Caesarea	191050	713305	8.4	0.9	8.0	0.9	1.0	0.2	1.0	0.2	0.1	0.2
2.	Sdot Yam	190120	710965	9.2	1.0	8.4	0.9	1.1	0.2	1.1	0.2	0.0	0.2
3.	Jissr a-Zarka	191834	715699	12.3	1.3	9.1	1.0	1.1	0.2	1.1	0.2	0.0	0.2
4.	Neveh Haim	191372	705984	8.8	0.9	7.6	0.8	0.9	0.2	0.7	0.1	0.0	0.1
5.	Hadera	192574	704836	25.9	2.8	25.9	2.8	1.6	0.3	1.6	0.3	0.0	0.2
6.	Givat Olga	189431	704942	8.6	0.9	8.6	0.9	0.8	0.1	0.7	0.1	0.0	0.2
7.	Or Akiva	192645	712884	7.4	0.8	7.4	0.8	0.8	0.1	0.8	0.1	0.0	0.1
8.	Beit Hanania	193160	714975	9.7	1.0	7.8	0.8	0.9	0.2	0.8	0.1	0.0	0.1

Table 4.1.4-11: Model results for sulfur dioxide SO_2 (emissions from natural gas operated facilities and diesel engines) after 2025[21]

Standard					Target 500		Target 500		Env. 350		Env. 350		Env. 350		Env. 125	Target 20		Env. 125	Target 20		Env. 60
No.	Location	X	Y	Highest 10-minute concentration (mcg/m³)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest second hourly concentration (mcg/m³)	Percent of env. value	Hourly 99.9 percentile (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m³)	Percent of annual env.
	Location of highest values for 2nd hourly and 10-minute averaging values	192335	710697			0.5	0.1			0.3	0.1										
	Location of highest values for highest hourly and daily averaging values	191085	710197	0.5	0.1			0.4	0.1			0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.1		
1.	Caesarea	191050	713305	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
2.	Sdot Yam	190120	710965	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
3.	Jissr a-Zarka	191834	715699	0.3	0.1	0.1	0.0	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
4.	Neveh Haim	191372	705984	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
5.	Hadera	192574	704836	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
6.	Givat Olga	189431	704942	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.	Or Akiva	192645	712884	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.	Beit Hanania	193160	714975	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[21] Negligible concentrations were recorded as 0

Model results for the southern compound

1. Scenario 1: current conditions – background

Model results for NO_X – see Chapter 1.4.4 Ttables 1.4.4-27 and 1.4.4-28, below.

Model results for SO_2 - see Chapter 1.4.4 Table 1.4.4-30, below.

Model results for particulate pollutants see Chapter 4.1.4 Tables 4.1.4-1 and 4.1.4-2 for the report on environmental impact – Meretz WWTP.

Scenario 2: Future normal scenario (2016-2024) – emissions from natural gas treatment facilities and diesel engines

Emissions from natural gas treatment facilities and diesel engines

Table 4.1.4-12: Model results for nitrogen oxide NO_X (emissions from natural gas treatment facilities and diesel engines

Standard					Env. 940		Env. 940		Env. 560		Env. 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for annual averaging values	188923	700710									0.1	0.2
	Location of highest values for 2nd half hour averaging values	187601	693984			59.7	6.4						
	Location of highest values for half hour and daily averaging values	188173	694710	66.4	7.1			3.0	0.5	2.2	0.4		
1.	Netanya north	187200	694800	10.1	1.1	9.9	1.1	0.9	0.2	0.8	0.1	0.0	0.1
2.	Netanya south	187601	693984	59.8	6.4	59.7	6.4	2.2	0.4	2.2	0.4	0.1	0.2
3.	Havazelet Hasharon	187004	696464	34.8	3.7	34.7	3.7	2.5	0.5	1.8	0.3	0.1	0.2
4.	Beit Herut	187810	698504	10.2	1.1	10.0	1.1	1.1	0.2	0.9	0.2	0.0	0.2
5.	Kfar Vitkin	188855	698743	10.0	1.1	9.8	1.0	1.1	0.2	0.9	0.2	0.0	0.2
6.	Givat Shapira	188450	696114	44.2	4.7	37.6	4.0	1.6	0.3	1.6	0.3	0.0	0.2
7.	Mikhmoret	188068	701509	10.2	1.1	8.4	0.9	1.0	0.2	1.0	0.2	0.0	0.1

Table 4.1.4-13: Model results for sulfur dioxide SO_2 (emissions from natural gas treatment facilities and diesel engines)

Standard					Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Env. 60
No.	Location	X	Y	Highest 10-minute concentration (mcg/m^3)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m^3)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m^3)	Percent of hourly env. value	Highest second hourly concentration (mcg/m^3)	Percent of env. value	Hourly 99.9 percentile (mcg/m^3)	Percent of hourly env. value	Highest daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m^3)	Percent of annual env.
	Location of highest values for all averaging values	187923	694460									0.1	0.0								
		185673	700710																	0.0	0.0
		185673	698710														0.0	0.0	0.1		
		185673	697710											0.0	0.0	0.2					
		188173	694710			0.5	0.1			0.4	0.1										
		185673	702460	0.7	0.1			0.5	0.1												
	Netanya north	187200	694800	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	Netanya south	187601	693984	0.5	0.1	0.5	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	Havazelet Hasharon	187004	696464	0.4	0.1	0.4	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	Beit Herut	187810	698504	0.4	0.1	0.4	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	Kfar Vitkin	188855	698743	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	Givat Shapira	188450	696114	0.4	0.1	0.3	0.1	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	Mikhmoret	188068	701509	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0

Table 4.1.4-14: Model results for particulate pollutants PM (emissions from diesel engines only[22])

Standard					Target/ env. 300		Target/ env. 300		Target/ env. 200	env	Target/ env. 200		Target/ env. 75
No.	Location	X	Y	3-hour concentration mcg/m³	Percent of 3-hour value	3-hour concentration - 2nd concentration mcg/m³	Percent of 3-hour value	Highest daily value mcg/m³	Percent of daily value	Second daily. value mcg/m³	Percent of env. daily value	Highest annual concentration mcg/m³	% annual env. value
	Location of highest values for all averaging values	187601	693984			1.9	0.6						
		188923	700710									0.0	0.0
		188173	694710					0.3	0.2	0.2	0.1		
		188423	697210	2.3	0.8								
1	Netanya north	187200	694800	0.6	0.2	0.5	0.2	0.1	0.0	0.1	0.0	0.0	0.0
2	Netanya south	187601	693984	1.9	0.6	1.9	0.6	0.2	0.1	0.2	0.1	0.0	0.0
3	Havazelet Hasharon	187004	696464	1.3	0.4	1.1	0.4	0.3	0.1	0.2	0.1	0.0	0.0
4	Beit Herut	187810	698504	0.5	0.2	0.5	0.2	0.1	0.1	0.1	0.1	0.0	0.0
5	Kfar Vitkin	188855	698743	0.5	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0
6	Givat Shapira	188450	696114	1.4	0.5	1.2	0.4	0.2	0.1	0.2	0.1	0.0	0.0
7	Mikhmoret	188068	701509	0.5	0.2	0.5	0.2	0.1	0.1	0.1	0.1	0.0	0.0

[22] Diesel-engines are the only source of particulate emissions at a natural gas treatment facility

Normal scenario (2016-2024) – Background emissions and emissions from natural gas treatment facilities and diesel engines

Table 4.1.4-15: Model results for nitrogen oxides NO_X (background emissions (point sources) and natural gas treatment facilities and diesel engines)

Standard					Env. 940		Env. 940		Env. 560		Env. 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
Location of highest values for all annual averaging values	Location of highest values for annual and daily averaging values	190173	700960					33.0	5.9	29.0	5.2	4.0	13.2
	Location of highest values for half hour averaging values	190173	692210	243.9	25.9	243.8	25.9						
1.	Netanya north	187200	694800	21.8	2.3	20.3	2.2	3.1	0.5	2.2	0.4	0.2	0.8
2.	Netanya south	187601	693984	78.0	8.3	77.1	8.2	5.5	1.0	5.3	0.9	0.5	1.5
3.	Havazelet Hasharon	187004	696464	34.8	3.7	34.7	3.7	2.6	0.5	2.0	0.4	0.2	0.7
4.	Beit Herut	187810	698504	17.1	1.8	17.0	1.8	3.2	0.6	2.0	0.4	0.3	0.9
5.	Kfar Vitkin	188855	698743	18.8	2.0	18.6	2.0	1.9	0.3	1.7	0.3	0.2	0.8
6.	Givat Shapira	188450	696114	44.2	4.7	41.8	4.4	2.5	0.4	2.1	0.4	0.2	0.8
7.	Mikhmoret	188068	701509	16.5	1.8	16.5	1.8	3.5	0.6	2.6	0.5	0.4	1.2

Table 4.1.4-16: Model results for sulfur dioxide SO_2 (background emissions (point sources) and emissions from natural gas treatment facilities and diesel engines)

Standard					Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Env 60
No.	Location	X	Y	Highest 10-minute concentration (mcg/m^3)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m^3)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m^3)	Percent of hourly env. value	Highest 2nd hourly concentration (mcg/m^3)	Percent of hourly env. value	Hourly 99.9 percentile (mcg/m^3)	Percent of hourly env. value	Highest daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m^3)	Percent of annual env.
	Location of highest values for daily and annual averaging values	190173	700960											99.2	79.3	495.8	87.6	70.1	438.2	12.0	20.1
	Location of highest values for highest hourly averaging values	190173	692210	988.8	197.8	988.4	197.7	691.0	197.4	690.7	197.4	323.0	92.3								
1	Netanya north	187200	694800	88.2	17.6	82.0	16.4	61.7	17.6	57.3	16.4	39.3	11.2	9.8	7.9	49.2	7.0	5.6	34.9	0.6	1.1
2	Netanya south	187601	693984	316.6	63.3	313.0	62.6	221.2	63.2	218.7	62.5	103.7	29.6	17.7	14.2	88.7	17.3	13.8	86.3	1.3	2.2
3	Havazelet Hasharon	187004	696464	51.5	10.3	50.6	10.1	36.0	10.3	35.4	10.1	29.9	8.6	6.6	5.3	33.0	5.1	4.1	25.4	0.4	0.7
4	Beit Herut	187810	698504	65.7	13.1	65.7	13.1	45.9	13.1	45.9	13.1	37.0	10.6	8.7	7.0	43.6	5.8	4.6	29.0	0.6	1.1
5	Kfar Vitkin	188855	698743	72.5	14.5	71.5	14.3	50.6	14.5	49.9	14.3	39.1	11.2	5.5	4.4	27.5	5.3	4.2	26.5	0.5	0.9
6	Givat Shapira	188450	696114	169.0	33.8	151.8	30.4	118.1	33.7	106.1	30.3	46.9	13.4	7.6	6.1	38.1	5.9	4.7	29.5	0.6	0.9
7	Mikhmoret	188068	701509	61.4	12.3	61.4	12.3	42.9	12.2	42.9	12.2	41.2	11.8	10.5	8.4	52.7	7.7	6.1	38.4	0.9	1.6

Table 4.1.4-17: Model results for particulate pollutants PM (background emissions (point sources) and diesel engines)

Standard					Target/ env. 300		Target/ env. 300		Target/ env. 200	env	Target/ env. 200		Target/ env 75
No.	Location	X	Y	3-hour concentration mcg/m³	Percent of 3-hour value	3-hour concentration - 2nd concentration mcg/m³	Percent of 3-hour value	Highest daily value mcg/m³	Percent of daily value	Second daily. value mcg/m³	Percent of env. daily value	Highest annual concentration mcg/m³	% annual env. value
	Location of highest values for 3-hour averaging values	190673	695210			92.2	30.7						
	Location of highest values for daily and annual averaging values	190673	696960							16.9	8.4	2.3	3.1
	Location of highest values for daily averaging values	190673	697210					20.7	10.3				
1	Location of highest values for highest 3-hour averaging values	190673	694960	106.6	35.5								
2	Netanya north	187200	694800	10.8	3.6	10.0	3.3	2.1	1.1	1.8	0.9	0.2	0.3
3	Netanya south	187601	693984	16.0	5.3	12.7	3.4	2.7	1.3	2.6	1.3	0.2	0.3
4	Havazelet Hasharon	187004	696464	16.1	5.4	14.2	4.7	2.5	1.2	2.4	1.2	0.2	0.2
5	Beit Herut	187810	698504	22.0	7.3	20.5	6.8	3.4	1.7	3.1	1.6	0.3	0.3
6	Kfar Vitkin	188855	698743	29.4	9.8	22.3	7.4	3.8	1.9	3.6	1.8	0.2	0.3
7	Givat Shapira	188450	696114	15.1	5.0	14.5	4.8	2.7	1.4	2.0	1.0	0.2	0.3
8	Mikhmoret	188068	701509	7.1	2.4	6.1	2.0	1.1	0.6	1.1	0.6	0.1	0.2

Table 4.1.4-18: Model results for particulate pollutants PM (background emissions (point sources and vehicles) and diesel engines)

Standard					Target/ env. 300		Target/ env. 300		Target/ env. 200	env	Target/ env. 200		Target/ env. 75
No.	Location	X	Y	3-hour concentration mcg/m³	Percent of 3-hour value	3-hour concentration - 2nd concentration mcg/m³	Percent of 3-hour value	Highest daily value mcg/m³	Percent of daily value	Second daily. value mcg/m³	Percent of env. daily value	Highest annual concentration mcg/m³	% annual env. value
	Location of highest values for daily averaging values	187923	692960					73.4	36.7				
	Location of highest values for all other averaging values	189423	702960	472.3	157.4	426.6	142.2			65.2	32.6	8.1	10.9
1	Netanya north	187200	694800	26.6	8.9	23.1	7.7	4.0	2.0	3.9	2.0	0.4	0.5
2	Netanya south	187601	693984	19.5	6.5	18.2	6.1	5.2	2.6	3.8	1.9	0.4	0.6
3	Havazelet Hasharon	187004	696464	30.1	10.0	26.8	8.9	4.3	2.2	3.8	1.9	0.4	0.6
4	Beit Herut	187810	698504	43.8	14.6	42.0	14.0	6.1	3.0	5.6	2.8	1.1	1.4
5	Kfar Vitkin	188855	698743	34.3	11.4	29.4	9.8	5.1	2.6	4.8	2.4	0.5	0.7
6	Givat Shapira	188450	696114	25.1	8.4	21.0	7.0	4.5	2.3	4.5	2.2	0.8	1.1
7	Mikhmoret	188068	701509	19.5	6.5	18.9	6.3	2.9	1.4	2.8	1.4	0.3	0.4

Scenario 2: Future normal scenario (after 2025)

Emissions from natural gas operated facilities and diesel engines

Table 4.1.4-19: Model results for nitrogen oxides NO_X (emissions from natural gas operated facilities and diesel engines) after 2025

Standard					Env. 940		Env. 940		Env. 560		Env. 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for all annual averaging values	187601	693984			59.8	6.4						
		188923	700710									0.1	0.3
		188173	694710	66.4	7.1			3.0	0.5	2.2	0.4		0.0
1.	Netanya north	187200	694800	10.1	1.1	9.9	1.1	0.9	0.2	0.8	0.1	0.0	0.2
2.	Netanya south	187601	693984	59.8	6.4	59.8	6.4	2.2	0.4	2.2	0.4	0.1	0.2
3.	Havazelet Hasharon	187004	696464	34.8	3.7	34.7	3.7	2.5	0.5	1.8	0.3	0.1	0.2
4.	Beit Herut	187810	698504	10.8	1.1	10.2	1.1	1.1	0.2	1.0	0.2	0.1	0.2
5.	Kfar Vitkin	188855	698743	10.0	1.1	9.8	1.0	1.1	0.2	0.9	0.2	0.1	0.2
6.	Givat Shapira	188450	696114	44.3	4.7	37.6	4.0	1.6	0.3	1.6	0.3	0.1	0.2
7.	Mikhmoret	188068	701509	10.2	1.1	8.7	0.9	1.1	0.2	1.0	0.2	0.1	0.2

Table 4.1.4-20: Model results for sulfur dioxide SO_2 (emissions from natural gas operated facilities and diesel engines) – after 2025

Standard					Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Env. 60
No.	Location	X	Y	Highest 10-minute concentration (mcg/m3)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m3)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m3)	Percent of hourly env. value	Highest second hourly concentration (mcg/m3)	Percent of env. value	Hourly 99.9 percentile (mcg/m3)	Percent of hourly env. value	Highest daily concentration (mcg/m3)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m3)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m3)	Percent of annual env.
	Location of highest values for all averaging values	186923	696710														0.0	0.0	0.1		
1		185673	700710																	0.0	0.0
2		188423	697460									0.1	0.0								
3		188173	694710	0.6	0.1	0.5	0.1	0.4	0.1	0.4	0.1			0.0	0.0	0.1		0.0	0.0		
4	Netanya north	187200	694800	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
5	Netanya south	187601	693984	0.5	0.1	0.5	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
6	Havazelet Hasharon	187004	696464	0.4	0.1	0.4	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
7	Beit Herut	187810	698504	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
8	Kfar Vitkin	188855	698743	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
9	Givat Shapira	188450	696114	0.4	0.1	0.3	0.1	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
10	Mikhmoret	188068	701509	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0

4.1.5 Model results

Northern compound

Discussion:

The following conclusions may be drawn from modeling facility operation in the northern compound (Tables 4.1.4-1 to 4.1.4-11) for each of the pollutants and according to the scenarios defined above:

Particulates

Scenario 1: Background emissions

Background emissions – particulates

Particulate emissions were not modeled in Chapter 1 of the survey, under the Air Quality test for current situation in Hadera. To be able to examine Air Quality before establishment of the natural gas treatment facility we therefore modeled PM emissions from factories and vehicles within a 10km range around the plan (Table 4.1.4-1 shows model results from point sources and vehicles and Table 4.1.4-2 shows model results from point sources and vehicles and Table 4.1.4-2 shows model results from point sources only). The results for point source and vehicle emissions (Table 4.1.4-1) show that the thresholds were exceeded in the maximum values for average concentrations of maximum 3-hour and second 3-hour relative to environmental and target values by 94% and 88% respectively. When the model was applied to point sources only (Table 4.1.4-2) no irregular values were recorded (the highest values found were approximately 55% lower relative to the target and environmental values).

Scenario 2: Emissions during normal operations (2016-2024)

Particulate emissions from diesel engines

Model results for particulate emissions from diesel engines (Table 4.1.4-5) showed no deviation from the threshold values. The highest values were lower than 5% relative to the threshold.

Particulate emissions from the background (point emissions) and diesel-operated installations

Model results for particulate emissions from the background (point only) and from diesel-operated installations (Table 4.1.4-8) showed that (like the results excluding installation and diesel engine emissions – Table 4.1.4-2) there were no irregular values, and highest values were lower than 55% relative to the target and environmental values.

Particulate emissions from the background (point-source and vehicles) and from diesel-

operated installations

Model results for particulate emissions from the background (point-source and vehicles) and from diesel-operated installations (Table 4.1.4-9) show that as in the case of excluding facility and diesel engine emissions maximum values exceed the thresholds for target and environment values of maximum 3-hour average and second 3-hour concentrations by 95% and 88%, respectively. Nevertheless, based on results for facility emissions only we see that at the same point particulate concentration is 0.69 microgram per cubic meter (target and environment threshold value is 300 microgram per cubic meter), in addition to this, this point is located on the road. We therefore conclude that the increase in particulate concentration from the natural gas treatment facility in the northern compound is negligible.

No future change in particulate emissions has been reported for future normal operations (after 2025) consequently this pollutant was not tested for this period.

Particulates conclusion

Based on the model results we may conclude that the future impact of PM from the plan alone in the northern compound (excluding the background) will be very small.

Nitrogen oxides NO_X

Scenario 2: Emissions under normal operating conditions (2016-2024)

Nitrogen oxide emissions from the facility and diesel engines

Based on model results for nitrogen oxide emissions from the facility and diesel engines (Table 4.1.4-3) threshold values were not exceeded. The highest value obtained was the half hour concentration which was 5% smaller relative to the environmental threshold value.

Background nitrogen oxide emissions (point-source only) from natural gas operated facilities and from diesel engines

Based on model results for nitrogen oxide emissions from the facility and background (point-source only) (Table 4.1.4-6) it is seen that the highest and the second half hour results exceed the thresholds by 11% and 4%. However, on examination of the locations of these deviations (according to the lattice map) we notice that:

1. The deviating area is located outside the impact range of the natural gas treatment facilities (beyond the 10km range).
2. Examination of model results from flare and diesel engines alone showed that at the same location nitrogen oxides for maximum half hour averaging is 1.4 microgram per cubic meter.

We may therefore conclude that the plan located in the northern compound contributes very little emissions.

Scenario 3: Emissions under future normal operations (after 2025)

Nitrogen oxide emissions from natural gas operated facilities

Based on results of the model for nitrogen oxide emissions from the natural gas treatment facilities under the future normal scenario (Table 4.1.4-10) we see that the results are similar to those for the first years of facility operations (first 8 years – Table 4.1.4-3) in which compressors are not operated.

NO_X summary

Results from the model lead to the conclusion that the impact of NO_X emissions from the plan during 2016-2024 and from future operation after 2025 will be very small.

Sulfur dioxide SO_2

Scenario 2: Emissions under normal operations (2016-2024)

Sulfur dioxide emissions from the facility and diesel engines

Based on model results for sulfur dioxide emissions from the facility and diesel engines (Table 4.1.4-4) no thresholds were exceeded and also highest values were very low (less than 0.1% compared with threshold values).

Sulfur dioxide emissions from the background, natural gas operated facilities, and diesel engines

Model results for sulfur dioxide emissions from the facility, diesel engines, and background (Table 4.1.4-7) show that several of them exceed environmental and target values. At the same time, modeling of the northern compound facility itself has shown that concentrations of sulfur dioxide are negligible. Accordingly, we may determine that the impact of operating the facility is negligible.

Scenario 3: Emissions during future normal operations (after 2025)

Sulfur dioxide emissions from natural gas operated facilities

Model results for sulfur dioxide emissions from the natural gas treatment facility in the normal future scenario (Table 4.1.4-11) show no threshold values are exceeded and even the maximum values were negligible (less than 0.2% relative to environment value).

SO_2 conclusion

Based on the model results we may conclude that the impact of SO_2 from the plan alone, during 2016-2024 and from operation after 2025, is negligible.

Southern Compound

Discussion:

A review of model results (Tables 4.1.4-12 to 4.1.4-20) for operating the facility in the southern compound leads to the following conclusions regarding each of the pollutants in the scenarios defined above:

Particulates

Scenario 2: Emissions during normal operations (2016-2024)

Particulate emissions from diesel engines

Model results for particulate emissions from diesel engines (Table 4.1.4-14) showed that no threshold values were exceeded. Highest values were smaller than 0.8% relative to environment and target values.

Particulate emissions from the background (point emissions) and from diesel-operated facilities

Model results for background particulate emissions (point source only) and from diesel-operated facilities (Table 4.1.4-17) showed no thresholds were exceeded; highest values were smaller than 36% relative to environmental and target values.

Particulate emissions from the background (point emissions and vehicles) and from diesel-operated facilities

Model results for background particulate emissions (point source and vehicles) and from diesel-operated facilities showed that the highest readings at average concentrations of 3-hour maximum and second 3-hour exceeded threshold environment and target values by 58% and 43%, respectively. However, results from modeling facility emissions only show that at the same point particulate concentration is 0.99 microgram per cubic meter (target and environment threshold value is 300 microgram per cubic meter). Results also indicate that the specific point is located on the road. We therefore conclude that the added contribution of particulate emissions from the plan is very small.

Under these normal future operations (after 2025) no future change in particulate emissions has been reported, so this pollutant was not tested for this period.

Particulates conclusion

Model results lead to the conclusion that the impact of particulate pollutants in the future from the plan alone in the southern compound (excluding the background) is very small.

<u>Nitrogen oxides NO_X</u>

Scenario 2: Emissions under normal operations (2016-2024)

<u>Nitrogen oxide emissions from the facility and diesel engines</u>

Model results for nitrogen oxide emissions from the facility and diesel engines (Table 4.1.4-12) shows no thresholds were exceeded. The highest value found was the half hour concentration which was smaller than 7% relative to the environmental threshold.

<u>Nitrogen oxide emissions from the background (point-source only) and natural gas operated facilities and diesel engines</u>

Model results for nitrogen oxide emissions from the facility and background (point-source emissions only) (Table 4.1.4-15) show that no thresholds are exceeded and the highest value was smaller than 26% relative to the threshold values.

Scenario 3: Emissions under future normal operations (after 2025)

<u>Nitrogen oxide emissions from natural gas operated facilities</u>

Model results for nitrogen oxide emissions from natural gas operated facilities under the scenario for normal operations (Table 4.1.4-19) show similarity to the facility's first years of operations (first 8 years – Table 4.1.4-12) in which compressors are not operated.

NO_X Conclusions

Based on the model we may conclude that impact of NO_X emissions from the plan during 2016-2024 and from its operation in the future after 2025, will be very small.

<u>Sulfur dioxide SO_2</u>

Scenario 2: Emissions under normal operations (2016-2024)

<u>SO_2 emissions from the facility and diesel engines</u>

Model results for sulfur dioxide emissions from the facility and diesel engines (Table 4.1.4-13) showed that no threshold was exceeded and even the maximum values were negligible (less than 0.2% relative to the thresholds).

<u>SO_2 emissions from the background, natural gas operated facilities and diesel engines</u>

Model results for SO_2 emissions from the facility, diesel engines, and background

(Table 4.1.4-16) show several values that exceed the environment and target values. However, based on model results from the facility in the northern compound, concentrations of SO_2 are negligible. Accordingly, we may establish that the impact of operating the facility is negligible.

Scenario 3: Emissions under future normal operations (after 2025)

SO_2 emissions from natural gas operated facilities

Model results for SO_2 emissions from the natural gas treatment facility in the future normal scenario (Table 4.1.4-20) showed that no thresholds were exceeded and even the highest values were negligible (less than 0.2% relative to the environmental value).

SO_2 Conclusion

Based on the model results we may conclude that the impact of SO_2 emissions from the plan alone, during 2016-2024 and during future operation after 2025, is negligible.

Conclusion

In conclusion, the environmental impact of natural gas operated facilities and of gas engines (associated with the tested pollutants: particulates, nitrogen oxides, and sulfur dioxide) in the northern and southern compounds is very small to negligible.

Note that in several of the tested cases emission-reducing methods were taken into account that would make it possible to meet the TA Luft 2002 standards. In addition to this, when implementing the plan, the contractor will be required to comply with these emission standards or any standard current at the time that is accepted by the Ministry for Environmental Protection, and will have to use BAT to reduce emissions.

AERMOD model results for normal operations are also shown using isoplates and lattices in Appendix F.

4.1.6 Malfunction or system failure

Malfunctions are defined as cases in which increased pollutant emissions from the flare into the air are expected. In such cases the FGRU for recycling emission gases will not be operated and emissions will be discharged directly into the atmosphere. Specific details of the FGRU device are available in Sections 6.4.8 and 9.4 of Appendix B.

Most malfunction cases will end with increased emissions of combustion gases through the flare using the over-pressure relief process or blowdown. Removing gas through the flare and burning it is a safe method of removing gases from the facility. Specific details regarding malfunction cases are available in Section 14.6.6 of

Appendix B.

4.1.7 Description of air quality status in case of malfunction

As noted before, potential malfunctions are listed in Table 4.1.1-9 and described in Section 14.6.6 in Appendix B. The most severe malfunction cases were selected out of all these malfunctions.

Malfunction cases selected and examined in this Chapter are:

- **Malfunction requiring blowdown from the platform topside.** Emission rate in this case is the highest of all malfunctions.
- **Operational malfunction.** In case of operational malfunction, emission duration of pollutants is the longest of all malfunction cases (approximately 10 days). We may therefore assume that the emitted quantities are the highest of all malfunctions, and it is for this reason that we selected this case.

Operational malfunctions have a constant and continuous emission rate lasting longer than two hours (approximately 10 days, see Table 4.1.1-9). The AERMOD model was chosen as most suitable for testing pollutant distribution in this type of malfunction.

Malfunctions that require blowdown from the platform topside are typically short-duration large quantity emissions (up to two hours, see Table 4.1.1-9). CULPUFF was selected as the appropriate tool to model pollutant distribution during short-duration, large-quantity emissions.

<u>CALPUFF input data</u>

Meteorological data:

Northern compound:

A WRF meteorological file for May 26, 2007 which was the worst day for pollutant distribution (stringent conditions) was entered into the model. Meteorological data for May 26, 2007 from the Hadera Port station were also applied.

Southern compound

A WRF meteorological file for May 18, 2009 which was the worst day for pollutant distribution (stringent conditions) was entered into the model. Meteorological data for May 18, 2009 from the Hadera Port station were also applied.

Land uses:

Land uses file was applied to the model from the site: http://edc2.usgs.gov/glcc/tablambert_euras_eur.php

Topography:

Topographical files from the site: http://dds.cr.usgs.gov/srtm/version2_1/SRTM3/Africa/ were entered into the model.

<u>Modeled scenarios</u>

No emissions are expected from natural gas operated facilities in case of malfunction; however, there remains the possibility of diesel engine emissions. Therefore, the scenarios to be tested during malfunction (using AERMOD) are:

Scenarios for operational malfunction:

- Emissions from the natural gas treatment facility (flare and diesel engines) during the malfunction only.
- Emissions from the natural gas treatment facility (flare and diesel engines) during the malfunction and from the background (point emissions).

Scenarios that will be modeled using CALPUFF for a malfunction that requires blowdown from the platform topside:

- Emissions from the natural gas treatment facility (flare and diesel engines) during the malfunction only.
- Emissions from the natural gas treatment facility (flare and diesel engines) during the malfunction and from the background (point emissions).

Model results from the **northern compound** for operational malfunction scenarios (modeled on AERMOD) are shown in Tables 4.1.7-1 to 4.1.7-4, and model results from the **northern compound** for malfunction scenarios in which blowdown from the topside platform structure is required (modeled on CALPUFF) are shown in Tables 4.1.7-5 to 4.1.7-8.

Model results from the **southern compound** for operational malfunction scenarios (modeled on AERMOD) are shown in Tables 4.1.7-9 to 4.1.7-12, and model results from the **southern compound** for malfunction scenarios in which blowdown from the platform topside is required (modeled on CALPUFF) are shown in Tables 4.1.7-13 to 4.1.7-16.

Model results for the northern compound

Model results for nitrogen oxide NO_X in case of operational malfunction

Table 4.1.7-1: Model results for nitrogen oxide NO_X in case of operational malfunction – from flare and diesel engines only

Standard					Environment 940		Environment 940		Environment 560		Environment 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for annual averaging values	188335	712697									0.3	0.9
	Location of highest values for daily averaging values	188335	708197							3.5	0.6		
		188335	709697					5.2	0.9				
	Location of highest values for half hour averaging values	191085	710197			47.2	5.0						
		188335	713947	50.0	5.3								
1.	Caesarea	191050	713305	28.0	3.0	21.8	2.3	2.4	0.4	2.1	0.4	0.2	0.6
2.	Sdot Yam	190120	710965	30.6	3.3	26.9	2.9	2.5	0.4	2.3	0.4	0.2	0.6
3.	Jissr a-Zarka	191834	715699	25.8	2.7	22.3	2.4	2.0	0.4	1.8	0.3	0.2	0.5
4.	Neveh Haim	191372	705984	23.9	2.5	20.7	2.2	2.5	0.4	2.2	0.4	0.1	0.4
5.	Hadera	192574	704836	25.9	2.8	25.9	2.8	2.3	0.4	1.7	0.3	0.1	0.4
6.	Givat Olga	189431	704942	24.7	2.6	21.7	2.3	1.8	0.3	1.6	0.3	0.1	0.4
7.	Or Akiva	192645	712884	22.6	2.4	21.5	2.3	1.9	0.3	1.7	0.3	0.2	0.5
8.	Beit Hanania	193160	714975	30.0	3.2	21.5	2.3	1.4	0.2	1.4	0.2	0.1	0.4

Table 4.1.7-2: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources)

Standard					Environment 940		Environment 940		Environment 560		Environment 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for daily and annual averaging values	192585	707447					62.8	11.2	58.3	10.4	8.3	27.5
	Location of highest values for half hour averaging values	193335	708697	1042.7	110.9	976.0	103.8						
1.	Caesarea	191050	713305	45.9	4.9	36.2	3.9	4.6	0.8	4.5	0.8	0.6	2.0
2.	Sdot Yam	190120	710965	56.3	6.0	55.5	5.9	4.0	0.7	3.9	0.7	0.8	2.8
3.	Jissr a-Zarka	191834	715699	29.2	3.1	27.7	2.9	2.6	0.5	2.3	0.4	0.4	1.4
4.	Neveh Haim	191372	705984	82.5	8.8	76.2	8.1	9.8	1.7	8.1	1.4	0.8	2.5
5.	Hadera	192574	704836	415.8	44.2	385.6	41.0	17.6	3.1	15.5	2.8	0.8	2.7
6.	Givat Olga	189431	704942	54.6	5.8	47.7	5.1	4.9	0.9	4.7	0.8	0.5	1.6
7.	Or Akiva	192645	712884	43.1	4.6	40.9	4.3	2.9	0.5	2.9	0.5	0.6	1.9
8.	Beit Hanania	193160	714975	34.2	3.6	31.7	3.4	2.8	0.5	2.7	0.5	0.4	1.5

Model results for nitrogen oxide SO_2 in case of operational malfunction

Table 4.1.7-3: Model results for nitrogen oxide NO_X in case of operational malfunction – from flare and diesel engines

				Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Env. 60
Location	X	Y	Highest 10--minute concentration (mcg/m^3)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m^3)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m^3)	Percent of hourly env. value	Highest second hourly concentration (mcg/m^3)	Percent of env. value	Hourly 99.9 percentile (mcg/m^3)	Percent of hourly env. value	Highest daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m^3)	Percent of annual env.
Location of highest values for annual averaging values	188335	712697																	0.0	0.0
Location of highest values for 2nd daily averaging values	188335	708197														0.0	0.0	0.2		
Location of highest values for highest daily averaging values	188335	709697											0.0	0.0	0.2					
Location of highest values for 99.9 percentile	191085	710197									0.1	0.0								
Location of highest values for 2nd hourly and 10-minute averaging values	192335	710697			0.6	0.1			0.3	0.1										
Location of highest values for highest hourly and 2nd 10-minute averaging values	188335	713947	0.6	0.1			0.4	0.1												
Caesarea	191050	713305	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Sdot Yam	190120	710965	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Jissr a-Zarka	191834	715699	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Neveh Haim	191372	705984	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Hadera	192574	704836	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Givat Olga	189431	704942	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Or Akiva	192645	712884	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
Beit Hanania	193160	714975	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0

Table 4.1.7-4: Model results for sulfur dioxide SO_2 in case of operational malfunction – from flare and diesel engines, and background (point sources only)

				Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Env. 60
Location	X	Y	Highest 10--minute concentration (mcg/m³)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest second hourly concentration (mcg/m³)	Percent of env. value	Hourly 99.9 percentile (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m³)	Percent of annual Env.
Location of highest values for annual and daily averaging values	192585	707447											150.7	120.6	753.5	138.4	110.8	692.2	18.4	30.7
Location of highest values for hourly and 10-minute averaging values	193335	708697									355.5	101.6								
Location of highest values for 2nd hourly averaging values	193335	708947			2821.7	564.3			1971.9	563.4										
Location of highest values for highest hourly averaging values	193335	708697	3014.3	602.9			2106.5	601.8												
Caesarea	191050	713305	132.9	26.6	94.9	19.0	92.9	26.5	66.3	18.9	36.4	10.4	9.1	7.3	45.6	6.9	5.5	34.3	0.5	0.8
Sdot Yam	190120	710965	162.7	32.5	160.3	32.1	113.7	32.5	112.0	32.0	50.8	14.5	8.4	6.7	41.8	8.0	6.4	40.0	0.8	1.4
Jissr a-Zarka	191834	715699	86.0	17.2	80.6	16.1	60.1	17.2	56.4	16.1	18.1	5.2	4.9	3.9	24.5	3.3	2.7	16.7	0.3	0.5
Neveh Haim	191372	705984	238.4	47.7	176.3	35.3	166.6	47.6	123.2	35.2	93.3	26.7	22.8	18.3	114.2	17.8	14.3	89.1	1.1	1.8
Hadera	192574	704836	1202.2	240.4	1115.0	223.0	840.1	240.0	779.2	222.6	112.5	32.1	40.2	32.2	201.0	35.2	28.2	176.1	1.1	1.8
Givat Olga	189431	704942	137.8	27.6	121.6	24.3	96.3	27.5	85.0	24.3	57.2	16.4	9.2	7.4	46.2	8.7	7.0	43.7	0.6	1.0
Or Akiva	192645	712884	105.8	21.2	95.4	19.1	73.9	21.1	66.7	19.1	26.8	7.7	5.0	4.0	24.8	4.2	3.4	21.2	0.4	0.7
Beit Hanania	193160	714975	100.2	20.0	83.1	16.6	70.0	20.0	58.1	16.6	20.8	5.9	4.5	3.6	22.6	4.4	3.6	22.2	0.3	0.5

Model results for nitrogen oxides NO_X during a malfunction that requires blowdown from the topside platform structure

Table 4.1.7-5: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines only

Standard					Environment 940		Environment 940		Environment 560
No.	Location	X (UTM)	Y (UTM)	Highest half hour concentration (mcg/m³)	Percent of half hour env. value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value
	Location of highest values for 2nd half hour averaging values	678725	3598375			28.3	3.0		
	Location of highest values for highest half hour and daily averaging values	677975	3596625	87.3	9.3			3.6	0.7
1.	Caesarea	678678	3598960	25.0	2.7	7.2	0.8	1.3	0.2
2.	Sdot Yam	677797	3596602	78.7	8.4	12.2	1.3	3.3	0.6
3.	Jissr a-Zarka	679412	3601371	18.0	1.9	6.2	0.7	1.1	0.2
4.	Neveh Haim	679151	3591648	29.3	3.1	3.8	0.4	1.2	0.2
5.	Hadera	680377	3590525	22.1	2.3	6.2	0.7	1.0	0.2
6.	Givat Olga	677232	3590566	9.7	1.0	0.0	0.0	0.4	0.1
7.	Or Akiva	680281	3598573	29.0	3.1	13.0	1.4	1.5	0.3
8.	Beit Hanania	680796	3598583	22.6	2.4	16.5	1.8	1.4	0.3

Table 4.1.7-6: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources only)

Standard					Environment 940		Environment 940		Environment 560
No.	**Location**	**X (UTM)**	**Y (UTM)**	**Highest half hour concentration (mcg/m3)**	**Percent of half hour env. value**	**Highest 2nd half hour concentration (mcg/m3)**	**Percent of half hour env. value**	**Highest daily concentration (mcg/m3)**	**Percent of daily env. value**
	Location of highest values all averaging values	680725	3593125	306.7	32.6	244.5	26.0	35.3	6.3
1.	Caesarea	678678	3598960	66.1	7.0	26.6	2.8	4.3	0.8
2.	Sdot Yam	677797	3596602	78.7	8.4	12.2	1.3	3.6	0.6
3.	Jissr a-Zarka	679412	3601371	23.0	2.4	19.4	2.1	2.4	0.4
4.	Neveh Haim	679151	3591648	49.8	5.3	38.1	4.1	5.6	1.0
5.	Hadera	680377	3590525	47.1	5.0	31.6	3.4	6.3	1.1
6.	Givat Olga	677232	3590566	9.7	1.0	3.3	0.3	0.5	0.1
7.	Or Akiva	680281	3598573	47.2	5.0	17.9	1.9	3.1	0.6
8.	Beit Hanania	680796	3598583	41.8	4.4	16.6	1.8	2.6	0.5

Table 4.1.7-7: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines only

Standard					Target 500		Target 500		Env 350		Env 350		Env 125	Target 20
No.	Location	X (UTM)	Y (UTM)	Highest 10-minute concentration (mcg/m³)	Percent of 10-minute target. value	Highest 2nd 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest 2nd hourly concentration (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target value
	Location of highest values for daily averaging values	669975	3596875									0.1	0.1	0.7
	Location of highest values for hourly and 10-minute averaging values	669725	3596375	3.5	0.7	3.5	0.7	2.4	0.7	1.1	0.3			
1	Caesarea	678678	3598960	0.6	0.1	0.6	0.1	0.4	0.1	0.3	0.1	0.0	0.0	0.2
2	Sdot Yam	677797	3596602	1.2	0.2	1.2	0.2	0.8	0.2	0.1	0.2	0.0	0.0	0.2
3	Jissr a-Zarka	679412	3601371	0.9	0.2	0.9	0.2	0.6	0.2	0.3	0.2	0.1	0.0	0.3
4	Neveh Haim	679151	3591648	0.4	0.1	0.4	0.1	0.3	0.1	0.0	0.1	0.0	0.0	0.1
5	Hadera	680377	3590525	0.3	0.1	0.3	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.1
6	Givat Olga	677232	3590566	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
7	Or Akiva	680281	3598573	0.4	0.1	0.4	0.1	0.3	0.1	0.1	0.1	0.0	0.0	0.1
8	Beit Hanania	680796	3598583	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.0	0.0	0.1

Table 4.1.7-8: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines, and background (point sources)

Standard					Target 500		Target 500		Env 350		Env 350		Env 125	Target 20
No.	Location	X (UTM)	Y (UTM)	Highest 10-minute concentration (mcg/m³)	Percent of 10-minute target. value	Highest 2nd 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest 2nd hourly concentration (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target value
	Location of highest values for all averaging values	680725	3593125	756.8	151.4	756.8	151.4	528.9	151.1	480.3	137.2	75.2	60.2	376.2
1	Caesarea	678678	3598960	79.4	15.9	79.4	15.9	55.5	15.9	11.7	15.9	2.9	2.3	14.4
2	Sdot Yam	677797	3596602	7.7	1.5	7.7	1.5	5.4	1.5	1.1	1.5	0.3	0.2	1.5
3	Jissr a-Zarka	679412	3601371	26.0	5.2	26.0	5.2	18.1	5.2	9.2	5.2	1.2	1.0	6.2
4	Neveh Haim	679151	3591648	58.2	11.6	58.2	11.6	40.7	11.6	31.7	11.6	5.0	4.0	24.8
5	Hadera	680377	3590525	51.7	10.3	51.7	10.3	36.2	10.3	21.5	10.3	5.4	4.3	27.1
6	Givat Olga	677232	3590566	9.5	1.9	9.5	1.9	6.6	1.9	2.6	1.9	0.4	0.3	1.9
7	Or Akiva	680281	3598573	21.6	4.3	21.6	4.3	15.1	4.3	15.1	4.3	1.5	1.2	7.7
8	Beit Hanania	680796	3598583	22.5	4.5	22.5	4.5	15.8	4.5	9.3	4.5	1.1	0.9	5.7

Model results for the southern compound

<u>Model results for nitrogen oxide NO_X in case of operational malfunction</u>

<u>Table 4.1.7-9: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines only</u>

rd					Environment 940		Environment 940		Environment 560		Environment 560		Target 30
.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour env. value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for all averaging values	185673	700710									0.3	0.9
		185673	696210							3.4	0.6		
		185673	697710					5.1	0.9				
		187601	693984			59.8	6.4						
		188173	694710	66.3	7.1								
.	Netanya north	187200	694800	27.5	2.9	24.2	2.6	2.9	0.5	2.4	0.4	0.1	0.5
.	Netanya south	187601	693984	59.8	6.4	59.8	6.4	2.7	0.5	2.5	0.4	0.1	0.5
.	Havazelet Hasharon	187004	696464	34.8	3.7	34.7	3.7	4.1	0.7	2.5	0.5	0.2	0.6
.	Beit Herut	187810	698504	30.5	3.2	23.6	2.5	2.6	0.5	2.3	0.4	0.2	0.6
.	Kfar Vitkin	188855	698743	26.5	2.8	22.8	2.4	2.0	0.4	1.9	0.3	0.2	0.5
.	Givat Shapira	188450	696114	44.2	4.7	37.6	4.0	3.6	0.6	1.9	0.3	0.1	0.5
.	Mikhmoret	188068	701509	28.5	3.0	22.3	2.4	2.3	0.4	2.1	0.4	0.2	0.6

Table 4.1.7-10: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources)

Standard					Environment 940		Environment 940		Environment 560		Environment 560		Target 30
No.	Location	X coordinate	Y coordinate	Highest half hour concentration (mcg/m³)	Percent of half hour env. value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Highest 2nd daily concentration (mcg/m³)	Percent of daily env. value	Highest annual concentration (mcg/m³)	Percent of annual target
	Location of highest values for daily and annual averaging values	190173	700960					33.0	5.9	29.0	5.2	4.1	13.6
	Location of highest values for half hour averaging values	190173	692210	243.9	25.9	243.8	25.9						
1.	Netanya north	187200	694800	27.5	2.9	24.2	2.6	3.1	0.5	3.0	0.5	0.3	1.1
2.	Netanya south	187601	693984	77.9	8.3	77.0	8.2	5.6	1.0	5.3	0.9	0.5	1.8
3.	Havazelet Hasharon	187004	696464	34.8	3.7	34.7	3.7	4.2	0.7	2.6	0.5	0.3	1.1
4.	Beit Herut	187810	698504	30.5	3.2	23.6	2.5	3.2	0.6	2.9	0.5	0.4	1.3
5.	Kfar Vitkin	188855	698743	26.5	2.8	22.8	2.4	2.2	0.4	2.0	0.4	0.3	1.1
6.	Givat Shapira	188450	696114	44.2	4.7	41.8	4.4	3.6	0.6	2.5	0.4	0.3	1.1
7.	Mikhmoret	188068	701509	28.5	3.0	22.3	2.4	3.5	0.6	3.3	0.6	0.5	1.6

Model results for sulfur oxide SO_2 in case of operational malfunction

Table 4.1.7-11: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines

				Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Target 60
ocation	X	Y	Highest 10--minute concentration (mcg/m³)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest second hourly concentration (mcg/m³)	Percent of hourly env. value	Hourly 99.9 percentile (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m³)	Percent of env. target
n of highest for all ng values	185673	697710											0.0	0.0	0.2					
	185673	700460																	0.0	0.0
	185673	696210														0.0	0.0	0.1		
	186923	696460									0.1	0.0								
	188173	694710	0.6	0.1	0.5	0.1	0.4	0.1	0.4	0.1										
north	187200	694800	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
south	187601	693984	0.5	0.1	0.5	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
et Hasharon	187004	696464	0.4	0.1	0.4	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
ut	187810	698504	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
xin	188855	698743	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
apira	188450	696114	0.4	0.1	0.3	0.1	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
ret	188068	701509	0.3	0.1	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0

Table 4.1.7-12: Model results for sulfur oxide SO_2 in case of malfunction – from flare and diesel engines, and background (point sources only)

				Target 500		Target 500		Env 350		Env 350		Env 350		Env 125	Target 20		Env. 125	Target 20		Env 60
ocation	X	Y	Highest 10--minute concentration (mcg/m³)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest second hourly concentration (mcg/m³)	Percent of env. value	Hourly 99.9 percentile (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Second daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value	Highest annual concentration (mcg/m³)	Percent of annual env.
n of highest or annual and eraging	190173	700960											99.16	79.3	495.8	87.64	70.1	438.2	12.0	20.1
n of highest or hourly and ute averaging	190173	692210	988.8	197.8	988.4	197.7	691.0	197.4	690.7	197.4	323.0	92.3								
north	187200	694800	88.2	17.6	82.0	16.4	61.7	17.6	57.3	16.4	39.3	11.2	9.85	7.9	49.2	6.99	5.6	34.9	0.6	1.1
south	187601	693984	316.0	63.2	312.3	62.5	220.8	63.1	218.2	62.3	103.4	29.6	17.71	14.2	88.6	17.22	13.8	86.1	1.3	2.2
t Hasharon	187004	696464	51.5	10.3	50.6	10.1	36.0	10.3	35.4	10.1	29.9	8.6	6.60	5.3	33.0	5.08	4.1	25.4	0.4	0.7
t	187810	698504	65.7	13.1	65.7	13.1	45.9	13.1	45.9	13.1	37.0	10.6	8.71	7.0	43.5	5.80	4.6	29.0	0.6	1.1
n	188855	698743	72.5	14.5	71.5	14.3	50.6	14.5	49.9	14.3	39.1	11.2	5.50	4.4	27.5	5.30	4.2	26.5	0.5	0.9
pira	188450	696114	169.0	33.8	151.8	30.4	118.1	33.7	106.1	30.3	46.9	13.4	7.63	6.1	38.1	5.90	4.7	29.5	0.6	0.9
et	188068	701509	61.3	12.3	61.3	12.3	42.9	12.2	42.9	12.2	41.2	11.8	10.55	8.4	52.7	7.69	6.1	38.4	0.9	1.6

Model results for nitrogen oxide NO_X in case of malfunction requiring blowdown from the topside platform structure

Table 4.1.7-13: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines only

Standard				Environment 940		Environment 940		Environment 560
Location	X (UTM)	Y (UTM)	Highest half hour concentration (mcg/m³)	Percent of half hour env. value	Highest 2nd half hour concentration (mcg/m³)	Percent of half hour env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value
on of highest values d half hour and daily ging values	667225	3584625			29.3	3.1	5.0	0.9
on of highest values f hour averaging	677475	3587625	49.2	5.2				
north	675210	3580381	21.6	2.3	14.0	1.5	1.3	0.2
south	675628	3579574	13.7	1.5	4.1	0.4	0.7	0.1
et Hasharon	674980	3582040	12.8	1.4	0.4	0.0	0.5	0.1
ut	675744	3584100	14.9	1.6	1.0	0.1	0.6	0.1
xin	676784	3584357	18.4	2.0	0.4	0.0	0.7	0.1
apira	676434	3581720	15.0	1.6	0.2	0.0	0.6	0.1
ret	675941	3587100	3.5	0.4	0.3	0.0	0.2	0.0

Table 4.1.7-14: Model results for nitrogen oxide NO_X in case of malfunction – from flare and diesel engines, and background (point sources)

Standard					Environment 940		Environment 940		Environment 560
No.	Location	X (UTM)	Y (UTM)	Highest half hour concentration (mcg/m^3)	Percent of half hour env. value	Highest 2nd half hour concentration (mcg/m^3)	Percent of half hour env. value	Highest daily concentration (mcg/m^3)	Percent of daily env. value
	Location of highest values for 2nd half hour and daily averaging values	678475	3586625			41.4	4.4		
	Location of highest values for highest and daily half hour averaging values	676725	3577875	64.7	6.9			5.8	1.0
1.	Netanya north	675210	3580381	21.6	2.3	14.0	1.5	1.7	0.3
2.	Netanya south	675628	3579574	13.7	1.5	4.1	0.4	1.1	0.2
3.	Havazelet Hasharon	674980	3582040	12.8	1.4	3.2	0.3	0.8	0.1
4.	Beit Herut	675744	3584100	14.9	1.6	1.9	0.2	0.7	0.1
5.	Kfar Vitkin	676784	3584357	18.5	2.0	2.3	0.2	0.9	0.2
6.	Givat Shapira	676434	3581720	15.0	1.6	4.0	0.4	1.0	0.2
7.	Mikhmoret	675941	3587100	3.5	0.4	3.4	0.4	0.4	0.1

Table 4.1.7-15: Model results for sulfur dioxide SO_2 in case of malfunction – from flare and diesel engines only

Standard					Target 500		Target 500		Env 350		Env 350		Env 125	Target 20
No.	Location	X (UTM)	Y (UTM)	Highest 10--minute concentration (mcg/m³)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m³)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m³)	Percent of hourly env. value	Highest second hourly concentration (mcg/m³)	Percent of hourly env. value	Highest daily concentration (mcg/m³)	Percent of daily env. value	Percent of daily target. value
	Location of highest values for 2nd half hour and daily averaging values	667225	3584625							0.2	0.0	0.0	0.0	0.2
	Location of highest values for hourly and 10-minute averaging values	677475	3587625	0.6	0.1	0.6	0.1	0.4	0.1					
1.	Netanya north	675210	3580381	0.3	0.1	0.3	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.1
2.	Netanya south	675628	3579574	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
3.	Havazelet Hasharon	674980	3582040	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
4.	Beit Herut	675744	3584100	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
5.	Kfar Vitkin	676784	3584357	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
6.	Givat Shapira	676434	3581720	0.2	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
7.	Mikhmoret	675941	3587100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4.1.7-16: Model results for sulfur dioxide SO_2 in case of malfunction – from flare and diesel engines, and from the background (point sources)

Standard					Target 500		Target 500		Env 350		Env 350		Env. 125	Target 20
No.	Location	X (UTM)	Y (UTM)	Highest 10--minute concentration (mcg/m^3)	Percent of 10-minute target value	Highest second 10-minute concentration (mcg/m^3)	Percent of 10-minute env. value	Highest hourly concentration (mcg/m^3)	Percent of hourly env. value	Highest second hourly concentration (mcg/m^3)	Percent of hourly env. value	Highest daily concentration (mcg/m^3)	Percent of daily env. value	Percent of daily target. value
	Location of highest values for daily averaging values	676975	3577625									15.6	12.5	78.2
	Location of highest values for 2nd hourly averaging values	678475	3586625							105.8	30.2			
	Location of highest values for half hour and 10-minute averaging values	676725	3577875	261.9	52.4	261.9	52.4	183.0	52.3					
1.	Netanya north	675210	3580381	10.8	2.2	10.8	2.2	7.6	2.2	6.0	2.2	1.1	0.9	5.3
2.	Netanya south	675628	3579574	9.3	1.9	9.3	1.9	6.5	1.8	6.2	1.8	1.2	0.9	5.8
3.	Havazelet Hasharon	674980	3582040	11.6	2.3	11.6	2.3	8.1	2.3	3.6	2.3	0.9	0.7	4.4
4.	Beit Herut	675744	3584100	6.7	1.3	6.7	1.3	4.7	1.3	1.3	1.3	0.4	0.3	1.9
5.	Kfar Vitkin	676784	3584357	8.9	1.8	8.9	1.8	6.2	1.8	5.8	1.8	0.6	0.5	3.2
6.	Givat Shapira	676434	3581720	14.5	2.9	14.5	2.9	10.1	2.9	7.2	2.9	1.4	1.1	7.0
7.	Mikhmoret	675941	3587100	12.1	2.4	12.1	2.4	8.5	2.4	5.3	2.4	0.7	0.6	3.6

<u>Discussion of results</u>

Northern compound

<u>Model results for operational malfunction</u>

Nitrogen oxide emissions during an operational malfunction

Nitrogen oxide emissions from flare and diesel-engine operated facilities

Model results for nitrogen oxide emissions from flare and diesel-engine operated facilities (Table 4.1.7-1) showed thresholds were not exceeded, and the maximum values were lower than 5.5% relative to the target and environmental values.

