APPENDIX A.11

Environmental Baseline Supporting Documentation and Maps

Letter Confirmation of Receipt of Antiquities Section in Noble Energy's Environmental Memorandum at the Leviathan Site

ISRAEL ANTIQUITIES AUTHORITY רשות העתיקות

Marine Archaeology Unit

1 Adar 5776
February 10, 2016

Mr. Ilan Nissim
Director, Environment Division
Natural Resources Administration
Ministry of National Infrastructures, Energy and Water Resources

Dear Mr. Nissim,

Re: **Confirmation of receipt of antiquities section in Noble Energy's environmental memorandum *At the Leviathan Site***

Further to the guidelines for preparing an environmental impact document for production drillings, production testing and their completion at the Leviathan field that were submitted to Noble Energy on October 5, 2014, and in accordance with Article 1.8 of the guidelines, a coordination meeting was held with Mr. Gil Zeidner and Adv. Uri Vitner at my office in Caesarea on May 31, 2014.

At the meeting the developer was given guidance regarding the environmental impact document guidelines, with particular attention to the antiquities section:

1. A map at a scale of 1:100,000 should be appended to the environmental impact document, with a polygon delineating the area where anomalies were detected that could potentially indicate archeological findings (38 sites) in the seismic surveys conducted.
2. In the environmental impact document it should be explicitly noted that all drillings to performed in the Leviathan development framework shall maintain a security distance of at least 305 meters (per the accepted Gulf of Mexico standard – and in this context we refer to NTL No. 2005-G07 of January 1, 2005, United States Department of the Interior – Minerals Management Service – Gulf of Mexico Region) from archeological finds, if any.

ISRAEL ANTIQUITIES AUTHORITY רשות העתיקות

Marine Archaeology Unit

3. It shall also be noted in the environmental impact document that all of the material required, in accordance with the guidelines, shall be sent to the Israel Antiquities Authority's Marine Archeology Unit.

I would like to note that the authors of the environmental impact document complied with all of the document guidelines and met all of the requirements, including submission of all written and digital information to the Israel Antiquities Authority; please find attached a document signed by me attesting to the fact that the material was submitted. **The material submitted to the Israel Antiquities Authority is satisfactory and meets the Authority's needs, and therefore the Israel Antiquities Authority has authorized continued development activity.**

I would like to emphasize that, due to a number of processes in which the Israel Antiquities Authority must engage jointly with other government ministries, it was decided that the material and information submitted to us shall remain confidential until the process has concluded.

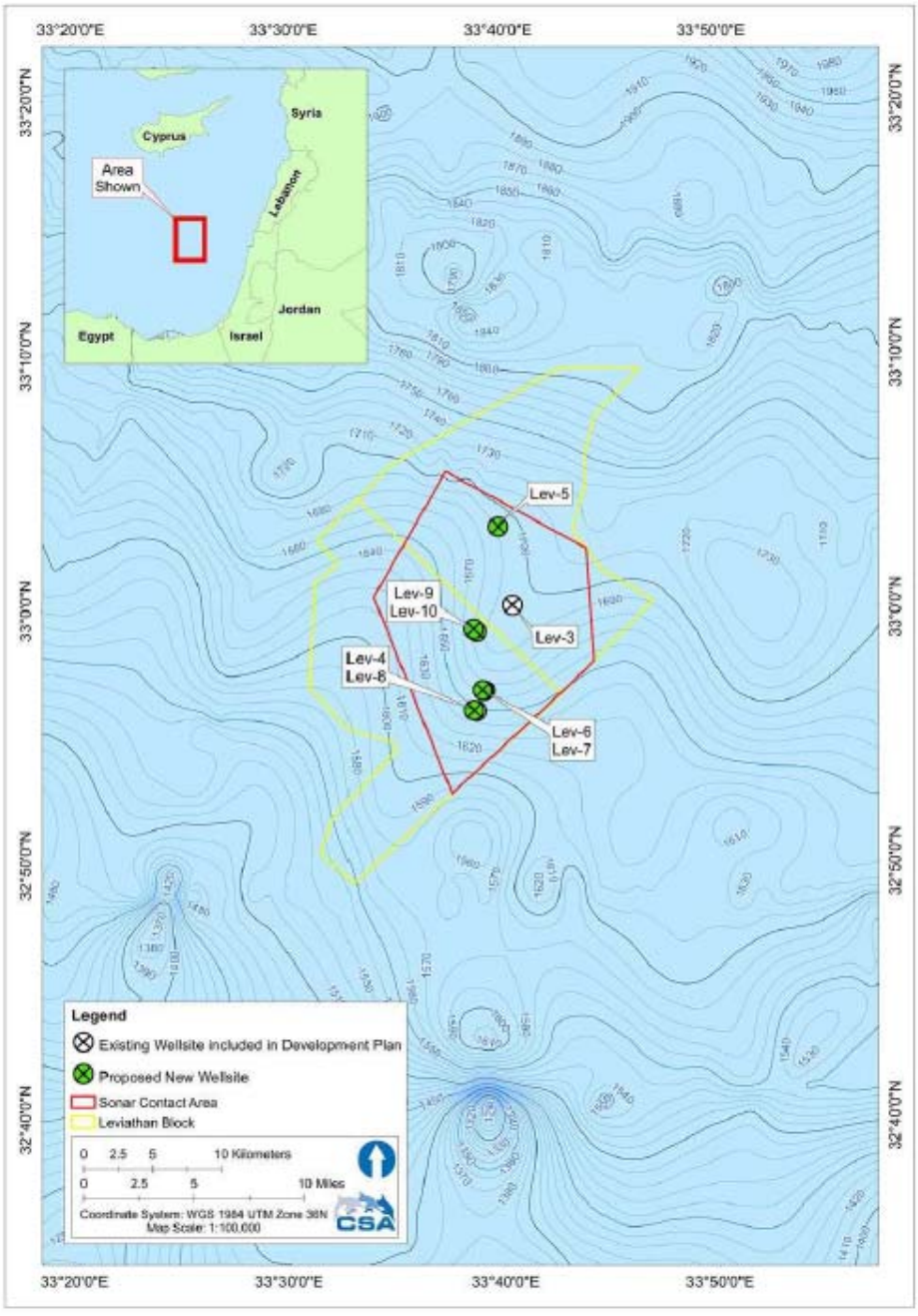
I also wish to stress that, despite the logistical difficulty and in order to ensure a more correct process, should a similar testing process be conducted or should the testing processes be continued at the site, we require that an Israel Antiquities Authority archeologist be added to the delegation, to provide point-specific, real-time input on archeological issues that may arise during the survey work or while the underwater vehicle is being lowered to assess the targets.

This process will save the developer and the State a great deal of time and money.

Sincerely,

Jacob Sharvit
Director, Marine Archeology Unit
Israel Antiquities Authority

cc.:
Mr. Israel Hasson – Director, Israel Antiquities Authority
Dr. Uzi Dahari – Deputy Director General and Chief Scientist, Israel Antiquities Authority
Adv. Uri Vitner – Noble Energy



APPENDIX B.1

No Chapter B Appendices

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APPENDIX C.1

Infrastructure Seabed Land-take

The seabed land-take associated with the subsea infrastructure has been estimated based on known, and predicted infrastructure dimensions. These calculations are detailed in the following sections.

C.1.1 Infield Infrastructure

For clarity, the following items are considered to be “Infield” when estimating the infield infrastructure land-take:

- Wells and wellheads – Not with the scope of this assessment;
- Production flowlines (22.5 km of 14”) and PLETs (10);
- Infield umbilicals (22.8 km of 7.17”) and UTAs (10);
- Infield Gathering Manifold (one (1)); and,
- MEG SDU (one (1)).

Land-take associated with the above infield infrastructure is detailed in Table C.1-1. This is calculated based on the following assumptions:

- Flowline and umbilical land-take are estimated based on the respective outer diameter and length;
- PLET land-take is estimated based on preliminary dimensions provided by Noble Energy:
    - Single PLET: Nine (9) m x 10 m (L x W); and,
    - Twin PLET: 12 m x 10 m (L x W).
- UTA land-take is estimated based on analogous structures on the Tamar field (seven (7) m x 3.1 m);
- Infield Gathering Manifold land-take is based on the suction pile diameter of six (6) m, the manifold structure will be supported above the sea floor; and,
- MEG SDU land-take is estimated based on a similar structure in place at the Tamar field with dimensions of 11.7 x 8.3 (L x W).

Table C.1-1: Land Take of Infield Infrastructure

Item	Foundation Type	Land Take per unit (m^2)	Units	Total Land Take (m^2)
Flowlines (14")	None	0.36 / m	22,500 m	8,001
PLET - Singles	Mudmat	90	7	630
PLET - Doubles	Mudmat	120	3	360
Infield Umbilicals	None	0.18 / m	22,800	4,152
UTAs	Mudmat	21.7	10	217
Infield Gathering Manifold	Suction Pile	28.3	1	28.3
MEG SDU	Mudmat	97.1	1	97.1
Total				13,485

C.1.2 Transmission Infrastructure

For clarity, the following items are considered when estimating the transmission infrastructure land-take:

- 18" DSM pipelines (two (2) by 117.5 km) and PLETs (two (2));
- MEG PLETs (two (2));
- 20" REM pipeline (one (1) by 117.5 km) and PLET (one (1));
- Electrohydraulic umbilical (117.5 km of 6.38") and associated UTAs (two (2));
- Production pipeline SSIVs (three (3));
- SSIV Umbilical UTA (one (1)); and,
- SSIV Umbilical (150 m by six (6) inches).

The LPP and export pipelines are not considered within this assessment. Additionally no land-take is attributed to the MEG supply pipelines in this section as it is assumed these will be piggybacked onto the 18" DSM pipelines. Standalone MEG supply pipelines are considered in Section C.1.3.

Land-take associated with the above transmission infrastructure is detailed in Table C.1-2. This is calculated based on the following assumptions:

- Pipeline and umbilical land-take are estimated based on the respective outer diameter and length;
- PLET land-take is estimated based on preliminary dimensions provided by Noble Energy:
    - Production PLET (DSM or REM): 11 m x 10 m (L x W); and,

- MEG PLET: Six (6) m x six (6) m (L x W);

- All UTA land-take is estimated based on analogous structures on the Tamar Field (seven (7) m x 3.1 m);
- Controls SDU land-take is estimated based on a similar structure in place at the Tamar Field with dimensions of 11.7 x 8.3 (L x W); and,
- SSIV land-take is estimated based on dimensions provided by Noble Energy (eight (8) m by eight (8) m (L x W)).

Table C.1-2: Land-take of Transmission Infrastructure

Item	Foundation Type	Land-take per unit (m^2)	Units	Total Land-take (m^2)
DSM Pipelines (18")	None	0.46 /m	235,000 m	107,442
DSM PLETs	Mudmat	110	2	220
MEG PLETs	Mudmat	36	2	72
REM Pipeline (20")	None	0.51 /m	117,500	59,690
REM PLET	Mudmat	110	1	110
Primary Umbilical	None	0.16 /m	117,500	19,041
UTAs	Mudmat	21.7	2	43.4
Controls SDU	Mudmat	97.1	1	97.1
SSIVs	Mudmat	64	3	192
SSIV UTA	Mudmat	21.7	1	21.7
SSIV Umbilical	None	0.15	150	15.2
Total				186,424

C.1.3 Standalone MEG Supply Lines

The alterative to piggybacked MEG supply lines is standalone MEG supply lines which will be laid into the same transmission corridor as the production pipelines and the primary umbilical. This will incur incremental land take as an additional 235 km (two (2) by 117.5 km) of 6" pipeline will be laid directly onto the seabed.

The incremental land-take associated with standalone MEG pipelines is reported in Table C.1-3. This is based on an outer diameter of 6.625" which is standard for 6" nominal bore line pipe.

Table C.1-3: Incremental Land Take of Standalone MEG Pipelines

Item	Foundation Type	Land Take per unit (m^2)	Units	Total Land Take (m^2)
Standalone MEG Pipelines (6”)	None	0.17 / m	235,000 m	39,544

C.1.4 Total subsea Land-take

The total land-take associated with the subsea infrastructure considered within this assessment is estimated as 239,983 m^2. The majority of this is attributed to the production pipelines, which alone account for almost 70% of this figure.