Nitrogen oxide emissions from the flare, diesel-engines and background

Model results for nitrogen oxide emissions from flare, diesel-engines and background (Table 4.1.7-2) showed that thresholds were exceeded at the maximum and second half hour values by 11% and 4% over the environmental threshold. However, on examining the locations of these high values (according to the lattice map), the following is evident:

1. The deviating area is located outside the impact range of the natural gas treatment facility (outside the 10km range).
2. Results of flare and diesel engines only show that for the same location the concentration of nitrogen oxides for maximum half hour averaging is 26 micrograms per cubic meter (the environmental half hour threshold is 940 micrograms per cubic meter).

We therefore conclude that emission contribution from the natural gas treatment facility located in the northern compound is small.

Sulfur dioxide emissions during an operational malfunction

Model results for sulfur dioxide emissions during an operational malfunction (Tables 4.1.7-3 to 4.1.7-4) show no thresholds were exceeded for flare and diesel engine emissions (maximum values were smaller than 0.6% relative to the target and environmental values). However, when running the model for sulfur dioxide emissions from flare, diesel engines, and background, excepting the maximum values by annual averaging, all maximum values exceeded the thresholds. When the model was applied to background sulfur dioxide emissions only, thresholds were exceeded similarly, but because sulfur dioxide results from the natural gas treatment facility and diesel engines only were negligible, we may conclude that the contribution of emissions from the northern compound as far as sulfur dioxide is concerned, is negligible.

<u>Model results during a malfunction that requires blowdown from the topside platform structure</u>

Nitrogen oxide emissions in case of a malfunction that requires blowdown from the topside platform structure

Nitrogen oxide emissions from flare and diesel engine operated facilities

Model results for emissions from flare and diesel engines in case of a malfunction that requires blowdown from the topside platform structure (Table 4.1.7-5) showed thresholds for nitrogen oxides were not exceeded, and the highest values were lower than 9.5% relative to the target and environmental values.

Nitrogen oxide emissions from flare and diesel engine operated facilities, and background (point sources)

Model results for emissions from flare and diesel engines (point sources) in case of a malfunction that requires blowdown from the topside platform structure (Table 4.1.7-6) showed thresholds were not exceeded, and the highest values were lower than 36% relative to target and environmental values.

Sulfur dioxide emissions from flare and diesel-engine operated facilities

Model results for emissions from flare and diesel engines in case of a malfunction that requires blowdown from the topside platform structure (Table 4.1.7-7) showed thresholds for sulfur dioxide were not exceeded, and even showed negligible values (the highest values were lower than 1% relative to target values).

Sulfur dioxide emissions from flare and diesel-engine operated facilities, and background (point sources)

Model results for emissions for sulfur dioxide emissions from flare and diesel engines, and background (point emissions) (Table 4.1.7-8) showed thresholds were exceeded on the hour and 10-minute values. As noted earlier, based on running the model for the plan alone during a malfunction, which found negligible concentrations of sulfur dioxide, and on background-only results from Chapter 1 of the survey, we may conclude that most of the pollution does not derive from flare and diesel-engine operated facilities. Moreover, we also conclude that the impact of sulfur dioxide from the plan during a malfunction that requires blowdown from the topside platform structure, is negligible.

Southern compound

Nitrogen oxide emissions during an operational malfunction

Nitrogen oxide emissions from flare and diesel-engine operated facilities

Model results for nitrogen oxide emissions from flare and diesel engine operated facilities (Table 4.1.7-9) showed no thresholds were exceeded and highest values were smaller than 7.5% relative to target and environment values.

Nitrogen oxide emissions from flare, diesel engines, and background

Model results for nitrogen oxide emissions from flare and diesel engine operated facilities (Table 4.1.7-10) showed thresholds were not exceeded, and highest values were smaller than 26% relative to the target and environmental values.

Sulfur dioxide emissions during an operational malfunction

Model results for sulfur dioxide during malfunction (Tables 4.1.7-11 and 4.1.7-12) showed thresholds were not exceeded for flare and diesel engine emissions (maximum values were lower than 0.1% of target and environmental values). However, when the model was applied to sulfur dioxide emissions from flare, diesel engines, and background, thresholds were exceeded at the highest hour and 10-minute averaging times. When the model was applied to sulfur dioxide emissions from background alone, similar deviations were observed; but because sulfur dioxide results for the natural gas treatment facility and diesel engines alone were negligible, we may conclude that the contribution of sulfur dioxide emissions from the southern compound are negligible.

Model results for a malfunction that requires blowdown from the topside platform structure

Nitrogen oxide emissions during a malfunction that requires blowdown from the topside platform structure

Nitrogen oxide emissions from flare and diesel engine operated facilities

Model results for nitrogen oxide emissions from flare and diesel engine operated facilities during a malfunction that requires blowdown from the topside platform structure (Table 4.1.7-13) showed thresholds were not exceeded for nitrogen oxides. Maximum values were smaller than 5.5% relative to target and environmental values.

Nitrogen oxide emissions from flare and diesel-engine operated facilities, and background (point sources)

Model results for a malfunction that requires blowdown from the topside platform structure, for emissions from flare and diesel-engine operated facilities, and background (point sources) (Table 4.1.7-14) showed thresholds were not exceeded. Highest values were smaller than 7% relative to target and environmental values.

Sulfur dioxide emissions from flare and diesel-engine operated facilities

Model results for a malfunction that requires blowdown from the topside platform structure, for emissions from flare and diesel-engine operated facilities (Table 4.1.7-15) showed sulfur dioxide thresholds were not exceeded; results were negligible (highest values were smaller than 0.2% relative to threshold values).

Sulfur dioxide emissions from flare and diesel-engine operated facilities, and background (point sources)

Model results for a malfunction that requires blowdown from the topside platform structure, for emissions from flare and diesel-engine operated facilities, and background (Table 4.1.7-16) showed sulfur dioxide thresholds were not exceeded. Highest values were smaller than 53% relative to target and environmental values.

Summary of malfunction cases

According to the results of the model for an operational malfunction and a malfunction that requires blowdown from the topside platform structure in the northern compound and southern compounds, we find that the impact of nitrogen oxides on the environment is small to very small, and the impact of sulfur dioxide is negligible.

AERMOD and CALPUFF results for the malfunction cases are presented also using isoplates and lattices in Appendix F.

4.1.8 Control systems and means of preventing leaks

During routine operations of the emission-gas treatment facility, non-point emissions may occur from equipment and pipe connections. Natural gas present in the system can escape through microscopic pores in valves and flanges. This type of emission is estimated at 10-100kg a year and is not a safety hazard, but the contractor is nevertheless required to use BAT to minimize these non-point emissions. Means of preventing leaks and control systems include:

1. Reducing non-point emissions by welding the joins instead of using flanges. This also minimizes the number of flanges, but on the other hand makes it impossible to open the pipeline for maintenance (see in detail Section 14.6.7 Appendix B). The future supplier must therefore make a decision regarding the number of flanges and welds to be used based on design considerations.
2. Routine maintenance of flanges and valves.
3. Operate control systems to identify leaks. Frequency of operating these systems as well as general operation must comply with the guidelines in the appropriate BREF[23] documents.

Control systems and means of preventing leaks are specified in detail in Section 3.3.3, above.

4.1.9 Gas flaring system

There will be cases in which, as part of the natural gas treatment process, excess gas will have to be removed from the system to protect the system from over-pressure. It is therefore necessary to establish a gas removal system in the plan area. Excess gas

[23] Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries, February, 2003.

will then be removed by venting or flaring (see details in Section 13, Appendix B).

Gas from this excess-gas treatment installation will be recovered using FGRU technology (which is part of the flare system). Increased amounts of excess gas emitted during malfunction (listed in Table 4.1.1-9) will be removed by flaring. This is a largely environmental decision. When venting, most emissions are of methane; flaring produces combustion products so the main gas emitted is carbon dioxide. Methane potentially contributes to the greenhouse effect 25 to 75 times more than carbon dioxide (see detailed explanation in Section 13.3, Appendix B). For safety restrictions and flare specifications see Section 3.4.7, above.

In the past, the flare included a small torch with a permanent flame, so in the case of a blowdown event through the flare, gas would ignite. One of the drawbacks of this ignition method is the permanent flame that is clearly visible from far away.

In the planned installation, the flare will have an on-demand ignition system. This way the flare will only burn when there is a blowdown event. The flare system includes the following devices:

- HP flare
- LP flare
- FGRU

Full details of each of these devices are available in Appendix B, Sections 13.5-13.7.

4.1.10 Magnetic media

Electronic data including input data for the calculations, calculation results, and meteorological data files, are attached to this document on digital media.

4.2 Assigned land-use, land-use, and activities

4.2.1 Compromising land-use and assigned land-use

Land uses and assigned uses within the plan and survey areas are reviewed in detail in Chapter 1 of the Impact Survey. Reference to activities, land-uses and assigned uses that are susceptible to harm as a result of plan implementation is made based on land-uses and assigned uses in the zoning plans and on data received from Survey of Israel. Restrictions associated with the various parts of the facilities are listed below:

- Gas pipeline
- Natural gas treatment facility (including the Israel Natural Gas Lines installation)

Uses and assigned uses within the plan boundaries and how implementing the plan affects them are reviewed below:

Table 4.2.1-1: Plan's impact on land uses and assigned uses

ned use	Relation to the proposed alternative and its surroundings			Impact/restrictions related to plan implementation
	Marine compound for placing the gas treatment facilities	Western pipeline route (from territorial waterline to the facility)	Eastern pipeline route (from the marine compounds to the coastal inlet system)	
rawl lines	inside both compounds	within the test range	within the test range	Trawlers (and other vessels) will not be allowed to fish and sail within 500m of the treatment platform compound[19]. Trawling will be forbidden in areas where piping is laid on the bed, not buried.
tes	none	within the test range	within the test range	No docking or fishing will be allowed along the pipeline route and within a distance of up to 500m from the marine pipeline.
oning plan sting gas pipe	none	none	within the test range	No restrictions or impact are expected
oning plan - existing LNG	none	within the test range	within the test range	No restrictions on existing pipe. If necessary pipe will be traversed according to the principles outlined in Appendix C Section 4.5.1-Operational and structural aspects
oning plan salination	none	within the test range	At the entrance to Mikhmoret in the RZP 34/b/2/2-Marine exploration area	Desalination plant planners/operators must be coordinated with when implementing the plan so as to prevent harm to quality of the water being pumped for desalination during work to lay the pipeline and to prevent damage to pipes and outlets, etc.
erve	none	within the test range	The route to the inlet system at Mikhmoret within a recognized marine nature reserve - Gedor Sea	Temporary disruption may occur during work to lay pipeline.
ations cables	within the northern compound	within the test range	none	Traversing communications cables will require, if needed, disconnecting and reconnecting the communications cable according to the principles outlined in Appendix C Section 4.5.2-Operational and structural aspects.

[19] According to guidelines of the Administration of Shipping and Ports, dated 12 Dec 2011, attached below in Appendix H.

4.2.2 Changing assigned uses and establishing restrictions

Changes in assigned uses and restrictions on land use as a result of implementing the plan are listed in Section 4.2.1, above.

4.2.3 Charts

Restrictions on land-uses and assignment in a marine environment that are listed in Section 4.1.1, will be determined at the building permit stage following a detailed outlay of the marine pipeline route and the exact location of offshore facilities.

4.3 Visuals

This section includes a landscape-visual analysis of the offshore natural gas treatment facilities. The analysis addresses the expected view from the shore to the platforms at sea, and its visual significance and impact on the horizon line.

This analysis is aware of the value of an open view of the sea and is sensitive to its significant role in creating a sense of open space in urban settings and in populated areas near the beach, both visually and as a recreational resource.

The underlying assumption for examining the offshore facilities is that they are visible from the shore line and from high areas near the shore, they disrupt the horizon, and the possibility of hiding or obscuring their presence, is limited. Nevertheless, compared with the vast expanse of sea, the length of the shoreline and horizon, from many locations the disrupted view will be localized and distant.

4.3.1 Visual analysis

Visual and landscape analysis of the offshore compounds is shown in **Figure 4.3.1-1.** The analysis includes views, simulations, and sections of the planned treatment facility placed on the backdrop of the current environment.

<u>Figure 4.3.1-1: Visual analysis</u>

figure is missing

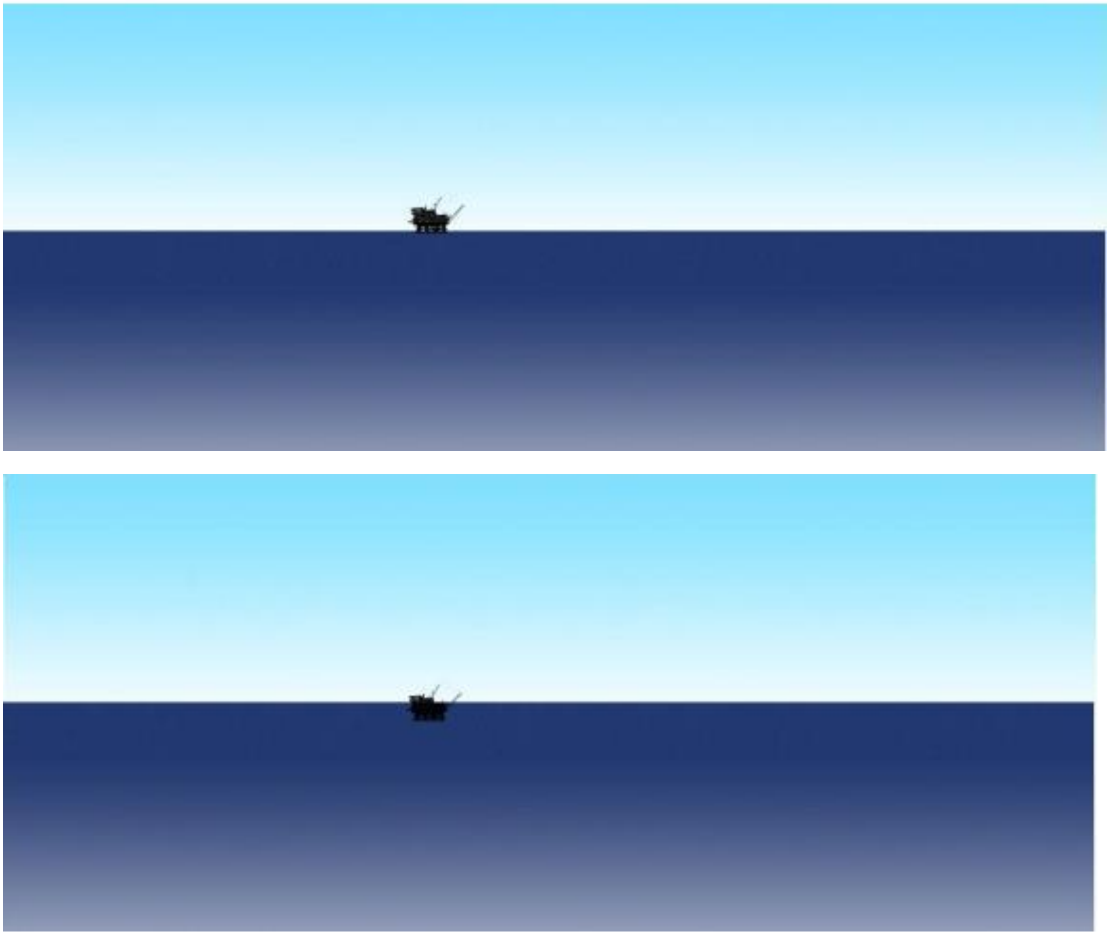
4.3.2 Description of findings

Treatment facility

Treatment platforms located at a minimum distance from the coastline of 7.5km are permanent and have a prominent presence in the landscape; they rise to a height of 80m above sea level, and are very massive (due to a safety requirement for separating activities on the platforms) (see Figure 3.1.1-2). In its final state there will probably be four facilities that are a few hundred meters apart; each facility comprises several sub-components. In addition to these, and adjacent to the platforms, there will be a flare 90m high above sea-level; its narrow structure precludes a prominent appearance, unlike the other facilities.

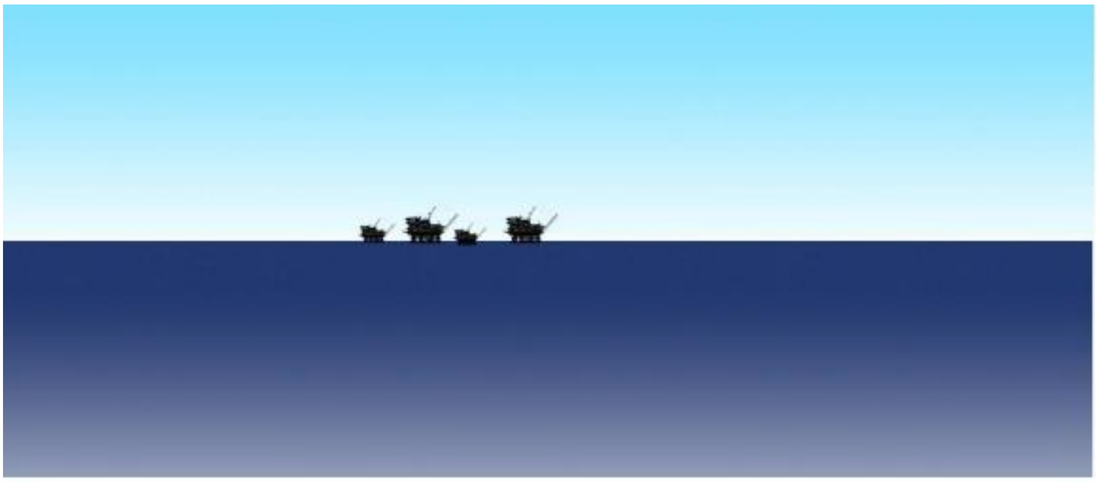
The visual analysis assumes that the installation will be viewed from the shore only (from north-east to south-east), looking to the west, from the coastline and from prominent points in its vicinity, and that the view from ships at sea has no significance. The fact that the view from the shore is from a distance of 7.5km together with the length of the coastline means that this is a view from a distance. So, most of the visual impact derives from the presence of the installations and the way they disrupt the horizon. Their great distance from the shore will make them seem like one mass, with no visible details beyond the flame at the top of the flare. For this reason there is no visual significance to the details that compose the whole of the facilities. It is the contour and impact on the horizon that is significant, mainly to observers at low elevations and less so to observers at high elevations. The latter will occur in certain cases where the observer is standing at a high elevation and the facility is relatively lower than the horizon. In these cases the facility will not alter the horizon and will be assimilated into the sea; it is therefore far less prominent, as, for example, for the hotels in Zichron Yaakov.

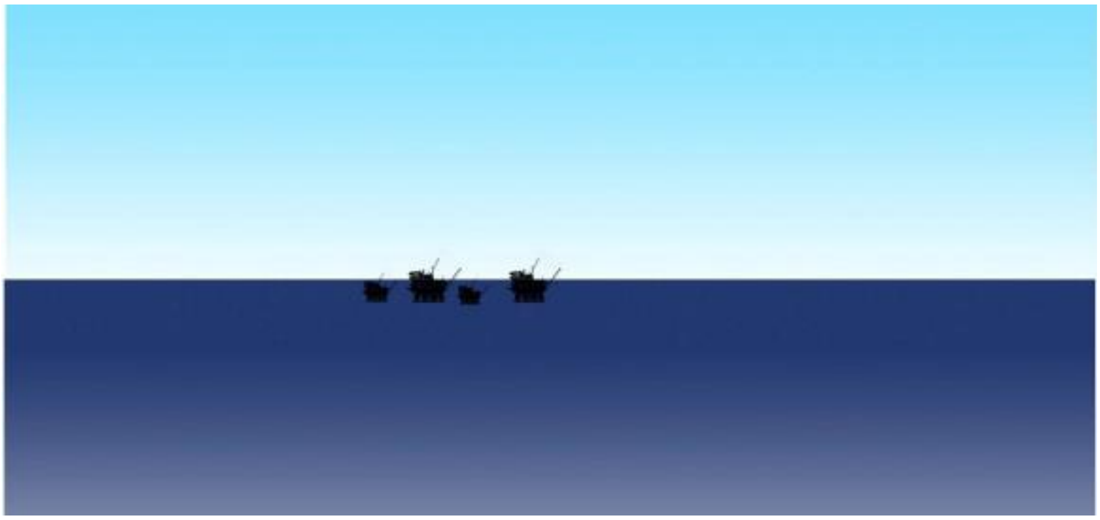
Figure 4.3.2-1: Impact of facility contour on the horizon – view from the coastline (top) and from higher elevations (bottom)



A further consideration for landscape is the number of facilities and their density. Few and distant facilities might be perceived as part of the landscape, as is a vessel at sea, possibly becoming a visual point of interest. But numerous fixed installations will have a more industrial nature and will have a greater impact on the area's image.

Figure 4.3.2-2: Impact on the horizon of a number of installations – view from the coastline (top) and from higher elevations (bottom)





The offshore area has been surveyed and analyzed in detail at the same time as the examination of visibility of the offshore alternatives in the Onshore Environment Impact Survey, Chapters 1-2. Being a large-scale analysis, it is based on national data from the national GIS (natural topography – contours at 10m intervals) and on a preliminary estimate of construction volume. Beyond that, the presented map did not take into account land cover surrounding the observation points tested; this includes embankments, vegetation, construction, etc. which are significant when it comes to concealing the sea and the facilities. For example, visibility east of Hadera, as obtained from the computerized analysis, includes the lower elements of the facility (up to 12m), but in fact the sea is not visible at all from the east part of the city. Clearly, the computerized analysis is a tool for preliminary analysis. Main visibility is obtained along the coastline and from the elevated areas relatively near the shore, as described in Section 1.5.4, in Chapter 1-2 of the Marine Survey.

The offshore compounds are located at a minimum distance of 7.5km from the shore; the 1 planned location of the offshore compound is in the area between Dor beach in the north and Or Akiva beach in the south, and Compound 2 is planned in the area between Beit Yannai in the north and the northern beaches of Netanya.

The primary view is from the coastline itself. These beaches have both a landscape and a functional role; they serve recreational purposes and are used as open spaces (Beit Yannai National Park, ancient Caesarea, Dor Beach nature reserve, Habonim beach, etc.), and serve as bathing beaches during the bathing season. Several holiday resorts are located near the beaches (Dor, Sdot Yam, and others). The Netanya beaches have an important role in the urban space, for example the highly active promenade located on an elevated Kurkar cliff approximately 30m high.

The sea-view is also significant to the more distant and mostly elevated view, both from natural open spaces such as the Carmel ridge as well as from elevated residential areas, such as the row of residences facing the shore in Zichron Yaakov and the residential high-rises in Hadera.

Landscape analysis demonstrates five main representative focal points that are at least 7.5km from the coastline, namely:

1. View from and along the coastline 7.5km distance
2. Tourism sites and visitor centers (e.g. Caesarea national park) 7.5km distance
3. Distant and elevated populated areas 10km distance
4. Road infrastructure, mainly on the Coastal Highway 8km distance

These foci were selected for their centrality in and importance to the project environment and due to the prominence of residents, passersby, hikers, and travelers (such as the hotel access route in Netanya) in this space. We must distinguish between permanent, stationary visibility by residents (small population with extended visibility), stationary visibility from sites being visited (short duration visit but with impact on the region's image), and transient visibility (large numbers of people traveling at high speeds exposed to the view very briefly).

The analysis addresses current conditions at the selected observation points, referring to: surface properties, local land cover, etc., as well as facility components from the point of view of the observer, and concentrating on elements affecting the facilities' contour.

The beach and tourism sites in its vicinity – permanent visibility

Offshore facilities are spread across areas with active beaches, particularly during the bathing season.

Beach – visibility from the beach is high from every point on the beach, and extends over time, as shown in Figure 4.3.1-1.

Tourism sites and hotels – visibility from tourisn sites such as the Caesarea National Park, and hotels along the Netanya beachfront is high and protracted, and the facilities cannot be concealed.

Roads and interchanges – transient visibility

Road No. 2 – visibility from the Road No. 2 national highway varies. Along most of the route visibility toward the shore is insignificant and in places completely obstructed by towns or by the Kurkar ridge. However, brief views open up near Beit Yannai on a road segment that is a few hundred meters long, specifically from the top of the interchange where there is full visibility to vehicles traveling both north and south. In addition, topography of the sandy hills and natural land cover affect visibility of the sea and the facility in particular. On days with good visibility the offshore facilities can be seen but due to the great distance, local land cover, and the brief duration of observation, the offshore facilities would appear as a passing vessel.

Localities:

Carmel ridge localities – located on the western face of the Carmel ridge, they have a view to the sea and can continually observe the offshore facilities. However, the great distance, the elevation relative to the horizon, and the land cover between the sea and these localities reduces the intensity of the view.

Night lighting – the facilities are illuminated at twilight and at night. On the one hand, this is a source of light pollution that interferes with the vivid scene of the beach at sunset and its naturally dark aspect at night. On the other hand, most beach users do not use it at night, so this loss is not very considerable and in certain cases the illuminated display may have a positive visual quality.

In conclusion:

We conclude that the offshore platforms definitely create a new disruption of the landscape in an area of high visual value and sensitivity; they do change the horizon to the proximal observer, but this is not always the case for distant observers. The analysis reveals that facility visibility from the coastline is high. The closer the observer to the facilities (at a distance of 7.5km and in the center of the field of vision), the more considerable the visibility. However, visibility to the north/south in areas that are further away from the facilities, or from places to the west that are far from the shore, is distant, elevated above the horizon, at the edge of the field of vision and is not highly significant. The number of facilities and their density will have a varying effect on the resulting view.

4.3.3 Landscape description

A visually-oriented landscape-related description is presented in detail in Section 4.3.2, above.

4.3.4 Means of reducing visual impact

Unlike onshore installations, the options for reducing the visual impact of offshore facilities, such as burying the planned installations or selecting alternative materials, are severely limited due to the great distance from the observation sites. Concealment is also irrelevant in this case due to the linearity and extended length of the area of visibility, and the fact that any attempt at concealment would itself mar the broad horizon, which is one of the core qualities of the coastline.

Nevertheless, we are still required to examine at the detailed planning stage the possibility of reducing installation height to the absolute minimum such that the impact on the overall contour and the horizon is minimized as far as possible.

A further method to apply is correct use of lighting during twilight and dark hours:

External facility lighting – direct illumination of the external walls facing the shore (either in parallel or at an angle) will reflect the light to the shore, increasing facility visibility at night. To minimize night visibility, these walls must be kept dark.

Internal facility lighting – low-pointing illumination better utilizes light given off by the light fittings; more light remains inside the facility and less is reflected out to the sky and environment. Lighting that is pointed up to the sky (particularly when it is cloudy and humid above the sea surface) will make the facilities stand out at night.

Therefore, to reduce illumination from the facilities, lighting must be installed such that it is directed downwards inside the facility and the plan must avoid illuminating tall elements unnecessarily.

4.3.5 Means of reducing harm to the environment/landscape

See Section 4.3.4, above.

4.4 Antiquities and heritage

4.4.1 Antiquity and heritage values

Historical sites in the plan boundaries have been reviewed in detail in Chapters 1 and 2 of the plan, and the position of the Antiquities Authority, Unit of Marine Archeology has been accepted.

Antiquities and heritage values that might be affected by the plan's implementation in the marine compound are: officially declared antiquity and heritage sites located in the pipeline work area or adjacent to it, and antiquity sites located at the coastal entry area.

These are the main points made by the Antiquities Authority as listed in Chapters 1 and 2 of the Survey:

1. The Antiquities Authority will have no objection in principle to alternatives provided that the method used is HDD insertion of pipes in the subsoil. The Antiquities Authority will object to constructing a cofferdam in the Dor alternative.
2. Archeological tests will be required at each of the coastal entry sites: surveys, and if necessary test/conservation excavations in the marine corridor area; if necessary the pipeline will be shifted within the blue-line area of the marine corridor. Mandatory archaeological tests will be required at the planning stage prior to receiving a building permit.
3. Of the suggested sites – the worst alternative as far as the Antiquities Authority is concerned is the Dor alternative. The region in question is a marine area that abounds with ancient installations and ships, so archaeological tests will be costly and protracted.

4.4.2 Means of minimizing the ramifications of implementing the plan

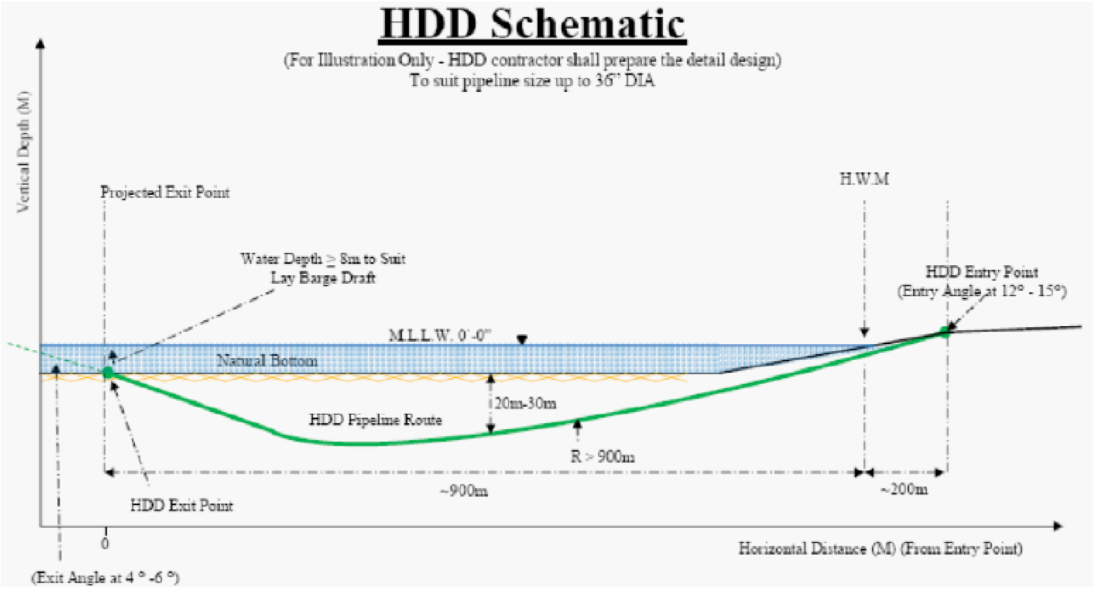
The means of minimizing the plan' ramifications are site-dependent, as detailed in Section 4.1.1.

In coastal entry areas, the HDD method will be used as described in detail in Section 3.1 of Appendix C, below (prepared by Bipol Energy, marine engineering consultants for the project).

Using this method, it is possible to reduce the effect on marine and coastal archeological sites by using a subterranean passage under the declared archeological sites.

A schematic illustration of the HDD drill is presented below:

Figure 4.4.2-1 : Schematic illustration of HDD



Marine pipeline routes can be shifted if they cross an archaeological site or discovery (such as shipwrecks) to avoid possible damage.

All works must be conducted according to instructions received in August 2012 from the Antiquities Authority; this requires compliance with the Antiquities Law – 1978, as well as preliminary tests before development works begin.

4.5 Seismology

During an earthquake, multiple systems on the various installations may potentially suffer damage simultaneously; this includes persons being placed in danger and initiation of a pollution incident. When addressing prevention as well as treatment, it is necessary to consider the possibility that critical systems such as electricity, water, and communications will collapse; this will hinder lifesaving and damage control efforts. Recall also that an earthquake will affect the availability of rescue services and there may be significant delay in arrival of external assistance. As far as preventing damage, an earthquake warning system must be installed capable of recognizing ground motion, providing voice alerts on the facility, and initiating a series of automated actions to reduce hazards – shutting off valves, switches, and other systems that control processes on the facility. In the matter of treatment, it is advisable to establish emergency procedures for the facility crew in case they are required to act on their own to save lives and contain damage for a few hours or even longer until rescue forces arrive.

Expected consequences of a medium to large earthquake are: fire, explosion, collapse, falling objects and equipment, pipes disconnecting and discharging hazardous materials to air and sea. Any unanchored object / piece of equipment must be assumed to be a threat to human life, even in case of a small earthquake.

Note that seismic design must also take into account stability of all non-structural components. Safeguarding the pipeline systems is a significant aspect of a project such as this one, as they are sensitive at connection and curve points as well as being sensitive to differential motion over distances; this is the case for pipes in the facility and pipes entering or exiting the facility.

4.5.1 Expected ramifications of seismic events

Analysis of potential technical failures in the context of a seismic event and appropriate preventive measures

Earthquake damage is caused directly by wave propagation through the ground. We refer to the platform in its entirety including the various installations and pipelines entering and exiting it. Danger to the offshore platform from tsunami waves includes structural damage from the wave load and from collision with vessels that are anchored to the platform or near it at the time. In the present plan, tearing of the surface is unlikely because no active faults are known to traverse the platform plan areas. Many examples of non-structural component failure, as well as positive examples of structures having withstood strong earthquakes are available in FEMA-E74 (2011)[20]. Principal failures that can be expected during a strong earthquake apart from damage to the platform structure are:

Pipeline damage – damage to pipeline systems as a result of an earthquake includes: bent pipes, detached anchoring points, and pipe perforation and tearing. Most failures occur at the join and weld points. Vibration from the tremor is the cause of damage inside structures and installations. Pipe resilience is determined by the way pipes are anchored, their resistance to tensile and bending stresses, and the resistance of the elements to which the pipes are anchored such as walls, pumps, tanks, etc. Buried pipelines (or pipes lying on the ground), such as the pipeline from platform to shore, can be damaged by soil-liquefaction related permanent strain. In fact, evidence from earthquakes in the US indicates that buried pipelines are mostly damaged by soil permanent strain resulting from soil liquefaction rather than by the vibrations themselves (FEMA-233, 1994). It was further found that most pipelines did withstand the tremors except for a few cases in which corrosion had developed or in which it turned out that quality of the welding

[20] http://www.fema.gov/library/viewRecord.do?id=4626

work was poor.

Preventive measures include: standard anchoring methods, use of piping that is resistant to tensile stresses and corrosion, and careful planning and close supervision of the welding work.

Tank damage – earthquake damage to tanks may appear as bulge and tearing of the tank base (elephant foot), tanks getting dragged, vertical cracks and puncture holes in the joins. Tanks with a large height-to-diameter ratio are more sensitive to overturning. Preventive measures include standard-compliant foundation and anchoring, pallets, and flexible pipe connectors.

Environmental implications and treatment methods

Should a pollution incident develop as a result of failure during an earthquake, the most important thing is to quickly discover the pollutant and treat it immediately at source – in case of fire or leak, see details in Section 4.7.7, below.

- Air pollution

  Failures resulting from an earthquake may discharge pollutants into the air that will impair air quality up to a certain distance from the facility. These substances will be gases released from pipes and tanks, vaporized liquids that have leaked and cover large areas, and products of fire in the facility. Potential emissions of substances following an earthquake are: gas emissions from methane and MEG pipes, from condensate tanks, and from methanol tanks. Emissions following combustion of the substances noted above will largely contain nitrogen oxide, sulfur oxides, particulates, and volatiles. If an air pollution incident develops following an earthquake, the most important thing is to immediately treat the pollution source, such as stopping or minimizing the leak by shutting off the valves.

- Sea pollution

  Possible scenarios associated with sea pollution following an earthquake are based on failures in condensate or diesel tanks, failure in the pipeline, and discharge of produced water. Appendix J contains models describing dispersion patterns and arrival at the shore of leaking pollutants under several scenarios: 100,000 barrels of condensate following a break in a storage tank, 31 tons of operational diesel from a storage tank, 6 cubic meters of diesel from a pipe malfunction, and discharge of produced water at a rate of 1,468 cubic meters/day. Other chemicals to be found on the platform are listed in Chapter 12: PDI Report, included in Appendix B, which addresses platform design and environmental implications. These substances, over and above those mentioned before, include: MEG in two 3200 cubic meter storage tanks, and methanol (30 cubic meters based on a preliminary assessment). There are also smaller amounts of additional substances such as chemicals that are needed during the gas treatment process, lubricants, detergents, and paints. The environmental implications of leaks will be outlined at the building-permit stage according to the planned specification.

4.5.2 Preventive and treatment measures for contamination incidents

Local early warning system for earthquakes

The local early warning system will have at least one sensor installed at the site capable of identifying the first waves (P waves) that reach the site when an earthquake occurs. This system can analyze P-wave frequency and decide whether it is an earthquake or some other event such as a blast in a quarry (Heiman, 2007)[21]. The waves responsible for most of the damage caused by earthquakes (S waves and surface waves) arrive after the P waves so it is possible to obtain some degree of notice (usually a few seconds) depending on the distance from the earthquake epicenter. The main source of future strong tremors is the Dead Sea fault located upwards of 80km away from the offshore facilities, which means at least 10 seconds early warning. More distant tremors along the Dead Sea fault, for instance in the Arava/Eilat and Hula valley/Lebanon, will have a 15 second warning or longer. These are gross time estimates that are based on the difference in velocity between P and S waves (Heiman, 2007; Figure 4); they do not include other time losses such as system calculation and decision times.

Connecting to a future national early warning system

National early warning systems for earthquakes (Truah) and tsunamis (Mayim Adirim) have been discussed by the ministerial committee for earthquake preparedness, appended to the government decision protocol, and ratified by government decision on 07 June 2012[22]. The system is currently expected to be operational in 2016. The national system will be composed of spatially deployed sensors that can provide short-term warning of an earthquake (effective warning of 1-30 seconds). The system's advantage compared to a local warning system is a somewhat extended span between identification and warning and arrival of the destructive waves, as well as a reduced chance of false-positive or false-negative identification of a tremor.

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[21] Heiman, A. 2007. Early warning in Israel. Geological Survey of Israel GSI/06/2007
[22] Resolution no. 4738 or RAD/22

Government decision also states that until the national system is installed: "local warning systems will be installed at factories and facilities that constitute a potential hazard to population if hit, and in which it is possible to install an automatic system that will prevent malfunctions from developing. The warning signal must automatically initiate a sequence that will prevent a failure from developing, for instance: shutting off valves, releasing locks, channeling chemicals, stopping or slowing down processes, etc."

In any case, future suppliers will have to communicate with the Earth Sciences Administration which is in responsible for planning, construction, and operations of the system and system deployment, as soon as it is operational. Initially, the warning is planned to be communicated via wireless connection to end-units that will issue a voice warning mainly in schools. As far as is known from pager-service literature it will also be possible to use the device to remotely activate emergency devices. Coordination regarding receiving the warning proceeds through the Home Front Command and the National Emergency Authority. In future it may become possible to disseminate the warning using other means such as computer, radio and TV communications, and mobile telephony.

Emergency systems – fire control and extinguishing

Emergency systems have an important role in preventing and minimizing damage during an earthquake. They must, therefore, be designed to stringent seismic standards. These include, for instance, anchoring critical systems and having a backup electric system in place, using extinguishing tanks when the external water supply is cut off, and having flexible pipes connected to the tanks.

Standards

This section will discuss the main standards related to developing the seismic component of the offshore platform and its installations.

IS 413 – Part 1

This section supplies data for developing a response spectrum for structures that are subject to this standard, as presented in Chapter 1 of the Survey and based on results of the seismotectonic analysis. IS 413 does not apply to the platform structure, but the response spectrum that it provides is based on the Israeli seismotectonic environment. The current standard provides information going back only 475 years. Information on longer return periods is presented in the appendices to the Standard, available on the Standards Institute of Israel website (http://www.sii.org.il/655-HE/SII-Israel.aspx). Information on longer return periods is also available in Amendment 5 of the Standard, which can already be used although it was is not yet validated at the time of writing.

In addition to the platform structure, there are non-structural components on the platform that must be able to withstand the expected seismic loads. The standard Design Provisions for Earthquake Resistance Design: non-building structures – General, and the standards that are subject to it address four types of non-structural installations: steel storage shelves (2.1), tanks on the surface (2.2), elevated tanks (2.3), and above-ground pipelines in industrial installations (2.4). Only a small number of the guidelines in this standard are applicable to the installations on the rig. Israeli standards for additional non-structural installations are being planned, but as they are not currently available non-Israeli standards and guidelines must be relied on. These are listed in IS 413, and for additional ones see below.

Platform design standards:

- International Organization for Standardization:

  Specific requirements for offshore structures (ISO-19901)

  Fixed steel offshore structures (ISO-19902)

- American Petroleum Institute:

  Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms (API RP 2A)

  The Norwegian NORSOK Standard

These standards largely overlap and have guidelines for all types of expected loads including seismic load. The NORSOK standard relies on existing international standards (ISO) adding emphases and improvements that are applicable to Norwegian platforms. This standard does not refer to seismic load in detail and will therefore not be discussed further. The ISO and API standards are going through a gradual harmonization process in terminology and in requirements (DNV, 2011).

Figure 4.5.2-1: Description of harmonization process between ISO and API standards for platform design (DNV, 2011)

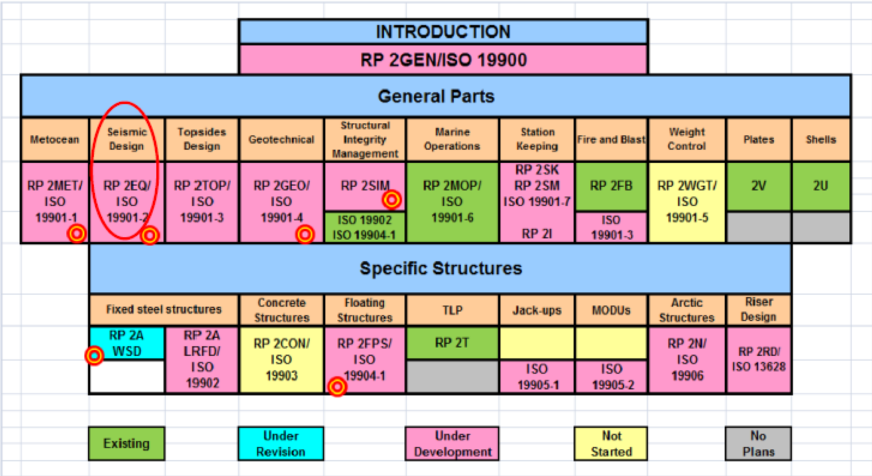


Figure 1-1 ISO API Standards Harmonization

According to both standards platform durability must be designed for two earthquake scenarios representative of two separate levels of seismic load:

1. Extreme Level Earthquake (API) or Strength Level Earthquake (ISO) tremor with a return period of 100-200 years. The durability requirement for this tremor is:

   "Structural stress should not exceed yield. Structure should sustain little or no damage"

2. Abnormal Level Earthquake (API) or Ductility Level Earthquake (ISO) tremor with a return period of 1000-5000 years. Durability requirement for this tremor is:

   "Structural stress may exceed yield but should not collapse"

This means that when conducting a seismic analysis for seismic platform design, design tremor and seismic load levels must be defined with a return period as described in the two reference scenarios defined above.