APPENDIX C.2

Material Safety Data Sheets

MacDermid

Health 1 | Flammability 1 | Reactivity 0 | Special

245 Freight St Waterbury, CT 06702

SAFETY DATA SHEET

Product name OCEANIC HW 540 P

Code 174913

Section 1. Identification

Product name : OCEANIC HW 540 P

Relevant identified uses of the substance or mixture and uses advised against

Identified uses	
Industrial use only.	

Uses advised against	Reason
Not applicable.	

Supplier's details : MacDermid
245 Freight St
Waterbury, CT 06702

Emergency telephone number (with hours of operation) : Chemtrec (1-800-424-9300) 24 Hours

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : ACUTE TOXICITY (oral) - Category 4
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2A

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements : Harmful if swallowed.
Causes serious eye irritation.

Precautionary statements

Prevention : Wear eye or face protection. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling.

Response : IF SWALLOWED: Call a POISON CENTER or physician if you feel unwell. Rinse mouth. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.

Storage : Not applicable.

Section 2. Hazards identification

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Hazardous ingredients	%	CAS number
ethylene glycol	40 - 50	107-21-1
ethylene glycol butyl ether	1 - 3	111-76-2

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. If necessary, call a poison center or physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : Harmful if swallowed. Irritating to mouth, throat and stomach.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

174913 OCEANIC HW 540 P

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

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Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Do not store above the following temperature: 48.9°C (120°F). Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
ethylene glycol	**OSHA PEL 1989 (United States, 3/1989).** CEIL: 50 ppm CEIL: 125 mg/m³ **ACGIH TLV (United States, 6/2013).** C: 100 mg/m³ Form: Aerosol
ethylene glycol butyl ether	**OSHA PEL 1989 (United States, 3/1989).** **Absorbed through skin.** TWA: 25 ppm 8 hours. TWA: 120 mg/m³ 8 hours. **NIOSH REL (United States, 10/2013).** **Absorbed through skin.** TWA: 5 ppm 10 hours. TWA: 24 mg/m³ 10 hours. **ACGIH TLV (United States, 6/2013).** TWA: 20 ppm 8 hours. **OSHA PEL (United States, 2/2013).** **Absorbed through skin.** TWA: 50 ppm 8 hours. TWA: 240 mg/m³ 8 hours.

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Section 8. Exposure controls/personal protection

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state	: Liquid.
Color	: Blue-green
Odor	: Mild.
Odor threshold	: Not available.
pH	: 9.4
Melting point	: Not available.
Boiling point	: 100°C (212°F)
Flash point	: Closed cup: >100°C (>212°F)
Evaporation rate	: Not available.
Flammability (solid, gas)	: Not available.
Lower and upper explosive (flammable) limits	: Not available.
Vapor pressure	: Not available.
Vapor density	: Not available.
Relative density	: 1.06
Solubility	: Not available.
Solubility in water	: Soluble
Partition coefficient: n-octanol/water	: Not available.
Auto-ignition temperature	: Not available.
Decomposition temperature	: Not available.
Viscosity	: Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : Oxidizers.

Hazardous decomposition products : Thermal decomposition may yield carbon monoxide and/or carbon dioxide.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
ethylene glycol	LD50 Oral	Rat	4700 mg/kg	-
ethylene glycol butyl ether	LC50 Inhalation Vapor	Rat	450 ppm	4 hours
	LD50 Dermal	Rabbit	220 mg/kg	-
	LD50 Oral	Rat	250 mg/kg	-

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
ethylene glycol	Eyes - Mild irritant	Rabbit	-	24 hours 500 milligrams	-
	Eyes - Mild irritant	Rabbit	-	1 hours 100 milligrams	-
	Eyes - Moderate irritant	Rabbit	-	6 hours 1440 milligrams	-
	Skin - Mild irritant	Rabbit	-	555 milligrams	-
ethylene glycol butyl ether	Eyes - Moderate irritant	Rabbit	-	24 hours 100 milligrams	-
	Eyes - Severe irritant	Rabbit	-	100 milligrams	-
	Skin - Mild irritant	Rabbit	-	500 milligrams	-

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Section 11. Toxicological information

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : Harmful if swallowed. Irritating to mouth, throat and stomach.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Route	ATE value
Oral Dermal Inhalation (vapors)	1020.4 mg/kg 11000 mg/kg 550 mg/l

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Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
ethylene glycol	Acute LC50 6900000 µg/l Fresh water	Crustaceans - Ceriodaphnia dubia - Neonate	48 hours
	Acute LC50 41000000 µg/l Fresh water	Daphnia - Daphnia magna - Neonate	48 hours
	Acute LC50 8050000 µg/l Fresh water	Fish - Pimephales promelas	96 hours
ethylene glycol butyl ether	Acute EC50 >1000 mg/l Fresh water	Daphnia - Daphnia magna	48 hours
	Acute LC50 800000 µg/l Marine water	Crustaceans - Crangon crangon	48 hours
	Acute LC50 1250000 µg/l Marine water	Fish - Menidia beryllina	96 hours

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
ethylene glycol	-1.36	-	low
ethylene glycol butyl ether	0.81	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	IMDG	IATA
UN number	UN3082	Not regulated.	UN3082
UN proper shipping name	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. CONTAINS ETHYLENE GLYCOL	ORGANIC ADDITIVE	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. CONTAINS ETHYLENE GLYCOL

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Section 14. Transport information

Transport hazard class(es)	9 	-	9 
Packing group	III	-	III
Environmental hazards	Yes.	No.	Yes.
Additional information	The marine pollutant mark is not required when transported on inland waterways in sizes of ≤5 L or ≤5 kg. Reportable quantity 1358 gal Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.	-	The environmentally hazardous substance mark is not required when transported in sizes of ≤5 L or ≤5 kg.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Section 15. Regulatory information

U.S. Federal regulations : **United States inventory (TSCA 8b):** All components are listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Immediate (acute) health hazard

Composition/information on ingredients

Section 15. Regulatory information

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
ethylene glycol ethylene glycol butyl ether	40 - 50 1 - 3	No. Yes.	No. No.	No. No.	Yes. Yes.	No. No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	ethylene glycol ethylene glycol butyl ether	107-21-1 111-76-2	40 - 50 1 - 3
Supplier notification	ethylene glycol ethylene glycol butyl ether	107-21-1 111-76-2	40 - 50 1 - 3

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : The following components are listed: ETHYLENE GLYCOL; 2-BUTOXYETHANOL

New York : The following components are listed: Ethylene glycol

New Jersey : The following components are listed: ETHYLENE GLYCOL; 1,2-ETHANEDIOL; 2-BUTOXY ETHANOL; BUTYL CELLOSOLVE

Pennsylvania : The following components are listed: 1,2-ETHANEDIOL; ETHANOL, 2-BUTOXY-

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Inform Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Section 16. Other information

History

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Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
UN = United Nations

☑ Indicates information that has changed from previously issued version.

Notice to reader

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Section 16. Other information

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Date of issue/Date of revision : 7/30/2015 11/11

MacDermid

Flammability
Health 1 1 0 Reactivity
Special

245 Freight St Waterbury, CT 06702

SAFETY DATA SHEET

Product name OCEANIC SST 5007

Code 174923

Section 1. Identification

Product name : OCEANIC SST 5007

Relevant identified uses of the substance or mixture and uses advised against

Identified uses	
Industrial use only.	

Uses advised against	Reason
Not applicable.	

Supplier's details : MacDermid
245 Freight St
Waterbury, CT 06702

Emergency telephone number (with hours of operation) : Chemtrec (1-800-424-9300) 24 Hours

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : ACUTE TOXICITY (oral) - Category 4
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2A

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements : Harmful if swallowed.
Causes serious eye irritation.

Precautionary statements

Prevention : Wear eye or face protection. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling.

Response : IF SWALLOWED: Call a POISON CENTER or physician if you feel unwell. Rinse mouth. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.

Storage : Not applicable.

Section 2. Hazards identification

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Hazardous ingredients	%	CAS number
ethylene glycol	35 - 45	107-21-1

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. If necessary, call a poison center or physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : Harmful if swallowed. Irritating to mouth, throat and stomach.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Storage temperature: 0 to 48.9°C (32 to 120°F). Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
ethylene glycol	**OSHA PEL 1989 (United States, 3/1989).** CEIL: 50 ppm CEIL: 125 mg/m³ **ACGIH TLV (United States, 6/2013).** C: 100 mg/m³ Form: Aerosol

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Section 8. Exposure controls/personal protection

Body protection	:	Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection	:	Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory protection	:	Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state	:	Liquid.
Color	:	Pink
Odor	:	Slight
Odor threshold	:	Not available.
pH	:	11.2
Melting point	:	Not available.
Boiling point	:	Not available.
Flash point	:	Closed cup: >104°C (>219.2°F)
Evaporation rate	:	Not available.
Flammability (solid, gas)	:	Not available.
Lower and upper explosive (flammable) limits	:	Not available.
Vapor pressure	:	Not available.
Vapor density	:	Not available.
Relative density	:	1.055
Solubility	:	Not available.
Solubility in water	:	Soluble
Partition coefficient: n-octanol/water	:	Not available.
Auto-ignition temperature	:	Not available.
Decomposition temperature	:	Not available.
Viscosity	:	Not available.

Section 10. Stability and reactivity

Reactivity	:	No specific test data related to reactivity available for this product or its ingredients.
Chemical stability	:	The product is stable.
Possibility of hazardous reactions	:	Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid	:	No specific data.
Incompatible materials	:	Acids and oxidizing agents
Hazardous decomposition products	:	Thermal decomposition may yield carbon monoxide and/or carbon dioxide.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
ethylene glycol	LD50 Oral	Rat	4700 mg/kg	-

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
ethylene glycol	Eyes - Mild irritant	Rabbit	-	24 hours 500 milligrams	-
	Eyes - Mild irritant	Rabbit	-	1 hours 100 milligrams	-
	Eyes - Moderate irritant	Rabbit	-	6 hours 1440 milligrams	-
	Skin - Mild irritant	Rabbit	-	555 milligrams	-

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : Harmful if swallowed. Irritating to mouth, throat and stomach.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Section 11. Toxicological information

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Route	ATE value
Oral	1250 mg/kg

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
ethylene glycol	Acute LC50 6900000 µg/l Fresh water	Crustaceans - Ceriodaphnia dubia - Neonate	48 hours
	Acute LC50 41000000 µg/l Fresh water	Daphnia - Daphnia magna - Neonate	48 hours
	Acute LC50 8050000 µg/l Fresh water	Fish - Pimephales promelas	96 hours

Persistence and degradability

Conclusion/Summary : Unknown

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
ethylene glycol	-1.36	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	IMDG	IATA
UN number	UN3082	Not regulated.	Not regulated.
UN proper shipping name	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. CONTAINS ETHYLENE GLYCOL	GLYCOL MIXTURE	GLYCOL MIXTURE
Transport hazard class(es)	9 	-	-
Packing group	III	-	-
Environmental hazards	Yes.	No.	No.
Additional information	Reportable quantity 1420 gal Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.	-	The environmentally hazardous substance mark may appear if required by other transportation regulations.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Section 15. Regulatory information

U.S. Federal regulations : **United States inventory (TSCA 8b):** All components are listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Listed

Clean Air Act Section 602 Class I Substances : Not listed

Section 15. Regulatory information

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
ethylene glycol	35 - 45	No.	No.	No.	Yes.	No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	ethylene glycol	107-21-1	35 - 45
Supplier notification	ethylene glycol	107-21-1	35 - 45

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : The following components are listed: ETHYLENE GLYCOL

New York : The following components are listed: Ethylene glycol

New Jersey : The following components are listed: ETHYLENE GLYCOL; 1,2-ETHANEDIOL

Pennsylvania : The following components are listed: 1,2-ETHANEDIOL

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Inform Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Section 16. Other information

History

Date of printing	:	5/26/2015.
Date of issue/Date of revision	:	5/26/2015.
Key to abbreviations	:	ATE = Acute Toxicity Estimate BCF = Bioconcentration Factor GHS = Globally Harmonized System of Classification and Labelling of Chemicals IATA = International Air Transport Association IMDG = International Maritime Dangerous Goods LogPow = logarithm of the octanol/water partition coefficient UN = United Nations

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
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APPENDIX C.3

Estimation of Installation Vessel Duration & Fuel Use

C.3.1 Vessels and Activities

Vessel use for the construction phase (installation, pre-commissioning and commissioning) of the Leviathan development project are estimated based on typical activity durations. The following vessels are considered to be required for this work:

- DP Pipelay Vessel;
- Pipe Supply Vessel;
- MSV - with ROV capability;
- Offshore Construction Vessel;
- Offshore Supply Vessel;
- Offshore Standby Vessel; and,
- Helicopter.