Note that the standards also include global maps and methods for calculating accelerations and response spectrum at each point. However, these maps are too generalized and a specific seismotectonic analysis must be conducted, as well as a site response survey that will articulate the seismic amplification at the site based on its soil's geotechnical properties – compliant with the guidelines in Chapter 5 of the Survey. All other guidelines associated with design and platform seismic durability must be derived from the API/ISO standards described here, and based on the calculated design accelerations, response and amplification spectra.

The table below, excerpted from the DNV report (2011), lists guidelines for seismic design of the platform and a comparison between the two standards.

	API RP 2A			ISO 19901-2		
Earthquake Design	SLE (Strength Level Eqrthquake) DLE (Ductility Level Earthquake)			ELE (Extreme Level Eqrthquake) ALE (Abnormal Level Earthquake)		
Seismic Risk Map	Figure C2.3.6.1 - Seismic Risk of United States Continental Shelves			Worldwide Seismic Maps (Appendix B) - The return period selected for the development of the ground motion maps is 1000 year. - The maps give generic 5% damped spectral accelerations, expressed in g, for bedrock outcrop for a 1.0 s oscillator period and for a 0.2 s oscillator period respectively.		
Seismic Zones	Zones 0 0.0g 1 0.05g 2 0.10g 3 0.20g 4 0.25g 5 0.40g Based on 200-year earthquake			Zones Sa, map (1.0) 0 <0.03g 1 0.03g - 0.10g 2 0.11g - 0.25g 3 0.26g - 0.45g 4 >0.45g Sa,map(1.0) is the rock outcrop 1.0 second horizontal spectral acceleration corresponding to 1000-year earthquake.		
Foundation Soil	Soil Class	Soil Profile	Soil shear wave velocity, ft/sec	Soil class	Soil profile name	Soil shear wave velocity, v_s, m/s
	A	Rock - crystalline, conglomerate, or shale-like material	> 3000 ft/sec (914 m/sec)	A/B	Hard rock/Rock, thickness of sediments < 5 m	$v_s > 750$
				C	Very dense hard soil and soft rock	$350 < v_s \leq 750$
	B	Shallow strong alluvium - component sands, silts and stiff clays with shear strengths in excess of about 1500psf (72 kPa), limited to depths of less than about 200 ft (61m), and overlying rock-like materials		D	Stiff to very stiff soil	$180 < v_s \leq 350$
	C	Deep strong alluvium - components sands, silts and stiff clays with thickness in excess of about 200 ft (61m) and overlying rock-like materials		E	Soft to firm soil	$120 < v_s \leq 180$
				F	-	Any profile, including those otherwise classified as A to E
Earthquake Directional Loads (Actions)	1.0:1.0 (two horizontal orthogonal dir.) and 0.5 (vertical), acted simultaneuously)			1.0:1.0 (two horizontal orthogonal dir.) and 0.5 (vertical), acted simultaneuously		
Earthquake Directional Combinations	root of the sum of the squares method(SRSS)			SRSS or 1 component 100%, and 40% of its maximum values in other 2 components combined linearly		
Time History Analysis	Minimum 3 sets of time history records			Minimum 4 sets of time history records		
Response Spectrum Shape	T≥4.0 seconds, Sa(T) proportional to 1/T			T≥4.0 seconds, Sa(T) proportional to $1/T^2$		
Structural Slenderness (DLE or ALE)	kl/r ≤ 80 (primary diagonal bracing)			kl/r ≤ 80 (primary diagonal bracing)		
Tubular D/t Ratio (DLE or ALE)	D/t ≤ $1900/F_y$			D/t ≤ $2000/F_y$		
Pile-Soil Performance for ELE	ϕ_{PE} = 0.80 (axial) (1/0.8 = 1.25)			Partial resistance factor - 1.25 (axial) Partial resistance factor - 1.00 (p-y curves)		
Pile-Soil Performance for ALE	ϕ_{PE} = 1.0 (axial)			Partial resistance factor - 1.00 (axial) Partial resistance factor - 1.00 (p-y curves)		
Pile Axial Capacity Requirements (General)	API-LRFD ϕ_{PE} = 0.80 (axial) (extreme conditions) (1/0.8 = 1.25) ϕ_{PO} = 0.70 (axial) (operating conditions) (1/0.7 = 1.429) API-WSD Factor of Safety = 1.50 (extreme conditions) Factor of Safety = 2.00 (operating conditions)			Partial resistance factor - 1.25 (extreme conditions) Partial resistance factor - 1.50 (operating conditions)		

Nati

	API RP 2A		ISO 19901-2		NORSOK N-003 & N-004
Provisions Purpose	1.The strength requirements are presented to provide resistance to moderate earthquake, which have a reasonable likelihood of not being exceeded during the life of the platform, without significant structural damage. 2. To prevent collapse of the platform in the event of rare intense earthquake ground motions.	**Provisions Purpose**	1. The seismic ULS design event is the extreme level earthquake (ELE). The structure shall be designed such that an ELE event will cause little or no damage. The ULS requirements are intended to ensure that no significant structural damage occurs for a level of earthquake ground motion with an adequately low likelihood of being exceeded during the design service life of the structure. 2. The ALE (abnormal level earthquake) requirements are intended to ensure that the structure and foundation have sufficient reserve strength, displacement and/or energy dissipation capacity to maintain the overall structural integrity and avoid structural collapse.	**Provisions Purpose**	1. ULS (strength) check of components based on earthquakes with an annual probability of occurrence of 10^{-2} and appropriate action and material factors; 2. ALS check of the overall structure to prevent its collapse during earthquakes with an annual probability of exceedance of 10^{-4} with appropriate action and material factors 3. This provisions mainly focus on Norwegian continental shelf.
Strength Requirement – Structural Modeling (section 2.3.6.c2)	1.The analysis model should include the three dimentsional distribution of platform stiffness and mass; 2. Earthquake loading should be combined with other simultaneous loadings such as gravity, buoyancy, and hydrostatic pressure; Gravity loading should include the platform dead weight (comprised of the weight of the structure, equipment, appurtenances), actual live loads and 75% of the maximum supply and storage loads. 3. In computing the dynamic characteristics of braced, pile supported steel strcutures, uniform modal damping ratios of 5% critical should be used for an elastic analysis.	**Extreme Level Earthquake Design** – Action Combinations	1. Design Action $F_d = 1.1G_1 + 1.1G_2 + 1.1Q_1 + 0.9E$ where E: the inertia action induced by the ELE ground-motion and determined using dynamic analysis procedures such as response spectrum or tme-history analysis G_1 and G_2: permanent actions; Q_1: variable action; and shall include actions that are likely to be present during earthquake. When contributions to the action effects due to weight oppose the inertia actions due to the earthquake, $F_d = 0.9G_1 + 0.9G_2 + 0.8Q_1 + 0.9E$ where G_1, G_2 and Q_1 shall include only actions that are reasonably certain to be present during an earthquake. 2. The mass used in the dynamic analysis: - the permanent actions G1 and G2 - 75% of the variable actions Q1 - the mass of entrapped water, and the added mass 3. A modal damping ratio of 5% of critical may be used in the dynamic analysis of the ELE event.	**ULS** – Action Combinations	1. The number of vibration modes in the analysis should represent at least 90% of the total response energy of all modes. 2. In the absence of more accurate information, a modal damping ratio of 5% of critical may be used. 3. Earthquake shall be handled as environmental action within the limit state design for ULS: ULS (a): 1.3G + 1.3Q + 0.7E ULS (b): 1.0G + 1.0Q + 1.3E
Response Analysis (section 2.3.6.c3)	1. **Response spectrum method** - one design spectrum is applied equally in both horizontal directions. An acceleration spectrum of one-half that for the given zone should be applied in the vertical direction. The complete quadratic combination (CQC) method may be used for combining modal responses and the square root of the sum of the squares (SRSS) may be used for combining the directional response. At least two modes having the highest overall response should be included for each of the three principal directions plus significant torsional modes. 2. **Time history method** - the design response should be calculated as the average of the maximum values for each of the time histories considered.	Response Analysis	1. In both methods, the base excitations shall be composed of three motions, i.e. two orthogonal horizontal motions and the vertical motions. 2. **Response spectrum method** - When responses due to each directional component of an earthquake are calculated separately, the responses due to the three earthquake directions may be combined using the root of the sum of the squares method. Alternatively, the three directional responses may be combined linearly assuming that one component is at its maximum while the other two components are at 40% of their respective maximum values. 3. **Time history method** - a minimum of 4 sets of time history records shall be used to capture the randomness in seismic motions. The ELE design is satisfactory if the code utilization maxima are less than 1.0 for half or more of the records; a scale factor of 1.05 shall be applied to the records if less than 7 sets of records are used.	Response Analysis	1.Earthquake motion can be described by two orthogonal horizontal motions and the vertical motion action simultaneously. 2. One of the horizontal excitations should be parallel to a main structural axis, with the major component directed to obtain the maximum value for the response quantity considered. Unless more accurate calculations are performed, the orthogonal horizontal component may be set equal to 2/3 of the major component and vertical component equal to 2/3 of the major component, referred to bedrock. 3. Time history method - the load effect should be calculated for at least three sets of time histories. The mean values of the calculated action effects from the time history analyses may be taken as basis for design.
ction 2.3.6.c4 & 2.3.6e)	1. The structural members should not exceed yielding of the complete section or buckling. 2. For strength requirement, the basic AISC allowable stresses and those presented in Section 3.2 (Allowable Stresses for Cylindrical Members) may be increased by 70 percent. 3. For combined earthquake loading and hydrostatic pressure, the suggested safety factors for local buckling and interaction formula listed in Section 3.2 are as follows: Axial Tension 1.0 Axial Compression 1.0-1.2 Hoop Compression 1.2 4. Addtional Guidelines	mance	1. All primary, secondary structural and foundation components shall sustain little or no damage to the structure. Limited non-linear behaviour (e.g. yielding in steel) is permitted, but brittle degradation (e.g. local buckling in steel) shall be avoided. 2. The internal forces in joints shall stay below the joint strengths, using the calculated (elastic) forces and moments. 3. Masts, derricks and flare structures shall be capable of sustaining the motions transmitted via the structure with little or no damage. 4. For the design of piles for ELE event, a partial resistance factor of 1.25 shall be used to determine the axial pile capacity and a partial resistance factor of p-y curves of 1.0 shall be used to determine the lateral pile performance.	ssessment	Material Factor γ_M =1.15

API RP 2A			ISO 19901-2			NORSOK N-003 & N-004		
	Response Assessment (se	a) Tubular joints are sized for the yield or buckling capacity of incoming members, so that premature failure of the joints will be avoided and the ductility of the overall structure can be fully developed. b) Joint capacity may be determined in accordance with Section 4.3 except that Equations 4.3-1, 4.3-2, and 4.3-3 should all have the safety factor (FS) set equal to 1.0. See Commentary for the influence of chord load and other detailed considerations. c) Deck-supported structures, and equipment tie-downs, should be designed with a **one-third increase** in basic allowable stresses. This lower increase in design allowables for strength level earthquake loads compared to a full yield stress allowable typically used for jackets is intended to provide a margin of safety in lieu of performing an explicit ductility level analysis.		ELE Perfo			Response As	
Ductility Requirements	Limitations (section 2.2.6 d2)	1. The intensity ratio of the rare, intense earthquake ground motions to strength level earthquake ground motions is 2 or less. 2. Systems are jacket type structures with 8 or more legs.	**Abnormal Level Earthquake Design**	Structural Modeling	1.Structural and foundation models shall include possible stiffness and strength degradation of componets under cyclic action reversals. 2. The ALS analysis shall be based on best estimate values of modelling parameters such as material strength, soil strength and soil stiffness. 3. A modal damping ratio of 5% of critical may be used in the dynamic analysis of the ALE event.	**ALS**	Structural Modeling	1. The number of vibration modes in the analysis should represent at least 90% of the total response energy of all modes. 2. In the absence of more accurate information, a modal damping ratio of 5% of critical may be used. 3. Earthquake shall be handled as environmental action within the limit state design for ALS (abnormal effect). ALS (a): 1.0G + 1.0Q + 1.0E
	Design Practice (section 2.3.6 d2)	1. Jacket legs, including any enclosed piles, are designed to meet the requirements of 2.3.6c4, using twice the strength level seimic loads; 2. Diagonal bracing in the vertical frames are configured such that shear forces between horizontal frames or in vertical runs between legs are distributed approximately equally to both tension and compression diagonal braces, and that "K" bracing is not used where the ability of a panel to transmit shear is lost if the compression brace buckles. Where these conditions are not met, including areas such as the portal frame between the jacket and the deck, the structural components should be designed to meet the requirements of Section 2.3.6c4 using twice the strength level seismic loads. 3. Horizontal members are provided between all adjacent legs at horizontal framing levels in vertical frames and that these members have sufficient compression capacity to support the redistribution of loads resulting from the buckling of adjacent diagonal braces. 4. The slenderness ratio (Kl/r) of primary diagonal bracing in vertical frames is limited to 80 and their ratio of diameter to thickness is limited to 1900/Fy where Fy is in ksi (13100/Fy for Fy in MPa). All non-tubular members at connections in vertical frames are designed as compact sections in accordance with the AISC Specifications or designed to meet the requirements of 2.3.6c4 using twice the strength level seismic loads.		Response Analysis	1. In both methods, the base excitations shall be composed of three motions, i.e. two orthogonal horizontal motions and the vertical motions. 2. The following two methods of analysis are allowed for the ALE design check: a) the static pushover or extreme displacement method - to be used to determine possible and controlling global mechanisms of failure, or the global displacement of the structure (beyond the ELE) b) the non-linear time history analysis method - performing a displacement controlled structural analysis. 3. A minimum of 4 sets of time history records shall be used to capture the randomness in seismic motions. If 7 or more time history records are used, global structure survival shall be demonstrated in half or more of the time history analyses. If fewer than 7 time history records are used, global survival shall be demonstrated in at least 4 time history analyses.		Response Analysis	1.Earthquake motion can be described by two orthogonal horizontal motions and the vertical motion action simultaneously. 2. One of the horizontal excitations should be parallel to a main structural axis, with the major component directed to obtain the maximum value for the response quantity considered. Unless more accurate calculations are performed, the orthogonal horizontal component may be set equal to 2/3 of the major component and vertical component equal to 2/3 of the major component, referred to bedrock. 3. Time history method - the load effect should be calculated for at least three sets of time histories. The mean values of the calculated action effects from the time history analyses may be taken as basis for design.
	Structural Analysis	1. Structure-foundation systems which do not meet the conditions listed in 2.3.6d2 should be analyzed to demonstrate their ability to withstand the rare, intense earthquake without collapsing. 2. The time history method of analysis is recommended. 3. At least three sets of representative earthquake ground motion time histories should be analyzed.		ALE Performance	1. Structural elements are allowed to exhibit plastic degrading behaviour (e.g. local buckling in steel), but catastrophic failures such as global collapse or failure of a cantilevered section of the deck should be avoided. 2. Stable plastic mechanisms in foundations are allowed, but catastrophic failure modes sych as instability and collapse should be avoided. 3. Joints are allowed to exhibit limited plastic behaviour but should stay within their ultimate strengths. Alternatively, where large deformations in the joints are anticipated, they shall be designed to demonstrate ductility and residual strength at anticipated deformation levels.		Response Analysis	Material Factor γ_M =1.0

Standard DNV-OS-F101 Submarine Pipeline Systems:

This standard contains guidelines and criteria for planning, building, and operating submarine pipelines. The standard encompasses all stresses that must be addressed, including the seismic aspect.

FEMA E-74 Guidelines and examples for additional nonstructural components:

Reducing the risks of nonstructural earthquake damage – A practical guide

This document refers in detail to three groups of components – architectural (e.g. windows, steps, cladding), mechanical, electrical, piping, and equipment components, other fixed elements, and furniture. The document also contains information about the standards to be used, mainly US standard ASCE/SEI 7-10 which refers to standard stresses on structures (including seismic stresses) and ASME B31 Process Piping, a specific standard for piping systems.

4.6 Noise

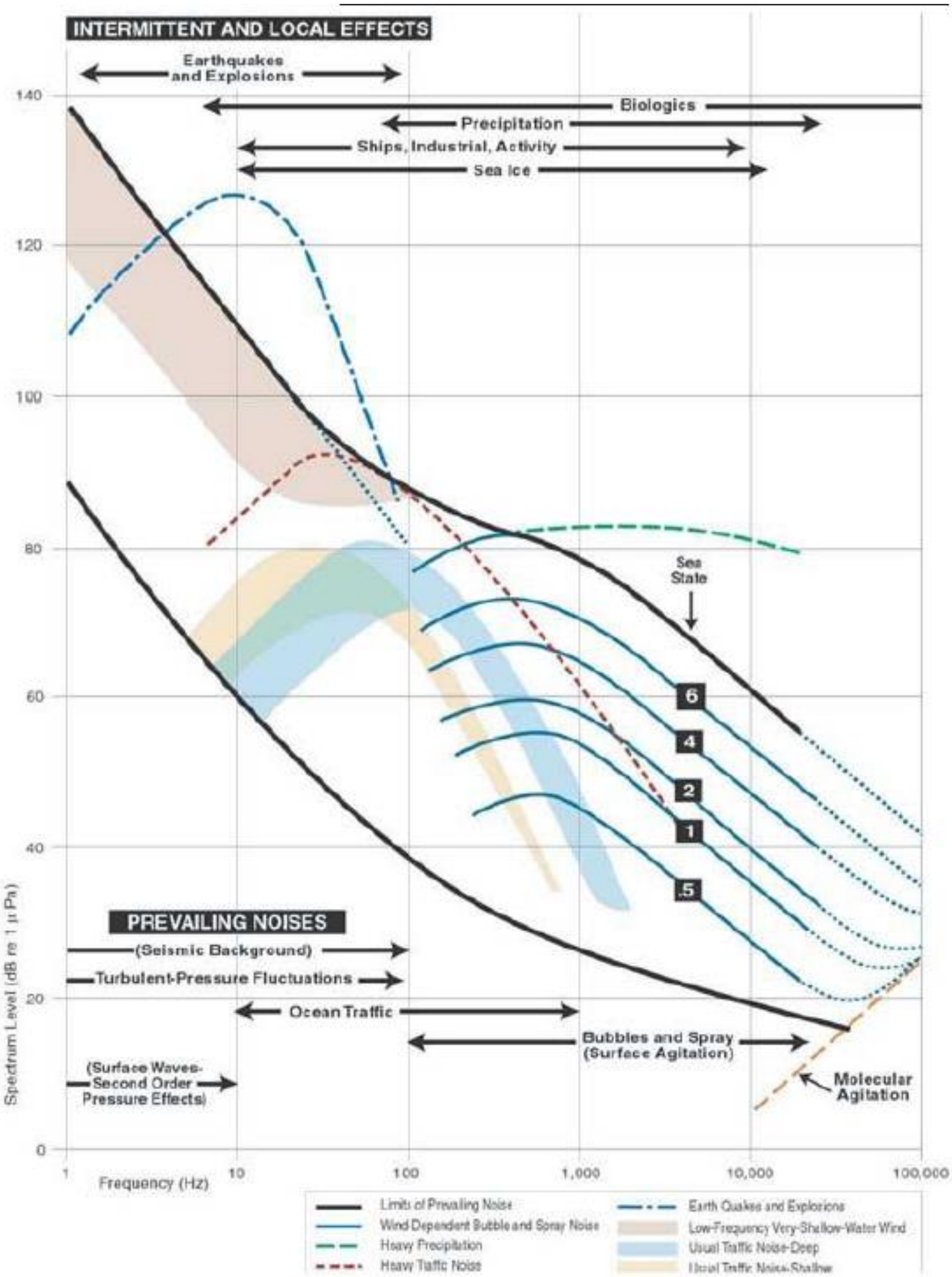
<u>On the offshore segment</u>

4.6.0 General – basic hydroacoustics

Sound waves occur in the water and have similar properties to sound waves in the air. Sound waves are cyclic pressure waves riding the static pressure in the medium. As in the air, wave intensity is measured in decibels based on a reference pressure. Reference pressure in air is 20 micropascal, and in seawater it is 1 micropascal. This difference in reference pressure means that sound intensity when expressed in decibels is greater by 26 decibels in the sea compared to the same pressure wave when it is carried through the air.

As in the air, there is background noise in the sea from various sources, manmade or naturally occurring. Figure 4.6.0-1 illustrates the variety of sounds in the sea and ranges of levels as a function of frequency.

Figure 4.6.0-1: Schematic illustration of noise levels in the open sea according to Wenz



The chart can be used to identify the sound sources that determine noise in the open sea far away from specific noise sources. We note that this chart shows noise spectrum at a spectrum of 1 Hertz. To determine total noise level the spectrum must be added up over the appropriate frequency range.

Dominant noise in the 1-100 Hertz frequency range is seismic noise and earthquakes.

Noise from ships and underwater industrial activity is in the range of 10-10,000 Hertz; ship noise does not usually exceed 3,000 Hertz.

Wave noise dominates the frequency range of 100-20,000 Hertz. Wave intensity and noise are wind-dependent which is why sea states have been defined; sea states define wave noise level as a function of wind speed. For our purposes, a sea state 0 or 0.5, defined as very calm sea with no wind or waves, is sufficient; under these conditions noise level is very low.

Just as it does in the air, noise level at sea attenuates with increasing distance from the noise source. At shallower depths noise propagation in the sea includes both a direct path and propagation paths created by sound waves reflecting off the seabed and the surface. Figure 4.6.0-2 is a schematic representation of noise propagation from a hammer striking a pile.

Figure 4.6.0-2: Noise propagation from a hammer striking a pile

Noise propagation from pile driving in a marine environment

At shallower depths pressure waves propagate cylindrically - by approximation - due to reflection off the water surface and from the seabed. Under this propagation model, noise level attenuates by 3 decibels with every doubling of the distance from the source.

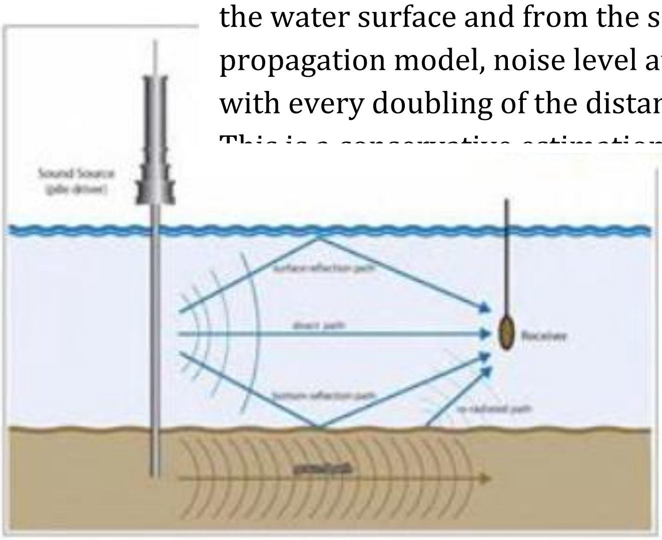


Figure 2-11. Underwater Sound Propagation Paths

If

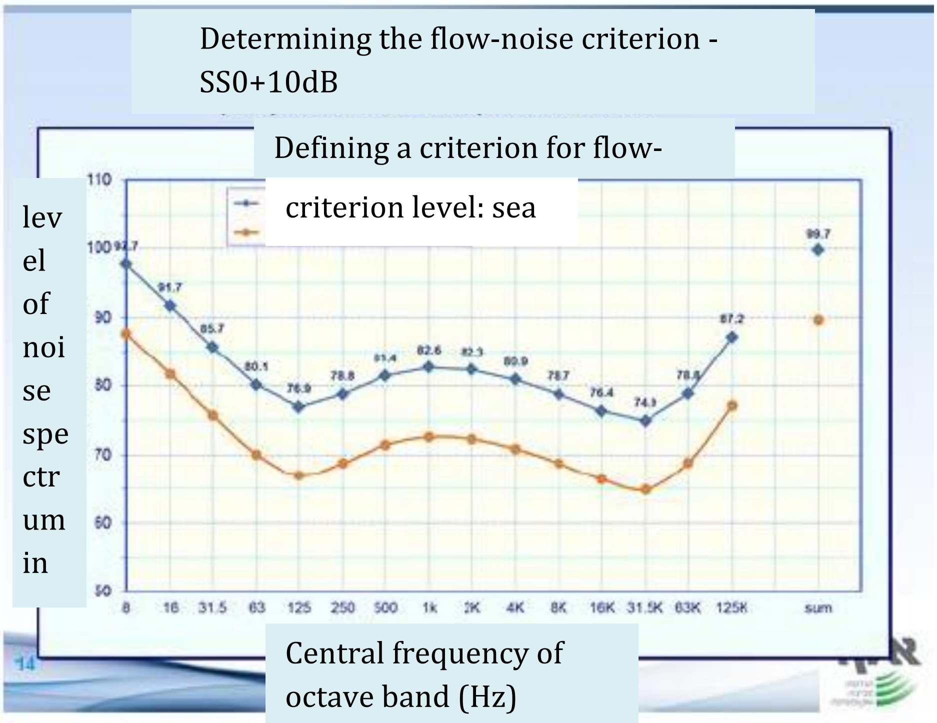
If noise would propagate through an infinite medium the wave would be spherical and its intensity would decrease inversely with the squared distance from the source, or by 6 decibels for each doubling of the distance. If sound propagates in a medium that is bounded by reflective surfaces, as seen in the illustration, noise attenuation with distance is smaller and propagation resembles cylindrical wave propagation making the noise attenuate by 3 decibels when distance is doubled. Added to the geometrical spreading factors are sound absorption mechanisms which strongly depend on wave frequency.

Many measurements made under various conditions at sea have shown that a good approximation of general noise attenuation in the frequency range of 10-10,000 Hertz is 4.5 decibels for every doubling of distance from the source.

It is common practice to establish a threshold for testing the impact of noise level from industrial applications on navigation and on military activity by referring to existing noise at sea-state 0 + 10 decibels. This value is close to the lowest noise level found and is therefore a good threshold for testing the impact of anthropogenic noise. Moreover, because a 0 sea-state is uncommon it is acceptable to assume that in most cases anthropogenic noise will be softer than wave noise and its impact will be negligible.

Figure 4.6.0-3 shows the noise spectrum – on octave bands – of marine noise at sea-state 0 and at sea-state 0 + 10 decibels. Total noise in this state is 100 decibels relative to 1 micropascal.

<u>Figure 4.6.0-3: Determining flow noise criterion</u>



4.6.0.1 Noise sources

Set-up phase

Setting up the gas treatment system, including laying piping and establishing 4 platforms to treat the gas produced from the wells and transfer it to the onshore facility as specified in the engineering report (Appendix B) will undoubtedly be the noisiest stage of the system life cycle.

The dominant noise source, unquestionably, will be the sound of driving the piles that will bear the platforms. These piles will probably be 0.75-1m diameter steel casings. Diesel or steam hammers will strike the pile heads above surface level and will drive them to a depth of 100m from seabed level. Pile driving work is estimated to last 45 workdays. During this period, and afterward while the platforms are being constructed, significant traffic is expected of vessels of various kinds that are participating in the construction. Supply vessels, cranes, vessels with dynamic location systems are to be expected, among others.

Pile driving noise is a strong impulsive sound made by repeatedly striking each pile many times every work day. This section addresses this sound due to its magnitude and its potential negative impact on marine animals.

Operational phase

During the operational phase noise sources will be completely different in nature and intensity from set-up noise. These sources include the sound of gas flowing through the pipeline from the wells to the platform, from the platform to the onshore facility, and from the onshore facility back to the INGL (Israel Natural Gas Line), and the noise from the gas treatment equipment installed on the platforms.

4.6.1 Expected noise level

4.6.1.1 Pile-driving noise

Pile driving is an impulsive noise with the following acoustic parameters:

1. Average level of pressure for a noise event, obtained from a compression wave schematic for a period of time that contains approximately 95% of the energy of the noise event, as shown below:

Main measures for evaluating noise impact

SPLrms or SPL - average square root of the squared sound (or noise) pressure in dB, relative to a 1µPa reference pressure.

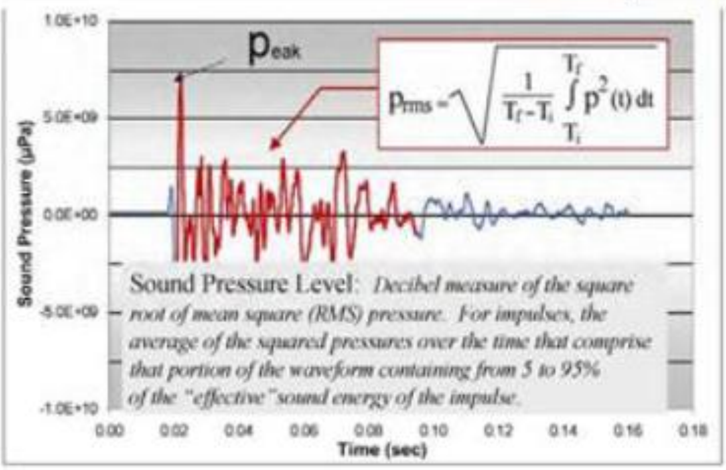


Figure 2-6. Effective Sound Pressure Level

2. Peak level of the noise event relative to the pressure wave peak caused by striking the pile, as shown below:

Main measures for evaluating noise impact

SPLpeak - peak level of the pressure wave at the same decibel scale. This level is higher by approximately 10dB than the SPLrms level.

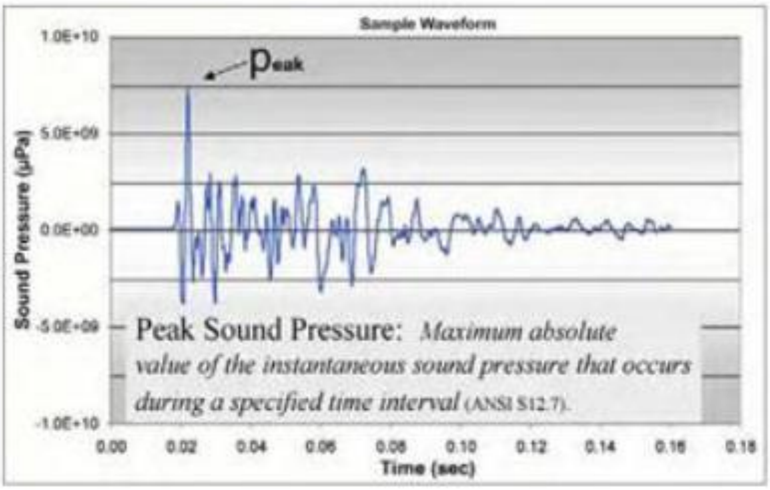


Figure 2-2. Peak Sound Pressure

3. Sound exposure level (SEL) obtained by integrating the sound pressure over

time and concentrating it to a period of one second. The significance of this sound level is that it is the level that would be obtained if the entire acoustic energy of the actual impulse was concentrated in a one-second acoustic impulse. See the illustration below:

Main measures for evaluating noise impact

SEL - Sound Exposure Level - total acoustic energy of the acoustic impulse obtained by integrating sound pressure over time - for a 1 second duration.

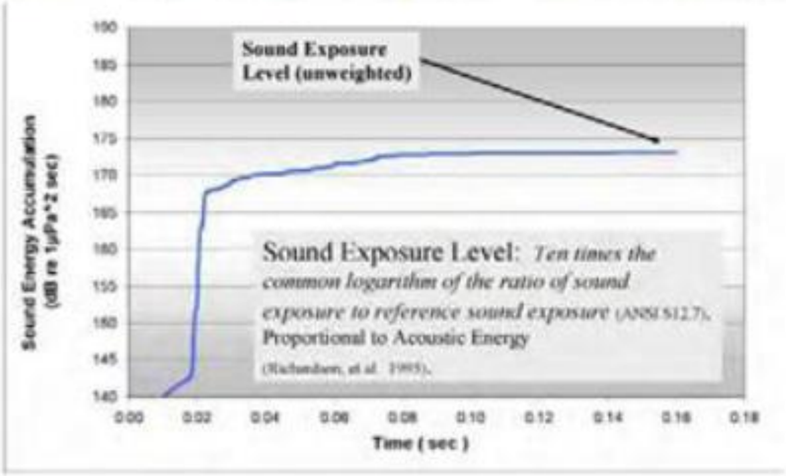


Figure 2-9. Sound Exposure Level

Many measurements of pile driving noise for piles the size that will be used to construct the present platforms have shown that SPL peaks at a distance of a few meters from the pile can be as high as 200 decibels. Mean noise level (SPLrms) at the same distance is approximately 180 decibels.

4.6.1.2 Noise from other sources

a. Noise from ships and vessels associated with setting up platforms

Source intensity for these vessels reaches an SPL peak of 181 decibels at a distance of 1m from the noise source. SEL for this source for a period of 24 hours will be 227 decibels at the same distance.

b. Noise of gas flow in pipelines

Gas flow noise in the pipelines was calculated for the expected flow data in the project's pipelines. Calculations show that even close to the pipeline they do not exceed the ambient noise level of sea-state 0 + 10 decibels.

c. Noise from equipment that will be installed on gas treatment platforms

The many machines that will be installed on the platforms will produce noise and vibrations that can potentially be carried underwater via the platform piles. However, equipment installed on the platform is required to comply with occupational hygiene requirements, so noise levels may not exceed 85 decibels(A) (in air). To achieve this, quiet equipment will be purchased, and it will be placed on elastic vibration isolators to prevent vibrations from passing to the platform body.

In conclusion we may state that underwater noise sources, other than pile-driving noise, are negligible and do not require any further examination under this study of their environmental impact, nor do they require control measures.

4.6.2 Impact of noise on marine mammals and turtles

4.6.2.1 General

The physical limitations of sensing by odor and vision in a marine environment mean that most marine animals use sound reception for long-range sensing in navigation, locating food and predators, and communication between individuals. Underwater noise from human activity can potentially mask important animal signals, cause severe or cumulative injury to animal auditory apparatus to the extent of partial of full deafness; at high intensities noise can injure tissue and cause death. Currently, there are field and lab reported findings of negative impact of noise on at least 55 marine species of invertebrates, fish, turtles, and marine mammals (Anon, 2012).

According to Richardson et al. (1995), the impact zone around a sound source can be divided into six zones corresponding with impact on animals:

No impact zone, in which the acoustic signal is low and blends into the ambient noise, or, alternatively, its intensity is lower than animals’ hearing threshold.

Detection / reception zone, noise level is above animals' hearing threshold and is therefore audible.

Behavioral response zone, animals respond to the noise, listen to it, and produce an intentional response.

Masking zone, noise causes functional disruption and impairs an animal's ability to detect signals that are significant to it.

Discomfort zone, the noise stimulus is perceived by the animal as hostile/ repulsive/ threatening and may result in the animal escaping from the noisy area.

Injury zone, noise stimulus may cause temporary or irreversible physiological trauma.

Although trauma thresholds are based on unambiguous pathological evidence, note that discomfort thresholds (as well as the milder influences) are usually based on behavioral observations such as changes or supposed changes in visible or audible aspects such as speed, direction of swimming, breath rate, vocal communication properties, etc. rather than on physiological or biochemical markers that indicate stress.

Objective trauma thresholds based on experiments on animals held in captivity (pools, cages, aquaria) do not necessarily reflect conditions at sea.

4.6.2.2 Acute injury and discomfort or displacement versus long-term cumulative injury

Up until recently, emphasis was placed on the range of acute injury and of discomfort, assuming that an animal located close enough to a loud noise will suffer a one-time irreversible injury, and at greater distances will move away from the noise source beyond the range of discomfort. These assumptions fail to consider the long-term cumulative impact on animals that choose to remain once they have become habituated to the given level of discomfort. Research into such chronic trauma is almost completely absent; lacking information regarding chronic exposure of marine animals (mainly mammals) we turn to industrial medicine principles of chronic exposure to noise in people lacking acoustic protection.

4.6.2.3 Data pertinent to noise impact from both plan sites

a. Environmental conditions and their significance to the groups of animals addressed by this report:

Both sites are located within the same geographical region, at a distance of 7.5km from the shore and at a depth of up to 100m. At both sites the seabed is a sandy clay bed, as far we know it is has no features (e.g., exposed Kurkar) that might be critical grounds for invertebrates and benthic fish that are conservationally valuable.

Regarding impact on trawl fishing, if benthic and/ or pelagic fish stay away from the site for the 6 week duration of the works, impact on fishing will be marginal and fishermen can move to other fishing grounds. Even if for some reason some fish will be missing from the available fishery, this will benefit conservation and in the long term will also benefit the fishing trade.

There are, therefore, two groups that must be addressed in detail: cetaceans and turtles. These are protected species which must not be harmed intentionally, and whose populations in the Mediterranean are endangered to various degrees.

b. Geographical overlap between species distribution areas and the two proposed sites

Creditable information regarding distribution ranges of these species is lacking. Most information is based on random sightings and beaching incidents in the case of cetaceans, and on distribution of nests on the shores in the case of turtles. We therefore apply the precautionary principle, and in case of doubt or absence of information will assume these species are present at the proposed sites.

Table 01 summarizes existing knowledge (Levi & Barash, 2011; Kerem et al., 2012) regarding species whose presence in the Sharon area is known or assumed.

<u>Table 02: Cetaceans and turtles whose presence in the Sharon area is known or assumed</u>

Species	Scientific Name	Seasonality	Conservation status[28]
Common bottlenose dolphin	Tursiops truncatus	Year-round	Vulnerable
Striped dolphin	Stenella coeruleoalba	Year-round	Vulnerable
Short-beaked common dolphin	Delphinus delphis	Higher in summer	Endangered
Rough-toothed dolphin	Steno bredanensis	February-June	Not evaluated
Loggerhead sea turtle	Caretta caretta caretta	Higher is spring and summer	Critically endangered
Green sea turtle	Chelonia mydas mydas	Higher is spring and summer	Critically endangered

c. Seasonality and regional distribution

As a rule, dolphins and coastal species in particular spend most of their lives in the area year-round, reproducing year-round with peak reproduction during the warm seasons. Migration in these species is limited to regional migration within a range of a few hundred kilometers.

Of the four dolphin species listed in the table, the first two have been observed and beachings sighted throughout the year along the entire coast. The third species shows increased presence in the summer on the Israeli southern coast. The last species is rare and most sightings and beachings to date have occurred in the spring. There is no evidence of seasonality or difference in distribution between the sites being examined. A distribution map for *Delphinus delphis* is shown in Figure 4.6.2.3-1.

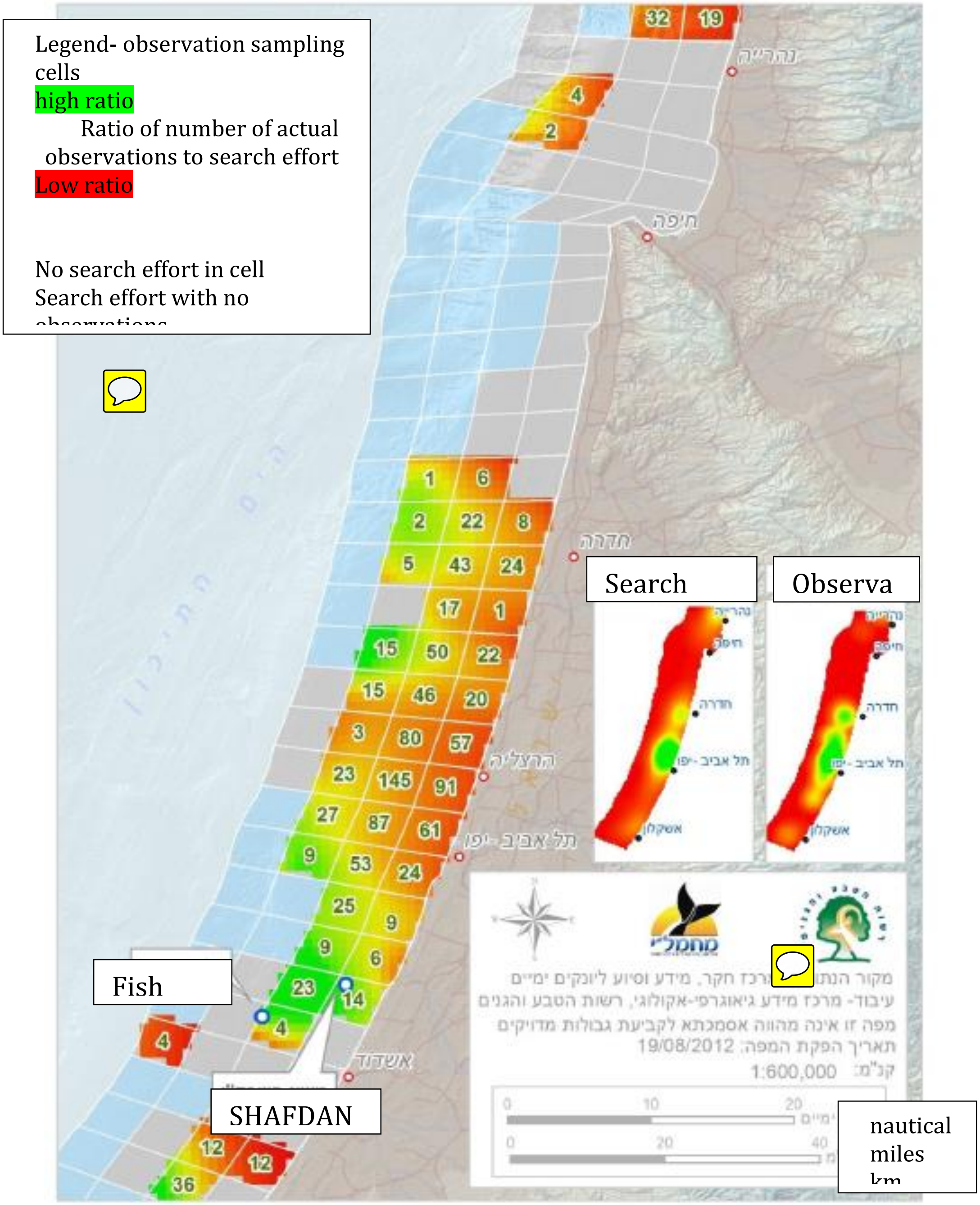
Turtles, usually adults, migrate across distances of thousands of kilometers from their warm-season shallow-water breeding grounds to their open sea wintering sites. Young ones may be found year-round near the shore. Nesting season for both species is between May and August and adults of both species come to shore to mate approximately 6 weeks before laying.

[28] Based on the IUCN Red Book, concerning Mediterranean populations or sea-turtles, based on the Red Book of Vertebrates in Israel.

Based on beaching data, turtles occur in Israel year-round along the coast, but they are not homogeneously distributed spatially or temporally. Temporal distribution is reflected by peak beaching numbers during May to June, overlapping the laying season. Spatial distribution shows a marked preference for the Sharon area. Relative numbers of beached brown and green turtles are 63% and 37%, respectively (Barash & Levi, 2011). There is no evidence of difference in beaching rates between the two examined sites.

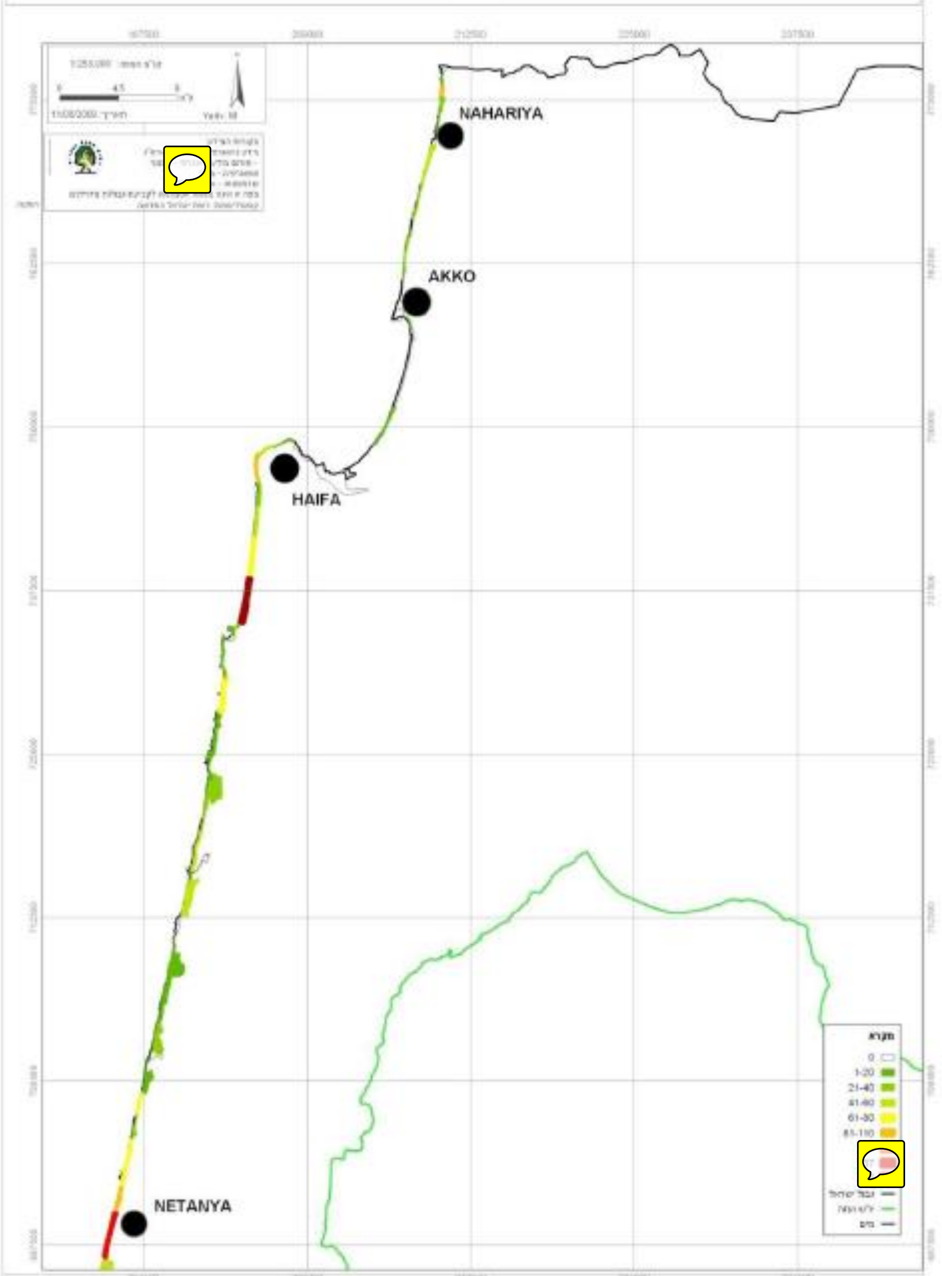
Due to female propensity to return every year to the same nesting site, and lacking information to the contrary, we assume that the females breed across from the their nesting sites. The national nest density map (see Figure 4.6.2.3-2) shows an increase in density as one moves south in the Sharon area. Of the two sites, Hadera is less likely to harbor nesting females.

Figure 0-1: Distribution map of *Tursiops truncatus* schools during 2003-2011 normalized for search effort (sea hours)[29]



[29] Map produced by Gilad Weil - Israel Nature and Parks Authority

Figure 0-2: Locations of natural sea turtle nests along the Israeli coast during 1993-2008[30]



d. Estimating population size and spatial density of individuals

There are no quantifiable data for cetaceans. For the common bottlenose dolphin (Tursiops truncatus), the commonest species on the Israeli coast, the best available estimate by IMMRAC (Israel Marine Mammal Research & Assistance Center) is 0.2 individuals per square kilometer, based on half-day survey sightings. Average pods

[30] Courtesy of Yaniv Levi, Israel Nature and Parks Authority.

number 5 individuals; this means that at any given time, there will be a pod in every 25 square kilometers. Dolphins are notably curious creatures and can be expected to explore a marine structure which would drive up density at the work sites.

There are no data regarding population size or spatial density of sea turtles off the Israeli coast. Average annual mortality rate for both species for the past 4 years is 170 individuals. We may safely assume that the size of the population off the shore is at least 10 times that number. Distribution area being of unknown dimensions, for the purposes of this discussion we have assumed a density of 0.5 individuals per square kilometer.

4.6.2.4 Influences of noise on marine mammals

a. General

Noise and its effect on cetaceans, the marine animal group that most relies on the auditory sense for both passive auditing and sonar echolocation by some, has been discussed in depth for many years. In this survey emphasis is placed on the species listed in Table 4.6.2.3-1, and specifically the common bottlenose. As noted above, driving the piles produces most of the noise, so this discussion focuses on this noise source.

Mammals are, characteristically, easily monitored for behavioral changes at sea by visual and acoustic tracking. On the other hand, there are ethical restrictions on conducting controlled noise testing on these mammals in ranges that could potentially be disturbing or harmful.