A total of 14 construction activities have been identified for the facilities located in Israeli economic waters, these are:

Infield

- Infield 1: Flowline and PLET installation;
- Infield 2: Infield Gathering Manifold installation and piling;
- Infield 3: Infield umbilical and associated structures installation;
- Infield 4: Flowline and umbilical tie-ins;
- Infield 5: Production system pre-commissioning and commissioning; and,
- Infield 6: Controls system pre-commissioning and commissioning.

Transmission

- Trans. 1: DSM production pipelines (two (2) by 117.5 km) and PLET installation;
- Trans. 2: REM production pipeline (one (1) by 117.5 km) and PLET installation;
- Trans. 3: Electrohydraulic umbilical installation (one (1) by 60 km + one (1) by 57.5 km) and associated structures (two (2) by intermediate UTAs + one (1) by infield Controls SDU);
- Trans. 4: Pipeline and Umbilical Tie-ins;
- Trans. 5 Production system pre-commissioning and commissioning;
- Trans. 6 MEG system pre-commissioning and commissioning; and,
- Trans. 7: Controls system pre-commissioning and commissioning.

Optional - (If MEG pipelines are to be Piggybacked this activity is part of Trans. 1)

- MEG 1: Installation of standalone MEG pipelines (two (2) by 117.5 km).

Assumptions

Vessel use is assigned to each activity as detailed in the vessel matrix (Table C.3-1). This considers the following assumptions to enable an estimate of vessel use to be made. This is a preliminary assessment and further details regarding vessel use and durations will be determined following installation contractor selection.

- All offshore actives require support in the form of:
    - ROV launch, operation and retrieve from an MSV;
    - General supply sorties from an Offshore Supply Vessel; and,
    - Emergency support and exclusion zone enforcement from a Standby Vessel.
- All pipelay activities require additional support from:
    - A dedicated Pipe Supply Vessel; and,
    - Helicopters for the purpose of weekly personnel transfers;
- An OCV is used for piling, heavy lift (Infield Gathering Manifold), umbilical lay and tie-in operations.

The marine vessels expected to be required to support each of the identified activities are reported in Table C.3-1.

Table C.3-1: Construction Vessel Use Matrix

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Infield 1	X	X	X	-	X	X	X
Infield 2	-	-	X	X	X	X	-
Infield 3	-	-	X	X	X	X	-
Infield 4	-	-	X	X	X	X	-
Infield 5	-	-	X	-	X	X	-
Infield 6	Performed as part of Trans. 7.						
Trans. 1	X	X	X	-	X	X	X
Trans. 2	X	X	X	-	X	X	X
Trans. 3	-	-	X	X	X	X	-
Trans. 4	-	-	X	X	X	X	-
Trans. 5	-	-	X	-	X	X	-
Trans. 6	-	-	X	-	X	X	-
Trans. 7	-	-	X	-	X	X	-
MEG 1	X	X	X	-	X	X	X

C.3.1.1 Infield 1

Infield 1 involves the installation of all infield production flowlines and the associated FLETs. The primary installation vessel for this activity it the DP Pipelay Vessel.

Activity duration is estimated based on flowlines being laid at an average rate of three (3) km/day with two (2) days allowed for start-up and set-down per flowline. The total infield flowline length to be laid is 22.5 km.

The above gives a total activity duration of 17.5 days which applies to the pipelay vessel and all marine support vessels associated with this activity. It is assumed that supply vessels (general and pipelay) are continuously operating during this period (either in transit or loading/offloading).

In addition to the marine support vessels, helicopter support is assumed for the pipelay activities based on a single round trip (one (1) hour each way) per week. This gives a total flight duration of five (5) hours for this activity.

Total vessel use for this activity is provided in Table C.3-2.

Table C.3-2: Infield 1 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	18	18	18	-	18	18	5 (hrs)

C.3.1.2 Infield 2

Infield 2 involves the installation of the Infield Gathering Manifold and associated suction pile. The primary installation vessel for this activity is the OCV.

Activity duration is based on three (3) discrete lifts so as to ensure the maximum single lift weight does not exceed the crane capacity of the vessel. Lifts are split as detailed below:

- Suction pile installation;
- Support structure installation; and,
- Piping installation.

Each lift is assumed to take one (1) day to complete, giving a total activity duration of three (3) days. Total vessel use for this activity is detailed in Table C.3-3.

Table C.3-3: Infield 2 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	3	3	3	3	-

C.3.1.3 Infield 3

Infield 3 involves the installation of all infield umbilicals and associated structures (UTAs). The primary installation vessel for the activity is the OCV which is assumed to be capable of flexible lay operations.

Activity duration is based on the OCV achieving an average flexible lay rate of 9.6 km/day. An additional two (2) days is allowed per infield umbilical for start-up and set-down. Further, a single day is allowed for the installation of the infield MEG SDU which will be installed from the OCV.

Based on the above lay rate and allowances the total activity duration is 13 days. Total vessel use for this activity is detailed in Table C.3-4.

Table C.3-4: Infield 3 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	13	13	13	13	-

C.3.1.4 Infield 4

Infield 4 involves the installation of all infield tie-ins and umbilical flying leads. This is assumed to be performed from the OCV with ROV support from the MSV. This is considered conservative as it is possible that the MSV vessel will have sufficient crane capacity to perform these installations, thus reducing overall fuel use associated with this activity.

All infield tie-in spools (production and MEG) will be of flexible construction, while the controls tie-ins will be made with hydraulic and electrical flying leads. Each tie-in spool is assumed to take two (2) days to install, with an additional day allowed per flying lead bundle.