As noted earlier, the common bottlenose is the commonest coastal dolphin species. During this last decade many annual data have been added regarding its distribution from half-day surveys. Despite this, this species' sightings map (see above), is limited and fragmented due to logistic constraints. We may, nevertheless, assume that it is uniformly distributed along the entire coast. This species feeds mainly on seabed fish and it routinely dives to depths in the 100m range. Individuals, including newborns and cubs are sighted year-round and it is the main species to be addressed by the survey.

b. Hearing

Cetaceans hear very well in the water. Sensitivity and frequency range of their auditory system are similar to those of terrestrial mammals. As a rule, very large species are sensitive to lower frequencies and the smaller species to the higher range. Accordingly, cetaceans are divided into three functional groups by bandwidth of the auditory system, as follows:

- Low-frequency cetaceans-z LF – 7Hz-22kHz

- Mid-frequency cetaceans MF – 150Hz-160kHz
- High-frequency cetaceans HF – 200Hz-180kHz

The common bottlenose (as well as the other dolphin species in Table 4.6.2.3-1) is a member of the MF cetaceans; their auditory spectrum is 150Hz-160 kHz.

We parenthetically note that the overlap between anthropogenic noise spectrum at sea and cetacean auditory spectrum is partial, and lies in the lower frequency range of sensitivity and in the higher noise range (Ketten, 1997, 2000).

c. Influences of noise

Although the literature is abundant, most empirical evidence relies on behavioral, visual, and acoustic observations and fewer studies are based on controlled lab experiments or dissections of beached animals or ones that died in captivity. A number of reviews provide an excellent summary of the subject and its ramifications (Southall et al. 2007, Weilgart, 2007; Tyack, 2008) with an emphasis on masking communication.

Impulsive noise, such as arises from driving piles, has a relatively small masking effect, due to the difference in spectral content (i.e. frequencies) between the percussive sound and the sounds used for communication, and because animals can broadcast and receive sounds between impulses. Moreover, cetaceans are able to adapt their communication and vocalization to minimize the masking effect (McIwem, 2006).

The rapid development of wind turbine farms in the North Sea, with infrastructure that requires driving piles has produced a series of studies on the impact of insertion noise on the harbor porpoise (Phcoena phocoena) the single cetacean endemic to the region (Tougaard et al, 2009; Thompson et al, 2010; Brandt et al, 2011).

The harbor porpoise is a small high-frequency cetacean and despite the care taken to drive the piles efficiently over short distances, studies show a significant drop in porpoise presence in the vicinity of work sites during pile driving.

This year saw the publication of the most comprehensive study ever conducted on the impact of pile driving in the German North Sea on harbor porpoise distribution. The study was part of the infrastructure work for a 12-turbine marine wind farm in 2008-2009 (Dähne et al, 2013).

When comparing aerial survey observations from three weeks before work commenced to a survey conducted while work was ongoing, a clear avoidance/ distancing response emerged within a 20km radius of the wind farm. Analysis of dolphin-detection sensors during work showed a significant drop on eight sensors that were placed at a distance of 1-10km and a surge on sensors located 25m and

50km away. These findings indicate that dolphins stayed away from the work site, moving in the direction of the more distant sensors. The study also indicated that displacement was reduced when work cycles were shorter.

d. Noise-impact criteria and thresholds

Since its publication in 2007, the Southall et al. paper has been used as a benchmark for most studies and environmental surveys analyzing impact of noise on marine mammals (e.g. Total, 2012).

The authors conducted a comprehensive review of behavioral observations of mammals that were exposed to noise from various sources. They then applied conservative considerations to infer from known information regarding noise injuries in terrestrial mammals and humans to injuries to marine mammals, and came up with recommendations.

These are the same researchers who defined the three functional groups of marine-mammal auditory systems described above.

e. Preventing auditory trauma

The recommended noise thresholds from the study only refer to preventing risk of auditory trauma and not injuries to other organs.

Auditory trauma caused by noise can be temporary and reversible, which is known as temporary threshold shift (TTS), or it can be permanent and is known as permanent threshold shift (PTS).

Pile-driving noise can create two types of harmful situations:

- Trauma from a single noise event
- Trauma from a protracted series of single noise events.

The following thresholds are recommended by the study authors (based on bottlenose dolphin experiments):

- Temporary threshold shift (TTS)

From a single event: **SPLpeak = 224 dB re 1µPa**

From a series of events during 24 hours: **SEL = 183 dB re: 1µPa2·s**

- Permanent threshold shift (PTS)

From a single event: SPLpeak = 230 dB re 1µPa

From a series of events during 24 hours: **SEL = 198 dB re: 1µPa2·s**

f. Preventing discomfort

The few observations of responses to repeated impulses, in the context of determining group member discomfort thresholds, were conflicting even within a single species. The little that is known about discomfort in cetaceans has led to a conservative value for a single event:

- Discomfort threshold for a single event: **SPLpeak = 140 dB re 1μPa**

These conservative thresholds were adopted as references for this report.

4.6.2.5 Sea turtles

a. General

Despite the fact that the auditory sense, as far as we know, plays a secondary role in sea turtle life, the precautionary principle is requisite here because all sea turtle species are endangered. And specifically in this case, even relatively small influences from noise may combine with other threats to endanger the local population.

Both endemic species, the green turtle (*Chelonia mydas*) and the brown turtle (*Caretta caretta*) are severely endangered in our region. Both species' laying season lasts from May until early in August. The number of laying female green turtles on the Israeli coast is not greater than 10, so deterring even a single female that is incidentally close to a noise source from laying its eggs can have a large impact on the local conservation effort (Levi and Barash, 2010).

b. Hearing

Sea turtle ears are less sensitive than fish ears, but like fish they are limited to lower frequencies. They are most sensitive at 200-400Hz and sensitivity declines sharply at the higher frequencies (DeRuiter, 2010).

The upper useable frequency range of turtles is near 1,000Hz and the upper frequency threshold that still produces auditory nerve potential without injuring the ear is approximately 2,000Hz (Wever & Vernon 1956; Ridgway et al., 1969; Martin et al., 2012).

c. Demonstrating behavioral changes and phonal trauma caused by loud noise sources at sea

Experiments on sea turtles in captivity have revealed withdrawal and avoidance responses to the noise of a single air canon, starting at exposure levels of 155 dB re 1 $\mu Pa^2 \cdot s$ SEL. An unstable swimming pattern was observed at exposure levels of 164 dB re 1 $\mu Pa^2 \cdot s$ SEL indicating possible stress (McCauley et al, 2000).

Noise from an air canon at 220 dB re 1μPa at 1m was used as a sound barrier preventing sea turtles from approaching marine excavators (Moein-Bartol et al., 1994).

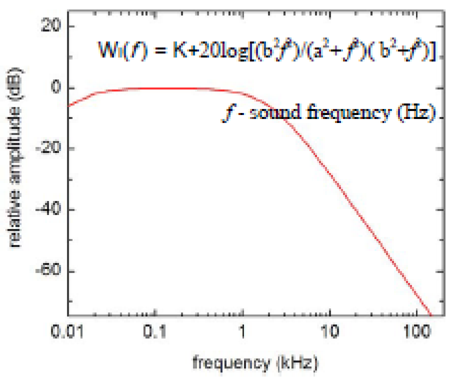
In an Australian study of nesting brown sea turtles, before, during, and a few months after driving piles near the shore, no significant difference was found in number of nests between the three periods. A survey conducted aboard a ship that was conducting seismic activity in Angola demonstrated double the number of sea turtle observations per hour when the canons were silent compared to when they were active, although median distance of individuals observed from the ship was not statistically significant (Weir, 2007). One possible explanation is that individuals that had come up to the surface to warm themselves didn't hear the noise so well, were less sensitive to the noise, or were less responsive than individuals that were diving. Another survey off the Moroccan shore in the Mediterranean (DeRuiter & Doukara, 2012) showed that brown turtles dived in when an air canon battery passed near them. However, the experiment lacked the control of sufficiently long inactive periods so it is not possible to distinguish clearly between response to noise and response to the ship passing.

d. Recommendations for sea turtle injury and discomfort thresholds

The US navy has borrowed the Southall et al. auditory weighting function to define thresholds for sea turtles; the function emphasizes the appropriate frequencies in the signal (low frequencies in the case of sea turtles) and downplays frequencies outside the range of sensitivity, before making the calculation. The weighting function for sea turtles is described in Figure 4.6.2.5-1:

<u>Figure 0-1: Spectral weighting function for sea turtles</u>

Functional Hearing Group	K	a (Hz)	b (Hz)
Sea turtles	0	10	2000



In the absence of more substantiated information we recommend adopting the thresholds listed above for marine mammals, in the clear understanding that these are conservative thresholds.

4.6.2.6 Means of reducing the impact of pile-driving noise on marine animals

The existing range of noise reduction methods during pile-driving is summarized in two new papers (Verfus, 2012; BOEM, 2013). Methods range from using alternative means to construct foundations in the sea, through inserting piles using pressure (which is not noisy) or vibration (less noisy), to reducing impulse noise by placing a blocking dome at the top of the pile (the only means of also reducing noise conduction through the seabed), a bubble screen, free or confined in flexible or rigid cylinders, and surrounding the pile throughout the length of the water column with a hermetically sealed water-free column. Most methods, for a variety of reasons, are not in wide use and most contractors do not include noise reduction in their operational procedures. State regulation, such as enacted in Germany, has forced the industry to explore several methods that will allow them to comply with the standard. It seems that the achievable noise reduction limit using the most effective means is 20 decibels, achievable for the largest piles.

In the absence of means, the methods employed to protect marine fauna as far as possible are:

1. Avoid operating during sensitive seasons and in sensitive areas.
2. Employ observers to scout for marine mammals and sea turtles near the site, so that operations can be stopped or not started if animals are present. Initiate or renew operation only if no animals have been observed for a predetermined time (20 minutes or so).
3. Ramp-up (soft start) pile insertion to allow animals to move away from the noise source. This method is based on the difference in sound intensities between detection threshold and discomfort/injury threshold, as well as on the animals' ability to locate the sound source; it also assumes distancing from the source at intensities that are not yet harmful. Ramp-up must be long enough to allow sufficient distancing; recommended duration is at least 20 minutes. This duration will allow a dolphin to move 2.4km away and a turtle 300m.
4. Halt operations for a few hours every day.

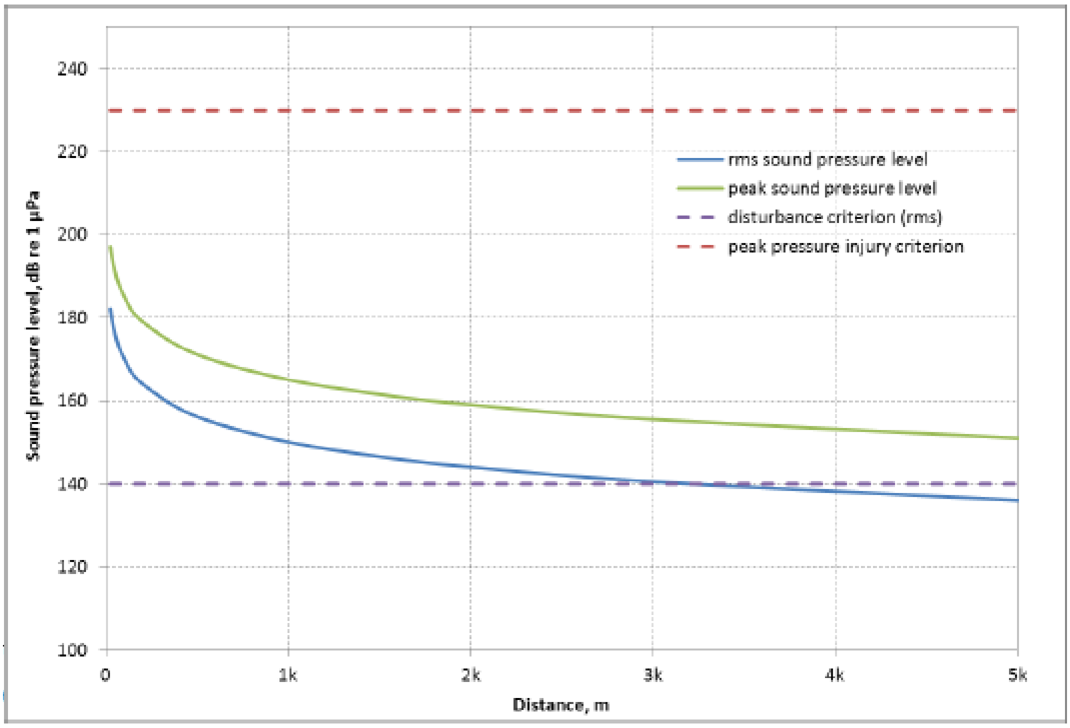
4.6.2.7 Addressing noise impact in Regional Zoning Plan 37-H

As noted earlier, we estimate that the single significant noise component that can potentially cause harm/ discomfort to marine mammals and turtles will occur during pile-driving. Although the operational stage will produce relatively low levels of noise, all steps must, nevertheless, be taken to minimize these as far as possible and in any case noise levels must comply with the appropriate recommendations in the European Marine Strategy Framework Directive (Van der Graaf et al., 2012).

In the absence of data regarding expected noise intensities from pile-driving, it is advisable to use data from calculations that were made in the survey preparatory to the gas production project in Edradour, located off England's continental shelf, 56km northwest of Shetland at a depth of 300m (Total, 2012). Calculations were made for 0.75m diameter piles, after extrapolating from data measured during actual pile-driving in the Baltic Sea where piles were 1.6m in diameter (Thomsen et al., 2006).

Attenuation curves of intensities by distance, adjusted for pile diameter of 75cm, taken from the source are shown in Figure 4.6.2.7-1, below:

Figure 0: Unweighted attenuation curves of source pressure level, with distance from pile-driving point



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The curves show that:

- No injury is expected at any distance from the sources
- Discomfort radius is expected to be 3.2km

The report also calculated exposure levels for 4-hour continuous impulses at several distances from the source, as follows:

<u>Table 0: Noise exposure level calculated for a stationary marine mammal exposed to 4 hours of pile-driving</u>

Distance from source (m)	SEL in dB re 1µPa2 s
25	207
50	201
100	195
200	189
500	181
1000	175
1500	171
2000	169
3000	165
5000	161
Injury criteria	198

It seems that to sustain injury, a marine mammal/ turtle must be closer than 50m to the source throughout the term of exposure. This is clearly an entirely improbable scenario.

A discomfort radius of 3.2km covers an area of 32km. Expected distribution of dolphins and turtle is one dolphin pod and 16 sea turtles (both genders and all ages) in an area this size.

4.6.2.8 Means of preventing harm to marine mammals and sea turtles during pile work

We recommend adopting the JNCC (Joint Nature Conservation Committee in the UK) guidelines; the 2010 guidelines refer to marine mammals and it is advisable to expand them to include sea turtles. In view of the low risk of harm to these animals there will be no need to use acoustic detectors (PAM) or acoustic deterrent devices (ADD). We may assume that the noise from the work itself will deter the animals from remaining in the works area.

Regarding risk of injury:

It is advisable to employ lookouts who are skilled at identifying cetaceans and sea turtles:

- At least 20 minutes before operating the hammer, the lookout must survey the sea surrounding the piles at a radius of 500m at least, from an elevated position using binoculars.

- Hammer will be soft-started for 20 minutes, ensuring a source intensity that is at least 10 decibels lower than the full-power intensity.
- If marine mammals or sea turtles are observed during full-power operation within the discomfort radius, they must be recorded but work need not be halted.

Concerning risks of discomfort and displacement:

Theoretical calculations based on auditory thresholds show that pile noise can be detected by marine mammals from a distance of a few hundred kilometers, and certainly throughout the length of Israel's coast (Thomsen et al.). Considering the sparse local distribution of marine mammals and sea turtles, the fact that the suggested sites are not known as critical to the species in question, and the relatively short term of operation (42 days), prognosis is for low risk of harmful discomfort at the population level.

Impact of noise from pipeline on military activity

Impact of pipeline noise on military activity is summarized in a separate document that has been submitted to the Ministry of Defense.

4.6.3 Acoustic protection

Most methods for reducing noise impact during setup works at sea are at the operational procedure level and less at an engineering level; these were reviewed in Section 4.6.2, above.

Onshore segment

Section 4.6.4-8, which examines the onshore noise aspect of plan implementation, also appears in the surveys of onshore environmental impact for Meretz and Hagit WWTP submitted under this plan.

4.7 Leaks contaminating the marine or terrestrial environment

Contamination of the marine environment around the pipeline and treatment-platform as a result of implementing the plan is addressed below.

4.7.1 Describing leak conditions

This section describes the conditions under which natural gas and fluids (produced water, oils, and condensate) leak from the system components:

- **Pipeline route** – leak conditions from the pipeline are described in Appendix C, Section 7 – Operational and engineering aspects of the offshore environment.
- **Treatment facility** – the offshore facility has been planned in such a way that it will not leak substances to the environment. However, conditions may

develop in which an unexpected leak will occur. Leaks may occur in the following cases:

- Collision at sea where a ship accidentally hits a tanker or the offshore facility, splitting the tanker or causing substance breakout.
- Earthquake – potentially destabilizing the facility and causing substances to leak (see details in Section 4.5, above).
- Fire – may cause substances to leak out.
- Fatigue and/or faulty maintenance – fracture, rust, corrosion, may cause negligible leaks.
- Human error – error in operation causing incorrect operation of a facility component.

See further details in Section 4.7.2, below.

Impact of dumping operational fuel on the marine environment is described using a dispersion model. The dispersion model for operational diesel spilled from the gas treatment platform as a result of a fueling pipe malfunction or a break in a storage tank was implemented according to Ministry for Environmental Protection guidelines. The model's technical specifications, input data, and model results for operational diesel dispersion are shown in Appendix J, below (Modeling the dispersion of produced water, condensate, and operational marine diesel fuel discharges from the proposed offshore natural gas platform). Density of operational diesel is approximately 15% lower than sea water density, which makes diesel behave like an oil slick floating on the surface. It is dispersed by currents, wind, and turbulent mixing, and is also affected by erosive processes such as evaporation and emulsification. Briefly put, the model that was implemented was the MEDSLIK model for oil spill dispersion. This model views operational diesel as a collection of suspended particles; Lagrangian trajectories were calculated for the particles. The model incorporates random eddying and weathering processes. The model's vertical resolution is one minute (ca. 1.7km) and it receives wind input from meteorological and wind data calculated by the POM oceanographic model (see Appendix J, Section 4.8.2).

Operational diesel dispersion was tested using several simulations of meteorological-oceanographic conditions representing worst case scenarios. The worst scenarios were selected according to the expected amount of material that would wash up to the shore. The model was applied to an immediate spill of 6 cubic meters of operational diesel (API 34.2) following a malfunction in the fueling line, and an immediate spill of 31 tons as a result of a storage tank failing. Three periods were selected, representing meteorological-oceanographic conditions that could potentially cause severe outcomes: (1) typical winter storm (25 November-1 December 2004); (2) extreme winter storm (11-18 December 2010); and (3) typical summertime conditions with north-westerly winds (28 July-1 August 2008). All scenarios were selected in coordination with the Ministry for Environmental Protection.

Currents near the platform are usually northerly so a spill is expected to move and disperse to the north. Under all three meteorological scenarios, winds have a dominant westerly component that will drive the spill toward the shore. Its point of arrival will be determined by the combination of current influence, and relative intensity of the wind's westerly component and its northerly or southerly component. Under all scenarios, more than 44% of the spill evaporates during the first hours. Over 54% of a spill will make landfall and disperse along a stretch of 20-35km, as far as the Carmel beach in Haifa, although most of the diesel will concentrate along a 3-5km shore segment, with location determined according to the scenario. During a typical winter storm, the spill will make landfall within 24 hours and the most impacted area is expected to be the Dor beach. The extreme winter storm is expected to produce the worst situation. The spill will make landfall within 12 hours and the most highly impacted area is expected to be Geva Carmel beach which is north of Dor beach. The highest concentration of diesel that will accumulate on the beach will be double the highest expected concentration during a typical winter storm. Diesel dispersion along the shore for this scenario, when 31 tons are dumped, is shown in Figure 4.7.1. Under the typical summer scenario, the spill will make landfall within 21 hours and the most highly impacted area is expected to be Maagan Michael beach, south of Dor beach. A very small portion of the diesel might accumulate along the Haifa bay beach. The highest expected concentration of accumulated diesel is 20% higher than the concentration expected during a typical winter storm. We must stress that in all cases, properties of the fluid making landfall will be different than those of the original spill, largely due to evaporation of the lighter fractions. Table 4.7.1-1 compares and summarizes results of the three scenarios for dumping 6 cubic meters. Table 4.7.1-2 compares and summarizes results of the three scenarios when dumping 31 tons.

In the tested scenarios, spatial variation in currents and winds over distances of 10-20km along the shore was small. For this reason, if the dumping point is shifted north to the center of Compound 1 (a distance ca. 15km) the dispersion pattern of operational diesel spill over the shore is expected to be similar to the dispersion in the present scenarios, but shifted approximately 15km north. In this case, the most impacted area will be the shore between Atlit and the northern Haifa beach (Dado beach). There is also a potential uncertainty of +/- 5km with regard to the point of arrival at shore; this is a result of the current along the coast in the surf zone which is formed by waves breaking near the shore.

Figure 4.7.1-1: Dispersion of operational diesel accumulated on the beach (ton/km) in an extreme winter storm scenario for dumping 31 tons.

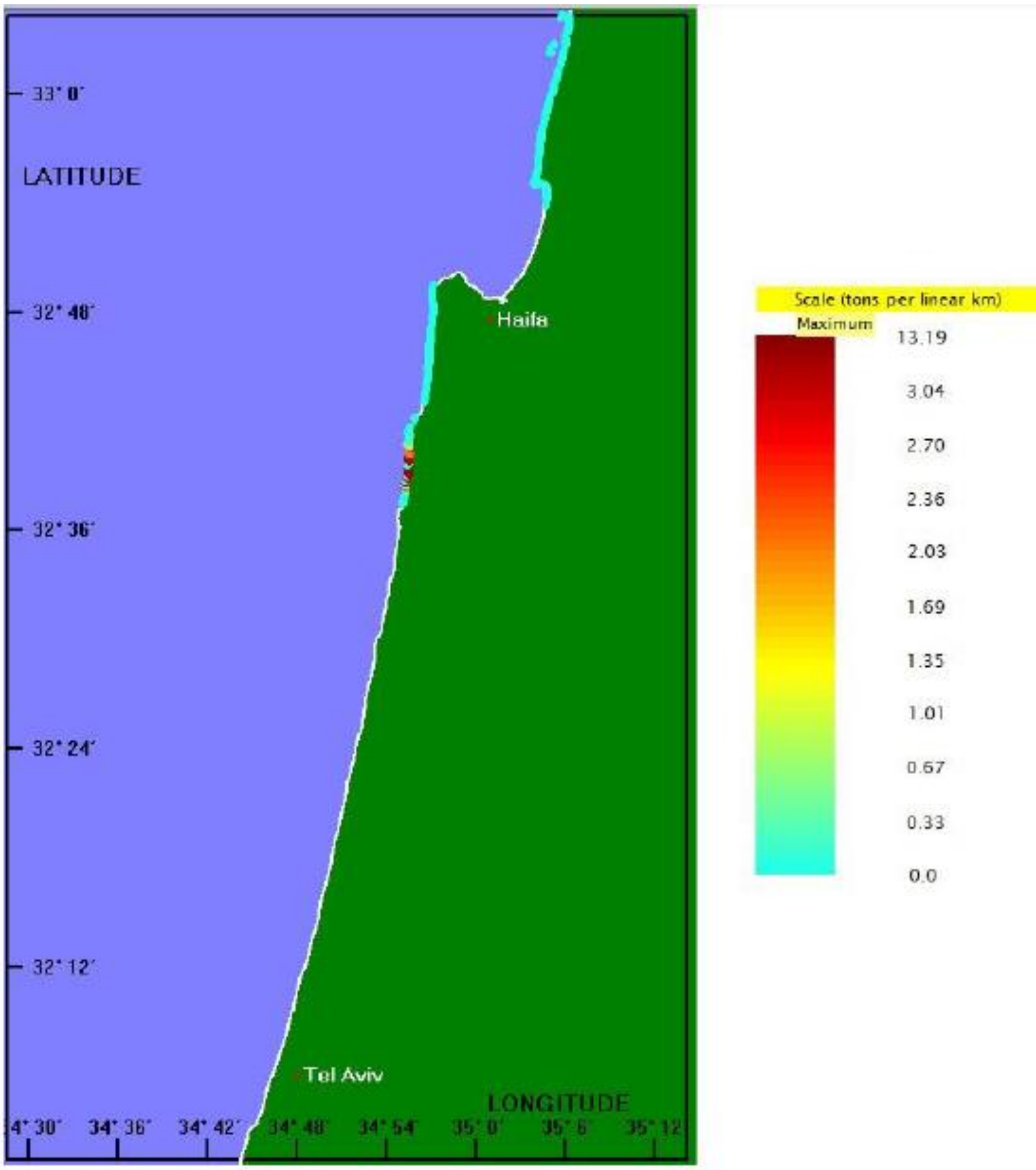


Table 4.7.1-1: Summary of operational diesel dispersion scenarios when dumping 6 cubic meters – landfall arrival times and most impacted areas

Scenario	Initial landfall (h)	Maximum concentration on the shore (m^3/km)	Most impacted area
Typical winter storm	24	1.18	Dor Beach
Extreme winter storm	12	2.59	Geva Carmel Beach
Summer north-westerly winds	21	1.41	Maagan Michael Beach

Table 4.7.1-2 : Summary of operational diesel dispersion scenarios when dumping 31 tons – landfall arrival times and most impacted areas

Scenario	Initial landfall (h)	Maximum concentration on the shore (ton/km)	Most impacted area
Typical winter storm	24	6.16	Dor Beach
Extreme winter storm	12	13.19	Geva Carmel Beach
Summer north-westerly winds	21	7.16	Maagan Michael Beach

4.7.2 Monitoring leaks – means and procedures

Under normal operating conditions no leaks are expected from the facility components. Leaks include: platform water (see details in Appendix B, Section 11), which is water that collects at drainage inlets and is chiefly composed of rain water; green water (sea spray); and water from the fire-extinguishing system which due to its large volume usually determines the system's configuration. There are two main systems for collecting water from the drainage inlets, one for areas that may carry traces of hydrocarbons, and one for clean areas. The initial assumption is that water from the drainage inlets is directed to the produced water system, compliant with the procedures for handling oils and solids.

Procedures and means also include command and control from a control room that receives and transmits signals to the system at all times. A SCADA system collects data 24 hours a day. Failures are identified by the control system and the valves can be opened and shut off from the control room. Patrols along the pipeline will be conducted routinely to ensure the equipment is in working order and the pipeline has not been damaged. In addition, periodical inspections and underwater surveys must be conducted in the vicinity of the pipeline; these are usually performed by ROV and divers. These inspections are intended to check the integrity of the pipes and look for development of corrosion. It is important to prepare a comprehensive fast-response plan (EPRS, Emergency Pipeline Response System). In the event of failure, fast responses are essential. There are many ways to repair pipes and each case must be reviewed individually. The core issue is equipment availability for performing the repair. During malfunction, the pipeline will have to be shut down.

Methods of discovering leaks

- Pipeline route – means and procedures for locating and handling gas leaks from the pipeline are described in Appendix C, Section 7 – Operational and engineering aspects in a marine environment.

- Treatment facility – apart from the monitoring methods listed in Sections 3.3.4 and 3.3.6, fluids must be collected in designated areas and directed to the shore for disposal or for continued treatment and discharge to sea, based on the type of fluid. In addition, during routine maintenance of the facility, a lookout must be posted to observe the proximal environment and ensure that there are no leaks outside the facility. A detailed list of methods and procedures for preventing leaks is available in Appendix B, Sections 9.5.1, 11, and 14.8.

4.7.3 Preventing environmental pollution – means and procedures

See detailed information in Section 4.7.2, above.

4.7.4 Plan of operation and means in case of a leak

The plan of operation and means applied in case of a leak of oils and other substances, including operational procedures and schedules must be submitted by the plan developer at the building permit stage and approved by the appropriate government authority.

A plan for handling oil spill incidents caused by leaking condensate or operational fuel must be prepared according to Ministry for Environmental Protection guidelines and must contain, as is accepted practice for contingency plans: a definition of forces and tasks, details of operation modes and methods outlined by stage in the treatment process and according to the incident type, communication and reporting procedures, coordination with other plans of operation (plans by the local authorities and the national contingency plan for responding to oil spills at sea). The plan for handling the various scenarios of condensate and operational fuel dumping must also address the models' forecasts of the fate of these substances under different meteorological-oceanographic conditions.

4.8 Handling produced water and condensate

4.8.1 Expected impact of produced water under the onshore treatment alternative

Impact on the onshore environment is addressed in the Environmental Impact Survey for onshore facilities at Meretz WWTP and the Hagit site, submitted under this plan.

4.8.2 Dispersion model

A dispersion model for produced water discharged from the gas treatment platform was implemented according to Ministry for Environmental Protection guidelines. Technical details of the model, input data, and results for produced water dispersion are shown in Appendix J. Briefly, the model under discussion is the POM (Princeton Ocean Model) three-dimensional hydrodynamic model. Produced water contains dissolved substances and fine particulates that get dispersed by currents and turbulent mixing. For this reason produced water was added as a passive and conservative tracer to the oceanographic model. This specific model does not incorporate chemical and biological weathering processes beyond dispersion by currents and turbulent mixing, so its results are conservative. The model's horizontal resolution is approximately 530m and it has 30 vertical sigma layers (bathymetry consistent). Bathymetry for the model was taken from GEBCO data at a one-minute resolution (ca. 1.7km).

Several simulations were modeled to test produced water dispersion under meteorological-oceanographic conditions that represent the severest situations. The worst case scenarios for produced water (minimal dilution) will occur when mixing and dilution are weak and when there is stratification. Stratification prevents vertical mixing and maintains the tracer near the discharge depth. For this simulation three representative periods were selected: (1) calm sea (31 May-4 June 2005), (2) fresh easterly breeze (27 November-2 December 2002), and (3) typical summer conditions with north-westerly winds (28 July-1 August 2008). Produced water was discharged to sea at a depth of 6m, continuously throughout the scenario, at a rate of 1,468 cubic meters/day, and a passive tracer concentration of 29ppm. The selected tracer concentration is the expected concentration of dispersed oil (monthly average); however, we note that the following dilution factors are correct for any substance that acts as a passive tracer. All scenarios were defined in coordination with the Ministry for Environmental Protection.

Tracer concentration at the lattice point of discharge (representing the initial dilution) will be inversely proportional to current speed, and the substance will mostly disperse down the current. A stronger current will produce more effective dispersion and the dilution factor will be greater. For a sample of model results see Figure-4.8.2-1, which shows the horizontal currents and tracer concentration at a depth of 6.5m, under a calm sea scenario. As mentioned earlier, the tracer moves mainly down the current (north – north-east) and attenuates quickly within two lattice points from the discharge points (1060m). The vertical section of relative tracer concentration is shown in Figure 4.8.2-2. The tracer disperses in a relatively thin layer (5-6m thick) located around the discharge depth. Stratification of the water column prevents vertical mixing of the substance. Table 4.8.2 shows that this is the worst case scenario.

Dilution within the first lattice point is very strong so no significant changes are expected in the results or in the conclusions if the discharge point is moved 15km north to the center of Compound 1.

Figure 4.8.2-1: Currents and tracer concentration (percent relative to the concentration at the discharge lattice point) at a depth of 6.5m for a calm sea scenario

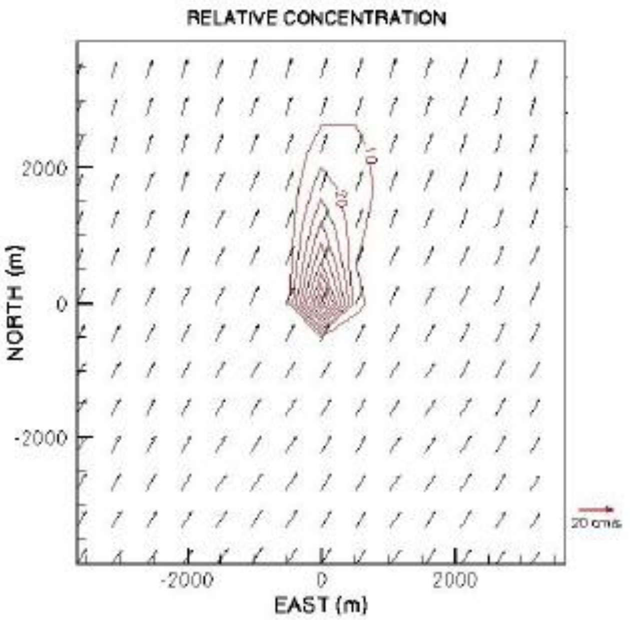
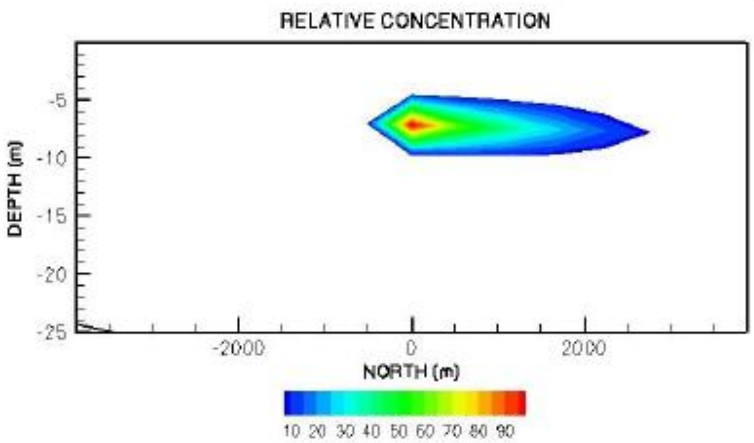


Figure 4.8.2-2: Vertical section of tracer concentration (percent relative to concentration at the discharge lattice point) with the current for a calm sea scenario.



Dilution factors at various distances from the gas treatment platform (discharge point of produced water) that were obtained from applying the model to the three scenarios are shown in Table 4.8.2. A minimal dilution of produced water (worst case scenario) is expected under calm sea conditions. At a distance of 250m down the current a 13,200 dilution factor was obtained. For the same distance under the other scenarios dilution factors 2.5 and 5.5 times larger were obtained. Decay rate is higher perpendicular to the current direction, because the substance hardly disperses in this direction. At a distance of 250m perpendicular to the current direction, dilution factors were greater by 12-37% from those down the current.

Table 4.8.2: Dilution factors obtained from the produced water dispersion model under various sea conditions and at different distances from the discharge point of produced water to the sea

Direction and distance from discharge point		Dilution factor		
Direction	Distance from discharge point (m)	Calm sea	Strong easterly wind	West to north-west summer wind
Down the current	250	13,200	72,700	32,200
	500	17,000	116,000	41,400
	1000	24,000	170,000	72,500
	1500	36,200	263,600	96,700
	2000	58,000	483,300	111,500
Perpendicular to the current	250	18,100	103,500	36,300
	500	72,500	966,700	96,700

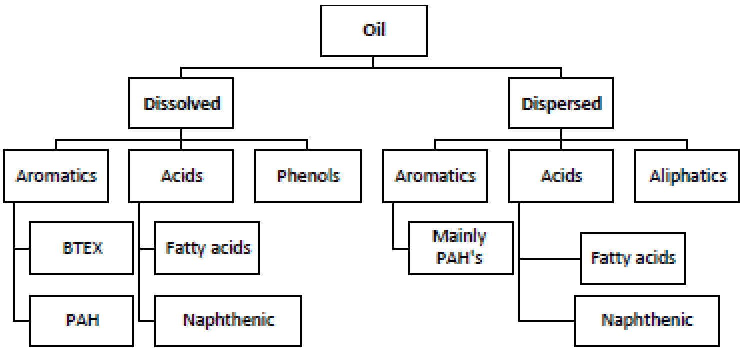
4.8.3 Estimating impact of produced water on the marine environment

Potential impact and fate of produced water in the marine environment, and method for making environmental assessments

As noted in Section 4.8.3, under both offshore and onshore gas treatment alternatives, produced water (formation water with condensate water) will be discharged to sea at the gas treatment platform site 8km from the shoreline, after it has been treated to reduce the concentration of dispersed oil (microscopic oil drops measuring up to a few hundred microns, present in water in emulsion form, referred to here as Dispersed Oil).

As described in general terms in Appendix J, produced water is a complex mixture of organic and inorganic substances in a solution and in particulate form, with a water salinity ranging from almost sweet water to highly concentrated brines. Treated produced water contains dispersed oil, a wide range of natural substances in solution, and low residual concentrations of gas treatment additives such as corrosion and sedimentation inhibitors, MEG, and biocides. The natural substances in typical produced water also include small amounts of toxic substances such as heavy metals, aromatic hydrocarbons, alkyl-phenols, and radioactive substances (OGP 2002; OGP 2005; Neff et al. 2011). Note that the definitions of Oil and Dispersed Oil in used produced water, as they are applied in international legislation and agreements for environmental control, are test-dependent; depending on the testing method these terms may include all or part of the compounds in Figure 4.8.3. In most countries and international agreements, the restrictions on oil content in produced water discharged to sea refer to dispersed oil, and oil content is measured using methods that measure only dispersed oil and not dissolved oil (Yang 2011; OGP 2005).

Figure 4.8.3: Compounds that may fall under the definitions of Oil and Dispersed Oil in produced water, depending on the testing method (according to Yang, 2011).



The potential environmental impact of discharging produced water into the sea is harm to marine organisms due to toxicity of produced water components. Because concentrations of gas treatment additives in typical produced water are low, total toxicity of produced water is largely dependent on the natural properties of the formation water. Of most concern are the three groups of micro-components: heavy metals (inorganic), and polycyclic aromatic hydrocarbons (organic), due to their toxicity and endurance in the marine environment, and alkyl phenols which are known to disrupt endocrine activity (Neff et al 2011; OGP 2005).

Toxicity to marine organisms of specific substances in produced water has been tested widely all over the world, but due to the variation in substances and in their concentrations in produced water from different sources it is difficult to generalize and give a reasonably accurate prediction of overall toxicity in specific produced water. It is preferable to estimate potential environmental impact using whole effluent toxicity tests in which marine organisms are exposed to produced water at various dilutions. Such tests, conducted in locations around the world with different organisms, indicate low acute toxicity with LC_{50}/EC_{50} (a concentration that produces a response in 50% of the test population) in a range of approximately 50% to 5% (dilution factor of 2 and up to 20). Chronic toxicity tests (impact on behavior, function, reproduction, etc.) have revealed influences at much lower concentrations of 0.01% to 0.1% (diluted by 1000 up to 10000) and also in cases of still less stringent test conditions (Neff et al 2011; Holdway 2002).

Actual environmental impact of produced water depends on the composition and quantity of produced water and on its fate in the receiving environment, i.e. physical, chemical, and biological processes (collectively known as weathering processes) which reduce component concentration and, subsequently, toxicity to marine organisms. Among the most important weathering processes are dispersion and dilution, vaporization of volatile hydrocarbons, adsorption by suspended particulates and settling, biodegradation, and photochemical oxidation. Produced water dilution depends on discharge rate, water salinity and temperature, water depth, and hydrodynamic conditions in the receiving environment. Simulations of dispersal in several regions (North Sea, Gulf of Mexico, Indonesia, Australia, the Mediterranean Sea, and others) have shown that produced water discharged to the sea is quickly diluted relatively near the discharge point. For example, an estimated dilution factor of 30 to 100 at a distance of a few meters from the discharge point, and a factor of 100,000 at a distance of 1km (OGP, 2005). A survey of environmental impact of a Dutch natural gas treatment platform in the North Sea relied on model findings that indicated a dilution factor of 10,000 at a distance of 100m from the discharge point (GSEPN 2012). Field measurements of produced water component dilutions conducted at various locations around the world confirm model predictions, i.e. usually dilution is rapid close to the discharge point (Neff et al. 2011). For example, measurements from the Gulf of Mexico found that radionuclide ^{226}Ra originating in a 1070 m^3/day discharge of produced water was diluted by factors of 426 and 1065 at distances of 5m and 50m from the discharge point, respectively. Current speed at the time of measurement was 15m/s (Lee et al. 2011).

Chemical weathering processes may have a greater and faster influence (hours to days) on some of the toxic constituents of produced water and therefore on the overall toxicity of produced water. For example, rapid vaporization of BTEX compounds (benzene, toluene, xylene, ethyl-benzene), which are the most common aromatic compounds in produced water, in conjunction with dilution processes can reduce the concentration of benzene in sea water by a factor of 50,000 to 150,000 at a distance of 20m from the discharge point (OGP, 2002). Heavy metals which are present in produced water in low oxidation states are another example; they are rapidly oxidized on entering a marine environment and may be adsorbed by suspended particulate or iron and manganese hydroxides, changing into non-toxic forms (Neff, 2002).

In the absence of information regarding produced water composition and quantity from the discovered gas fields addressed in this report, the following assessment of produced water impact refers to a typical produced water composition established according to data from natural gas fields in other places in the world and on produced water quantity in the representative case shown in Appendix B (1,468,066 kg/day, approximately 1,468 m^3/day). The environmental assessment is based on a calculated expected concentration of toxic components of produced water in the area of the discharge compared to sea water quality standards that were instated to protect marine fauna and the marine ecology. Expected concentrations of produced water components were calculated using results from the model for produced water dispersion described in Section 4.8.2 and in Appendix J. These calculations do not incorporate decline in concentrations by chemical and biological weathering processes; together with other considerations discussed below, these calculations produce a very conservative assessment. These conclusions of the environmental evaluation are supported by the conclusions of studies and monitoring programs conducted at produced water discharge points in variation locations around the world.

Produced water composition

The most environmentally significant constituents are present in all produced water, at various concentrations, depending on the gas reservoir's properties. Given that it is only possible to know produced water composition after production has started, environmental impact surveys for gas field development plans commonly refer to composition of typical produced water, preferably, of course, from fields with similar properties (e.g. Woodside 2011, GSEPN 2012). Produced water composition for this environmental assessment's purposes was determined based on international data shown in Tables 4.8.3-1/2. These data include potentially toxic heavy metals and substances from the three groups of aromatic hydrocarbons: BTEX, NPD (naphthalene, phenanthrene, and dibenzothiophene), and PAH (anthracene is a member of this group). Data from the 2005 OGP report are chiefly from the North Sea platforms, although data from some other locations such as Indonesia are also included. Concentration ranges (highest and lowest values) do not include outlying data which in the report's estimate reflect sampling and measurement problems. For instance, some platforms reported values that are up to 40 times higher than the maximum values in Table 4.8.3-2. So, to ensure a conservative environmental evaluation, the table includes a line called Maximum Value with the maximum values from the range line multiplied by 40. The Woodside (2011) data originate in the gas platforms on the north-west Australian continental shelf.

For comparison, Table 4.8.3-1 shows typical test results for overall concentrations of heavy-metals in the Israeli coastal waters. Tests were conducted at the Geological Institute using ICP-MS under various background surveys and monitoring programs. BTEX compounds that were tested in the background survey and monitoring programs were usually not found in unpolluted areas of the Israeli coastal waters, at a detection level of 5mcg/l.

Table 4.8.3-1: Heavy metal concentrations in produced water on gas treatment platforms worldwide, in microgram/liter

Metal	Mercury Hg	Cadmium Cd	Lead Pb	Zinc Zn	Copper Cu	Chromium Cr	Arsenic As	Nickel Ni
Global data OGP (2005)								
Range	1 - 8.9	0.07 - 5	0.19-9	0.37-145	0.14-0.6	0.07-1600		
Average	2.3	1.3	4.1	26	0.4	420		60
North-west Australia (Woodside, 2011)								
	0.1; 0.1	<5	<5	10; 23	<5	20; 8	<5	<5
Naturally occurring concentrations in Israel coastal waters								
	<0.001	<0.1	<0.1	<5	<1	<10	<7	<1

Table 4.8.3-2: Concentrations of selected organic components of produced water on gas treatment platforms worldwide, in microgram/liter

	Benzene	Toluene	Ethylbenzene	Xylene	Naphthalene	Phenanthrene	Anthracene
OGP 2005							
Range	1.6-43.4	0.4-26.5	0.07-3.9	0.2-13.8			
Average	14.6	7.48	0.78	3.17	115	20.9	110
Maximum value	1736	1060	156	552			
North-west Australia (Woodside, 2011)							
	1200; 7300	1300; 13000	800 ; 100	700 ; 8300			

Under the present environmental evaluation we also examined the question of whether the expected discharge to sea of produced water can have a significant impact on the content of dissolved oxygen in sea water due to the overall content of degradable organic substances. In general, oxygen consumption of produced water that has been treated to the accepted level of 30 mg/l dispersed oil, and then discharged to sea is, internationally, not considered to be of environmental concern (OGP 2005). This matter is, therefore, usually not addressed in environmental impact surveys for development plans of marine gas treatment (e.g. Woodside 2011, GSEPN 2012).

Biochemical oxygen demand (BOD) and total organic carbon (TOC) of produced water from various gas fields around the world vary greatly. Below is a brief summary of data collected in the North Sea and in the Gulf of Mexico (Neff et al. 2011; Veil et al. 2005; OGP 2005).

TOC concentrations are usually in the range of 10 to several hundred micrograms per liter. Produced water from North Sea natural gas platforms measured concentrations of up to 2100mcg/l but the typical concentrations are much lower. Produced water from 20 platforms in the Gulf of Mexico measured an average 888mcg/l (out of a large number of repeated measurements on gas and oil platforms only four were higher than 1000mcg/l). Produced water from eight platforms in the south North Sea measured BOD_5 values in the range of 28-6700mcg/l (mg O_2/l). A large number of repeated measurements of produced water collected over three years from 50 gas and oil platforms in the North Sea were as high as 11,100 mcg/l, but only two measurements were higher than 1800mcg/l. Excluding the two outliers the range was 80-1821 mcg/l, average value and standard deviation were 654±394 mcg/l, and the median was 576mcg/l.

Biodegradation tests of produced water from the North Sea showed that most organic material is biodegraded rapidly: the final BOD value was achieved within fewer than nine days and 90% of the TOC were degraded within eight days (Rabalais 2005).

As noted earlier, produced water may also contain small amounts of naturally occurring radioactive materials (NORM). In principle, environmental concern regarding discharging natural radionuclides to sea does not center on their toxicity, but on the potential impact of the emitted ionizing radiation on marine organisms and on consumers of food of marine origin. Concerning NORM in produced water, studies and risk assessments conducted around the world lead to the conclusion that they do not pose a significant risk to marine and human life. We therefore address this matter in brief.

The commonest radionuclides in produced water are Radium 226 (^{226}Ra) which emits alpha particles, and Radium 228 (^{228}Ra) which emits beta radiation. Their source is radioactive decay of uranium and thorium in rock and clays in the gas reservoirs. Usually, concentrations of both these radionuclides in produced water are not high but they vary greatly in range in produced water from various sources and may also be higher by several orders of magnitude from their natural concentrations in sea water. However, due to the rapid dilution of produced water discharged to sea in the immediate vicinity of the gas and oil production platforms in various locations (Canada, North Sea, Brazil, etc.) only natural background radiation was measured (Sergio et al. 2002; Neff et al. 2011). The risks associated with radium emissions from produced water were evaluated in the US and in Europe. A study conducted for the US Energy Office by the Brookhaven National Laboratory determined that no effects on fish and crab are expected from radium in produced water discharged in large quantities to open bays in the Gulf of Mexico (Meinhold et al. 1996). According to Neff

(2002), radium concentrations in produced water from gas and oil platforms in the Gulf of Mexico are the highest in the world, so if radium from produced water does not pose a risk to marine organisms in proximity to these platforms, it will not endanger marine biota elsewhere. A study conducted for the Norwegian research network concluded that North Sea fish exposed to radionuclides from produced water do not pose a risk to the populations of the EU (Stralberg 2003). An up-to-date, comprehensive review of the influences of produced water NORM on marine biota leads to the conclusion that all studies researching this question indicate that the risk is negligible, but knowledge gaps do exist (Hosseini et al. 2012).

In view of the above and considering both the expected quantity of produced water from the gas reservoirs that this report addresses, which will be relatively small compared to the quantities in the Gulf of Mexico and the North Sea, and the results of the produced water dispersion model (see below), it is reasonable to assume that no significant environmental influences can be expected from the presence of NORM in produced water discharged to sea.

Sea water quality standards

The standards selected to conduct the environmental evaluation are the European Union EQS (Environmental Quality Standards) sea water quality standards which were established under the Water Framework Directive (WFD) which, in turn, also supports the European Marine Strategy Framework Directive. WFD standards which were updated in 2008 and again recently in 2012 (see Table 4.8.3-3) are among the most stringent standards in the world for sea water (far more stringent that US federal standards) and were intended to provide overall protection to the marine ecology from exposure to chemicals, covering both organisms in the water and in the seabed (WFD 2008, 2012). Two types of standards were established to cover both long-term and short-term influences of exposure to chemicals. Both standards apply outside the dilution zone, which is the area close to the chemicals' entry point into the marine environment:

- AA-EQS: average annual concentration, intended to protect from chronic influences.
- MAC-EQS: maximum allowable concentration, intended to protect from acute influences of peak concentrations of substances with a high acute toxicity.

Of significant note is the fact that in 2012 the OSPAR Commission adopted AA-EQS values as Predicted No Effects Concentrations (PNEC) for impact on marine organisms when assessing the environmental risks from discharging produced water to sea (OSPAR Commission 2012).

Table 4.8.3-3 also shows the standards for quality of the Mediterranean Sea water in Israel that were recommended by the Ministry for Environmental Protection in 2002 for a period of five years (Ministry for Environmental Protection 2002). These suggested standards, which are less stringent than the WFD standards, do not have a uniform theoretical basis and have no statutory standing.

Table 4.8.3-3: EU sea water quality standards and Israeli Mediterranean Sea water quality proposed standards by the Ministry for Environmental Protection, microgram/liter

Substance		Environmental standards				
		Israel (Ministry of Environmental Protection, 2002)			EU (WFD 2008, 2012)	
		Maximum	Average		MAC -EQS	AA -EQS
Heavy metals	Mercury Hg	0.4	0.16		0.07	
	Cadmium Cd	2	0.5		1.5	0.2
	Lead Pb	20	5		14	1.3
	Zinc Zn	100	40			Natural background+3*
	Nickel Ni	50	10		34	8.6
	Chromium Cr	20	10			
Hydrocarbons	Benzene		170		50	8
Aromatics	Toluene		200			
	Ethylbenzene		20			
	Naphthalene					2
	Anthracene				0.4	0.1

*The value for zinc is informal

Expected concentrations of produced water components compared with sea water quality standards

Dilution factors obtained from modeling produced water dispersion as described in Section 4.8.2 and in Appendix J are shown in Table 4.8.3-4. The least dilution of produced water (worst case scenario) is expected when the sea is calm, at a distance of 250m from the gas treatment platform (produced water discharge point down the current). Table 4.8.3-5 shows critical dilution factors for components of produced water listed in Tables 4.8.3-1 and 2. These are the dilutions necessary to ensure compliance with the water quality standards listed in Table 4.8.3-3. For each substance, the critical dilution factor was calculated both for the average concentrations and for the maximum concentrations that are listed in Tables 4.8.3-1 and 2. Calculations were made according to the most stringent standards, i.e. EQS values where available. For zinc, calculation was made according to the standard value irrespective of the natural background, for mercury the calculation was made according to MAC-EQS, and only for chromium, toluene, and ethyl-benzene which do not have a WFD standard, calculations were made according to the standards proposed by the Ministry for Environmental Protection.

Table 4.8.3-4: Dilution factors obtained from the produced water dispersion model, under different sea conditions and at varying distances from the point of discharge of produced water

Direction and distance from discharge point		Dilution factor		
Direction	Distance from discharge point (m)	Quiet sea conditions	Strong easterly wind	West to north-west summer wind
With the current	250	13,200	72,700	32,200
	500	17,000	116,000	41,400
	1000	24,000	170,000	72,500
	1500	36,200	263,600	96,700
	2000	58,000	483,300	111,500
Perpendicular to current	250	18,100	103,500	36,300
	500	72,500	966,700	96,700

Table 4.8.3-5: Critical dilution factors (dilution necessary to ensure compliance with stringent sea water quality standards) for average and maximum produced water concentrations, and the least dilution (quiet sea) expected at a distance of 250m from the gas treatment platform

Substance	Average concentration at discharge point, mcg/l	Critical dilution factor	Maximum concentration at discharge point, mcg/l	Critical dilution factor	Least dilution expected at a distance of 250m from the rig
Mercury	2.3	33	8.9	127	
Cadmium	1.3	6.5	5	25	
Lead	4.1	3	9	7	
Zinc	26	9	145	48	
Nickel			60	7	
Chromium	420	42	1,600	160	13,200
Benzene	14.6	2	7,300	913	
Toluene	7.48	1	13,000	65	
Ethyl benzene	0.78	1	800	40	
Naphthalene	115	58			
Anthracene	110	1,100			

The data in Table 4.8.3-5 indicate that even under the most stringent scenario, with maximum concentrations of the substances in the produced water and the least dilution (calm sea), the expected dilution at a distance of 250m from the gas treatment platform in every direction is greater by at least one order of magnitude than the critical dilutions.

Calculated maximum concentrations of produced water components at distances of 250m and 500m from the gas treatment platform down the current and perpendicular to the current are shown in Table 4.8.3-6 (for naphthalene and anthracene the average calculated concentrations are shown). In all directions around the platform, the calculated concentrations in the sea are smaller by at least one order of magnitude than the stringent standards for sea water quality.

Table 4.8.3-7 shows the calculated concentrations of dispersed oil around the platform relative to an average concentration of 29 mcg/l and relative to a maximum concentration of 42 mcg/l at the discharge point (the 42 mcg/l value was taken from the permits granted to Noble Energy by the inter-ministerial committee for granting permits for discharging produced water to sea from the Mari and Tamar gas fields). The calculated maximum concentrations at a distance of 250m around the platform are smaller than 0.07 mcg/l by an order of magnitude, which is the PNEC value adopted by the OSPAR Commission (OSPAR Commission 2012). Concentrations around the platform are also smaller by an order of magnitude than the dispersed oil concentrations calculated for the survey of the environmental impact of developing a gas field in Western Australia as the PNEC threshold including the most sensitive organisms (Woodside 2011).

Table 4.8.3-6: Calculated maximum concentrations of produced water components around the gas treatment platform (for naphthalene and anthracene the average calculated concentrations are shown)

	Maximum concentration				
Substance	At discharge point	250m down current	250m perpendicular to current	500m down current	500m perpendicular to current
Mercury	8.9	0.0007	0.0005	0.0005	0.0001
Cadmium	5	0.0004	0.0003	0.0003	0.00007
Lead	9	0.0007	0.0005	0.0005	0.0001
Zinc	145	0.011	0.008	0.009	0.002
Nickel	60	0.005	0.003	0.004	0.0008
Benzene	7,300	0.55	0.40	0.43	0.10
Naphtalene	115	0.009	0.006	0.007	0.002
Anthracene	110	0.008	0.006	0.006	0.002

Table 4.8.3-7: Calculated average and maximum concentrations of dispersed oil around the gas treatment rig

	Concentration, mg/l				
spersed oil	At discharge point	250m down current	250m perpendicular to current	500m down current	500m perpendicular to current
	29 average	0.002	0.002	0.002	0.0004
	42 maximum	0.003	0.002	0.003	0.0006

Assuming that heavy-metal and aromatics concentrations in produced water from the gas discoveries addressed by this survey will not be higher by more than one order of magnitude than the concentrations examined above, the overall conclusion from Tables 4.8.3-5 to 7 is that no significant influences are expected on the marine biota and ecological system beyond the immediate surroundings of the gas treatment platform, within a radius of 250m from the platform at the most. This is a conservative conclusion for several reasons:

- All dilution calculations were made for a least dilution scenario (calm sea and zero salinity of the produced water)
- Lattice resolution for the produced water dispersion model makes it impossible to estimate at what distance from the platform the critical dilutions will be achieved and at which no harmful impact is expected. However, based on global experience with produced water dilution it is reasonable to assume that these dilutions will be achieved within a 250m radius from the platform, and probably even closer than 100m.
- Calculations above refer only to the physical dilution of produced water, and do not incorporate chemical and biological weathering processes. These processes, as noted, may rapidly reduce concentrations of some of the produced water components and the range of their subsequent environmental impact.

Considering dilution calculations for produced water at sea and the existing knowledge regarding biodegradation rates of organic components of produced water, even assuming that BOD and TOC values for produced water will be in the upper range of measured values, as listed above, no significant impact on dissolved oxygen content is expected in the areas beyond the 100-250m radius around the gas treatment platform.

Conclusions from studies and monitoring programs of produced water discharge sites

Studies and monitoring programs conducted during the past 20 years around the world have made it possible to estimate influences on marine organisms and on the marine ecology. The general conclusion from all these findings is that the risk to the marine environment from discharging produced water to the open sea is small and limited to the immediate surroundings of the discharge points. Substances originating in produced water have been found in sea water and in sediments at distances of several miles away from the oil and gas platforms, but beyond the immediate proximity of the platforms (a few hundred meters) concentrations were below the PNEC threshold (Lee and Neff 2011). To demonstrate, see a few examples of study and monitoring results that were obtained by various methods:

A study was conducted in the Gulf of Mexico in 1990 as ordered by the US EPA. The study's goals were to:

1. Determine whether produced water chemicals are building up in tissue of representative edible fish and invertebrates that inhabit areas near two oil and gas platforms that discharge 7000 and 11000 barrels a day of produced water,

compared to organisms that live near platforms that do not discharge produced water to sea.

2. Evaluate health risks to the ecological system and sea-food consumers from produced water chemicals that are present in tissue of animals that live near platforms that discharge produced water to sea and in tissues of animals that live near platforms that do not discharge produced water to sea (OOC 1997).

To meet the first goal, 60 chemicals were tested, of which most were identified in the produced water discharge permits as substances with accumulation potential (heavy metals, BTEX, PAHs, other organic compounds including phenols, and radionuclides Ra-226 and Ra-228). For the second goal, 12 chemicals were tested that had been identified by the US EPA as target pollutants. Hundreds of organism samples were tested, and the study's conclusions were:

3. There is no evidence of build-up of harmful substances originating in produced water in the tissue of organisms inhabiting the immediate vicinity of platforms that discharge produced water to sea (there is no association between proximity of organisms to the discharging platforms and the concentration of substances in their tissue).
4. Substance concentrations in animal tissue in the Gulf of Mexico, including organisms inhabiting the immediate vicinity of platforms that discharge produced water to sea, were lower than concentrations that might be harmful to the organisms themselves or to their consumers, including humans.

A comprehensive study conducted in the late 1990s in the Norwegian sector of the North Sea, examined the ecological risk to populations in the water column as a result of discharge of produced water. Two tools were used: (1) Dose related Risk and Effect Assessment Model (DREAM) for predicting concentrations of chemicals originating in produced water and the subsequent ecological risks at varying distances from the discharge point, (2) estimating PAH concentrations in sea water based on measuring these compounds in clams that were placed in cages for approximately one month at varying distances from the discharge point of produced water from oil and gas platforms (Neff et al. 2006; Durrel et al. 2006). The study focused on PAH because this group of compounds is considered to be the main contributor to potential ecological risk from discharging produced water to sea. The study was conducted in an area densely populated with gas and oil platforms that discharge approximately 70% of the total amount of produced water discharged into the North Sea. In the early years of the 21st century 180,000 cubic meters/day were discharged to sea in this area (approximately 120 times the expected amount of produced water discharge expected in the case examined in this report). Both research methods tested the relationship between calculated PAH concentrations in sea water at varying distances from the discharge source and the PNEC concentrations. The conclusion was that both methods did not identify a significant ecological risk that derives from the presence of PAH in the water column.

Since 1999, under the Norwegian North Sea monitoring program, possible impact of produced water discharges on organisms in the water column is monitored using chemical tests and a variety of biomarkers to identify chemical exposure (OSPAR 2009; Børsethand & Tollefsen 2004). There are two components of monitoring: testing for accumulation of selected hydrocarbons in commercial fish (from the wild) from contaminated areas and from clean areas (once every three years), and annual tests for accumulated chemicals and biomarkers in fish and clams from cages that have been placed near gas and oil production platforms. The following biomarkers are used: lysosomal stability, vitellogenin, DNA adducts, GST ,EROD, and others. Monitoring findings elicited the following conclusions: fish and clams in the cages showed identifiable reactions to several (but not all) biomarkers of chemicals originating in produced water, but the significance of these findings for the individual, the population, and the ecological systems are unclear. Fish from the wild showed no accumulation or impact from chemicals originating in produced water.

Summary

5. Based on a conservative environmental evaluation that builds on results of modeling produced water dispersion, the environmental impact of discharging produced water to sea is expected to be very small. It is reasonable to assume that any influence on marine biota will be limited to the immediate vicinity of the gas treatment platform, within a 250m radius from the platform at the most.
6. Conclusions from studies and monitoring programs in the context of environmental impact of produced water conducted in places where extremely large amounts of produced water are discharged to sea (much larger amounts than the expected discharge from the gas discoveries addressed by this paper) support the above environmental evaluation.
7. As is commonly accepted, and especially since produced water discharges from the gas fields addressed by this paper are planned to continue over dozens of years and there are still a number of unknowns regarding ecological influences for these time-frames, it will be necessary to monitor the environment in the discharge area.

4.8.4 Removal via an existing outlet

There will be no removal via an existing or approved outlet.

4.8.5 Removal via a new outlet

Dispersion model for produces-water outlet according to Ministry of Environmental Protection guidelines is listed in Section 4.8.2, above.

4.8.6 Failure in condensate storage

This section examines a case of failure in the condensate storage, its dispersion in the sea and the possible impact of a pollution incident on the marine environment. The dispersion model for condensate at sea was applied as follows:

What is condensate?

Natural gas produced from seabed reservoirs naturally contains varying quantities of short-chain hydrocarbons in addition to methane. In the reservoir these molecules are gaseous but when they arrive at the surface under normal atmospheric pressure, they are liquefied and in this form are referred to as condensate (Energy Information Administration, 2006). The precise composition of the condensate varies according to the reservoir's properties but in general it is known to contain mostly low molecular weight hydrocarbons, it is light in color and is flammable and explosive (GSPEN, 2012).

This dispersion model of a condensate spill following failure in a storage tank located near the gas treatment platform was conducted according to Ministry for Environmental Protection guidelines. Model technical details, input data, and results for condensate dispersion are shown in Appendix J. Condensate is approximately 15% less dense than sea water which means that is floats on the sea surface like an oil slick. Condensate is dispersed by currents, wind, and turbulent mixing; it is also affected by weathering processes such as evaporation and emulsification. Briefly put, the model applied was the MEDSLIK oil slick dispersion model. The model treats condensate as a collection of suspended particulates with Lagrangian trajectories and incorporates random mixing and weathering processes. Its horizontal resolution is 1 minute (ca. 1.7km) and it accepts wind input from meteorological data and currents calculated by the POM oceanographic model (see Section 4.8.2 and Appendix J).

Several simulations were used to test condensate dispersion, with meteorological-oceanographic conditions that represent worst case scenarios. The worst case scenarios were selected according to the amount of substances that is expected to make landfall. The model was applied to an immediate spill of 100,000 barrels of condensate (API 34.6). Three periods were selected representing meteorological-oceanographic conditions that can potentially cause serious situations: (1) typical winter storm (25 November-1 December 2004), (2) extreme winter storm (11-18 December 2010), and (3) typical summer conditions with north-westerly winds (28 July-1 August 2008). All scenarios were selected in coordination with the Ministry for Environmental Protection.

Currents in the platform area usually run northward so the slick is expected to travel and disperse to the north. Under all three meteorological scenarios, winds have a dominant westerly component which will drive the slick toward shore. The landfall arrival point will be determined by a combination of current effect and the relative intensity of the wind's northerly and its westerly or southerly components. In all scenarios over 44% of the spill will evaporate during the first hours. Approximately 53-55% of the spill (53,000-55,000 barrels) will make landfall and disperse mainly along a 20-35km stretch of beach up to the Carmel beach in Haifa, although most of the condensate will concentrate in a 3-5km stretch at a location that is scenario dependent. During a typical winter storm the slick will make landfall within 24 hours and the most impacted area is expected to be the Dor beach. The extreme winter storm scenario is expected to be the worst case. The slick will make landfall within 12 hours and the most impacted area is expected to be the Geva Carmel beach north of Dor beach. The maximum concentration of condensate that will build up on the shore will be double the maximum concentration that will reach the shore during a winter storm. Condensate distribution along the shore under this scenario is illustrated in Figure 4.8.6. Under the typical summer scenario the slick will make landfall within 21 hours and the most impacted area is expected to be Maagan Michael, south of Dor beach. A very small portion of the condensate might also build up along the Haifa Bay beach. The maximum condensate concentration that will accumulate will be 40% greater than the concentration from a typical wind's storm. We emphasize that in all cases the properties of the oil making landfall will be different than those of the original spill, largely due to evaporation of the lighter fractions. Table 4.8.6-1 compares and summarizes the results for the three scenarios.

Figure 4.8.6: Distribution of condensate accumulated on the shore (barrels/km) under the extreme winter storm scenario (1 barrel=0.16m3)

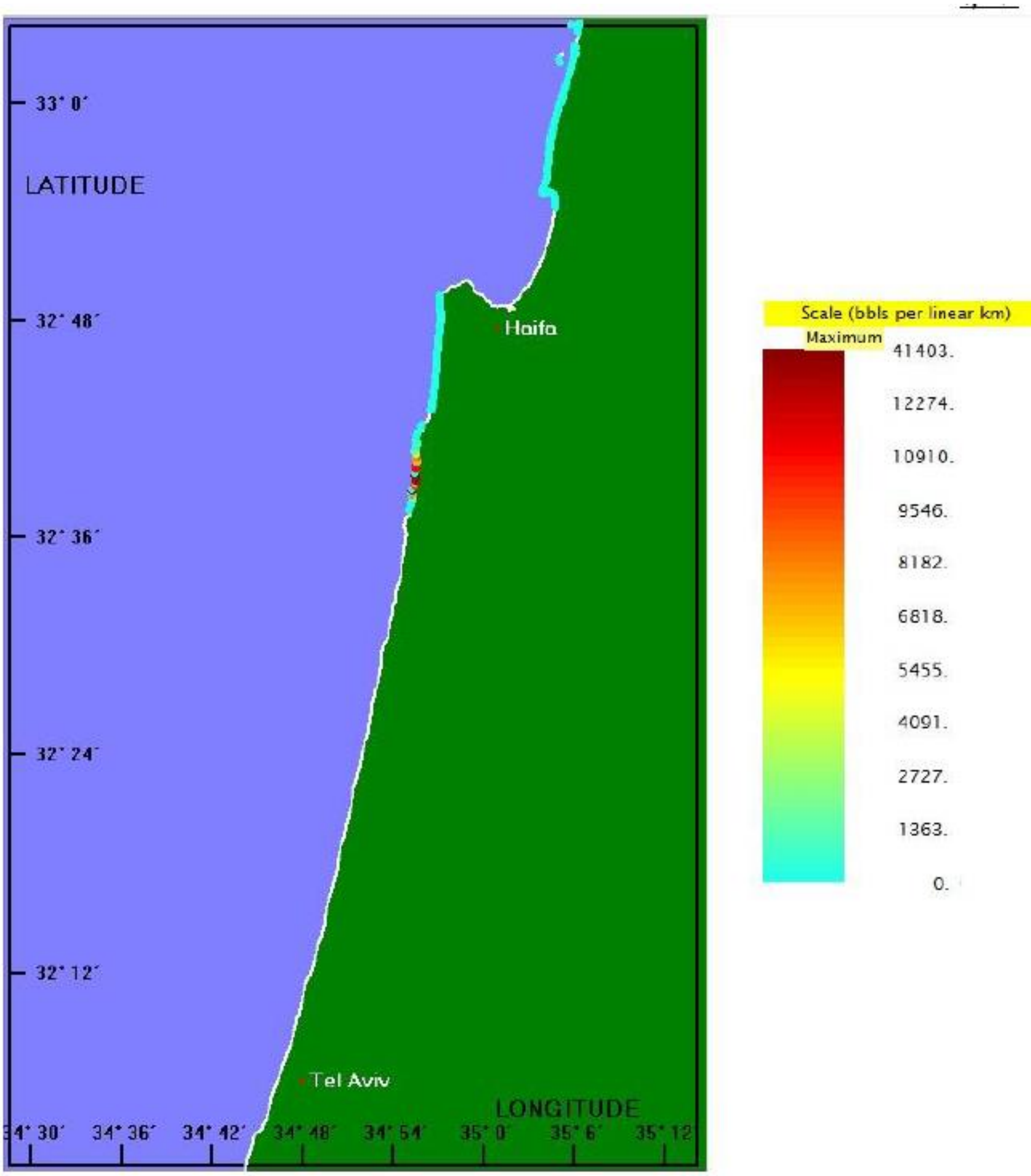


Table 4.8.6-1: Summary of condensate dispersion scenarios –landfall arrival times and most impacted areas

Scenario	Initial landfall (hours)	Maximum concentration on the shore (barrels/km)	Most impacted area
Typical winter storm	24	16,240	Dor beach
Extreme winter storm	12	41,403	Geva Carmel beach
Summer north-westerly winds	21	23,863	Maagan Michael beach

In the tested scenarios, the spatial variation in currents and wind over distances of 10-20km along the shore was small. Therefore, if the spill point is shifted north to the center of the Hadera compound (ca. 15km to the north) the slick's dispersion pattern on the shore is expected to be similar to the current scenarios' dispersion with a 15km shift to the north. In this case, the most impacted area would be the beach between the Atlit fortress and the southern beach in Haifa (Dado beach). There is also a potential +/-5km uncertainty regarding the arrival point of the condensate slick at the shore due to the current along the coast in the surf zone, which is formed by waves breaking near the shore.

Environmental influences of contamination by condensate

Fate of condensate in sea water

When oil is discharged to sea water several chemical, physical, and biological processes take place. These are referred to as weathering processes, and evaporation, dilution, chemical decomposition, emulsification, photolysis, and biodegradation are examples of this. Weathering changes the chemical and physical properties of the liquid with implications on the influence of contamination on the environment (Neff et al., 2000). In the first days following a contamination incident, the most dominant weathering processes influencing the liquid's chemical and physical properties are evaporation and spreading. The rate of these processes mostly depends on the condensate properties and on conditions at sea (Neff et al., 2000). Condensate weathering usually proceeds with a high evaporation rate and a tendency to form unstable emulsions depending on the specific properties of the oil (very light oils with API environment values that are higher than 45 may not emulsify at all) (WA Oil Classification, 2010).

Hydrocarbon influence on the marine environment[31]

The impact of presence of hydrocarbons in a marine environment may be acute or

[31] http://www.nap.edu/openbook.php?isbn=0309084385

chronic.

Acute toxicity – immediate short-term impact of a single exposure to a toxin

Chronic toxicity – ongoing exposure to a toxin

Hydrocarbons' acute and chronic toxicity to marine organisms depends on several factors:

1. Hydrocarbon concentration and length of exposure
2. Bioavailability and persistence of the specific hydrocarbon
3. Ability of the organism to accumulate and metabolize the hydrocarbons
4. Ability of the hydrocarbon metabolites to interfere with vital physiological processes (growth, reproduction, survivability)
5. Narcotic effect on neural conductance

A study conducted in Australia under controlled laboratory conditions (Neff et al., 2000) tested chemical and physical changes in various oils as a result of evaporation and the impact of these changes on their chemical composition and toxicity to marine organisms. Condensate was one of the tested substances. Study results show that in a fresh contamination, MAH (monocyclic aromatic hydrocarbons) are the most substantial contributors to acute toxicity, and when weathering processes have had some time PAH (polycyclic aromatic hydrocarbons) become more prominent contributors.

PAH toxicity depends among other factors on molecular structure. In general, the light aromatic hydrocarbons (including MAH) are considered acutely toxic but not carcinogenic to marine organisms. Heavy aromatic hydrocarbons, on the other hand, are not acutely toxic but several of them are known carcinogens (see Canadian Council of Ministers of the Environment, 1999). The high acute toxicity of light aromatic hydrocarbons is mainly ascribed to their being highly water-soluble. In a hydrocarbon mixture (such as that in condensate) overall acute toxicity is the cumulative product of the individual components' toxicity. Narcotic effects of hydrocarbons are mainly ascribed to light volatile hydrocarbons[32].

Considering that the tested scenario in the present survey outlines an extreme incident with damage to a condensate storage tank and a one-time dumping of liquid into the sea, and based on the information regarding the chemical properties of the liquid (high content of light hydrocarbons) we estimate that the expected impact on organisms in the shore area will be classified as acute.

Environmental impact

[32] http://www.nap.edu/openbook.php?isbn=0309084385

The impact of hydrocarbon pollution, including that of condensate, on the marine environment varies depending on a large range of factors, the main ones being: the exact chemical composition of the spilled liquid, weather conditions at the time of contamination and afterward, properties of the receiving medium (water, sand, rock), and the composition of the exposed population. To predict the nature of the expected trauma to some habitat as a result of hydrocarbon contamination it is advisable to review studies conducted in the field in the wake of similar contamination incidents, and find relevant information from lab experiments. Pertinent data must be cross-referenced regarding impact on similar taxa, even if the geographical regions are different.

Open sea environment

Condensate contamination originates in the open sea environment so the contamination is expected to travel on the water surface. At this point weathering processes will be in their early stages and the most impacted will be organisms that inhabit the open waters and the upper portion of the water column. Most impacted organisms at this stage are populations of plankton, fish, and birds that come into contact with the water, but also marine mammals and sea turtles are at risk of exposure.

Plankton

Phytoplankton and zooplankton, including larval forms of many invertebrates as well as fish eggs and larvae[33] have a central role in primary production in the marine environment. A study conducted in Australia under controlled laboratory conditions (Neff et al., 2000) that tested toxicity of condensate and three other oils has shown that acute toxicity of the two light oils was higher than that of the heavy oils in all six species of organisms that were tested (2 species of fish, an elongated-abdomen decapod, a mysid, a sea urchin, and sea urchin larvae). Tracking the impact of pollution on plankton populations in the open sea is difficult to unachievable, so it is impossible to rule out long-term effects of such pollution which may manifest in harm to the adult population of certain species (as a result of injury to the larval stages)[34].

Birds

Sea-birds are considered to be highly vulnerable to hydrocarbon pollution because they come in direct contact with the substances floating on the water surface. Species that concentrate at the water surface and/or dive in search of food are at high risk of injury. Main causes of death on exposure to pollution are: drowning, starvation, poisoning, and loss of body heat caused by feathers being covered in tar. Although there have been attempts to clean birds who were affected few survive the process,

[33] http://www.itopf.com/marine-spills/effects/environmental-impact)/
[34] http://www.itopf.com/marine-spills/effects/environmental-impact/

and it transpires that their chances of reproducing successfully are small[35]. Detailed information regarding the bird population of the Carmel beach area is available in Appendix N, attached below.

Marine mammals and sea turtles[36]

Marine mammals and sea turtles breathe air and must come up to the surface to do so. In case of a large oil slick, these creatures will be exposed to chemicals' toxic fumes particularly if they are exposed during the spill's first hours. Inhaling toxic fumes may injure the respiratory system and cause irritation to a varying degree. Organisms may also be exposed to oil pollution through feeding and skin contact. Digesting chemicals after consuming contaminated organisms or accidental ingestion of oil may injure the liver and kidneys, cause anemia, immune depression, reproductive dysfunction, and even death.

Terrestrial environment on the shore

The slick's final destination is the beach, where it will land on a sandy or a rocky bed (see below). The sandy environment in the shallows and in the surf zone is a homogenous habitat (with relatively few ecological niches) and it has a low stability which dictates a relatively small variety of species compared to rocky habitats and sandy habitats in deeper water. Nevertheless, pollution reaching the sandy beach will largely contain a mixture of hydrocarbons at advanced weathering stages. As noted earlier, at this point we know that the mixture's acute toxicity can be ascribed to PAHs. We further know from a study conducted following the Exxon Valdez disaster that exposing fish eggs to degradation products of the spilled oil caused developmental and genetic damage as well as death (at exposure levels of 0.4-0.7ppb PAH). Other studies have demonstrated developmental damage also in invertebrates when exposed to lower concentrations of hydrocarbons[37].

Organisms that inhabit the beach such as the tufted ghost crab (*Ocypode cursor*) and crabs that live on the wave-washed swash zone such as *Gastrosaccus sanctus*) can be expected to suffer harm from exposure to pollution, as are birds that feed in this area by feeding on contaminated organisms. Sea turtles may also be exposed to pollution impact in their laying areas; this poses a hazard to adult turtles, egg development, as well as survival of the young turtles.

If hydrocarbons are also present on the sandy bed, then the benthic population of the soft bed, meiofauna in particular, will be adversely affected by the presence of PAHs. Experiments conducted in closed systems have found that PAHs have an inhibitory effect on physiological processes also in microalgae. When present in sediment, PAHs

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[35] http://www.itopf.com/marine-spills/effects/environmental-impact/
[36] http://www.noaa.gov/factsheets/new%20version/marinemammals_seaturtles.pdf
[37] http://www.nap.edu/openbook.php?isbn=0309084385

may also affect the composition of species in the benthic community by boosting the numbers of resistant species such as nematodes, an effect that could cascade up the food chain (Sammarco, 1997).

Intertidal zone

The rocky intertidal zone's vulnerability to hydrocarbon contamination and its ability to recover is directly related regional geomorphology. Shore structure and degree of exposure to wave energy in addition to the factors noted above are also significant (see also the table of oil spill sensitivities, below). On a rocky beach that is exposed to wave energy the slick's retention time will be limited and recovery is expected to be rapid. If a rocky beach has an irregular front, with many small bays and areas that are protected from wave action, the slick can be expected to get trapped in the protected areas causing ongoing damage and slowed recovery.[38] Under the condensate pollution scenario, physical coating and asphyxiation of organisms by heavy hydrocarbons is not expected, but toxic effects from water-soluble components are a possibility. These effects may be short-lived (a few hours) but in protected areas like small bays and tidal pools such as those found in the abrasion platform area may increase the water's retention time (with toxins present) and therefore also organisms' exposure time to toxins. Organisms from a wide variety of groups are vulnerable, algae, clams, crabs, worms, sponges, bryozoa, cnidaria, fish, and others (see Appendix N). Note that sedentary organisms that are incapable of movement will be harder hit than motile organisms that can move away from the contamination. Data gathered in studies of intertidal zones in North America with similar biological land-cover seem to indicate that despite these organisms' sensitivity to hydrocarbon contamination, almost complete recovery was observed within approximately two years[39]. At the same time, there is a risk of harm to key species, and harming these could set in motion longer term changes.

It is worth noting that weather conditions at the time the contamination reaches the shore and afterward has significant bearing on its impact on biota. A violent storm accompanied by a stormy sea will mix and disperse the contamination and will probably lessen organism exposure (mostly sedentary ones) to toxins. A calm sea and a dry heat wave can cause extended exposure to toxins; if this is accompanied by an extreme low tide, damage to the rocky intertidal zone organisms will be lethal.

Impact of pollution on the Carmel beach area

The shore between Maagan Michael and Geva Carmel beach is composed of Kurkar islands off the shore, sandy beach areas, rocky beaches, and abrasion platforms of the most complex and valuable along the Israeli coast. These areas, some of which have

[38] http://www.nap.edu/openbook.php?isbn=0309084385
[39] http://www.nap.edu/openbook.php?isbn=0309084385

been declared nature reserves (Dor island and Maagan Michael nature reserve, Habonim beach reserve) and some are slated to become nature reserves in the future (Dalia River estuary, and the area from Givat Michal at Dor to Taninim River, along a 7km section of shore) include a great variety or animals and plants in many different habitats (see in detail Appendices M and N of this document). In case of a condensate leak from a storage tank in the southern compound (Compound 2) where the gas treatment platform is planned, contamination will make landfall between Maagan Michael and Geva Carmel within 12 to 24 hours (see model results above). If there is a leak incident in the northern compound (Compound 1) the contamination is expected to make landfall between Neve Yam and Dado beach (on the southern outskirts of Haifa). Also along this shore segment are rocky and sandy habitats as well as sea turtle laying grounds, as listed in Appendix M. Marine organisms are expected to suffer harm from the time the substance is discharged to sea and up to an unknown time post-discharge. Initially, the dominant source of acute toxicity will be MAH, and as the contamination advances and weathering progresses, PAH concentration will increase and they will become the chief contributors to toxicity. Organisms first in line to be hurt are those inhabiting the top water column (plankton, fish, marine mammals, and sea turtles) and the surface (birds). Next, as the contamination nears the shore, Dor and Maagan Michael beach islands will be impacted (rocky bed habitat and bird population) as well as the rocky area opposite Neve Yam (leak scenario in Compound 1) and immediately afterward the sandy shore between Maagan Michael and Dor, and the area north of the Atlit fortress on to Dado beach in Haifa, and the rocky area/abrasion platforms of Dor/Habonim nature reserve and a little further north of there, and the area adjacent to Atlit (leak scenario in Compound 1).

It is important to note that due to the absence of closed bays that are protected from wave energy on the sandy shoreline between Maagan Michael and Dor beach, hydrocarbon compounds are unlikely to be found accumulating in the sediment. However, even if sedimentation occurs following decomposition and adhesion to particulate matter,[40] the sedimentary material is expected to continue mixing into the body of water and be carried away with the currents.

It is difficult to estimate the degree of injury, capacity for recovery, and duration. All these vary with the species, weather conditions, and biological processes (reproduction, recruiting, nutrition). We must also emphasize that until actual production from the submarine reservoirs begins and the exact composition of the condensate becomes known, treatment methods remain unknown. Condensate contamination is expected to harm various organisms (as listed above) as it progresses toward the shore. Among these are invertebrates as well as vertebrates from a wide range of systems and habitats in the open sea, on the islands near the

[40] http://www.nap.edu/openbook.php?isbn=0309084385

shore, and on the shore in highly valuable sandy and rocky areas. Note that significant portions of the shore between Maagan Michael to the south and Dado beach to the north are nature reserves, and additional sections are slated to be included in future nature reserves.

Classifying contamination landing sites based on the oil spill sensitivity atlas (Ministry for Environmental Protection, 2006)

The table below summarizes data taken from the Israeli coast oil spill sensitivity atlas of the Mediterranean Sea for coastal segments starting at Maagan Michael to the south and on to Dado beach to the north, which are expected to be hit by condensate pollution in the event of either of the two condensate leak incidents (storage tank failure in Compound 1 or 2). The listed level of sensitivity is of course subject to change depending on specific conditions at the time and place, and the nature of the spill (Ministry for Environmental Protection, 2006). Complementary biological data for the information listed in the following table is provided in Appendix M.

Table 4.8.6-2 : Sensitivity of shores to oil spills

Shore segment	Definition – type of shore	Main properties/permeability
Maagan Michael to Dor-south	Sandy beach, fine to medium grain size (usually moderate slope)	Low to medium oil permeability, shore is exposed to waves, medium to high cleaning capacity
Maagan Michael beach and Dor beach islands	Sites with protected and rare/ highly sensitive nature values	Beaches with highly sensitive resources, of natural or other significance
Shore stretch between Dor beach-south and Habonim beach	Abundant abrasion platforms, areas defined as irregular shore with a mixture of sand and rock to varying degree/horizontal exposed rock formed by the waves/discontinuous rocky surface projecting from the sea/sand.	When the sea is high, the rocky surfaces are almost impermeable to oil. But when the sea is calm or during low tide, the rocky surfaces are defined as permeable. Limited natural cleaning capacity in permeable and protected places, and high cleaning capacity in exposed places.
Habonim beach to Neve Yam	Sandy beach with fine-medium grain size (usually moderate slope). Across from Neve Yam is a Kurkar island that is intended	Low to medium permeability to oil, shore exposed to waves, medium to high cleaning capacity.

Shore segment	Definition – type of shore	Main properties/permeability
	to become a nature reserve (Engert and Yahel, 2011). There is a known sea turtle laying grounds in the shore area.	
Atlit fortress area	No information is available in the atlas	No information
North of Atlit fortress to Megadim beach	Coarse grain sand, medium to steep slope or beach with mixed sand and pebbles, gravel, or shells. There is a known sea turtle laying ground marked 500m north of Atlit fortress	Medium to high permeability, medium natural cleaning capacity
Megadim beach and further north up to Dado beach	Fine to medium grain size sandy beach (usually with a moderate slope)	Low to medium permeability to oil, shore exposes to the waves, medium to high cleaning capacity

4.9 Impact on habitats and nature values

4.9.1 Onshore environment

a. Expected impact on the natural environment

Influences of the plan on the onshore environment were surveyed in detail in the environmental surveys for onshore sites at the Meretz WWTP and Hagit site which have been submitted under this plan. This section addresses foraging and migration of birds at sea and the possible impact of treatment platforms in these activities.

Impact on migration and bird activity

A detailed ornithological expert opinion has been prepared by ornithologist Asaf Meroz, to examine impact on bird activity (see Appendix D). Below is a summary of the main points and the conclusions of this paper:

Introduction

Israel is an inter-continental junction and bottleneck of global importance to migratory birds. Migration of birds over the skies in Israel has intrigued many researchers and the extent of migration over land is known to some degree of certainty, depending on the species.

In contrast, we are much less familiar with migration patterns over the Mediterranean west of the Israeli coast, and the case is the same for birds that spend time over Israel's continental shelf and beyond it for extended periods, during the winter or summer.

This section is based on data gathered over many years of observations from Israel's coast, on non-commercial sea voyages and by migration surveys conducted in northern Sinai shores in the 1970s and 1980s. **The only way to obtain more accurate data regarding the use birds make of the marine compounds designated for the installations is to conduct a long-term survey from within the installation, using suitable equipment (radar/night vision gear). The monitoring program is being proposed for this reason.**

Birds in the plan perimeter

Birds observed off the Israeli coast, at a distance of several kilometers into the sea, can be divided in two groups:

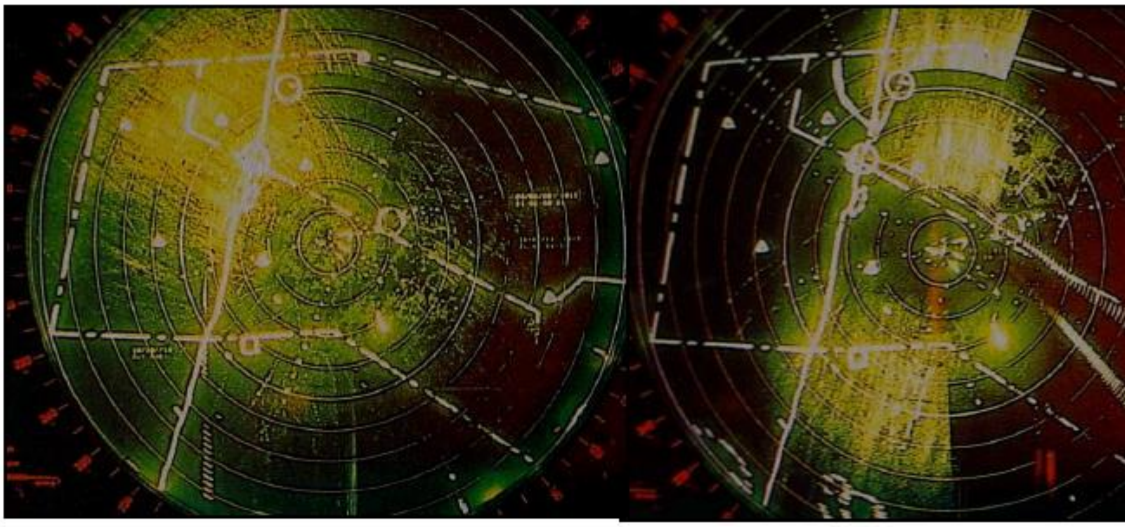
Sea birds: species adapted to flight and foraging in the open sea, such as seagulls, petrels, terns, gannets, and jaegers . Most of these species do not nest in Israel but they do spend time on the shores and offshore in the deep sea several months a year, feeding and resting at sea. Some of these species are true pelagics (petrels, gannets). They only set foot on land to nest. Others are not true pelagics, like the seagulls and terns, and spend a significant amount of time on land. One species of seagull (yellow-legged gull) and two species of terns (common tern, little tern) nest in Israel on small islands near the shore and in inland water bodies.

Photograph 4.9.1-1: Armenian gull (right) and Cory's Shearwater (left) photographed opposite the Herzlia beach (Asaf Meroz)

Birds that are not sea birds: Most are birds that are not adapted to extended stay and foraging at sea, but do migrate across the sea. This group numbers ca. 100 species of water birds such as ducks (garganey, common teal, shoveler), cranes (little egret, grey heron, night heron), Charadriiformes (little stint, plover, sandpiper) and a further 140 species of song birds (mainly Fringillidae, Alaudidae,Hirundinidae) and members of related orders (Meropidae, hoopoe, and others). Larger birds, such as most birds of prey, pelicans, and storks do not usually cross the sea; they bypass it over the shortest land bridge.

There are several differences between song-bird migration and water-bird migration: song-birds seem to have a preference for ending the night migration flight in the morning hours, landing at a terrestrial habitat (along the coastal plain), which allows them to rest and store fat (Figure 2). In contrast, water birds which migrate over the sea continue their flight south uninterrupted, or land on the water to rest (this is the case for ducks and seagulls, which are able to do this).

Figure 4.9.1-2: Two photos from the access-control radar at Ben-Gurion Airport showing Gush Dan sky on a night in October during the fall migration (the Israeli coastline is the light colored line crossing the picture from top to bottom). The bright clumps are flocks of migratory birds. In the photo on the right birds are migrating in parallel to the coastline from north to south. These are birds that took off on their night migration in the Galilee, Lebanon, or western Syria. In the photo on the left, flocks of birds arrive after midnight from the north-west, having crossed the Mediterranean from Cyprus or western Turkey (Leshem and Bahat, 1994).



Main characteristics of bird migration over the sea:

1. **Time**: mostly at night, peaking an hour after sunset, gradually declining during the second half of the night, and partly continuing into the morning hours up to 10:00 am or so (Sobel, 1985; Bruderer, 1994). During these hours some of the

birds (song-birds in particular) land in suitable habitats along the coastal plain and others actively fly further south.

2. **Migration route over the sea**: during the autumn birds have a broad migration front earlier in the night, closing in on the shore toward the small hours, passing a few kilometers west of the shore (Shirihai, 1996) and gradually descending (see below).
3. **Bird numbers:** radar surveys indicate that the number of birds crossing the sky over a 1km section ranges between 4000-5000 individuals an hour, in other words 40,000 birds a night (Bruderer, 1994). A survey of water birds conducted in northern Sinai by direct observation from the shore, counted lower numbers (mainly because the survey only recorded daytime migration and excluded the large population of song-birds), up to a peak of ca. 100,000 birds a day over a 3km cross-section.
4. **Spring migration** over western Israel and the east Mediterranean is sparser. Bird density in this region during spring migration is approximately 40% of the fall migration (during March to May).
5. **Altitude**: altitude is most dominantly affected by wind direction, temperature, and relative humidity. The common hypothesis is that birds migrate during the night because during continuous flight their flight muscles warm up and they lose body fluids. They are better off flying during cooler, and more humid hours at altitudes where the temperature is sufficiently low on the one hand, and oxygen concentration can support strenuous breathing, on the other. In north-east Africa and in our region, trade-winds generally blow north to south up to an altitude of 1500m above sea level, and in the opposite direction (anti-trade) above this altitude. This means that in the fall, when birds migrate from north to south they are better off migrating below this altitude so they can benefit from the tailwind. Indeed, there is evidence that in the fall 50% of birds fly below a 900m altitude. In the spring, though, birds can benefit from migrating above an altitude of 1500m riding a south to north tailwind. Indeed, it has been found that most birds fly higher to the extent that 50% of birds pass through 1800m (Bruderer, 1994). Although radar studies indicate that most migration takes place at an altitude of 500-2500m above sea level, direct observations show significant numbers migrating also at 100m and lower. A migration survey of song-birds conducted at Tel-Baruch has revealed migration of 150,000 birds per season at low altitudes of 5-50m (Sobel, 1985). These numbers may represent only a small fraction of the birds that pass over at low altitudes because counting was conducted only during daylight hours. However, radar studies indicate that birds descend lower during the morning hours before landing.

Potential impact of facility's construction on birds

There are two types of potential impacts:

- Occupying an important living area for birds
- Disturbing and obstructing migratory and wandering birds (glare, shifting flight route, collisions, etc.)

Occupying an important living area for birds

This is significant in the case of sea birds that inhabit the open sea. Although we may tend to think the effect will be negligible because the planned facility is very small relative to the open sea, there are two factors involved that must be considered:

1. Some of the birds avoid passing in and around artificial structures. So the scope of impact of the facility is much larger than the built-up area; it also includes at least all the space between the platforms, and the entire perimeter that is illuminated by the platforms as well as at least a 1km radius around them.
2. Bird wandering and foraging grounds are not uniformly divided over the whole sea. Some areas become hot-spots with a higher biodiversity (both for species and for biomass) that birds can feed on. This is the reason that Marine Important Bird Areas have been declared in Europe and they are treated like marine nature reserves (Birdlife International 2012, UNEP 2010). This phenomenon has not yet been investigated in the Israeli marine space so we cannot point at this stage to important bird areas off the Israeli coast.

Disturbing migratory birds

As shown earlier, millions of migrating birds pass near the Israeli coast. Most migration takes place at night, some at very low altitudes. Migratory birds can collide with artificial structures as they fly. This phenomenon has been well documented in North America, where an estimated 5 million birds are killed colliding with buildings (Erickson et al. 2005).

Some collisions are unavoidable. Birds do not expect to run into an artificial obstacle that has been newly constructed, and under stormy or poor vision conditions may collide with the structure. There are, however, several factors that increase the chance of accidental collisions:

- Collisions with structures and infrastructure caused by incorrect lighting that blinds the birds, shifts their route, or draws them toward the obstacle.
- Collisions with walls and windows **made of glass**, which mislead the birds by reflecting the sky.

- Collisions with antennas and power lines which are difficult for birds to see due to their small volume

b. Means of mitigating the impact

The following approaches can be used to mitigate the impact on birds in the marine environment:

Lighting and light pollution

Overall, artificial lighting has a negative effect on birds and it should be kept to a minimum. Especially in the open sea, darkness must be viewed as an important component of the natural system, and compromising it must be avoided as far as possible.

In any event, best practices are in place for mitigating the impact on birds of artificial lighting of marine structures (Lieder, 2008; Evans, 2002; OSPAR 2012, Lieder and Hazofeh, Science Division at Israel Nature and Parks Authority, verbal communication):

1. Minimize use of light, both in illumination time and in intensity
2. Direct lighting towards the facility, not outward. Ensure illumination is not blinding by using lighting that points downward (full cutoff).
3. Use short-wave narrow-spectrum lighting, and avoid using white light.
4. Impact of artificial lighting on birds has been found to increase dramatically on nights with poor vision, precipitation, or full cloud cover. On such nights it is advisable to further restrict the use of artificial lighting (see Item 8, in this list).
5. Special attention must be given to illumination of tall structures such as stacks or antennas. These installations are usually illuminated with a continuous red light, marking the facility for aircraft. This type of lighting has been found to be dangerous to migratory birds, causing route shifts and multiplying collisions. Discontinuous light and short waves lengths are recommended.
6. Marking lights – flickering rather than constant light, with flashes that are relatively short compared to the intervals. In the US, it has been proven that a LED flickering at a frequency of 27-33 flashes a minute is most effective at preventing bird collisions (Patterson, 2012).
7. The lighting map must be supported by a photometric map showing light dispersion around the installation and demonstrating that the illumination does not exceed the constraints.
8. Monitoring. Facility operation must have a monitoring program to estimate

how many birds are harmed by the facility existence, and appropriate adjustments will be made if critical episodes of bird death are discovered. The monitoring program must be created based on experience from similar platforms overseas.

Preventing collisions

With buildings: Using glass on external walls of structures increases the rate of bird collisions. It is advisable to reduce use of glass on structure exteriors, and if glass must be used it should be masked on the outside by anything that will prevent reflection. This can be achieved by using curtains or external blinds, painting the windows or closely covering them with stickers.

With power lines: Birds flying at night collide with power cables and antennas. It is advisable to avoid installing cables and thin antenna rods that are difficult for birds to see. Whenever above-ground cables are installed they must be suitably marked with reflectors or similar means (Figure 4.9.1) (recommendations of tried methods are available in the planning departments of the Israel Nature and Parks Authority).

Photograph 4.9.1: Reflector for marking cables[41]

Trash and scraps: Birds forage for food using their sense of smell and they are attracted to scraps from miles away. Dumping trash and scraps outside the facility

[41] http://www.hammarprodukter.com/659.php?itemgroup=107

may draw birds to it and impact the inter-species competition interactions in its vicinity. This can increase the chances of bird collisions with the facility. Dumping trash into the sea must be completely avoided.

Additional recommendations: monitoring

As noted earlier, the entire State of Israel and the western Mediterranean Sea basin are located on one of the most important migratory routes in the world, hosting a confluence of bird populations that nest throughout eastern Europe and western Asia. Israel is the juncture of three continents, Europe, Asia, and Africa, and the number birds that pass through it is estimated at 500 million birds a season (fall and spring). **Together with other countries along the migration route, Israel has an impact on the integrity of the ecological systems on these three continents which is a heavy responsibility to carry. Among others, Israel has signed international treaties for protecting migratory species (Bonn Convention) and for preservation of the Mediterranean Sea (Barcelona Convention).**

There is great potential harm to migratory birds, but we are lacking current information from this region about migration magnitude and properties (altitude, timing, etc.) and about composition and number of vulnerable species and individuals. In comparison, the estimates of bird fatalities from collisions with a single platform in the North Sea (a minor migration route compared to Israel) range from 200 to 60,000 individuals a year (OSPAR 2012).