A total of 15 infield tie-in spools have been identified (13x production + two (2) by MEG) and 14 flying lead bundles. This puts total infield production, MEG and controls tie-in installation at 44 days. Total vessel use for this activity is detailed in Table C.3-5.

Table C.3-5: Infield 4 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	44	44	44	44	-

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C.3.1.5 Infield 5

Infield 5 involves the Pre-commissioning and Commissioning of the infield production infrastructure. Specifically this activity includes flooding, hydrotesting, leak testing connections, dewatering and drying production flowlines and spools. These operations are assumed to be performed from a vessel based spread installed on the MSV.

Based on Genesis-in house knowledge this is estimated to take six (6) days assuming that all flowlines can be simultaneously hydro tested and leak tested. Vessel use associated with this activity is provided in Table C.3-6.

Table C.3-6: Infield 5 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	6	-	6	6	-

C.3.1.6 Trans. 1

Trans. 1 involves the installation of the dual 117.5 km 18” DSM production pipelines. Additionally, if a piggybacked MEG pipeline configuration is selected then these lines will be laid simultaneously with the DSM production lines. The primary vessel associated with this activity is the DP Pipelay Vessel.

As per Infield 1 the average lay rate achieved by the DP Pipelay Vessel is assumed to be three (3) km/day with two (2) days allowed per pipeline for start-up and set-down. The total length of DSM production pipelines to be laid is 235 km.

The above basis gives a total activity duration of 82 days. It is assumed that supply vessels (general and pipelay) are continuously operating during this period (either in transit or loading/offloading).

As stated previously weekly helicopter transfers to and from the DP Pipelay Vessel are assumed at an average duration of one (1) hour each way. Total vessel use for this activity is provided in Table C.3-7.

Table C.3-7: Trans. 1 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	82	82	82		82	82	23.4 (hrs)

C.3.1.7 Trans. 2

Trans. 2 involves the installation of the single 117.5 km 20” REM transmission pipelines. The primary vessel associated with this activity is the DP Pipelay Vessel.

As per Trans. 1 the average lay rate achieved by the DP Pipelay Vessel is assumed to be three (3) km/day with two (2) days allowed for start-up and set-down.

The above basis gives a total activity duration of 41 days. It is assumed that supply vessels (general and pipelay) are continuously operating during this period (either in transit or loading/offloading).

As stated previously weekly helicopter transfers to and from the DP Pipelay Vessel are assumed at an average duration of one (1) hour each way. Total vessel use for this activity is provided in Table C.3-8.

Table C.3-8: Trans. 2 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	41	41	41	-	41	41	11.7 (hrs)

C.3.1.8 Trans. 3

Trans. 3 involves the installation of the two (2) lengths of static electrohydraulic umbilical and associated termination and distribution structures that make up the primary controls system from the LPP to the infield location. Additional activities included under this activity include the installation of the SSIV umbilical and its associated UTA. The primary installation vessel for this activity is the OCV which is assumed to be capable of flexible lay operations.

The total length of the primary umbilical to be installed is 117.5 km, with two (2) intermediate UTAs required to allow the lengths to be tied into each other subsea. The SSIV umbilical is assumed to be approximately 150 m in length. Additionally, this activity includes the installation of the infield Subsea Distribution Unit which is required to allow controls and chemicals from the primary umbilical to be routed to the infield umbilical UTAs.

Activity duration is based on achieving an average lay rate of 9.6 km/day from the OCV, with an additional two (2) days allowed per umbilical length to allow for start-up and set-down of the umbilical. A single installation day is allowed for the installation of the infield SDU, with a further two (2) days allowed for installation of the SSIV umbilical and UTA. This gives a total installation duration of 19 days.

Total vessel use for this activity is detailed in Table C.3-9.

Table C.3-9: Trans. 3 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	19	19	19	19	-

C.3.1.9 Trans. 4

Trans.4 involves the installation of the production SSIVs, transmission pipeline tie-in spools, and the flying leads associated with the umbilicals to the infield SDU and the SSIVs.

A total of nine (9) tie-in spools have been identified for the production system, with a further four (4) required to tie-in the 6” MEG lines. A total of one (1) set of controls flying leads must be installed to link the two (2) intermediate UTAs, with a further set required to connect the SSIV UTA to the SSIVs. Note that these figures include the tie-in spools required to connect into the risers at the LPP

Based on the assumptions previously detailed for Infield 4 the total duration of this activity is estimated at 31 days (assuming one (1) day for installation of each SSIV structure). The total vessel use associated with this activity is detailed in Table C.3-10.

Table C.3-10: Trans. 4 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	31	31	31	31	-

C.3.1.10 Trans. 5

Trans. 5 involves pre-commissioning and commissioning activities associated with the three (3) 117.5 km production pipelines. Specifically this is flooding, hydrotesting, leak testing, dewatering and drying.

Based on Genesis in-house knowledge this is estimated to take 10 days per pipeline for a total activity duration of 30 days. This assumes that hydrotesting of the production pipelines will not occur simultaneously. Vessel use associated with activity is provided in Table C.3-11.

Table C.3-11: Trans. 5 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	30	-	30	30	-

C.3.1.11 Trans. 6

Trans. 6 involves pre-commissioning and commissioning activities associated with the two (2) 117.5 km MEG supply lines. Specifically these activities include flooding, hydrotesting, leak testing, and dewatering through displacement with MEG.

Based on Genesis in-house knowledge this is estimated to take eight (8) days per pipeline for a total activity duration of 16 days. This assumes that hydrotesting of the MEG pipelines will not occur simultaneously. Vessel use associated with activity is provided in Table C.3-12.

Table C.3-12: Trans. 6 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	16	-	16	16	-

C.3.1.12 Trans. 7

Trans 7 involves all pre-commissioning and commissioning activities associated with the Leviathan controls system. This includes the primary umbilical from the LPP to the Infield Gather Manifold, and the infield umbilicals. Specific activities associated with this operation are hydrotesting of hydraulic/chemical cores, displacement of storage fluid, and function testing.

This activity is estimated to take a total of 23 days assuming that umbilical cores in the primary umbilical cannot be hydrotested simultaneously. Vessel use associated with activity is provided in Table C.3-13.