We propose a preliminary and a supporting monitoring program to overcome the large gaps in information, to facilitate a true examination of the facility's impact on birds, and ultimately minimize the negative impact.

2. Monitoring guidelines

   The large information gaps, the significant migration route along our shores, and the size of the planned facilities, require us to act with the utmost care and responsibility, and examine the extent of harm to birds.

   This proposed monitoring program is not an optimal one; it is a less comprehensive program that has been constructed knowing that a full monitoring plan (night and day for a full year) is very costly. We suggest that the initial effort be limited to monitoring migration during peak season as is it currently known, i.e. the fall migration.

   In this format, birds will be counted in the marine compound sector by day and night, and a sample test will be conducted of the number of birds that are injured by the facilities (by collecting carcasses). Wherever birds are injured, the injury will be analyzed and means devised to reduce the hazard.

3. Monitoring goals

- Collect data regarding the extent and nature of migration over the open sea.
- Examine the potential harm, sample test actual bird death cases, and profile the bird populations that are at a greater risk of being harmed by the marine facilities.
- Examine tools and methods for continued monitoring and researching of bird activity at sea.

4. Methods

- **Manned survey**: Expert ornithologists will be stationed on the platforms to locate, identify, and count passing birds. Observers will be stationed as appropriate to the deployment of the installations, assuming that each observation post can provide good coverage for a 1km radius around the platform. The chief difficulty with a manned survey is the extremely limited ability to identify birds at night.
- **Automated survey**: Full coverage by day and night using radar or an electro-optical system for sighting birds. The best such system today (Interceptor Bird Detection, CONTROP Ltd.) is capable of detecting small birds at a distance of 2km (based on manufacturer specifications).

Data will be collected using both methods (ornithologists and electro-optical) which will make it possible to compare the methods, add a mutual control, and increase the percentage of located and identified birds.

- **Monitoring period**: fall migration which peaks between August 15 and November 15.

Table 4.9.1: Guidelines for preliminary monitoring program

Information gaps	Tested parameters	Actions	Accessories/notes
Scope of daytime migration in the facilities' perimeter	Number of passing birds by species and distance from the shore	Ornithologists stationed on the platforms to identify and count passing birds	Conventional optical aids (binoculars, telescope)
Scope of nighttime migration in the facilities' perimeter	Number of passing birds by species and distance from the shore	Employ an electro-optical system	
Migration timing	Identify main migratory waves	Employ surveyors throughout the migration period (August-November)	

Information gaps	Tested parameters	Actions	Accessories/notes
Estimate of species and number of birds that are at risk of collision	Which species of birds and how many individuals fly low in the facilities' perimeter	Accurately record passing birds by distance from platform	Observer's estimation using electro-optical system
Number of birds that actually collide with existing facilities	Number of collisions (at the facility/night)	Search for carcasses near the facilities every morning (most accidents occur at night)	Pads for collecting the carcasses may need to be installed
Impact of weather and visibility on the probability of birds colliding with the facilities	Impact of wind, visibility conditions, and precipitation on the intensity of migration, migrator altitude, and distance from platform	Collect data from meteorological stations and accurately record weather conditions along with migration data collection	Requires analysis to understand the relationship between environmental conditions and irregular migration events

4.9.2 Marine Environment

The marine environment has been described through a marine survey conducted during January-May 2013 using a methodology compatible with the Ministry for Environmental Protection (see Appendix A1). The biological survey was conducted in to marine perimeters where gas treatment platforms are being planned; Perimeter 1 (hereby Dor Perimeter) and Perimeter 2 (hereby Havazelet Hasharon Perimeter) and in three corridors:

- Dor corridor – from inlet to the shore at Dor and westward
- Mikhmoret corridor –a photo-survey of the rocky substrate from the inlet at Mikhmoret beach to a depth of approximately 10m.
- Alexander River corridor – from Alexander River area westward.

The corridors lie within the area being searched for a pipeline lane, and they extend from the eastern boundary of the marine perimeters up to the shore, as described in Figure 4.9.2-1 (exact locations of the sampling points are listed in Appendix 12).

Figure 4.9.2-1 – map of the sampled area – Yellow dots are sampling points within the platform perimeter and dots with a black cross are sampling points in the pipe corridor (representing depth intervals of 10m vertical). Red lines represent trawling lines for biota sampling on the bed. A black line (near Mikhmoret) represents a line of photo-survey conducted by diving up to a distance of 900m from the shore in the Mikhmoret pipeline corridor.

Sediment samples were collected by grab loader and the robot filmed and photographed at the sampling points (in the platform perimeters and the pipeline corridors); samples were analyzed for grain size, organic material in the sediment, biota in the bed (see also Appendix 12). CTD (salinity, temperature, and oxygen) data were recorded. For every red line a net was trawled to sample the biota on the bed (see details in Appendix 12).

a. Habitat substrates

Perimeter 1 and 2 have a soft floor and so have the Dor pipeline corridor and part of the Mikhmoret corridor. The soft floor habitat is labeled Habitat 1, but in the biological description an additional subdivision was created for convenience sake; Habitat 1a for depths of 10-50m located in the Dor pipeline corridor and part of the Mikhmoret corridor (see Section d. below).

The rocky area discovered in the Mikhmoret pipeline corridor is defined as Habitat 2, and includes a rocky area at a depth of 3m and at depths of 8-11m (800m from the shoreline). Figure 4.9.2-1 shows a schematic chart of the habitats as documented in the present survey. A description of the habitat substrate is presented below together with data for grain size and organic material content. Sampling specification and sampling point map are available in Appendix 12, below.

Figure 4.9.2-1 shows Habitat 1 (soft floor substrate) in green and Habitat 2 (Kurkar rock substrate) in yellow.

Grain size

Dominant grain size in the depth range of 10-100m in both perimeters and in the pipeline corridors is shown in Table 4.9.2-1. Note that for the depth range of 10-50m in Perimeter 2 the grain size data was taken from samples collected 1km south of the Mikhmoret pipeline corridor (Alexander River pipeline corridor). Detailed results for grain size in both perimeters with diagrams of grain size distribution can be found in Appendix 12 of the survey report.

Figure 4.9.2-1: Survey and habitat boundaries

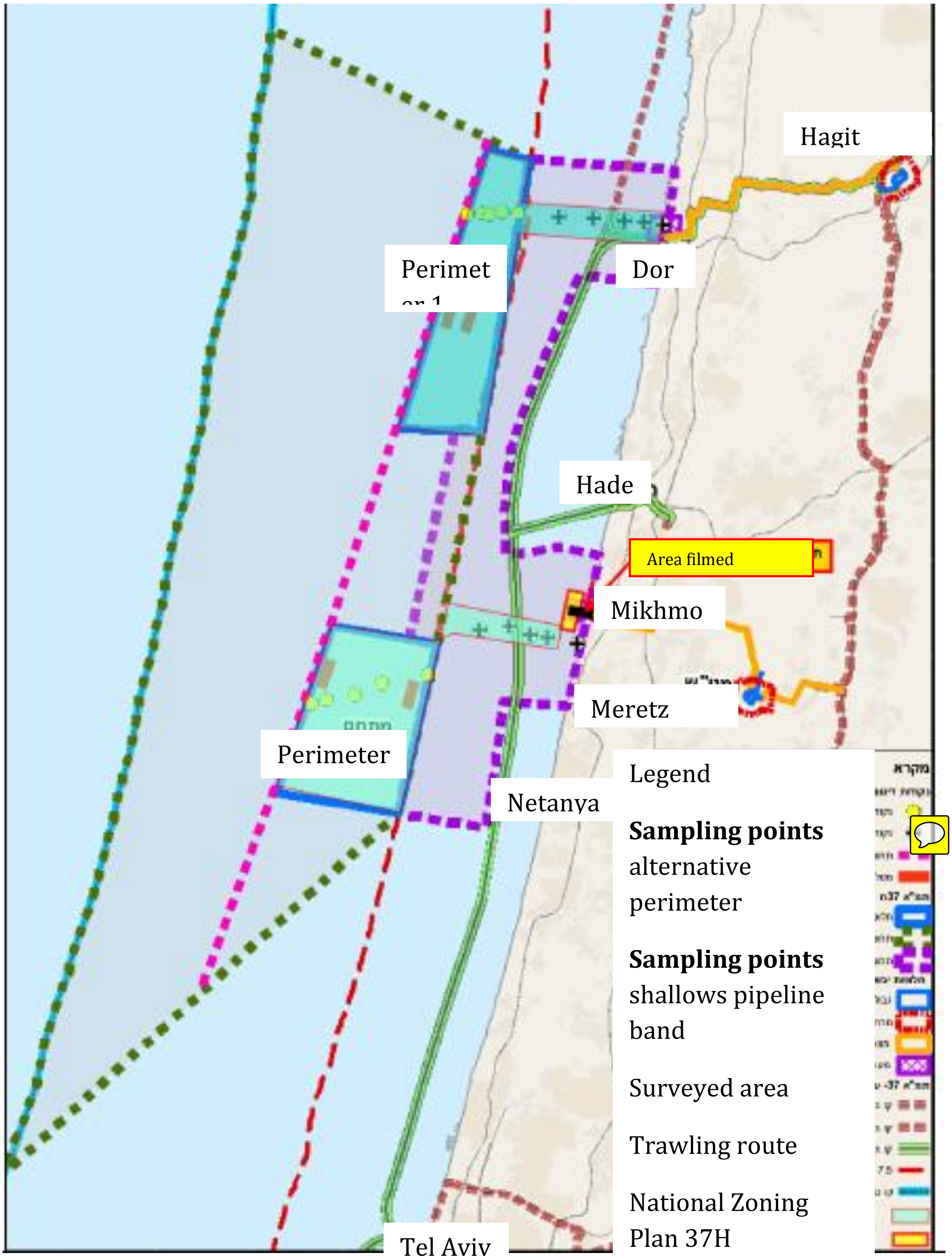


Table 4.9.2-1 shows dominant grain size results in Perimeter 1 (Dor) and Perimeter 2 (Havazelet) and in the Dor and Mikhmoret pipeline corridors. Depths 10-50m are representative of the pipeline corridors and depths 60-100m are representative of the platform perimeters.

Table 4.9.2-1: Dominant grain size results from Perimeter 1 (Dor) and Perimeter 2 (Havazelet) and pipeline corridors

Dominant grain size (micron)	Depth (m)	Perimeter 2 (Havazelet)	Dominant grain size (micron)	Depth (m)	Perimeter 1 (Dor)
182	10	1	183	10	1
173	20	2	178	20	2
193	30	3	171	30	3
150,500,1300	40	4	150	40	4
75	50	5	10, 90, 600	50	5
75	60	6	100	60	6
10-60	70	7	6-100	70	7
45	80	8	90	80	8
45	90	9	6-100	90	9
1-80	100	10	6-100	100	10

Organic material in the sediment

Concentrations of organic material found in the survey samples of both perimeters (Dor and Havazelet Hasharon) were exceptionally high; values were so unreasonable (compared to earlier data from nearby locations) that we assume that there was some error in the work process and we decided not to rely on these data. At the time of writing we have used data collected during the survey of the LNG buoy (TAHAL, 2011) in the area between the two sites and examined in the National Outline Plan 37H; their exact locations are listed in Table 4.9.2-2 We would like to stress that if necessary it will be possible to repeat the floor samples from these locations and conduct a repeat analysis.

Table 4.9.2-2: Table 3: Data for grain size and concentrations of organic material for sampling stations in the depth range of 40-85m (TAHAL, 2011)

Station	Depth (m)	LAT/LONG	Concentration of organic material (%)
B1	85	32°26'40.729N 34°45'13.4755E	0.660936
B2	78	32°27'8.6816N 34°4544.7865′E	1.14584
B3	67	32°26'41.7362N 34°46'17.290E	0.64766

Station	Depth (m)	LAT/LONG	Concentration of organic material (%)
B4	71	32°26'14.7642N 34°457433.′E	0.648
B5	75	32°26'41.452N 34°4544.2259′E	0.668
B6	67	32°26'56.8432N 34°46'19.9933E	0.671
B7	64	32°27'9.8706N 34°46'45.3689E	0.6453
B8	61	32°27'18.3800N 34°47'8.6860E	1.01207
B9	55	32°27'27.9213N 34°4748.1883′E	0.613
B10	49	32°27'27.0854N 34°48'33.2888E	0.60618
B13	41	32°27'8.0709N 34°49'39.0473E	0.54846

Biota in the bed was sampled at depth intervals of 10m in the platform perimeters and in the pipeline corridors. Results are shown below for each perimeter separately. Biota in the bed at depths of 10-50m in the Havazelet Hasharon perimeter was sampled in the Alexander River pipeline corridor, located approximately 1km south of the Mikhmoret corridor (during the survey this corridor was included in the sampling plan).

b. Description of biota in the bed at representative depth points

Biota in the bed was sampled at depth intervals of 10m in the platform perimeters and in the pipeline corridors. Results are shown below for each perimeter separately. Biota in the bed at depths of 10-50m in the Havazelet Hasharon perimeter was sampled in the Alexander River pipeline corridor, located approximately 1km south of the Mikhmoret corridor (during the survey this corridor was included in the sampling plan).

1. Perimeter 1 – Dor

Biota in the bed in Perimeter 1 was sampled on February 19, 2013. Ten points were sampled at depths of 10-100m (three repeats at each sampling station except Station 10 which was only sampled once due to a technical problem). The biota sampled in the platform perimeter and the pipeline corridor is shown in the 10-100m depth range.

A summary of the data revealed that 67 different taxa[37] were observed. However, because the organisms are not identified at the species level, in practice the number of species is higher. Data from all the samples shows that most taxa, 25 in number, are bristle worms from various families, 15 taxa of arthropods, 11 taxa of mollusks, 5 taxa of Cnidaria, and a few representatives of other taxa amongst them were Hemichordata, Cnidaria, Nemerata, Echiuria, Sipuncula. A full list of taxa is available in Appendix 12. The most dominant taxa were: Nematoda, N*=78; polychaetes from the families: Paraonideae, N=43; Spionidae N=181; Magelonidae N=83; Nephtyidae N=60; and Harpacticoid copepods (N=45).

*N is the number of individuals

Diagram 4.9.2-2 shows a multi-dimensional scaling of the results from samples collected opposite Dor; results are square root transformed according to the Bray-Curtis similarity matrix. The stations are shown by depth and repetition number (for example, first repetition of a sample from 40m is shown as 40a).

<u>Figure 4.9.2-2: Multi- Dimensional Scaling of the sampling results at Dor</u>

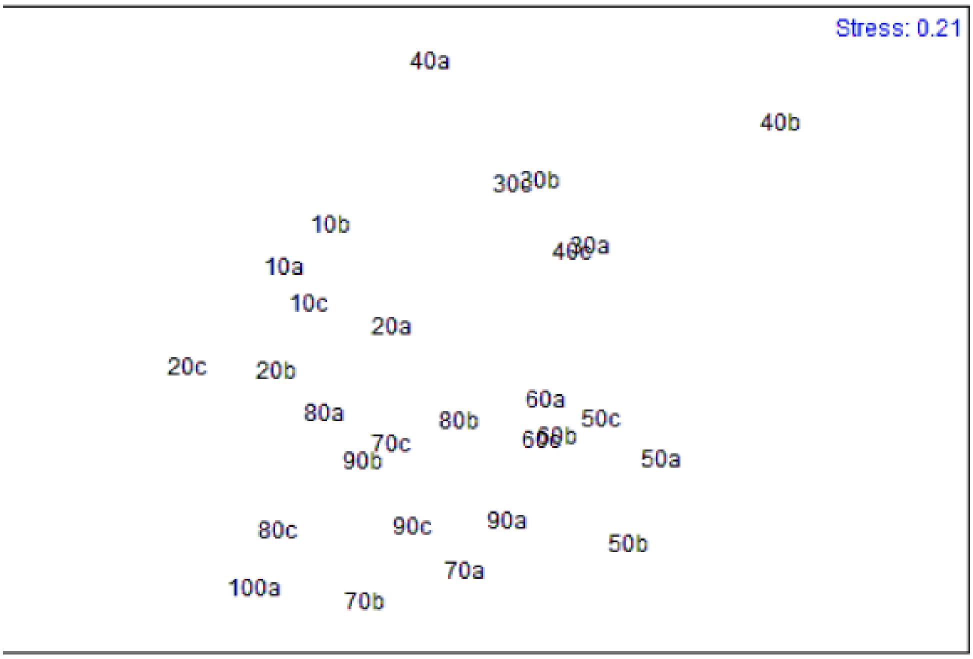


Figure 4.9.2-2 shows results from samples biota inside the bed from the Dor perimeter after MDS analysis (for data that was transformed by square root according to the Bray-Curtis matrix). Biota at Dor received a relatively high Stress value (above

[37] The term taxon refers to individuals that were defined to an unfixed taxonomic level (class/order/family/genus etc.)

0.15) and is therefore not representative of the data we collected. In general, a change can be observed in the composition of the community as depth increases, moving clockwise; the samples from 80m and 90m resemble those from the shallow waters. Figure 4.9.2-3 shows a cluster for these data by degree of resemblance in community composition of each sample. Most of the samples from 10m and 20m are clustered together indicating a similarity in community composition. Another cluster is visible at 30m and 40m, a third cluster of samples at 50-60m, and a fourth cluster at 70m-90m. The latter cluster includes samples from various depths: 70m, 80m, 90m, and 110m. A look at the species diversity indices (Figures 4.9.2- 5 and 6) reveals a relatively low number of taxa in the shallow stations 1-3, and a correspondingly low biological diversity; in the mid-range depths there is an increase in species diversity and abundance that peaks at depths of 50-60m. The diagrams in Figures 4.9.2-6 – 4.9.2-9 show that the percentage of (bristle worms) Polychaeta in the samples increases with depth; the families Nephtyidae, Magelonidae, and Spionidae are common at all depths, Syllidae is present mainly in the mid-range depths (50-60m) and Lumbreneridae, Onuphidae, and Paraonidae are present starting at 40m and at the deeper stations. The percentage of crabs is highest at depths of 30-40m, largely due to the presence of Amphipoda and Tanaidacea (see details below).

The bed samples from the Dor area, at depths of 40m-90m display shell fragments and calcareous skeletons (e.g. sea urchins). This is reflected in the grain size analysis, which shows very low percentages of particles sized 600-1000 micron (see Appendix 12). The presence of shell fragments and calcareous skeletons is significant because unlike the soft silty soil, these fragments form firm elements for stationary organisms' larvae to attach to, such as Cnidaria, bryozoa, and ascidians, which are able to establish themselves and thereby increase the structural complexity of the habitat. The presence of colonial Cnidaria such as hydrozoa and/or bryozoa increases the biodiversity locally in samples that contain them because these organisms create niches in the soft-soil habitat that can support an additional variety of organisms. Where colonial hydrozoa are present we see a concomitant presence of amphipod crabs from the Caprellidae family. These are known to populate branched structures such as algae, hydrozoa and/or bryozoa (Caine, 1998), and are usually not documented in other samples that do not contain the latter. Analysis of the data reveals that Pycnogonida sea-spiders are also exclusively documented in samples carrying colonial hydrozoa or bryozoa. This is probably because sea-spiders feed on the former. Of note are the worm tubes (such as Hemichordata tubes as seen in Sample 6a), constructed of a thick organic matrix (viscous mucous-like) and densely populated by *Magelonidae Spionidae* bristle worms, Isopoda crabs and Sipuncula worms.

Figure 4.9.2-3 shows a cluster analysis of the Dor sampling results, square root transformed according to the Bray-Curtis similarity matrix.

Figure 4.9.2-3 Cluster analysis of the Dor sampling results

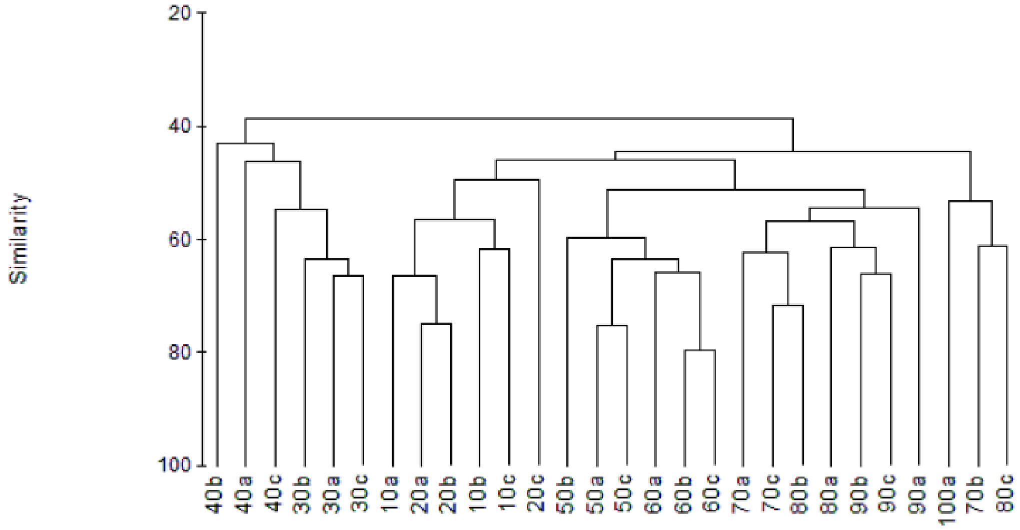


Figure 4.9.2-4: Average taxa diversity at depths of 10-100m at Dor

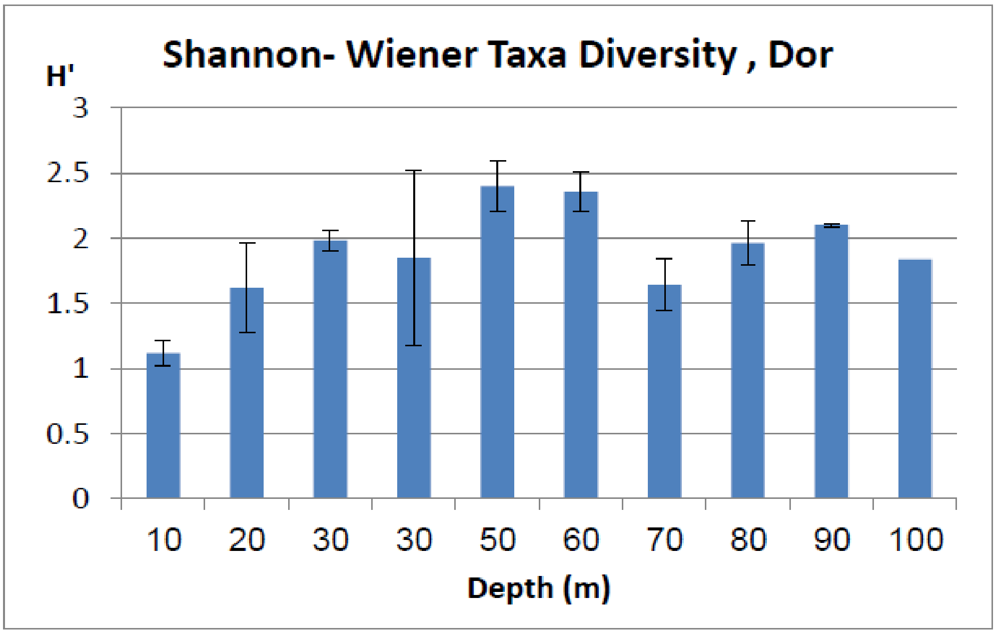
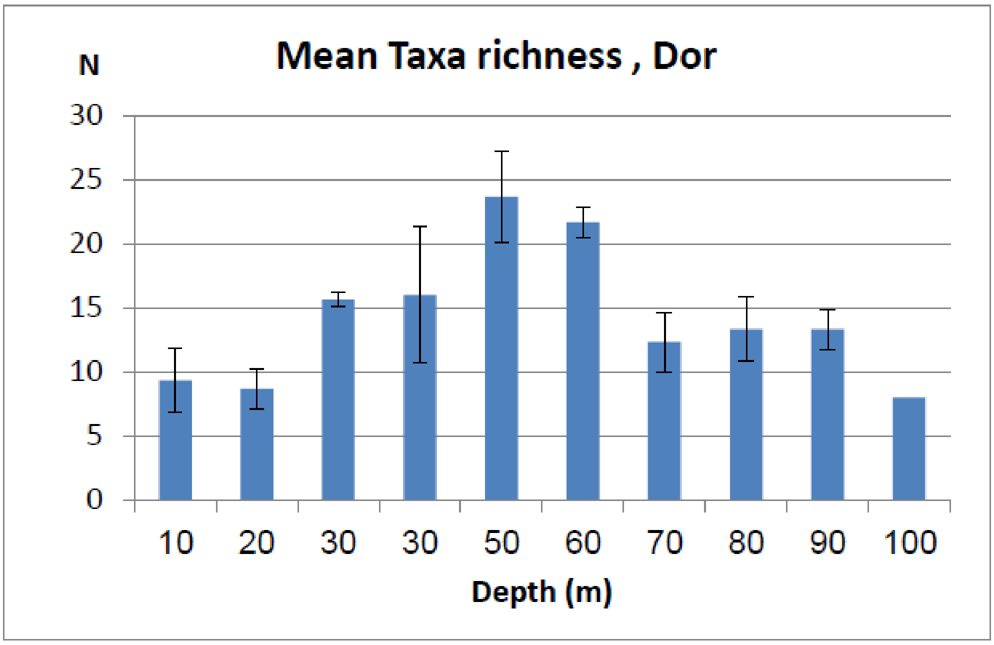


Figure 4.9.2-5 Average richness of taxa at depth of 100m, Dor



Figures 4.9.2-6 – 4.9.2-9 show composition of biodiversity in samples in the bed according to results obtained in the MDS analysis (see Figure 4.9.2-2). Each page shows a pie chart of the division into main groups (most of the groups are phyla). There are also pictures of various organisms observed in the samples and additional data about grain size and percentage of organic material in the sediment.

Figure 4.9.2-6: Dor, depth 10-20m

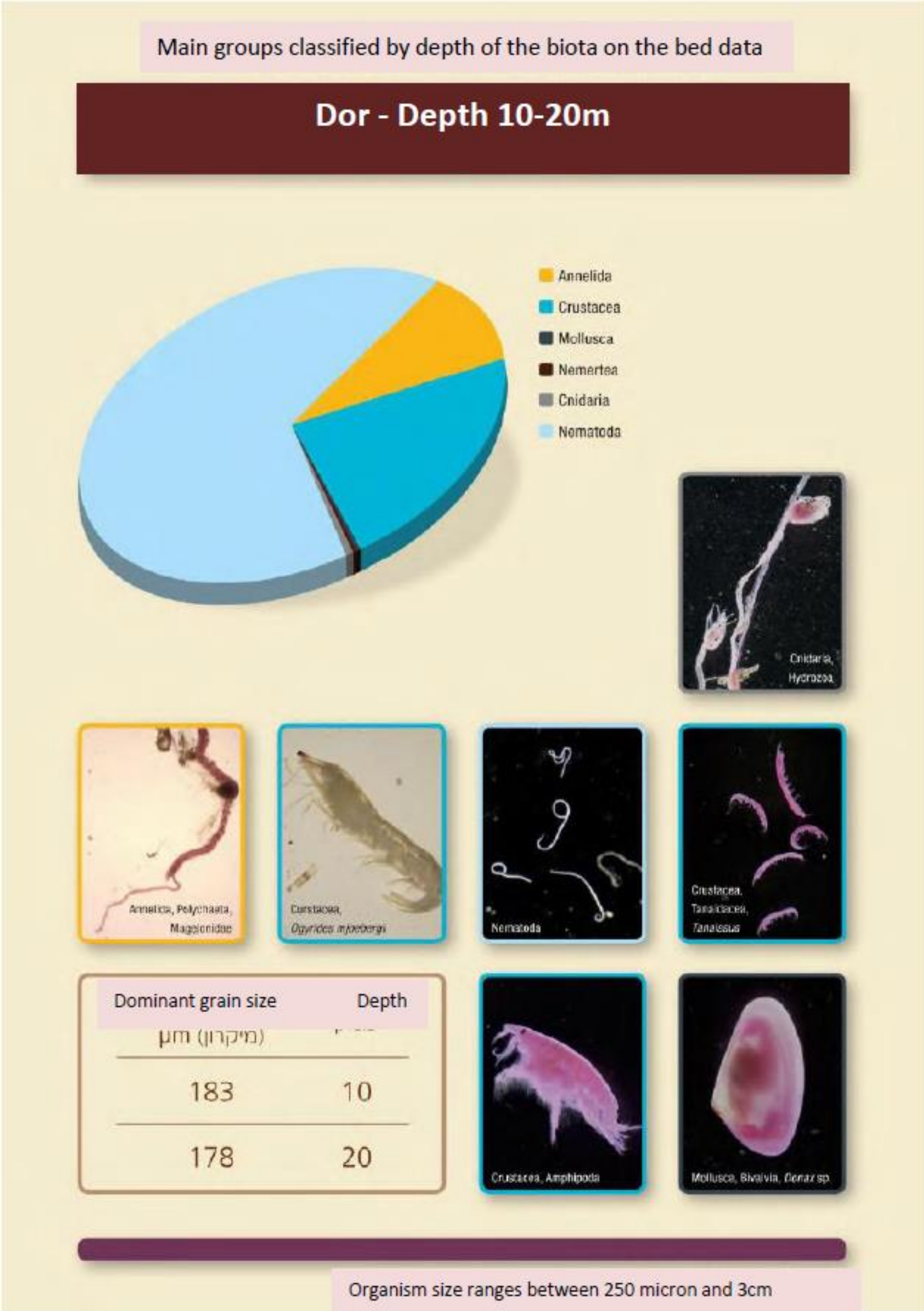


Figure 4.9.2-7: Dor, depth 30-40m

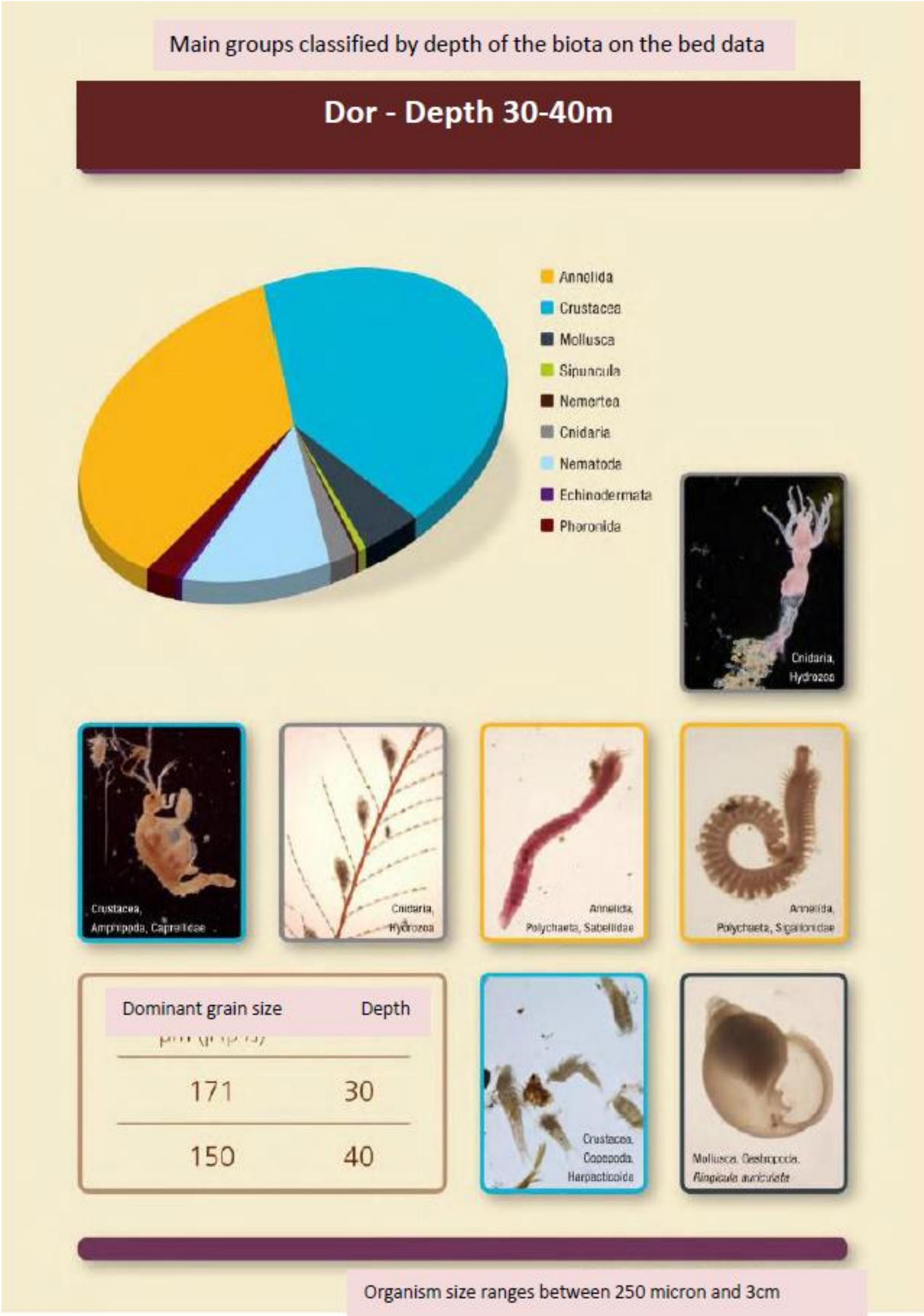


Figure 4.9.2-8: Dor, depth 50-60m

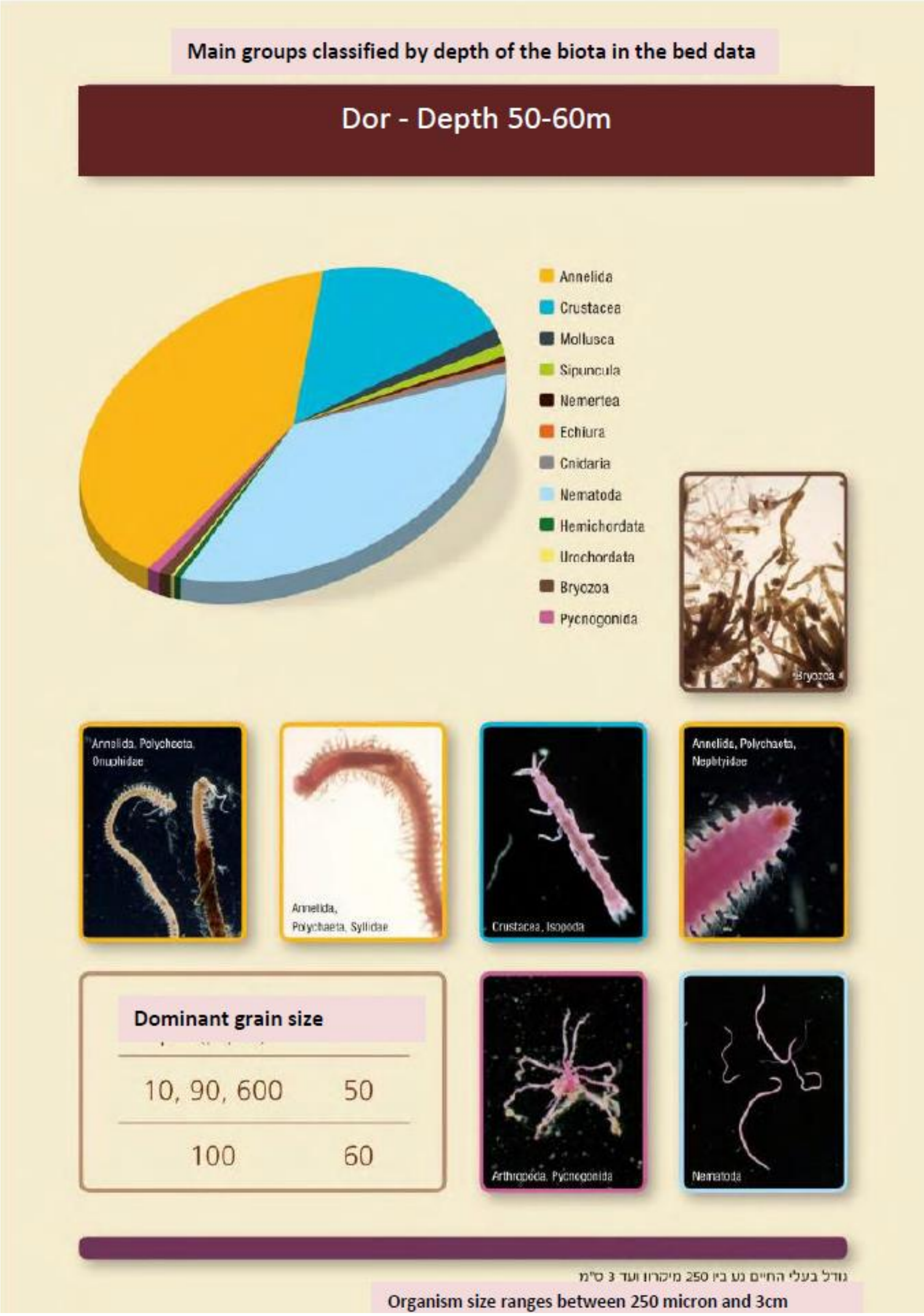
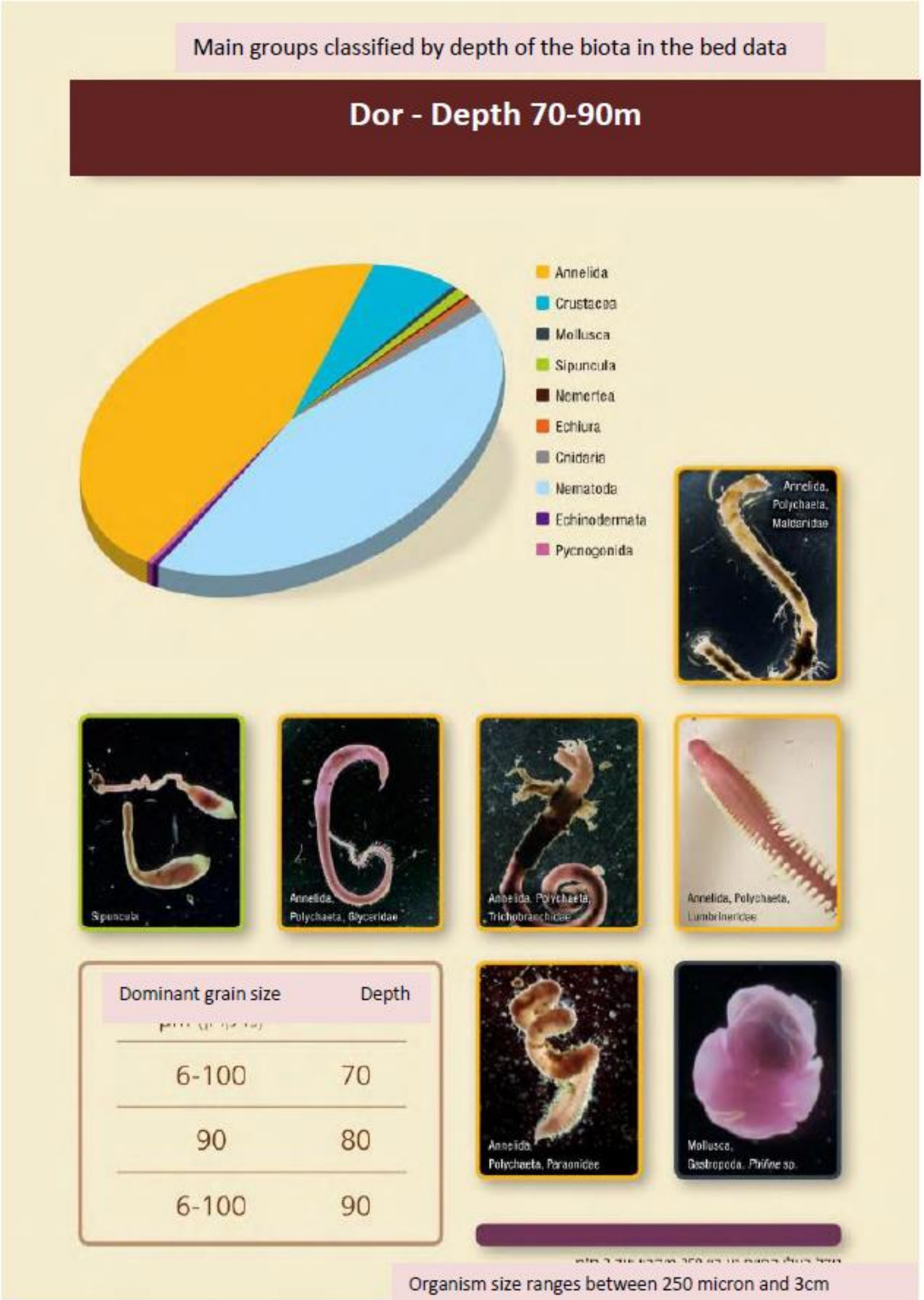


Figure 4.9.2-9: Dor, depth 70-90m



2. Perimeter 2 – Havazelet Hasharon

Biota in the bed at Havazelet Hasharon was sampled on January 16, 2013; 10 points were samples at depths of 10-100m (three repeats at each station). Results of the samples from the platform perimeter and the pipeline corridor were analyzed together and are presented in a single sequence of depths 10-100m.

Summing up the data shows that a total of 57 different taxa[38] were observed; however, because organisms were not identified to the species level, there is a greater diversity of species in actual fact. Data from all the samples indicates that most taxa, 24 of them, are various families of bristle worms, 13 arthropod taxa, 8 molluscs, and some few members of other taxa, such as Cnidaria, Hemichordata, Sipunculida, Echiura, and Nemertea. The full list of taxa appears in Appendix 12. The dominant taxa were: nematodes (N=492), polychaetes of the following families Nephtyidae (N=59), Spionidae (N=247), and Magelonidae (N=56); and harpacticoid copepod crabs (N=205).

Composition of the animal community in the various samples from Havazelet Hasharon area is described in the following ordination diagram, with a multi-dimensional scaling of the results from Havazelet Hasharon square root transformed according to the Bray-Curtis similarity matrix.

[38] The term taxon refers to individuals identified to a unfixed taxonomic level (class/order/family/genus etc.).

Figure 4.9.2-10: Multi-dimensional scaling of the sampling results at Havazelet Hasharon

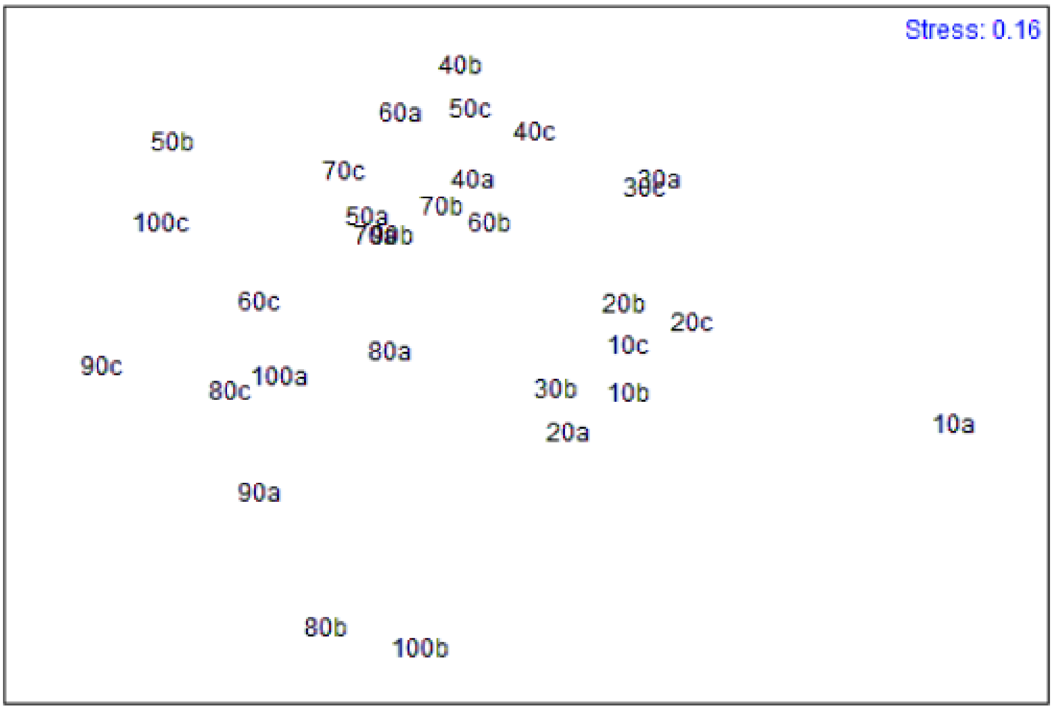


Figure 4.9.2-11 shows a cluster ordination of the sample results collected across from Havazelet Hasharon. Square root transformed according to the Bray-Curtis similarity matrix.

Figure 4.9.2-11: Cluster ordination of the sample results collected across from Havazelet Hasharon

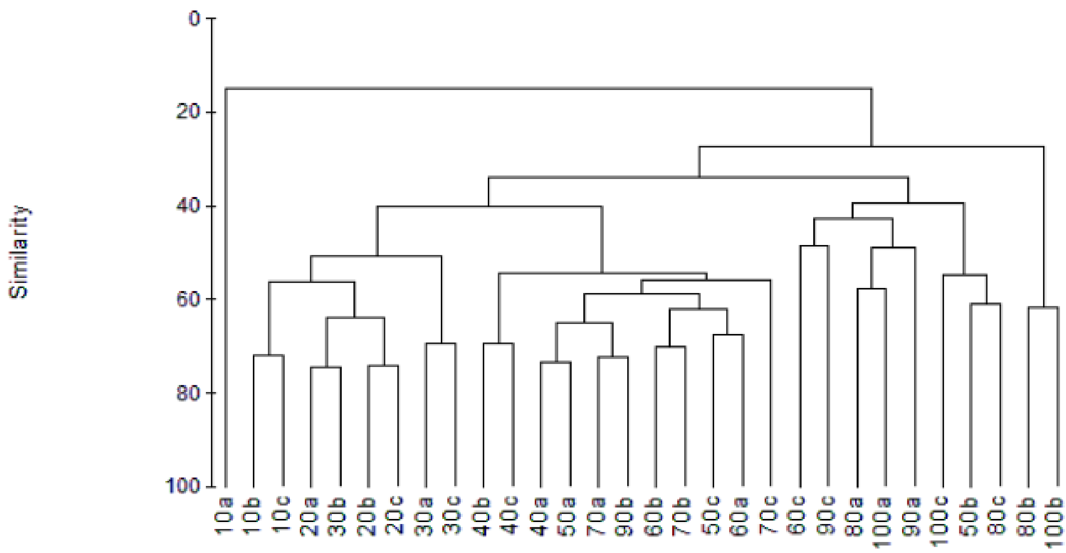


Figure 4.9.2-10 shows an MDS analysis of the distribution of all sampling stations. The MDS analysis makes it possible to identify samples that are similar or dissimilar (in taxon composition) based on their spatial distribution. Close proximity of the points means similar taxon composition. Notice that the samples from Stations 1-3 (depths 10m-30m) form a cluster (except for Sample 1a, which is removed from the cluster, almost no polychaetes were observed in this sample) which indicates similarity in composition of the samples. In the same way, samples from the mid-range depths 40m-70m form a distinct cluster (Figure 4.9.2-11). An examination of the diversity and abundance indices (Figures 4.9.2-12 and 13) reveals the following points. The shallow stations 1-3 have a relatively low taxon number and a respectively lower biological diversity. Species diversity and abundance peaks in the mid-range depths and drops at depths of 80m-100m. The highest taxon number (22) was found at sampling station 6a (60m depth). The samples from stations 8, 9, and 11 are different from each other and have a greater variance between repeat samples; they do not cluster. Station 8 displayed particularly low species diversity and abundance (see Figures 4.9.2-12 and 13). An analysis of all the data revealed that the bristle worms are the commonest group in most sampling stations and this finding corresponds with the information collected in similar studies all over the world of the biota in the bed (Dean, 2008).

The results show a rising trend in species abundance with depth that peaks at 60m and then drops in diversity. It is significant to note that as the depth increases the physical conditions of the floor environment stabilize (wave impact decreases) and the incidence of organisms that affect the floor structure increases. These creatures, called bioturbators, form structures such as burrows, hills, tubes, and other three-dimensional structures that create niche habitats for other creatures (Kaiser et al. 2005). Bioturbators number representatives of various phyla, among them are crabs, Echiuria worms, Echinoderms, and others. Apart from increasing the bed's complexity, their activity is associated with another advantage, increasing oxygen and nutrient exchange in the sandy soil (for instance, inside burrows, Kaiser et al. 2005). The dramatic drop in diversity and abundance at Station 8 (80m depth) is very surprising. One of the possible explanations is that recent activity of a trawler that passed through the lane at this depth depleted the floor population and it has not yet recovered.

It is noteworthy that the 30m sample had a living individual of the Scaphopoda tusk-shell. This is a unique find, as usually only empty shells are recovered (see Figure 4.9.2-14). The tusk-shell belongs to a class of the mollusk phylum. The organism has small arms near its foot that gather food from the sand and transfer it to the mouth. An unidentified organism was also observed, probably a member of the Cnidaria. At 100m depth an unidentified shrimp was observed and sent overseas for classification (classification conducted by Dr. C.H.J.M. Fransen); it was identified as *Upogebia tipica* previously documented on the Israeli coast (Holthuis & Gottlieb, 1958).

Figure 4.9.2-12: Average taxon diversity at sampling stations 1-10 at Havazelet Hasharon

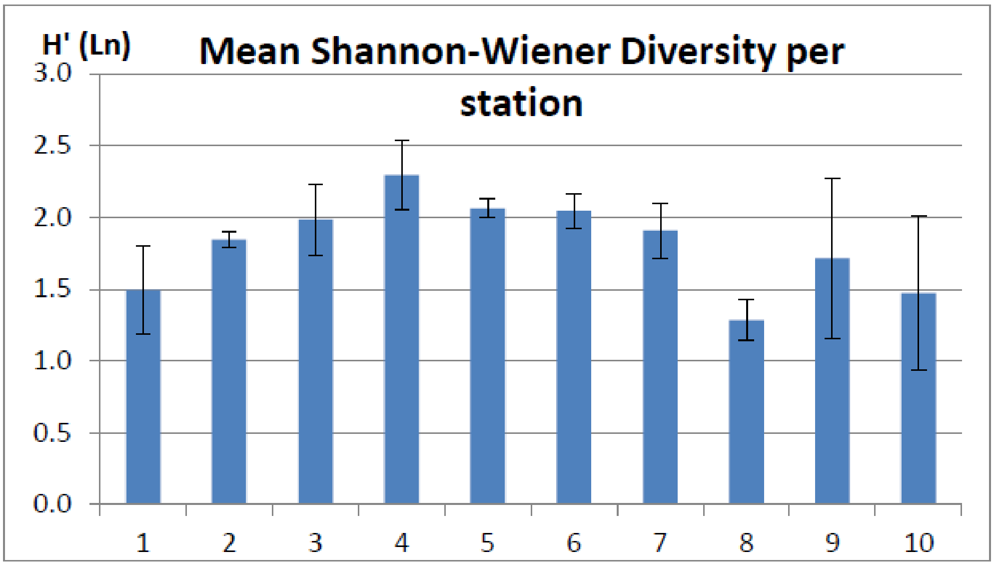
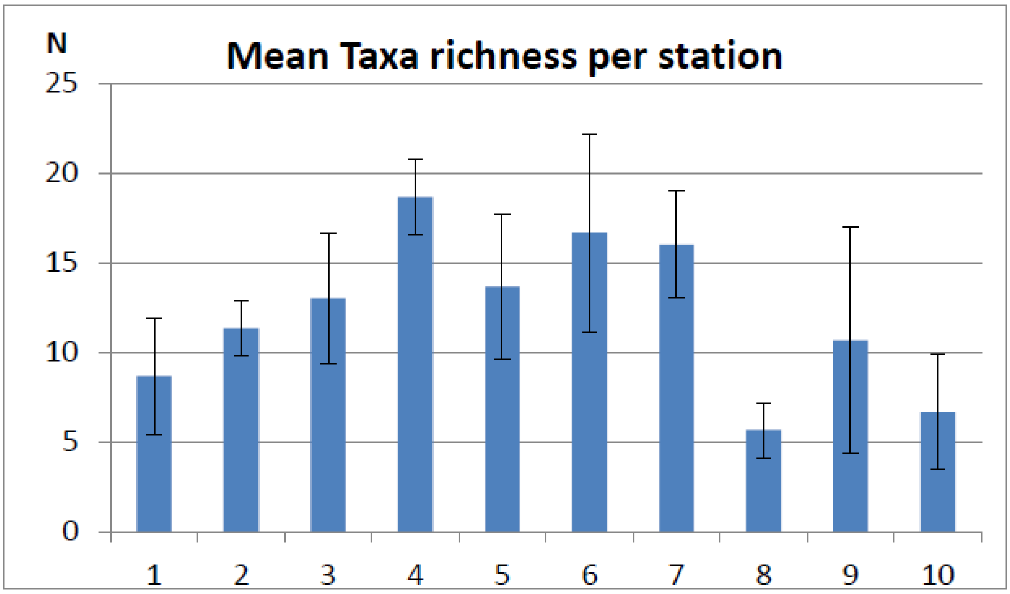
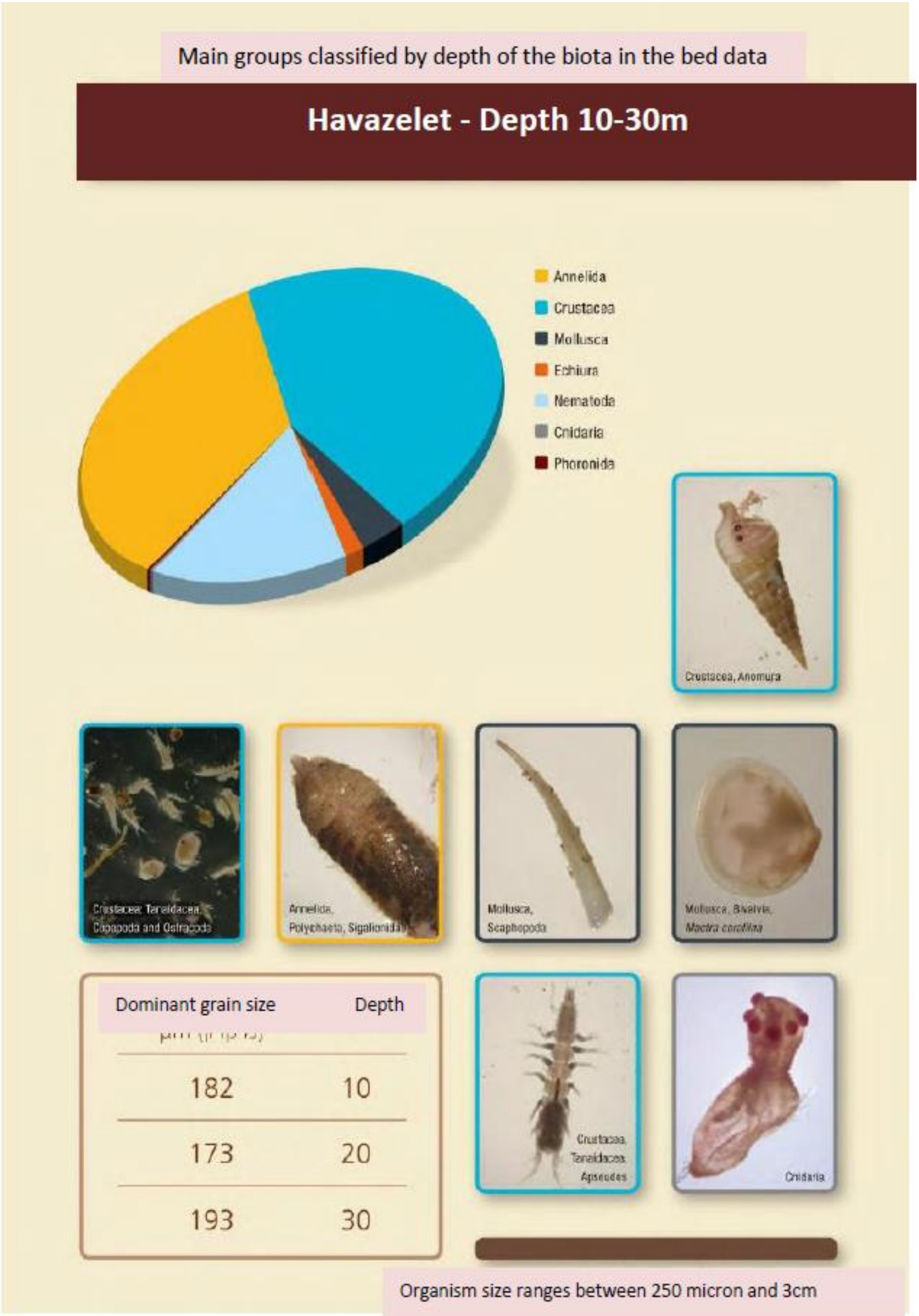


Figure 4.9.2-13: Average taxon abundance at sampling stations 1 to 10 at Havazelet Hasharon



Figures 4.9.2-14 – 4.9.2-16 show compositions of the bed biota samples as obtained from MDS analysis (see Figure 4.9.2-10). Each page shows a pie chart with a division into main groups, (most of these groups are phyla). Images of various organisms observed in the samples are also shown, as well as grain size data and percent of organic matter in the sediment.

Figure 4.9.2-14: Havazelet Hasharon, depth 10-30m



Dominant grain size	Depth
182	10
173	20
193	30

Figure 4.9.2-15: Havazelet Hasharon, depth 40-70m

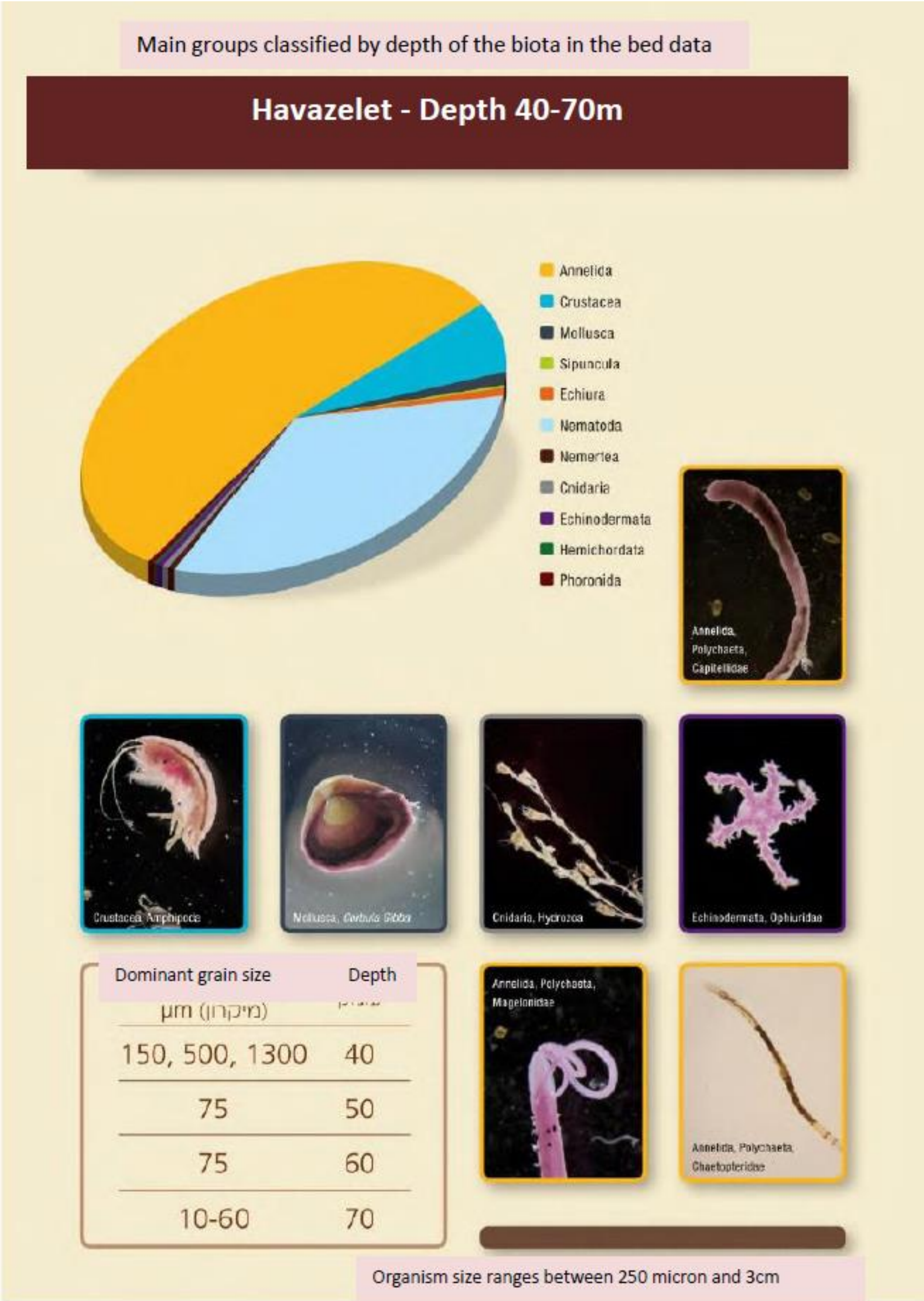
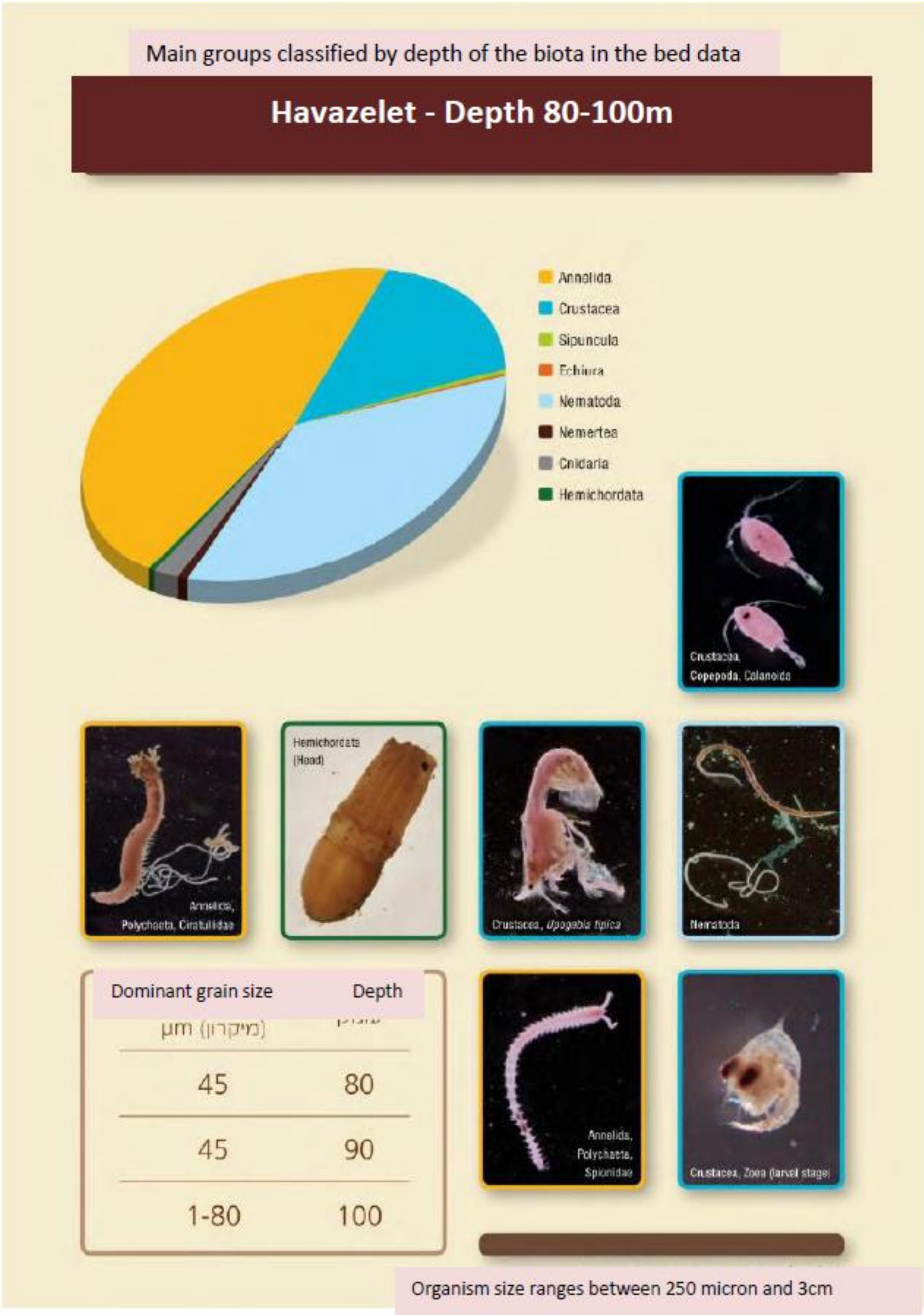


Figure 4.9.2-16: Havazelet Hasharon, depth 80-100m



c. Description of the biota in the bed obtained by trawling

Description of biota on the bed is shown separately for each perimeter. Data from footage filmed by the robot at each station are added as well.

1. Biota on the bed samples and analysis of robot videos – Dor Perimeter

We obtained information about biota in the bed from trawling at depths of 60m and 80m (Tables 4.9.2-3 and 4.9.2-4) and from robot images taken at depths of 60m, 70m, 80m, 90m, and 100m in the marine perimeter where a platform for natural gas treatment is planned. The survey, conducted during daylight hours, shows a floor that is poor in animal life but nevertheless the presence of the Red Sea-feather (*Pennatula rubra*) of the Cnidaria phylum is easily recognizable by their orange color (4.9.2-1). The sea-feather can expel water from its body achieving a significant decrease in size. Robot images show individuals of these species at intervals of several meters from each other. In view of the plough signs left by fishing nets we estimate that the population was much denser in the past. We also observed bristle worms from the Sabellidae family. Some of the images show only the tube they live in obtruding above the floor surface, and some images show a filtering fan (the worms' legs) fanned out and quickly retracted in reaction to the robot's motion. We also observed on the floor Echiura worm burrow openings. We typically found at all depths (60-100m) plough marks made by the fishing nets (see Section f, below) as well as refuse, mostly plastic bags. From a depth of 70m down to 100m we observed the sea-star *Astropecten bispinosus*. In some cases the floor showed star-shaped indentations indicating that a sea-star had been there and had either burrowed down or moved away. At a depth of 90m the sea-anemone *Cerianthus membranaceus* that inhabits sandy/ silty soils, was observed inside the tube it constructs from a mixture of mucus and sand. When in danger the anemone retracts into its tube. At a depth of 100m a further species of sea-feather was observed, *Veretillum cynomorium*, and the soft coral *Alcyonium palmatum*, recognizable by its white/ orange color and the white polyps emerging from the colony (Figure 4.9.2-1). This coral as well as the sea-feathers and sea-stars are known to inhabit silty soils as documented by Fishelson (2000) in his review of Israeli Mediterranean habitats.

Trawling data from 60m and 80m depth (see Tables 4.9.2-3 and 4.9.2-4) complete the picture of the fauna inhabiting the soft floor. These data reveal that in addition to the filmed organisms there is a relatively high presence *of Corbula gibba* with its typically unequal valves. In addition, individual shrimp were documented at depths of 64 and 84m as well as brittle-stars and a small number of slugs molecularly identified as *Paleurabrachaea meckeli* (Tsadok, unpublished data). Sea urchins of the species *Echinocardium cordatum* were observed at a depth of 64m as well as a hydrozoa colony. At both depths the nets caught also Mnemiopsis that were probably in the water column just above the floor. The absence of fish from the net samples is surprising but this may be a result of the small dimensions of the sampling net. The net's small opening must have allowed the fish to escape quickly over the net frame.

Note: up to date images of the habitat are attached in video format on the CD attached to the survey report (as required by Section 4.9.2.i of the survey guidelines).

Photograph 4.9.2-1: On the right a sea-feather *Pennatula rubra*, depth 90m. On the left a soft coral, *Alcyonium palmata*, (in white) and burrow marks of the sea-star *Astropecten bispinosus.*

<u>Table 4.9.2-3: List of biota on the bed and background data for the Dor perimeter</u>

Net trawl route	Perimeter 1 – Dor – depth 80m	Perimeter 1 – Dor – depth 80m
Date	March 14, 2013	March 14, 2013
Time	11:30	12:45
Starting point	32° 34' 18.8226" N 34° 47' 49.6184"E	32° 34' 8.2391" N 34° 49' 38.6257" E
End point	32° 34' 32.0349" N 34° 47' 54.3631" E	32° 34' 19.0709" N 34° 49' 43.8864" E
Distance trawled (m)	412m	360m
Floor depth	84m	64m

Net trawl route	Perimeter 1 – Dor – depth 80m	Perimeter 1 – Dor – depth 80m
Calculated trawled area	206 square meters	180 square meters

Table 4.9.2-4: Findings from biota on the bed sampling conducted at the Dor perimeter

Dor 80m		Dor 60m		Trawling route
84m		64m		Floor depth
206m		180m		Calculated trawl area
Quantity in 100m²	Quantity	Quantity in 100m²	Quantity	Organism
0.97	2	3.3	6	Ctenophora
0.485	1	1.65	3	Polychaeta
		1.65	3	Echinocardium cordatum
3.86	8	4.95	9	Ophiuridae
		0.55	1	Hydrozoa -thecata
0.97	2	1.1	2	Opistobranchia Paleurobranchaea Meckeli
5.82	12	9.9	18	Decapoda, Penaeidae
12.125	25	30.25	55	Corbula gibba

2. Biota on the bed samples, and analysis of robot videos – Havazelet Hasharon Perimeter

Information about biota on the bed was obtained by trawling at depths of 60m and 80m (Tables 4.9.2-5 and 4.9.2-6) and from the robot footage taken at 60m, 70m, 80m, 90m, and 100m in the marine perimeter where the gas treatment platform will be built. At a depth of 60m several star-fish shaped indentations were observed probably belonging to the *Astropecten bispinosus* seen in the footage. We also found a brittle-star and sea-feathers *Pennatula rubra;* their numbers grew at 70m at which depth we also found the soft coral *Alcyonium palmata*. At a depth of 80m, in addition to these organisms, we also observed sea-lilies (*Antedon mediterranea*) and sea-anemones of the genus Cerianthus. At 90m depth a single *Serranus hepatus* was observed; this fish, known to inhabit this depth, inhabits sandy-silty areas and feeds mainly on crabs (http://www.fishbase.org/search.php). Lanice polychaetes were also observed as well as burrow openings of worms of the phylum Echiuria. At a 100m depth a further species of sea-feather was observed, *Veretillum cynomorium*. We draw your attention to the fact that at depths of 60-90m, in the area that the robot scanned, few trawling marks were to be seen, but at a depth of 100m there were many such plough marks.

Net towing data from 60m and 80m depth (see Tables 4 and 5) complete the picture of the fauna inhabiting the soft floor. These data reveal that in addition to the filmed organisms there is a relatively high presence of *Corbula gibba*. In addition, individual shrimp were documented at depths of 60-80m as well as brittle-stars and a small number of slugs molecularly identified as *Paleurabrachaea meckeli* (Tsadok, unpublished data). Sea urchins of the species *Echinocardium cordatum* were observed at a depth of 60m as well as a hydrozoa colony. At both depths the nets caught also Mnemiopsis that were probably in the water column just above the floor. The absence of fish from the net samples is surprising but this may be a result of the small dimensions of the sampling net. The net's small opening must have allowed the fish to escape quickly over the net frame.

Note: Updated images of the habitat are attached as in video format on the DVD attached to the survey (as required by Section 4.9.2.i of the survey guidelines).

Photograph 4.9.2-2 On the right the fish *Serranus hepatus*. On the left, the floor with burrow openings (probably crabs)

Table 4.9.2-5: List of biota on the bed and background data for the Havazelet Hasharon perimeter

Trawling route	Perimeter 2 - Havazelet Hasharon – depth 60m	Perimeter 2 - Havazelet Hasharon - depth 80m
Date	March 14, 2013	March 14, 2013

Time	07:00	09:00
Starting point	32° 20' 29.4142" N 34° 43' 43.8236" E	32° 20' 6.9590" N 34° 42' 11.2175" E
End point	32° 20' 39.5515" N 34° 43' 48.2068" E	32° 20' 17.0898" N 34° 42' 16.1561" E
Distance trawled (m)	348m	352m
Floor depth	59m	80m
Calculated trawl depth	174m^2	176m^2

Table 4.9.2-6: Biota on the bed findings, in the Havazelet Hasharon perimeter

Trawling route	Havazelet Hasharon 60m		Havazelet Hasharon 80m	
Floor depth	59m		80m	
Calculated trawled area	174m^2		176m^2	
Organism	Quantity	Quantity in 100m^2	Quantity	Quantity in 100m^2
Ctenophora	8	4.6	4	2.272
Polychaeta	5	2.87	2	1.136
Echinocardium cordatum	3	0.99		
Ophiuridae	11	6.325	6	3.408
Opistobranchia Paleurobranchaea Meckeli*	2	1.15	1	0.568
Decapoda, Penaeidae	16	9.2	8	4.544
Corbula gibba	48	27.6	12	6.816

d. Description of habitats and special assets

The following description relies on data collected during January-March 2013 as part of the survey. Note that sampling the biota on and in the bed, as well as the images supplied by the robot provide important information regarding the habitat but the information is not complete. To obtain a more comprehensive view samples must be collected during the other seasons and data gathered also at night. Up to date images of the habitats appear on the video recording on the DVD supplied with the report.

The Kurkar ridge that has been discovered in the Mikhmoret pipeline corridor is a hard bed, which is a rarity in the largely sandy Israeli Mediterranean shore. Every natural hard bed becomes an oasis of complexity in a poor sandy environment. The rocky bed habitat supports a broad range of fauna and flora (see details below) that are unique to this habitat, such as types of Cnidaria, sponges, molluscs, ascidians, hydrozoa, worms, and fish, particularly groupers*. This habitat and the species populating it are one of a kind, so harming them can be destructive in itself (mainly because most of the species are sessile) but over and above such damage is the risk posed to the habitat's ability to recover from the loss of reproductive species and the damage to potential for reproduction and re-population. <u>We must emphasize</u> that in the case of the rocky habitat, the special nature of the bed dictates the rare habitat and the rarity of its inhabitants.

Habitat 1 – Sites of Dor and Havazelet Hasharon platforms (60m-100m depth)	
Type of substrate	Sand-silt-clay
Representative image of the floor 100m depth, at Dor A soft coral is visible in the center	
Description of the surface	The floor is generally level and exceptionally soft. The soil is covered with pits, depressions and protrusions. Most of the pits and depressions are 5-10cm in diameter and the

*

Habitat 1 – Sites of Dor and Havazelet Hasharon platforms (60m-100m depth)	
	protrusions are 10-25cm in diameter and 10cm high. This type of topography is associated with organisms called bioturbators that create burrows, hills, tubes, and other three-dimensional structures that in turn become niches for other organisms (Kaiser et al., 2005). As depth increases physical conditions on the floor stabilize (wave impact decreases) and these creatures become more prevalent.
Sediment properties	Dominant grain size is 1-160 micron Organic material in the sediment 0.64-1.14% (based on TAHAL results, 2011)
Biological properties – biota on the bed	Sea feather Pennatula rubra, Veretillum cynomori, soft coral Alcyonium palmatum, sea-anemone Cerianthus membranaceus, sea-star Astropecten bispinosus, Brittle stars, sea-urchins Echinocardium cordatum, the mussel Corbula gibba, slugs Paleurabrachaea meckeli
Biological properties – biota in the bed	At a depth of 60m there was a great abundance and diversity of species. Polychaeta, which are the most dominant species in the samples, largely from the families Nephtyidae, Magelonidae, Onuphidae ,Lumbreneridae, Syllidae, Spionidae and Paraonidae. Shell and calcarous skeleton fragments were observed in the samples which are used by organisms such as Cnidaria, bryozoa, and ascidians to adhere to the bed. These organisms successfully establish themselves, develop, and increase the habitat's structural complexity and its biodiversity. (Presence of sea spiders and Caprellidae crabs was recorded only in samples that also contained Cnidaria and bryozoa). At these depths we recorded worms of the Hemichordata phylum; these construct thick tubes from an organic matrix (a viscuous mucus) that is

Habitat 1 – Sites of Dor and Havazelet Hasharon platforms (60m-100m depth)	
	densely populated by bristle worms, Isopoda crabs, and Sipuncula worms.
Notes	• No fish were observed other than a single *Serranus herpatus* • Trawler markings were observed at all depths in Dor perimeter and mainly at a depth of 100m in Havazelet Hasharon • Biota samples in the bed showed a small amount of mussels and minute amounts of snails

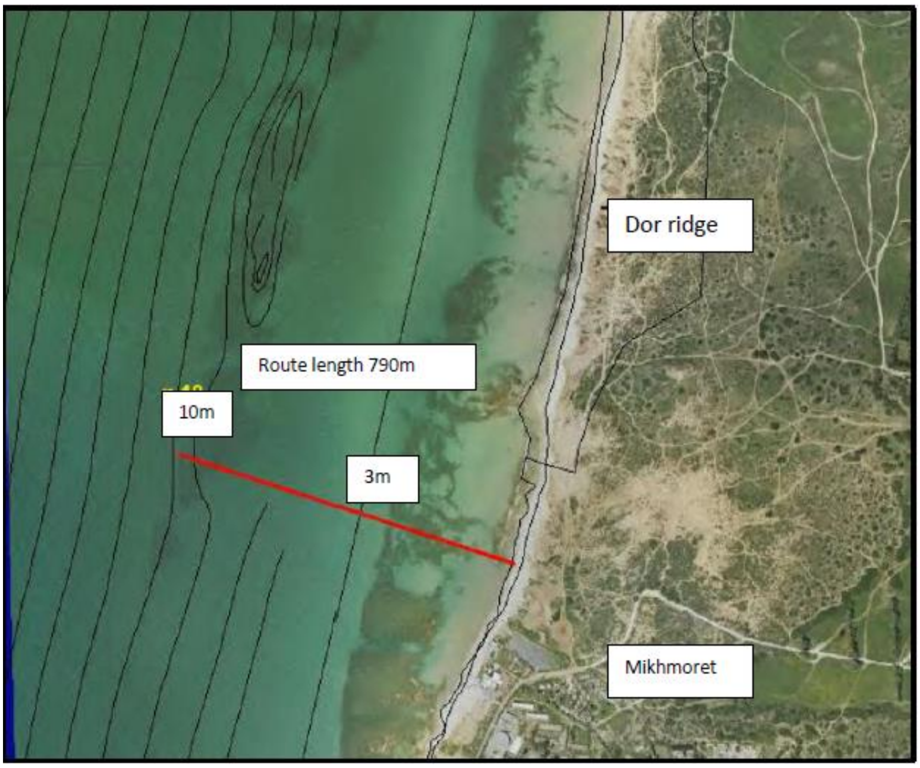
Habitat 1a – Pipeline corridor Dor and Havazelet Hasharon platforms (10m-50m depth)	
Type of substrate	Sand and silt (silt percentage increases with depth)
Representative image of the floor 20m depth, at Dor The snails *Conomurex persicus* are visible	
Representative image of the floor 50m depth, at Dor	
Description of the surface	At a depth of 10-20m the floor is sandy with a morphology of sand waves (see image above). At depths of 30-50m the effects of waves declines and the floor typically shows holes and hills associated with biological activity (see image above). Shell fragments are also visible and occasional colonies of bryozoa and hydra adhering to these fragments.
Sediment properties	Dominant grain size is 40-200 micron
Biological properties – biota on the bed	At depths of 30m in both perimeters many migrant snails *Conomurex persicus* were

Habitat 1a – Pipeline corridor Dor and Havazelet Hasharon platforms (10m-50m depth)	
	observed. At a depth of 20m there were fewer Conomurex snails and hermit crabs were visible. At Havazelet Hasharon at 20m depth a fish (*Xyrichthis novacula)* was observed.
Biological properties – biota in the bed	Based on the statistical analysis performed (see Section 4.9.2 b) the sampling stations at 10-30m depth (Havazelet Hasharon) and 10-20m depth (Dor) were grouped together based on their biota properties. Similarly, the 30-40m depth samplings from Dor and the 40-70m samplings from Havazelet Hasharon were grouped together. **Depths of 10-30m**: in Dor a large number of nematodes were found and a relatively small number of bristle worms (polychaetes). At Havazelet Hasharon crabs (mostly Copepoda and Tanaidacea) make up the majority at depths of 10-30m and bristle worms are the second large group. Solitary and colonial hyrozoa were recorded at depths of 20-30m. **Depths of 30-50m**: at this depth in both perimeters there was an increase in diversity and abundance; these peaked at 60m depth at Havazelet Hasharon. Individuals of the mussel *Corbula gibba* were observed and of the bristle worms the prominent families were Spionidae, Magelonidae, Nephtyidae, and Sigalionidae. The following phyla were represented at these depths: Nemertea, Echinodermata, Echiura, Sipuncula, and Phoronida.
Notes	This is a soft floor habitat; it is contiguous with Habitat No. 1 and lies at depths of 10-50m. Plough signs made by trawlers were observed at depths of 40-50m at Havazelet Hasharon and at 50m at Dor.

Habitat 2 – Rocky bed in the Mikhmoret pipeline corridor (depth 10m)

Robot sea-floor footage and bathymetric data revealed a rocky bed within the Mikhmoret pipeline corridor, approximately 800m from the shore. Another rocky bed was discovered at a depth of 3m in the same corridor.

Below is an aerial photo of the Mikhmoret pipeline corridor. The survey diving route is marked with a red line. The end of the red line is also the western boundary of the rocky area that is located 800m from the shoreline.



Description of the habitat

In the northern part of the Mikhmoret community beach there is an opening in the Dor range, the coastal Kurkar ridge in this area. This opening was formed by and serves to drain the trough between Dor Ridge and Megadim Ridge to the east. The survey documented a narrow corridor, 30m wide from the shoreline and 830 meters into the sea. The survey was conducted by instrument diving; findings were recorded, the infrastructure and its environment as well as what was happening on it, was photographed and filmed.

Description of the infrastructure at the Mikhmoret entrance on the east-west gradient (westward from the shoreline):

From the shoreline to a depth of 3m

On the shore near the water line and up to a depth of approximately three meters are the western vestiges of the Dor Ridge. These rocks are relatively level and appear chiefly as broad plates. They rise approximately 30cm above sea level. On the west of these rock surfaces at a depth of three meters the rock is still flat with some protrusions and formations created by wave energy. On the rock we find the intertidal zonation typical of organisms that are environmentally adapted to this high energy environment. The rocks abound with red calcareous algae of the genera: Corallina, Jania, Lithophyllum, Neogalyonithum; brown algae such as Padina and Cystoseira; and green algae such as Ulva and Enteromorpha. Many sponge genera populate these rocks, chief among them are: Chondrosia, Crambe, Spirastrella, and Ircinia. On the rock face many mud clams are visible, as well as Vermetidae polychaetes building calcareous tubes, Serpullidae worms, rock-boring clams and various types of snails. Also observed were colonies of bryozoa and various Cnidaria (hydrozoa, sea-anemones, and colonies of the migrating coral *Oculina patagonica*). Solitary and encrusting ascidians were also observed. In the crevices there were true crabs such as Pachygrapsus and Atergatis. This rocky area, abounding with sandy pools, and on the border between rock and sandy seabed many fish can be found: Ophiactidae, Sargus, Sparidae, Scorpaeniformes, Blenniidae, Gobiidae, Chromis, Mugilidae, Wrasses and other species of Labridae.

From 3m depth to 8m depth

When advancing westward on the sea bed there is a broad sandy segment approximately 350-400m wide. The sand-band depth varies from approximately 1.5m to 8m depth. This sand-band is highly affected by wave energy and current directions change frequently with the forces in action. The floor is sandy with sand ripples and long ridges that protrude only a few centimeters (1-3cm) above the floor. This area is not structurally complex and most organisms on the bed and in the water in this area are passing visitors. The most widely distributed organism is the alien/migrating snail *Conomurex persicus* and a few transient fish.

From 8m depth to 11m depth

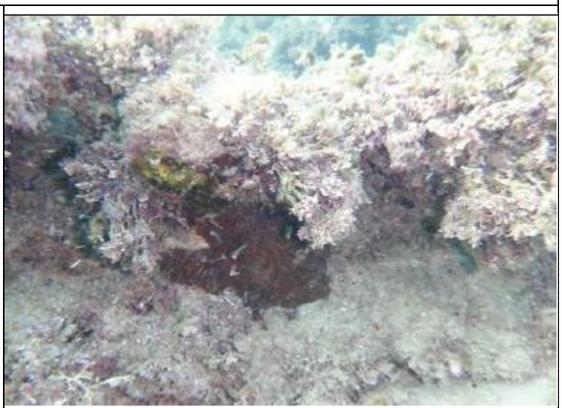
West of the sandy band described above, 600m from the shore in the 8m-11m depth range, there is a rocky band (laid south to north). Its width is 150m-200m, and its western edge is 800m west of the shoreline.

The rocky area has a highly complex structure; rock walls can be seen rising to heights of up to 3m above the bed or the rock surface, many pits, depressions and caves with wide openings up to 1m in diameter, and a wide variety of sessile and mobile organisms. Some of these are part of the biogenic building process as well as of the erosion. The Kurkar rock typically has a thick upper layer of animal source (biogenic construction). Core drills taken from a similar rock (on the same sub-marine ridge) in Sdot Yam and Mikhmoret (Tsadok, unpublished information) revealed that the Kurkar rock lies under 10-15cm of skeletons of organisms such as clams (Spondylus, Pinctada, etc.), polychaetes with calcareous tubes, snail shells, calcareous algae, bryozoa colonies, and sediment grains caught amongst these structures. Biogenic erosion processes take place concomitantly with construction. Main contributors to erosion are rock-boring sponges (Cliona), rock-boring clams (Lithophaga), fish from the Labridae family which bite the rock, and others. Environmental conditions also contribute to mechanical erosion processes.

Activity of fish, crabs, snails, and Echinoderms (sea-cucumbers mostly), was observed in the rocky area. Of the fish, the following genera were observed: Blenniidae, Gobiidae,, sweepers, Sargocentron, Ophiactidae, mullets, wrasses and other Labridae, Sparidae, sargus, many chromis, Scorpaeniformes, goatfish, triggerfish, catfish eel, stingrays and morays, and Sciaena. There was also significant traffic of transient fish, mostly moving through the body of water above the rock, flying fish and sardines. Fish species identified on the dive and on video: *Diplodus sargus, Diplodus cervinus, Sargocentron rubrum, Oblada melanura, Diplodus vulgaris, Chromis chromis, Thalassoma pavo.*

Regarding fish, it is of particular importance to note the observations of young grouper. It is highly probable that the rocky area described here serves as a **breeding gathering site** (fishermen call them weddings), as well as a nursery for young fish also from other families.

In view of the findings it is possible to state that the rocky area at the depth range of 8-11m is a valuable habitat with a highly complex structure and great biological diversity. The bed complexity and the three-dimensional structure provide varied niches that support the existence of many organisms and many hideaways. This makes it an optimal site for a nursery for young fish and invertebrates.

Habitat 2 – Kurkar rock from Mikhmoret	
	
a. General view of the rocky area	
	
b. Clump of sponge on rocky bed	c. Red algae of the Corallina genus and an encrusting sponge on the rocky bed
	
d. Red algae, colonies of Cnidaria, sponges and a fish	e. Spondylus mussel on the rocky bed camouflaged by a population of

	barnacles that settled over them
	
f. Pair of slugs belonging to the migrant species *Chromodoris annulata*	g. Colony of an encrusting bryozoa from the Schizoporella genus

e. Fish populations in the platform perimeters

The number of fish observed during the photo-survey (by the robot) is very small. Also when trawling for biota on the bed no fish were found (see Section c, above). In the rocky habitat on the Mikhmoret pipeline corridor at a depth of 8-11m several members of a number of fish families were recorded, some were young groupers (see Section d, above). Details and images of the fish in the rocky habitat are shown in Section d and in Appendix 12. The significance of having found young groupers is discussed in detail in Sections f and h, below.

Regarding the absence of fish, it is possible that the robot (ROV) was a deterrent but our opinion is that this was not the sole reason for the paucity of observations. As is well known, Israeli coastal regions on the Mediterranean up to the continental shelf are subject to very high fishing pressures to the point of over-fishing (Spanier and Adelist, 2012). Together with invasion of species from the Red Sea and warming of the sea water the fish population has changed as well as the ability of some species to breed (Sheinin et al. 2013). Over-fishing causes long term damage to fish and invertebrate populations and destabilizes the ecological system and its ability to recover from further injuries. An increase in the ratio of effort to catch in trawl-fishing and a significant increase in discarded catch are typical of this situation. On examining trawl fishing data in Israel in 1991 we found that more than half the shallow-water catch was discarded, or 61% of all fish. Of these, most of the discarded fish (61%) were young commercially-fished fish. The percentage of discarded fish declines with increase in depth (Edelist et al. 2011). In 1998-1999 trawlers were stopped for 45 days during the summer as part of the fishing regime, but this procedure was discontinued despite the encouraging results of the interim test (Pisant et al. 2000).

Over-fishing in Israel also expresses itself in the phenomena called 'fishing down the food web': a significant decline in quality preying fish like hake and grouper, and a concomitant rise in numbers of jelly-fish and blooms of the invasive shrimp Marsupenaeus japonicas (Sheinin, 2010).

Current information regarding fish that are found at depth range of 60-100m in which the platforms are planned was obtained from a study performed on trawler catches during 2008-2011 (Edelist, 2013). During the study the catch of 251 trawls were sampled over 40 trips. Data regarding fish inhabiting the depths 60m-100m were taken from this study (boney and cartilaginous fish) and the species are listed in Table 4.9.2-7:

Table 4.9.2-7: Distribution range (average depth +/- SD) of trawled fish on the Israeli coast, with an emphasis on the 50-100m depth range (Edelist, 2013)

Cartilaginous fish	Bottom depth	Top depth	Notes
Dasytatis pastinaca	30	60	
Torpedo torpedo	40	100	
Raja miraletus	30	100	
Carcharhinus obscurus	45	100	Shark, distribution is limited to depths of 50-100m
Bony fish			
Alectis alexandrinus	25	55	
Epinephelus aeneus	10	70	
Spicara maena	20	60	
Lagocephalus sceleratus	25	60	
Cynoglossus sinusarabici	20	60	
Lagocephalus spadiceus	25	55	
Ariosoma balearicum	20	60	
Leiognathus klunzingeri	30	55	
Apogos imberbis	30	55	
Saphyraena saphyraena	30	55	
Sardinella aurita	25	60	
Scomberomorus	25	70	

Commerson			
Gobius niger	30	60	
Sphyraena chrysotaenia	30	60	
Nemipterus randalli	25	75	
Apogis smithi	25	80	
Saurida undosquamis	25	80	
Serranus cabrilla	25	80	
Dussumieria elopsoides	45	60	Sardine, distribution limited to 50-100m depth
Mullus surmuletus	25	80	
Mullus barbatus	30	105	
Scorpaena notate	30	80	
Pagellus acarne	25	95	
Pagellus erythrinus	30	95	
Trigloparus lastoviza	25	90	
Serranus hepatus	30	80	
Synodus saurus	30	90	
Bregmasceros atlanticus	20	105	
Trachurus mediterraneus	30	90	
*Upeneus moluccensis	45	80	Distribution limited to 50-100m depth
Spicara flexuosa	25	105	
Spicara smaris	30	110	
*Etrumeus golani	45	95	Distribution limited to 50-100m depth
Echelus myrus	40	105	
Boops boops	30	120	
Engraulis encrasicolus	25	125	
Trachurus trachurus	25	130	

Microchirus ocellatus	40	125	
Zeus faber	40	130	
Lapidotrigla cavillom	50	125	
Scomber japonicas	50	130	
Sardina pilchardus	75	125	
Citharus linguatula	40	160	
Lesuerigobius suerii	81	135	
Uranoscopus scaber	40	180	
Trichiurus lepturus	50	175	
Conger conger	20	120	
Blennius ocelatus	60	175	
Ophiodon barbatum	75	120	

*migrant species from the Red Sea

f. Existing disruptions of the habitat

1. Trash

The photo survey conducted by the robot on both sites revealed trash on the seabed; mostly plastic bags (Figure 4.9.2-3). Sampling points at which trash was documented:

Dor: 6, 9, 10 (depths 60m, 90m, 100m)

Havazelet Hasharon: 4, 5 (depths 40m, 50m)

Photograph 4.9.2-3: Plastic bag in the seabed at the Dor site, depth 60m

2. Fishing

One of the most significant findings of the visual survey conducted at both offshore sites Havazelet Hasharon and Dor is the presence of drag and plough marks on the soft bed that are caused by trawler vessels (Figure 4.9.2-4). At the Dor site plough marks were found at depths of 50-100m and at Havazelet Hasharon site mostly in the range of 50-100m. Almost all the footage produced for the survey shows evidence of trawl fishing activity in the area designated for gas treatment platforms (see video in the DVD attached to the report).

Photograph 4.9.2-4: Plough marks made by trawler nets at the Havazelet Hasharon site depth 50m.

Trawl fishing works by dragging a net on the sea floor. The trawl net has an elongated funnel shape with two wings. The wings and the top of the funnel are made of sheets of netting with a large mesh size, and the tail end (the part in contact with the floor) is made of thick fibers. At the tail of the funnel there is a small-mesh (4cm) collecting sack (Scheinin et al. 2013). The wing edges are attached by ropes to metal plates called otterboards. The latter are connected to the towing ship with steel cables; when the otterboards are dragged along the floor they leave plow marks. When the trawler moves the otterboards move away from one another up to 45-75m apart creating a collection fan in which the sea-floor is mechanically disturbed. The net opening is approximately 12-15m (Scheinin et al. 2013). As the trawler moves and the otterboards drag along the floor, floor inhabitants are raised up and caught in the net moving toward them.

Trawling is a non-selective fishing method that physically harms the sea-floor and kills a wide variety of animals some with commercial value and some with none. The harm to animals and the sea-floor environment rises in proportion to depth. This is because as depth increases physical conditions are more stable on the floor (wave impact decreases), and the incidence of organisms that affect sea-floor structure increases. These bioturbators form structures such as burrows, hills, tubes, and other three-dimensional structures that become niche habitats to other organisms (Kaiser et al. 2005). Among these organisms are representatives of several phyla; crabs, worms from various phyla, echinoderms, and others. Over and above increasing bed complexity, their activity is associated with another advantage, that of increasing oxygen and nutrient exchange inside the sandy floor (for instance inside the burrows) (Kaiser et al. 2005). As seen, trawling harms also the delicate structure of the sea-floor.