Commissioning of the SSIV umbilical is assumed to occur in parallel with the commissioning of the primary controls infrastructure and so no additional vessel duration is allowed for the commissioning of the SSIVs and their associated infrastructure.

Table C.3-13: Trans. 7 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	-	-	23	-	23	23	-

C.3.1.13 MEG 1

MEG 1 is an optional activity associated to install standalone MEG supply lines in the event that a non-piggybacked configuration is selected. The total length of MEG pipelines to be installed under this activity is 235 km (two (2) by 117.5 km). The primary installation vessel for this operation will be the DP Pipelay Vessel.

As per Trans. 1 and 2, the average lay rate achieved by the DP Pipelay Vessel is assumed to be three (3) km/day with two (2) days allowed for start-up and set-down per pipeline.

The above basis gives a total activity duration of 82 days. It is assumed that supply vessels (general and pipelay) are continuously operating during this period (either in transit or loading/offloading).

As stated previously weekly helicopter transfers to and from the DP Pipelay Vessel are assumed at an average duration of one (1) hour each way. Total vessel use for this activity is provided in Table C.3-14.

Table C.3-14: MEG 1 Vessel Use

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter
Duration (days)	82	82	82		82	82	23 (hrs)

C.3.2 Total Vessel Use

Total vessel use associated with the construction of the subsea infrastructure for the Leviathan development project are provided in Table C.3-15.

Table C.3-15: Construction Phase Vessel Use (days)

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter (hrs)
Infield 1	18	18	18	-	18	18	5
Infield 2	-	-	3	3	3	3	-
Infield 3	-	-	13	13	13	13	-
Infield 4	-	-	44	44	44	44	-
Infield 5	-	-	6	-	6	6	-
Infield 6	Performed as part of Trans. 7.						
Infield Total	**18**	**18**	**84**	**60**	**84**	**84**	**5 (hrs)**
Trans. 1	82	82	82	-	82	82	23.4
Trans. 2	41	41	41	-	41	41	11.7
Trans. 3	-	-	19	19	19	19	-
Trans. 4	-	-	31	31	31	31	-
Trans. 5	-	-	30	-	30	30	-
Trans. 6	-	-	16	-	16	16	-
Trans. 7	-	-	23	-	23	23	-
Trans. Total	**123**	**123**	**242**	**50**	**242**	**242**	**35 (hrs)**
MEG 1	82	82	82	-	82	82	23
Total	**223**	**223**	**408**	**110**	**408**	**408**	**63 (hrs)**

C.3.3 Vessel Fuel Consumption

Fuel use for each vessel type is calculated as an average daily consumption based on available data for typical vessels that are capable of performing the required duties. The following assumptions are applied when estimating fuel use:

- Fuel used on marine vessels is assumed to be conventional marine diesel with an LHV of 42.8 MJ / kg;

- Where a vessel features more than two (2) generators these are assumed to be operated in an N+1 (spare) configuration. E.g. if four (4) generators are present, three (3) are assumed operating with the fourth available as a standby;
- Average power consumption is assumed to be 66% of the peak generating capacity after allowing for generator sparing; and,
- Diesel generator efficiency is assumed at 45%.

The following sections detail the calculation and basis of fuel consumption figures for each vessel type.

C.3.3.1 DP Pipelay Vessel

The Allseas' Solitaire Pipelay Vessel is considered representative of the type of vessel to be used for pipeline / flowline installation at the Leviathan Field. Vessel power generation parameters, and estimated daily fuel consumption are provided in Table C.3-16 and are based on the generic assumptions stated previously.

Table C.3-16: Allseas Solitaire Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		Allseas Solitaire
Total Installed Power	MWe	51.5
Assumed Generator Configuration	-	7 x15%
Peak Operating Power	MWe	45.1
Average Running Power (Thermal)	MWt	66.1
Fuel Use	kg / s	1.5
	Te / day	130

C.3.3.2 Pipe Supply Vessel

The DP2 Pipe Haul / Platform Supply Vessel Toisa Invincible is considered broadly representative of the type of vessel that will be utilised for pipe supply operations during flowline and pipeline installation. Based on the information available, and the generic assumptions stated previously, daily fuel consumption is estimated in Table C.3-17.

Table C.3-17: Toisa Invincible Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		Toisa Invincible
Total Installed Power	MWe	4.9
Assumed Generator Configuration	-	2x 50%
Peak Operating Power	MWe	4.9
Average Running Power (Thermal)	MWt	7.2
Fuel Use	kg / s	0.17
	Te / day	15

C.3.3.3 Multipurpose Support Vessel

The light construction vessel, Siem Stingray, is considered broadly representative of the type of MSV that will be utilized on the Leviathan development project. This vessel is equipped with deck cranes and two (2) work-class ROVs. Based on the information available, and the generic assumptions stated previously, daily fuel consumption is estimated in Table C.3-18.

Table C.3-18: Siem Stingray Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		Siem Stingray
Total Installed Power	MWe	11.5
Assumed Generator Configuration	-	4x 33%
Peak Operating Power	MWe	8.6
Average Running Power (Thermal)	MWt	12.7
Fuel Use	kg / s	0.30
	Te / day	26

C.3.3.4 Offshore Construction Vessel

The subsea OCV, Boa Sub C, is considered representative of the type of OCV that will be utilised on the Leviathan development project. This vessel has an Active Heave Compensated (AHC) main crane rated for 400 Te which is expected to be capable of installing the Infield Gathering Manifold. Based on the information available, and the generic assumptions stated previously, daily fuel consumption is estimated in Table C.3-19.

Table C.3-19: Boa Sub C Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		Boa Sub C
Total Installed Power	MWe	23.0
Assumed Generator Configuration	-	4x 33%
Peak Operating Power	MWe	17.3
Average Running Power (Thermal)	MWt	25.3
Fuel Use	kg / s	0.59
	Te / day	51

C.3.3.5 Supply Vessel

The platform supply vessel, M.V Highland Rover, is considered representative of the type of the type of supply vessel that will be utilised for regular supply sorties between the onshore supply base and the offshore marine fleet. Based on the information available, and the generic assumptions stated previously, daily fuel consumption is estimated in Table C.3-20.