Many existing studies explore the impact of trawling on the floor populations and the main impacts as they are listed in the book published by the American Academy of Sciences (Steele et al. 2002) are:

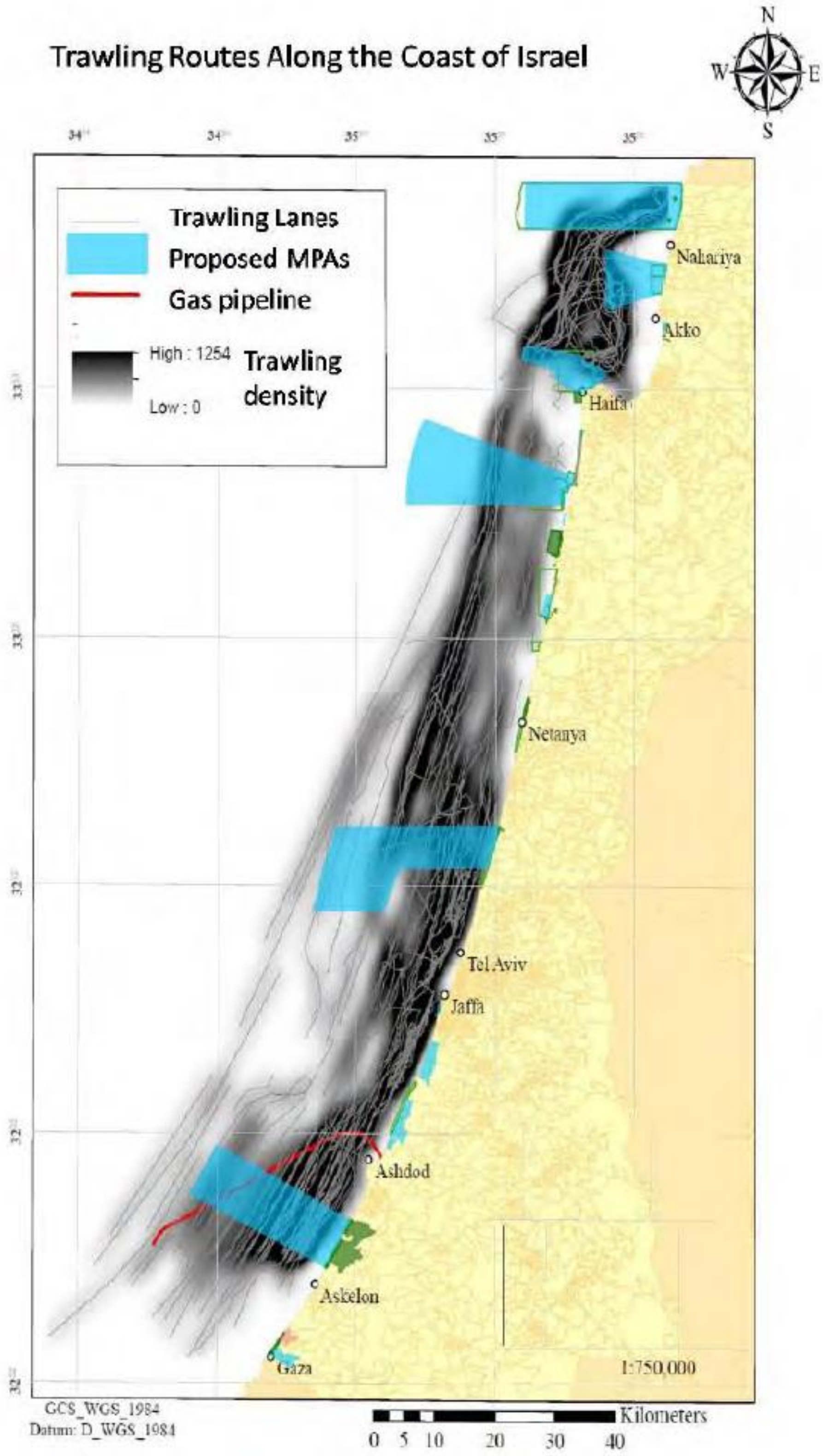
- Harm to floor complexity (harming structure-forming organisms)
- Changing species' diversity in sea floor populations depending on sensitive species and up to the point of a community shift
- Harming productivity of the floor communities as a result of the decline in biomass

Clearly, trawling disrupts the sea floor habitat, and as is known from the literature, frequency of the disruption has a deciding influence on the repercussions of the disruption for the structure of the animal community populating the disrupted area (Connell 1978). One of the well-known theories in ecology was examined by Connell (1978) in the tropical rainforest and on the coral reef, and shows that in an environment that suffers infrequent disruptions the natural succession process will eventually lead to a climax community composed of a small number of species with a high biomass. When there is medium frequency disruption, environmental changes occur (such as clearing the bed for colonizing the coral reef) allowing new species, some of them opportunists, to enter. In these cases diversity increases because the community includes the climax species as well as the opportunists. The increase in strength and frequency of the disruption leads to increased incidence of opportunistic species who are the only ones who can cope with the disrupted conditions and the unstable system. The result is a decline in species diversity and the disappearance of species (Kaiser et al. 2005). This last state of affairs is a description of a chronic disruption; based on data published recently by Edelist (2013) it seems that most of the soft floor areas on the Israeli continental shelf are under chronic disruption as a result of massive trawling activities.

In contrast to other countries in the world, including some Mediterranean countries, Israel does not regulate catches or limit fishing seasons. The result has been ongoing damage to the commercial fish populations as well as harm to other sea-floor populations. Note that Israel is the only country on the Mediterranean coast that is not a member of the General Fisheries Commission of the Mediterranean (GFCM). This organization has demanded that Israel reduce the fishing pressure and run a correct and sustainable fishing regime by applying the principle of caution (Edelist et al. 2013). The OECD, which Israel joined in 2011, has recommended that Israel reduce its fishing fleet and improve fishery regulations.

In view of the survey findings and the extent of trawling in Israeli territorial waters (see Figure 4.9.2-17) it is possible to estimate that the areas in which the gas treatment platforms will be erected, and which will have safe zones that exclude marine vessels and trawling, may become de facto Marine Protected Areas (MPA). These could become recruiting sites also for the unprotected environment surrounding the facilities (Boehlert and Gill, 2010). It is possible that combining a no-fishing zone and a three-dimensional structure (the platform) in the water body to serve as a fish aggregating device (FAD) will create a compound in which the fishery gets a chance to recover (see details in Section h below). In this context the work of Sonin and Spanier (2009) is noteworthy; their study was conducted in a closed military zone at the Atlit naval special forces base. The study compared the catch in the military zone which is closed to all vessels and fishing (serving as an MPA) to the nearby area of similar depth north of the military base. Study findings indicated that the number and diversity of species and the size of individuals were always higher in the protected area. Moreover, species were found in the closed area that were absent from the nearby open fishing area (Sonin and Spanier, 2009).

Figure 4.9.2-17: Trawling routes along the Mediterranean coast of Israel (Edelist, 2013)



. 7. Geographic representation of trawling lanes and effort distribution in Israel. Grey hairlines show the lanes, derived mainly from the GPS readings of the author during surveys and complimented by southern tracks attained from other trawl GPS readings (Courtesy Oren Sonin and Levi Ornoi). Trawling effort (black/grey/white shades) is extrapolated from trawling lane density. Current closed areas appear in green and proposed MPAs extending to the12NM territorial water boundary are superimposed in blue.

g. Existing infrastructure lines

At this point of the plan there are no finalized routes for the pipelines. As far as we know, the only infrastructure line that lies within the suggested pipeline perimeter is the gas pipeline which transmits gas from Ashdod to Dor and runs parallel to the shoreline at depths of 37-45m (depth depends on the location). No disruptions are known to have been caused by its presence.

h. Implications of laying the pipelines and putting up a platform over the habitat (during set up and during operations)

1. Laying pipes from the wells area up to the platform

The gas pipes that will transmit gas from the wells to the platform will pass through deep sea; the pipeline will be laid by a specialized vessel that is very accurately stabilized along the pipe lane using a dynamic positioning system (DP) and high-power engines. Assuming that the pipeline lane passes through soft media and the pipes are laid uncovered on the floor (at these depths covering the pipes is not a requirement) the main impact will be that of adding a rigid element to the floor environment. The presence of a new rigid artificial structure in a soft-bed area may attract larval stages of various invertebrates, including invasive species (Boehlert and Gill. 2010). Inhabitants of the new rigid bed (epifauna) may locally enrich the area with organic material in their immediate vicinity (within a few meters of the structure perimeter) as a result of feeding and expelling feces that will sink to the bottom. This local eutrophication can bring in its wake a change in species composition in the soft bed around the structure (Coates et al. 2011).

2. Laying a pipeline from the platform to the shore

This pipeline includes four pipes for each supplier. The total length of the pipeline lane is approximately 10km (see Appendix 3, below).

The pipeline will be laid from the platform to the shore by a specialized vessel, an anchored lay-barge, which is capable of maintaining its location with the assistance of several anchors deployed around it by accompanying vessels called anchor-handling vessels. The ship progresses slowly as it lays the pipe from its rear. The pipe segments are welded and sealed on the deck and then lowered to the sea floor. After a few hundred meters have been laid, the anchors are moved and the ship is stabilized in its new location. Unlike the DP stabilizing method which relies on powerful engines, this method requires interaction between the vessel and the sea floor via the anchors (each anchor weighs 50 ton). This activity involves localized physical/ mechanical damage to the sea floor along the pipeline lane and at specific points a few hundred meters on both sides (where the anchors are dropped). There is also the possibility of further physical damage from dragging the anchor chains. Then, at a depth of 60m (and up to the shoreline) the pipe must be buried at a depth of 3m. There are two methods of doing this – ploughing and jetting, as specified in Appendix 3. Both methods create a trench in the sea floor, with the dug-up sediment piled on both sides of the trench. The pipe will be laid in the trench and covered with the dug-up sediment.

Assuming the lane passes through a soft medium, digging, dropping anchors, and dragging the anchor chains can cause mechanical damage to the floor; in practice this means removing part of the sandy habitat bed. Results of such damage include:

1. Uncovering cryptic species (such as worms, crabs, clams, sea urchins) and exposing them to predation
2. Injuring the delicate texture of the habitat bed, the burrows and tubes made by worms, crabs, and various Cnidaria.
3. Local change in the habitat bed for organisms that live on the bed.

The disruptions listed above are limited in scope and will only occur in the pipeline lane and on its sides (as described above). Assuming this is a one-time disruption, within a few months from covering the pipeline, the fauna in the bed can be expected to recover and the excavated area will be repopulated (OSPAR, 2009). It is of significant note that there is a high probability of finding opportunist species such as polychaetes and nematoda in the initial stages of repopulation.

3. Rock dumping and using concrete mattresses

In some places along the pipeline, for instance where crossing other pipelines, or where excavation depth is limited or the bed is hard (see below), rock dumping or concrete mattresses will be required. These sites will be located by performing a survey after laying the pipeline.

These activities, if implemented in areas where the bed is commonly sand/ silt, will create a change in the nature of the bed and add rigid bed where there was none before. This will create a potential colonizing site for reproductive material that is carried on the currents. Availability of reproductive materials depends on a variety of factors: season, depth, current regime, vicinity to natural rigid medium, etc. there are other factors that influence the colonizing process itself (nature of the medium, chemical stimulation, etc.) In view of all this, it is difficult to predict the exact composition of the population that will develop on the artificial bed; only future monitoring can provide an answer to that question. The inhabitants of the new rigid bed (epifauna) may locally enrich the area with organic material in their immediate vicinity (within a few meters of the structure perimeter) as a result of feeding and discharging feces that will sink to the bottom. Local eutrophicaton can bring in its wake a change in species composition in the soft bed around the structure (Coates et al., 2011).

4. Laying the pipeline in the Kurkar ridge area – possible scenarios

The exact pipeline route is unknown at the time of writing this report. We emphasize that in our opinion passing the pipeline through exposed rock beds should be avoided as far as possible. In view of the existing information (Chapter 1 of the marine report) we know that most of the sea floor in Israeli territorial waters is soft and only small areas have a rigid bed in the form of exposed Kurkar rocks (see Chapter 1). There should therefore not be a problem finding a suitable route for the pipeline so as to avoid harming hard-bed habitats.

If it is found necessary to pass pipes through the Kurkar ridges there are two possible scenarios for performing the work (see details in Appendix 3):

- Scenario 1 - Laying the pipeline on a series of ridges (there are areas with varying height on which the pipes rest). In places where the pipe stability is at risk bags of gravel must be used to stabilize it and then rock dumping applied for final stability.
- Scenario 2 - Laying the pipe on a series of ridges by excavating the rocky bed and stabilizing first using sand bags and then by rock dumping.

4.1 Repercussions of Scenario 1

Laying the pipeline on the Kurkar ridges and using gravel bags and rock dumping will cause significant mechanical damage to the rocky habitat and its inhabitants. The area under the pipe and around it (rock dumping area) will be destroyed and the sessile animals will not survive. Assuming this activity leaves some of the habitat standing, the pipe and its stabilizing accessories will become a potential bed to be re-colonized. This bed will gradually become colonized by reproductive material of organisms from the neighboring bed as well as by fish and motile invertebrates.

4.2 Repercussions of Scenario 2

The physical damage to the rocky bed, of the kind that excavation will cause, will first and foremost eradicate part of the habitat and its inhabitants (sessile organisms that have been disconnected from the bed cannot reattach themselves). Further, apart from the population on the rock there is also an entire population inside the rock (mainly in Kurkar, which is porous). If the rocky bed is damaged in part but there is still some intact rocky bed nearby, the sessile organisms may still recover through supplies of larval stages from the neighboring beds. If no such beds are available, there will be a problem repopulating the remaining bed.

A further problem that may arise as a result of excavating the rocky bed is that the stability of the remaining bed may be compromised. It is possible that excavating in the middle of a Kurkar ridge will weaken it to the extent that it will eventually crumble (crumbling can be caused by a combination of physical erosion such as that caused by current activity and biological erosion as in the case of rock-boring organisms weakening the rock). Note that if the ridge in question is deeper than 100m, the chance of physical erosion decreases with depth.

5. Laying pipes using the Horizontal Directional Drilling Method

In recent years the HDD method is gaining popularity mainly because many infrastructure lines must pass through physical obstacles or populated areas. This method, which does not require digging an open trench to bury the pipe, is a clean and effective solution for crossing a variety of areas on land and in the sea: streets, train tracks, water sources, sensitive ecological regions (Schaiter and Girmscheid, 2008). The HDD process has four main steps: (1) preliminary planning on the site (2) drilling a pilot hole (3) expanding the pilot hole (4) pulling the pipe through the borehole.

HDD is commonly used also in marine projects where sensitive habitats must be traversed such as coral reefs, birds' coastal nesting sites , marshes, seagrass meadows (URS, 2002), and mangroves (Australia Pacific LNG Project EIS, 2010). Note that in most cases this method is indeed preferable in sensitive areas, but it does have its drawbacks and each project must be examined individually.

The most common environmental problems associated with HDD in marine environments usually result from failures during performance. This includes:

i. Incomplete seal of the borehole so that there is uncontrolled release of drilling mud into the body of water. The drilling mud used is based on natural fine-grain clays (like bentonite) and if released causes the water at the site to become turbid (CAPP, 2004). In any case of such failure all drilling activities must be stopped immediately until the problem is corrected. As far as using drilling mud and the chance of its leaching into the marine environment, the developer must ensure that there is a plan for removing and recycling the mud (see details in Appendix 3). It is important to note that bentonite is considered a substance that poses little to no risk to marine environments by the OSPAR Commission[*].

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ii. A malfunction in the drilling-mud circulation system causing circulation loss to the environment. This can increase water turbidity as described in Point 1, above (CAPP, 2004).

iii. Collapse of the borehole (as a result of problematic soil composition). This can result in an unplanned expansion of the drilling area, uncontrolled release of drilling mud into the water and delay in project completion to the extent that the project may have to be moved to a different area or an alternative technique applied.

iv. Mechanical failure of the drilling equipment and the loss of a part/parts inside the borehole. This may require digging and expanding the borehole to retrieve the lost part (CAPP, 2004).

This method also produces underwater noise that may interfere with marine mammals (Australia Pacific LNG Project EIS, 2010). However, it is likely that the range of the disruption will be short in time and small in space (depending on the number of workdays) and the marine mammals will voluntarily stay away from the source of noise. (see details in Section 4.6, above).

National Outline Plan 37h suggests using HDD at both entry sites of the pipeline into the shore areas: at Dor and at Mikhmoret. Before work begins, detailed soil surveys must be conducted to ensure that the method can be applied to each of the sites. Specifications of the required operations and safety measures are listed in Appendix 3 to this report. We emphasize that the opinion given here relies on the assumption that the developer in the field will comply with the environmental and safety requirements as expected.

Based on the work plan we know that the pipeline's point of exit into the sea will be 900m from the shoreline and work is generally expected to continue for approximately 35 days.

Dor corridor:

The alternative site is located in an existing marine corridor based on the approved National Outline Plan, and in its vicinity there already is a landing site of a gas pipeline transmitting gas to the Hagit site. The corridor is located approximately 500m south of the Dor islands and the HDD exit point (on the shore), 500m north of the Dalia estuary. Note that the shore section in question does not have abrasion platforms banding the coastal strip, but north of there are the coastal and marine nature reserves of Dor-Habonim along a 4.5km stretch of beach from Tel Dor in the south up to the Habonim community in the north. The most highly embayed coastline in Israel lies within this reserve and it has a stretch of a well-developed abrasion platform with a rich biota. The corridor's proximity to a biologically valuable area, its position to the south of this area, and the fact that the dominant coastal current in Israel flows from south to north requires special attention in case of possible failure in the performance stages of the HDD process.

Mikhmoret corridor:

The biological survey findings indicate that there is a rocky area 800m from the shore in the pipeline corridor (see Section d above, Habitat 2). The western boundary of the rocky area is 100m from the place designated for the pipe's exit to sea. To minimize the chance of harming the rocky habitat, the option of moving the exit point of the pipe as far from the rocky area as technology will allow must be examined.

Breeding gatherings of fish from the grouper family in rocky areas north of the corridor have been reported (see Section d above and Appendix 12). To minimize the chance of disrupting breeding of these fish, considered at risk by the IUCN (Cornish and Hermelin-Vivien, 2004), we recommended timing the HDD work so that it does not coincide with the fish breeding season (April-June, as far as is known).

Breeding zones of two grouper species from the Epinephelinae sub-family

The information presented below is significant in the context of works to push an underwater pipeline using the HDD method in the Mikhmoret pipeline corridor. During the survey several young members of the grouper family were observed in the surveyed rocky area. It is also established that in the nearby rocky area north of the Mikhmoret corridor a population of these fish can be found and breeding gatherings have been documented. The presence of noisy vessels, and suspended sediments or drilling mud in the vicinity of breeding gatherings may disrupt them.

Aharonov, in an MA thesis (2002), studied three species of groupers from the Israeli coast at various sites along the Israeli Mediterranean coast. One of the sites observed was opposite the Givat Olga fishing pier, 700-900m from the shore at a depth of 8-15m. Breeding gatherings of the comb grouper *Mycteroperca rubra* were observed between mid-April and mid-May. In this area 500 individuals were seen at most. The researcher estimates that comb groupers gather from mid-January until early June at regular sites with a typically unique and complex topography like caves and niches interspersed with level surfaces (sandy or rocky).

Breeding gathering of another grouper species *Epinephelus marginatus* was observed at the same site from end of April until early June. The highest number of individuals was lower than for the comb grouper; approximately 30 individuals (Aharonov, 2002).

The site where breeding gatherings were observed is located between the Hadera and Mikhmoret alternatives, at a distance from the shore where a pipe is expected to exit when the HDD is completed (from the shore toward the sea). At present it is still unknown whether similar breeding gatherings take place in other adjacent sites, but the possibility cannot be ruled out. When the exact location of the pipeline entry/exit point is known, observations of the relevant sites must be made to prevent the possibility of harming breeding gatherings of two grouper species. Alternatively, a schedule must be selected that will not interfere with the gatherings. Fishing that interferes with breeding gatherings is a known cause of injuring populations and their ability to recruit new individuals (see Aharonov, 2002).

The dusky grouper *Epinephelus marginatus* is an endangered species on the Red List of endangered species issued by IUCN (Cornish and Hermelin-Vivien, 2004). This species of grouper is highly prized by fishermen, and because it breeds in breeding gatherings it is extremely vulnerable. It matures very slowly, females at five years and males at 12 years (!). Gender ratio leans slightly toward the female; there is one male for every seven females. Because the male is larger than the female it is a more attractive target for fishing; harming males can endanger future breeding potential. There are reports from around the world of a drastic decline of 88% in catches of this species. This number reflects the data from seven different countries during 1990-2001. Note that in Israel there is no limit on fishing this species other than the prohibition on using fishing guns when scuba diving.

6. Impacts of constructing the platforms

The plan for treating the highest amount of gas on an offshore installation requires establishing a complex of four platforms (see details in Appendix 3) as follows:

1. Gas treatment platform
2. Residential and services platform
3. Riser platform – the pipes transmitting the gas from the wells connect to this platform
4. Compression platform – to be built at a later stage of the program

All offshore structures will be built at shipyards overseas and then pulled to the site by barges. Water-depth at the designated platform site is 80m.

Table 4.9.2-8 below summarizes the construction stages and implementation method:

Table 4.9.2-8: Platform construction stages

Time to complete	Method	Activity	
14 days	The base will be placed on the floor by a crane and fixed in place by piles that will be driven into the seabed by a specialized vessel (approximately 100m deep)	Position and fix the platform base (jacket)	1
42 days (to connect the top 3 parts)	Welding	Connect the functional (top) part of the platform	2
	Welding/ J tube (see Bipol document)	Connect the horizontal pipes (on the floor) to the platform – connect vertical pipes (risers) using connectors	3
	Welding/ J tube (see Bipol document)	Connect the riser platform to 3 pipes coming in from the wells	4
	Lay pipes from the platform to the buoy, connect with flexible pipes to the discharge buoy through a PLEM and anchor the buoy with 6 anchors	Build the discharge buoy for the condensate	5

The activities described in rows 1 and 5 of the table above include activity in the water column and around the floor that will temporarily alter normal conditions. These changes include:

5. Significant physical disruption of the seabed in the construction area – turning and mixing the sediment, breaking up biogenic structures in the floor, exposing organisms that live in the bed to probable predation or death.
6. Sediment suspension – laying the platform bases and the pipes, and driving piles will suspend fine-grain sediments (silt) that will make the water turbid around the bed and in the water column in the work area. The extent of the suspension depends on several factors such as water depth, water current conditions, and sea condition (GDF Suez, 2012). Increasing the

amount of suspended material around the bed can mainly harm filtering organisms found on the edges of the work area, and that were not directly injured by the floor being dug up. The expected impact includes compromised ability to filter and feed, and physical injury of the filtering apparatus (they get blocked by the suspended material) (Kerr, 1995). The suspended material may also be harmful to larval forms and plankton. At the same time, the extent of the damage will be small because the works are limited in time. Suspended sediments in the water column might decrease the amount of light that penetrates the water with the result that the primary production will be compromised. However, because work will be relatively limited in duration and area, we assume that the injury will be localized and temporary.

7. Acoustic disruption – during construction while the piles are being driven (see in detail Section 4.6.2, above).

7. Impacts during operations

Gas treatment platforms as fish aggregating devices (FAD), and artificial reefs

Offshore installations change the open-sea environment by creating a hard surface where there was none before. Adding this bed allows organisms to settle, thereby forming an artificial reef. The structure itself may attract pelagic organisms like fish, and become an FAD (Boehlert and Gill,2010). FADs facilitate settling by meroplankton (larval stages of various creatures that are not plankton in their mature stage), provide young fish with shelter (Kingsford, 1993), and induce gatherings of fish and fingerlings that attract larger carnivores (Boehlert and Gill, 2010). Fish assemblage effect is noticeable within a few days of installing the FAD in the open sea (Armstrong and Oliver, 1996).

Platforms and platforms act as FADs and fish density on them can reach values 20-50 times greater than in the surrounding open water. All around the world these are arousing the interest of fishermen, who wish to tap into the local abundance of fish despite regulations that prohibit fishing in the platform area (Jablonski, 2008). The hard artificial surface facilitates colonizing by many sessile invertebrates (such as clams, barnacles, and sea-anemones), covering the piles, pipes, and platform bottom and turning the new surface into another habitat. Note that using an antifouling paint can decrease the extent of settling on the structure, but will not affect the attraction of fish.

There is a notable FAD study on the Israeli Mediterranean shore conducted off Shikmona, Haifa. This was a year-long study of a fish assemblage around an artificial reef 20m deep whose upper part served as an FAD in the water body 10m above the artificial reef. Four sections of the artificial reef were examined and compared to the natural environment at the site, which comprised a soft bottom and a natural reef (rock bed). The study recorded 30 fish species (from 18 families). On the artificial reef there were 27 species of fish compared to 11 on the sandy floor, and 18 on the natural reef. More than a quarter of the observations on the artificial reef were of Lessepsian migrants (6 species). Economically significant species, the groupers *Epinephelus costae* and *Epinephelus marginatus* were regularly observed on the artificial reef. Species diversity on the artificial reef was high and the biomass was 20 times larger than in the natural environment (Edelist & Spanier, 2009).

Offshore installations with a no-fishing zone around them, despite the possible negative impacts during construction, operations, and dismantling, with good management, can contribute to increasing local biodiversity. This increase will come about in response to adding the structure and surfaces that will function as FAD and an artificial reef (Inger et al., 2006). If a no-fishing zone is not established around the offshore installation, fishery conditions can be expected to deteriorate.

7.1 Offshore structures as a springboard for advancing invasive species?

The Mediterranean's east basin's geographical location near the Red Sea and the Pontian (Black Sea and Caspian Sea) and its connection to the Atlantic Ocean dictates its role as a potential site for invasive species to settle (Galil and Zenetos, 2002). Large numbers of invasive species came in with the opening of the Suez Canal in 1869; Eritrean and Indo-Pacific fauna penetrated the Mediterranean. Since then 300 species of fish, invertebrates, and algae have invaded the Mediterranean, causing far-reaching changes to the coastal biota in the Levant (Galil, 2000; Galil and Zenetos, 2002).

Biological invasions are common in the marine environment of coastal regions. In the Levant, the Suez Canal connecting the Red Sea to the Mediterranean Sea is known to be a main conduit for invasive species (Por, 1978). Hundreds of species are known today to have passed the Suez Canal as larvae or adults and establish populations in the Levant as they progressed north. According to Galil and Zenetos (2012) Eritrean species have traversed the Canal, established populations, and some have reached as far as west Tunisia, Malta, and Sicily. Commercial fishing is another route for transporting invasive species.

The idea that a hard artificial surface can serve as a latching point, stepping stone or springboard for invasive species is gaining wider support among scientists (Ruiz et al., 2009; Rocha et al. 2010). This position is supported by a number of studies conducted recently (Tyrrell and Byers 2007; Glasby et al. 2007; Sheehy and Vik 2010). The presence of hard artificial structures in areas of soft floor could become an attraction point for larval stages of diverse invertebrates including invasive species (Boehlert and Gill, 2010). In this context it is worth mentioning the Shenkar and Loya (2008) study of the solitary ascidian *Herdmania momus*, a common inhabitant of Red Sea reefs (Eilat Bay, Aden Bay). First evidence of its existence in the Mediterranean Sea was obtained by Pérés (1958) and later by Nishikawa (2002), who reported its presence on the coasts of Israel, Lebanon, and Cyprus. This species is considered a Lesspesian migrant (Por, 1978). The Shenkar and Loya study compared the population of *Herdmania mumus* in the Red Sea to its population in the Mediterranean on several parameters. Regarding species distribution, the Mediterranean population was found to be limited to artificial beds at greater depths. The study also found that average individual size is greater in the Mediterranean, symbiont content is different, and the breeding season is shorter (Shenkar and Loya, 2008). Another recently published study claimed that in Israel, despite finding many migrant species on artificial bodies, these same species are also found in nearby rocky areas; up until now this theory has not been confirmed for conditions on the Israeli coastline (see Sheshar and Shalev, 2013).

i. Up-to-date images

A DVD is attached to this report with four videos that were shot during the biological survey conducted for National Zoning Plan 37h:

1. Two films shot by the robot camera and a second camera connected to the robot that documented the seabed at the ten sampling points (listed in Appendix 12) at depth intervals of 10m in the two platform perimeters and the pipeline corridor. One video is a record of the Dor perimeter and the Dor corridor and a second video is a record of the Havazelet Hasharon perimeter and the Alexander River corridor (when this corridor was surveyed it was still one of the alternatives).
2. A video documenting the rocky area that was discovered in the Mikhmoret pipeline corridor and filmed during an instrument dive using a GoPro camera. The video surveys a line perpendicular to the shoreline from the shallows to a depth of 11m inside the corridor.
3. A video with footage from all survey days documenting evidence of trawling vessels of the seabed at depths of 30-100m.

4.10 Drainage and hydrogeology

The plan's impact on groundwater and runoff is only relevant to the onshore components of the plan, and the subject was presented in the reports on the impact on the onshore environment in the Meretz WWTP and in Hagit that were submitted as part of this plan.

4.11 Hazardous materials

The offshore installation is far from public receptors and does not endanger them. The hazards of this facility are operational, safety, and security related, and are typical of industrial facility of this kind. <u>Therefore, the means of minimizing risks in the perimeter of the offshore installation and separation distances from hazardous</u>

materials refer to the risk to a population other than employees is not relevant to the report on the impact of offshore installations and are not reviewed in the present document.

Chapter 5

Proposal for Plan Provisions

5. Chapter 5 – Proposal for Plan Provisions

5.0 General

This chapter sets forth the proposed plan provisions regarding environmental issues that were examined in this document with respect to all stages of plan implementation.

Because the plan is a detailed one that, however, is characterized by a lack of information on certain matters of import for planning (e.g., the composition of the gas in the reservoir and the technology envisioned by the developer), a guideline document was drawn up for the preparation of an Environmental Management and Monitoring Plan (EMMP). The guidelines set forth the environmental issues that the developer must address at the building permit request stage. The document is appended to this survey as Appendix I. The supplements required at the building permit stage as part of, and in addition to, the EMMP document to be prepared in advance of plan implementation are presented as well.

5.1 Proposal for Plan Provisions

A. Project implementation stages

<u>General</u>

The site can serve several different suppliers, coordinate the supply of gas from different suppliers from offshore discoveries up to 2 million m^3/hour per supplier.

The development processes of a given supplier are not dependent on those of any other.

Determining the project implementation stages depends on a number of major elements, including: finding and developing offshore natural gas fields/reservoirs, the type of gas and gas pressure in the reservoirs, the nature of the development chosen for the given reservoir and whether there has been joint development of several reservoirs that reach a single supplier's processing facility, the nature of the commercial agreements reached with consumers, the entry of additional developers, the development of gas consumption in Israel and the technological option selected for treating the natural gas.

Since at this stage of the project it is impossible to define all of the variables noted above, it was decided that the plan would be as "enabling" as possible. For this reason the plan guidelines that relate to development and to the staging of project implementation (including division among the various suppliers) will be characterized by maximum flexibility.

In accordance with the above, it is proposed that the following provisions be included in the plan:

A.1. The technological option will be proposed by the supplier within the building permits framework and will be approved by the Natural Gas Authority. The range of technological options spans maximal onshore processing to maximal offshore processing; gas entry pressure from sea to shore should not exceed 100 bar.

B. Processing of dangerous substances

The offshore facility is far from public receptors and does not endanger them. The risks posed by the facility are operational, safety and security risks typical of industrial facilities of this kind. Guidelines on this issue are thus relevant to the marine environment impact survey. Recommendations for guidelines on the processing of dangerous substances and on minimizing risks in the onshore environment were set forth in the environmental impact surveys for the Hagit and Mertz sewage treatment sites that were submitted in the framework of this plan.

C. Preventing marine pollution and handling pollution incidents

C1. The plan of action and the measures to be taken in case of leakage of oil or other substances, including procedures and timetables for action, will be submitted by the plan developer at the building permit stage and be approved by the relevant governmental authorities.

C2. A plan for handling marine oil pollution incidents due to leakage of condensate or operating fuel will be formulated per Ministry of Environmental Protection guidelines and will include, as is customary for pollution incident contingency plans: a definition of forces and tasks and a list of action methods and means per stage of incident handling, in accordance with the nature of the incident, communication and reporting procedures, and coordination with other action plans (plans of the relevant local authorities and the National Contingency Plan for Preparedness and Response to Incidents of Oil Pollution at Sea).

D. Preventing air pollution

General

At this stage of the plan it is impossible to make a best available technology (BAT) recommendation for reducing specific emissions, as we cannot predict which technologies will be available 3 or 4 years from now – given that the best technologies available today could become obsolete in the future. Still, we can recommend theoretical means of reducing emissions, if not specific technologies for emission reduction.

Recommendations for inclusion in theoretical guidelines for reducing emissions from the natural gas processing facility:

D1. Theoretical technology for reducing torch emissions

A technology that returns the emission gases to the system should be used, e.g. a flare gas recovery unit – FGRU.

D2. Theoretical technologies for reducing emissions from fuel-burning facilities (liquid or gas)

The emission rates of all installations that emit flue gases should be brought into conformity with the emission rates noted in ALUFT 2002 or any other up-to-date standard to be adopted by the Ministry of Environmental Protection. In addition to the guideline calling for compliance with standards, the best available means of reducing emissions should be installed at these installations.

D3. Theoretical technologies for reducing fugitive emissions

As part of the routine operation of the flue gas processing facility, there could potentially be fugitive emissions from the equipment and from the connections between pipes. In order to reduce these emissions the following measures should be taken:

Welding as many of the connections as possible

Ongoing maintenance of connector and valve sources.

Operating leak-detecting control systems. The operation – and operating frequency -- of such systems would conform to the guidelines in the relevant BREF documents.[42]

Generator use should also be reduced, and preference be given to electricity from the local power station or from the national power grid.

E. Preventing pollution of land, surface water and groundwater

Recommended provisions pertaining to the plan's onshore environment regarding the prevention of land, surface water and groundwater pollution were set forth in the framework of the environmental impact surveys for Hagit and the Mertz sewage treatment facility submitted in the framework of this plan.

F. Preventing degradation of the natural landscape

F.1. Before deciding on the final pipeline corridor route, the developer most conduct a ground survey of habitats with an emphasis on exposed rocky substrate. One should avoid, insofar as possible, bringing the pipeline through and/or near areas of exposed rocky substrate.

F.2. In order to lower the risk of harming rocky habitats in the coastal entry area of Michmoret, the possibility should be considered of moving the pipeline's exit point westward from the rocky area, should this be technologically feasible.

F. 3. It will be prohibited, while the pipeline is being laid, to place anchors in the exposed rocky areas that constitute a major habitat.

[42] Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries, February, 2003.

F. 4. Vessels that carry out the construction work must comply with procedures for loading and releasing sailing ballast.

F.5 Before product water begins to flow into the marine environment, chemical and biological background monitoring must be conducted, in coordination with the Ministry of Environmental Protection.

F.6. In order to measure the environmental impacts, a plan for continuous monitoring of chemical and biological parameters must be drawn up, in coordination with the Ministry of Environmental Protection.

Light pollution and mitigating its effects

F.7. The use of light should be kept to a minimum, both in terms of lighting duration and in terms of intensity.

F.8. The lights should be focused on the facility, not beyond it, and glare should be prevented by the use of down-facing light fixtures (full cutoff).

F.9. Shortwave, narrow-spectrum lighting should be used – avoid using white light.

F.10. Use of discontinuous and shortwave lighting is recommended.

F. 11. Marking lights – insofar as possible, use flashing rather than continuous lights, with light flashes that are short relative to the intervals between flashes.

F. 12. The lighting plan should be backed up by photometric mapping that shows how light is dispersed around the facility and confirms that no lighting is distributed beyond the necessary area.

F. 13. Check how the light is distributed beyond the plan area and present means of reducing/minimizing its effects, in accordance with INPA-approved design principles.

F. 14. Monitoring: facility operation should be accompanied by monitoring to determine the number of birds harmed by the facility and adjustments should be made if critical times for bird mortality are found. The monitoring program should be based on the past experience of similar platforms abroad.

Preventing bird collisions

F. 15. It is recommended that the use of glass in the structure's façade be minimized; if glass must be used, it should be screened from the outside by something non-reflective, e.g. curtains or external screens, painted windows or densely-packed adhesives.

F. 16. In any instance of overhead cables the cables should be marked by appropriate means, such as reflectors, in coordination with the INPA.

G. Control and processing of leaks

G.1. Processing facility: during ongoing facility maintenance an observer should be posted to survey the immediate environment and confirm that there are no leaks outside the facility.

Pipeline – see Item O below.

H. Visual handling of the site

The aim of these provisions is to minimize the facility's scenic impact, by the following means:

Minimizing the installations' visibility

H.1. During the facility's engineering design process the compound's contours and the ratio between installations will be examined, and the installations' dimensions will be limited to the minimum necessary per existing standards and technologies, so as to limit the installations' contours and impact on the skyline.

H. 2. Lighting outside the facility – when designing the lighting, make sure that the external facility walls facing the coast (whether parallel or diagonally) are not illuminated directly, except for flashing collision-avoidance lights for air and sea craft. The facility's internal lighting should be directed low, not skyward.

I. Provisions for the collection, handling and removal of sewage, brine and product water

Sanitary sewage

I.1. Sanitary sewage will be treated on the platform to the accepted standard before being discharged to the sea.

Industrial sewage

I.2. At the building permit stage, when the platform location and anticipated condensate composition are known, a treatment plan will be drawn up for various different scenarios in which condensate or operating fuel is discharged into the sea. The plan will address the outcomes of models forecasting the fate of these substances in different meteo-oceanographic situations.

I.3. Due to the anticipated effects of a condensate spill incident at sea, it is preferable that a decision be made in favor of onshore condensate storage and processing, in any offshore-onshore mix to be determined.

I.4. During system initialization, a one-time removal of pressure-check water (2900 c^3 per kilometer of gas pipeline) is necessary. The anticipated water composition should be noted and permission obtained to discharge it to sea, per the Prevention of Sea Pollution from Land-Based Sources Law and its provisions.

J. Executing earthworks and drainage systems both in the installations and along the pipeline route

Provision recommendations regarding earthworks and drainage systems are relevant solely to the plan's onshore environment and have been set forth in the framework of the environmental impact surveys for the Hagit and Mertz sewage treatment sites that were submitted in the framework of this plan.

K. Safety of the buildings and installations in seismic terms, with attention to each potential cause of damage.

K.1. In order to develop the platform's seismic design, a site response survey should be carried out as noted in Appendix E to Amendment 5 of Standard 413 (Consolidated Edition 2011 or a more up-to-date edition), with consideration of the following guidelines:

i. A seismotectonic analysis should be conducted in order to determine the seismic load level at the top of the hard rock layer for the reference scenarios defined in standards relevant to the rigs (e.g., Extreme Level Earthquake or Abnormal Level Earthquake per the API standard).

ii. The amplification factors will be determined on the basis of site-specific information to be collected as part of the soil survey.

iii. The results of the soil survey and the site-response survey will be used to calculate the soil liquefaction potential.

iv. The worst-case reference scenario will have a repeat time of at least 2500 years, so that the seismic design can meet Ministry of Environmental Protection requirements.

K.2. Design of the platform to withstand the seismic loads calculated in Item A above and load activation, will be carried out in accordance with the guidelines set forth in the API/ISO platform standards, and/or in the guidelines included in the international standard for platforms (general): DVN-OS-C101 (LRFD method) – Design of Offshore Steel Structures, General, and/or in accordance with comparable standards in the field.

K.3. With the aid of a three-dimensional model and dedicated software, the dynamic behavior of the platform and the foundations should be calculated in light of anticipated seismic loads. The model should also take into account soil property changes during seismic activation (=soil liquefaction).

K.4. Non-structural components that are not subject to SI 413 Part 2 will be designed in accordance with the international standards mentioned in the Israeli standard, by default per the US standard ASCE/SEI 7-10.

K.5. Emergency systems, e.g. control and firefighting, should be designed in accordance with rigorous seismic standards. The system components should, at the very least, be able to withstand an earthquake whose repeat time is 2,500 years.

K.6. At the subsoil investigation stage we should also assess/rule out the presence of superficial methane in the subsurface, as has been found elsewhere on the continental shelf. The consequences of the gas layer and its byproducts in terms of ground and platform stability should be assessed, and appropriate engineering solutions developed.

K.7. The platform should be designed to be tsunami resistant. The issue of tsunamis is not explicitly addressed in platform standards but falls into the category of wave and flow loads that these standards take into account. Tsunami waves a few meters high are expected at the relevant distances from the coast and depths. Scenario-based analysis may be conducted at the designer's discretion to assess the nature of the waves anticipated at the specific point where the platform will be built.

K.8. A soil survey should be conducted to identify discontinuities that could reflect activity along the platform pipeline route. Should such discontinuities be found, the pipeline should be designed to withstand the potential strains.

K.9. The design should include a local earthquake warning system, address future connection to a national earthquake and tsunami warning system, and set forth the automatic and non-automatic actions to be taken when a warning is received from the system.

K.10. The team that prepares the plans for the building-permit stage should include an earthquake engineer who is familiar with current practice in the field and the body of knowledge that has been amassed regarding the seismic design of facilities subject to this plan, in light of past incidents in which facilities of these kinds were exposed to seismic forces.

L. Instructions for noise reduction, at both the construction stage and at the ongoing activity stage

In order to minimize the impact of noise on the marine environment, we propose that the plan instructions be supplemented by the following items that address noise reduction:

Construction stage

L.1. At the detailed design stage and as a condition for obtaining a building permit, the project developer should submit an acoustic appendix for the gas processing facility, to be prepared by a recognized acoustic consultant. The acoustic appendix should be called "Detailed Acoustic Appendix for NOP 37H – Natural Gas Processing Facility (hereinafter: "the Acoustic Appendix").

L.2. The Acoustic Appendix will include a list of the dominant noise sources at the construction stage and the anticipated noise levels with an emphasis on sheet piling, but also addressing other works and work-supporting seacraft.

L.3. The Acoustic Appendix will re-examine current marine-mammal and sea-turtle harm and nuisance thresholds, which will be updated as needed.

L.4. The Acoustic Appendix will include a timetable for performing the works, including a list of the tools to be operated at each stage, the locations at which they will be operated, and the amount of time per day that the tools will be operated in the field.

L.5. During the sheet piling period, observers skilled at detecting whales and sea turtles will be employed in shifts. At least 20 minutes before the start of hammer operation, the observer will survey with binoculars, from a high platform, the area around the sheet pile, to a radius of at least 500 m.

L.6. The sheet pile driver should be operated in soft start mode for 20 minutes. The degree to which the original noise intensity is reduced during soft start, compared with maximum intensity, should be determined on the basis of data provided by the manufacturer in the Acoustic Appendix.

L.7. Should a marine mammal or sea turtle be observed during full operation in the vicinity of the sheet piling site, they should be documented but there is no need to halt work.

L.8. Actual noise measurements should be carried out at measured distances from the sheet piling so as to validate theoretical spatial noise reduction calculations.

Operation stage:

L.9. Maximum measures should be taken to control noise and to minimize noise transmission from the platform to the marine environment.

M. Rehabilitation of the offshore seabed environment

M.1. While the pipeline is being laid, material that piles up during excavation should be put back for coverage as soon as possible.

N. Rehabilitation of the onshore pipeline route

Recommendations for guidelines on rehabilitating the onshore pipeline route were set forth in the environmental impact surveys for the Hagit and Mertz sewage treatment sites that were submitted in the framework of this plan.

O. Sealing and monitoring pipeline leaks (gas and fuel)

O.1. The gas pipeline is made of steel with cathodic protection coating.

O.2. Pressure control systems for the pipeline and facility components should be installed that give warning of unplanned drops in pressure.

O.3. A plan for leak detection via continuous measurement of pipeline engineering parameters should be prepared (rate of flow, pressure, etc.).

O.4. A plan for periodic pipeline testing should be drawn up, to include periodic equipment-based marine surveys, e.g. an underwater camera mounted on a floating device and controlled from the survey ship.

O.5. A plan should be prepared for internal inspection of the pipeline via an intelligent diagnostic pig that will obtain information on the state of the pipe, corrosion, irregular pipe shape, etc.

P. Handling related infrastructures

Handling of the facility's related infrastructures, power lines, sewage, etc., should be in accordance with the customary requirements and standards.

Q. Dismantling of installations and restoration of the status quo ante at the end of the project's life cycle

The detailed engineering design of the natural gas processing facility and its related infrastructures should include a section on dismantling the facility and recycling/removing its components, per the preferred options.

A preliminary dismantling plan should be included in the EMMP and should provide an initial definition regarding removal of the various components per handling method: recycling, transport to waste site, etc. The plan should address the following:

- Removal of liquids from the pipeline works.
- Removal of debris and pollutants from the pipeline works.
- Removal of all facility structures and components from the area of the natural gas processing facility.
- Dismantling of the pipeline.
- Rehabilitation of the site and restoration to the status quo ante.

The plan should be updated and approved periodically throughout the period of facility activity to ensure adjustment for technological, regulatory and other changes. The plan should be completed by the end of the project's lifecycle and should provide for dismantling and removal as well for managing and monitoring the area and its rehabilitation.

R. Antiquity and heritage sites

R.1. All work within areas recognized as antiquity sites should be coordinated and performed only upon receipt of written authorization from the Israel Antiquities Authority, as mandated, and subject to the instructions of the Antiquities Law, 5738-1978.

R.2. Advance archeological assessments should be performed along the route (supervision; test cuts; test excavation/sample rescue excavation; rescue excavation), per conditions set by the Antiquities Authority and at the developer's expense.

R.3. Should antiquities be discovered that justify preservation/removal of the find per the Antiquities Law, 5738-1978 or the Antiquities Authority Law, 5749-1989, the developer will, at his expense, perform all of the actions necessary for preservation of the antiquities.

R.4. The Israel Antiquities Authority does not undertake to permit development or construction activity of any kind in the area or any portion of it even after testing/excavation, should unique antiquities be discovered in the area that entail preservation of the ancient remains on site. Nor should such permission be regarded as exemption of the remains from the Antiquities Law but rather consent in principle only.

5.2 Provisions and conditions for issuing building permits

5.2.1 Buildout reduction

Recommendations for guidelines on reducing the onshore facilities' buildout profile were set forth in the environmental impact surveys for the Hagit and Mertz sewage treatment sites that were submitted in the framework of this plan.

5.2.2 Separation distances and restriction update

The offshore facility is far from public receptors and does not endanger them. The risks posed by the facility are operational, safety and security risks that are typical of industrial facilities of this kind. Guidelines on the issue of separation distances and restriction updates are thus not relevant to the marine environment impact survey. Recommendations for guidelines on this issue in the onshore environment were presented in the environmental impact surveys for the Hagit and Mertz sewage treatment sites that were submitted in the framework of this plan.

5.2.3 Emission permit

At the building permit request stage an emission permit request should be submitted per the Clean Air Law, 5768-2008 updated to the request submission period.

5.2.4 Environmental management and monitoring plan

An environmental monitoring and management plan should be drawn up that includes environmental document requirements at the building permit submission stage, plans of action to prevent and handle emissions (with an emphasis on cooperation between entities and authorities, including military and civilian systems), as well as guidelines that address monitoring systems in a variety of areas (air, dangerous substances, marine pollution, etc.) to be designed and operated at the facilities, including emergency plans and procedures for fire, emissions and environmental leakage situations. The monitoring plan should include routine control/management procedures for offshore and onshore installations, including assignment of responsibility and supervision procedures and timetables for handling incidents should they arise.

Theoretical guidelines for the preparation of an environmental management and monitoring plan (EMMP) were drawn up by Royal Haskoninig DHV, the program's international consultant. The guidelines are attached as Appendix I of the NOP37 H offshore survey and address the assessment of best available technologies for preventing/minimizing environmental impact at the building-permit and EMMP preparation stage.

In addition to the EMMP and the instructions for its implementation, the ENVD prepared jointly with the Ministry of Environmental Protection and the relevant entities, which is attached as Appendix G of the NOP 37 H offshore survey and deals with the natural gas processing facilities' environmental impact at sea and on land, may also be of use.

5.2.5 Reducing fuel storage

General:

The plan enables condensate to be stored in a container whose total capacity is 100,000 m^3.

Recommendation to incorporate provisions:

The developer will explore the possibility of reducing condensate storage by transmitting it via the dedicated pipeline to a designated endpoint (e.g. the oil refineries), per two theoretical treatment options, in the following order of preference:

> Preference I – Processing the fuels onshore at the oil refineries – via a dedicated fuel pipeline that would remove the fuel from the treatment facility and bring it to the Haifa oil refineries.
>
> Preference II – Processing the fuels in the offshore area via a dedicated treatment facility (FSO).

5.2.6 Supplementary requirements for the building-permit stage

As noted, in accordance with the guidelines for its implementation, the plan is an enabling and flexible one that offers the possibility of implementing a variety of natural gas processing methods, including offshore and onshore processing – in light of the fact that the plan will enable all future offshore gas discoveries to be addressed so that they can supply gas to the transmission system.

Since no developer has yet been chosen to implement the plan, and because there is a dearth of information needed to plan the processing system (e.g., the composition of the gas in the reservoir, the planned technology and the exact location of the offshore installations and pipeline), supplements will be needed for the building-permit stage on a range of issues that are as yet unknown.

These issues include theoretical guidelines for the preparation of an environmental management and monitoring plan (EMMP), instructions for the facility dismantling stage, rehabilitation of the area and other environmental issues, and are presented in Items 5.1 and 5.2. Additional topics, such as the creation of a mechanism for communicating with residents of nearby localities, and a mechanism for submitting complaints, are set forth in the environmental impact surveys for the onshore Hagit and Mertz sites that were submitted in the framework of this plan.

5.3 Restrictions and conditions regarding zoning, uses and activities

Compared with the plan's onshore environment, the marine environment is relatively sparse in terms of uses and zoning. Moreover, at this stage the plan includes search corridors and sites for the exact placement of platforms and pipeline routes, and there is no way of determining whether and which uses will be restricted due to the plan's implementation.

However, there are several offshore uses and zonings that could be negatively affected by plan implementation as noted in Item 4.2.1. Below is a list of the offshore uses liable to be compromised by plan implementation (subject to the components' final location):

- Trawling activity – fishing nets (and other seacraft) will not be permitted to engage in fishing or sailing within 500 m. of the platform treatment site.43 In areas where a pipeline lies on the seabed and is not buried, trawling activity will be forbidden.
- Sea lanes – No anchoring or fishing activity will be permitted along the pipeline route or within 500 m. of the offshore pipeline.
- NOP 34/B/2, Desalination – coordination is needed between the desalination facility's designers/operators during plan implementation, to keep the water pumped for desalination from being compromised during pipeline laying/if pipeline and openings are damaged, etc.
- Communication cables – crossing communication cables will, if necessary, entail cable disconnection and reconnection per the principles set forth in Item 4.5.2 of Appendix C – Operational and Engineering Issues.

[43] In accordance with the guidelines of the Shipping and Ports Authority.