Table C.3-20: M.V Highland Rover Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		M.V Highland Rover
Total Installed Power	MWe	4.1
Assumed Generator Configuration	-	2x 50%
Peak Operating Power	MWe	4.1
Average Running Power (Thermal)	MWt	6.0
Fuel Use	kg / s	0.14
	Te / day	12

C.3.3.6 Standby Vessel

The standby safety vessel, Vos Fantastic, is considered representative of a typical standby safety vessel that may be utilised during the construction phase of the Leviathan development. This is a “Group A” survivor class vessel with capacity for more than 300 survivors. Based on the information available, and the generic assumptions stated previously, daily fuel consumption is estimated in Table C.3-21. Note that fuel consumption for this vessel is based on an assumed running load of 33% of the peak operating power to allow for the substantial duration of idling anticipated for this vessel.

Table C.3-21: Vos Fantastic Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		Vos Fantastic
Total Installed Power	MWe	1.6
Assumed Generator Configuration	-	1x 100%
Peak Operating Power	MWe	1.6
Average Running Power (Thermal)	MWt	1.2
Fuel Use	kg / s	0.03
	Te / day	2.4

C.3.3.7 Helicopter

Helicopters will be used during construction operations in order to transfer personnel to and from the DP Pipelay Vessel. This is nominally assumed to be a Sikorsky-61N, for which the Allseas Solitaire's helipad is classified for. This has capacity to transport up to 30 passengers.

Hourly fuel consumption for a Sikorsky-61N is estimated in Table C.3-22 based on the following assumptions specific to this section:

- Fuel : Jet A with a LHV of 42.8 MJ / kg;
- Average running power of 75% of peak operating load;
- Engines utilised in a 2x 50% configuration during normal operation; and,
- Generation efficiency of 35%.

Table C.3-22: Sikorsky-61N Estimated Fuel Consumption

Parameter	Units	Value
Reference Vessel		Sikorsky-61N
Total Installed Power	MWe	2.24
Assumed Generator Configuration	-	2x 50%
Peak Operating Power	MWe	2.24
Average Running Power (Thermal)	MWt	4.8
Fuel Use	kg / s	0.11
	Te / hr	0.40

C.3.4 Total Fuel Use

Based on the total vessel use previously provided in Table C.3-15, and the fuel consumption rates estimated in Section C.3.3C.3.3, the total fuel consumption associated with the Leviathan installation, pre-commissioning and commissioning activities has been estimated by vessel type and is reported in Table C.3-23. The total fuel use over the entire campaign is estimated at 54,453 Te if standalone MEG pipelines are installed, this reduces to 39,241 if a piggybacked configuration is selected.

Table C.3-23: Construction Phase Fuel Use (Te)

	Pipelay	Pipe Supply	MSV	OCV	Supply Vessel	Standby Vessel	Helicopter (hrs)
Infield Total	2,340	270	2,184	3,060	1,008	201.6	2.0
Trans. Total	15,990	1,845	6,292	2,550	2,904	580.8	14.0
MEG (Optional)	*10,660*	*1,230*	*2,132*	*0*	*984*	*196.8*	*9.2*
Total	**28,990**	**3,345**	**10,608**	**5,610**	**4,896**	**979.2**	**25.2**

C.3.5 Air Emissions Factors

Air emissions arising from marine fuel combustion are estimated based on emission factors recommended by the UK Department of Energy & Climate Change (DECC, 2008). Where DECC does not provide an emissions factor (e.g., PM10) the equivalent emissions factor recommended by the US Environmental Protection Agency is utilised (US EPA, 1995). Total CO_2 equivalent emissions are calculated based on the Global Warming Potential (GWP) of combustion emissions where the GWP CO_2 is equal to one (1). Methane and N_2O along with CO_2 are the three (3) main greenhouse gasses, with the former having GWPs of 25 and 298 respectively (US EPA, 2014). N_2O emissions have not been estimated in this work and thus the CO_2e emissions figure consists of CO_2 and Methane only.

The emission factors used are provided in Table C.3-24, while the total emissions from all vessels used during the construction campaign are provided in Table C.3-25, based on a total fuel consumption of 54,543 Te.

Table C.3-24: Air Emissions Factors (kg / Te fuel)

	CO_2	NO_X	SO_2	CO	CH_4	VOCs	PM_{10}
Marine Vessels	3,200	59.4	4	15.7	0.18	2	6.4
Helicopters	3,200	12.5	8	5.2	0.087	0.80	-

Table C.3-25: Total Air Emissions During Construction Phase (Te)

	CO_2	NO_X	SO_2	CO	CH_4	VOCs	PM_{10}	CO_2e
All Vessels	174,251	3,233	218	855	10	109	348	174,496

APPENDIX D.1

OCSAR Modelling Approval Request Technical Note

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Leviathan Development EIA

OSCAR Approval Note

Prepared for: Noble Energy

Prepared by: Genesis
1 St Paul's Churchyard
London EC4M 8AP
Tel: +44 [0]20 7585 5555
Fax: +44 [0]20 7585 5550
www.genesisoilandgas.com

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ABBREVIATIONS

2D	Two Dimensional
3D	Three Dimensional
AMOS	Advanced Management of Oil Spills
API	American Petroleum Institute
bbl	Barrel (of oil)
CFS	Climate Forecasting System
EIA	Environmental Impact Assessment
GODAE	Global Ocean Data Assimilation Experiment
HYCOM	Consortium for Data Assimilative Modelling
IBCAO	International Bathymetry Chart of the Arctic Ocean
LPP	Leviathan Production Platform
MMscf	Million Standard Cubic Feet
MoEP	Ministry of Environmental Protection
NASA	National Aeronautics and Space Administration (NASA)
NCEP	National Centers for Environmental Prediction
NCODA	Navy Coupled Ocean Data Assimilation
NEML	Noble Energy Mediterranean Ltd.
NOAA	National Oceanic and Atmospheric Administration
OSCAR	Oil Spill Contingency and Response Model
SINTEF	The Foundation for Scientific and Industrial Research
Synbaps	Synthetic Bathymetric Profiling System
UK	United Kingdom
US	United States (of America)
USEPA	United States Environmental Protection Agency
WAF	Water Accommodated Fraction

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1.0 PREFACE

Genesis are providing Environmental Consultancy services to Noble Energy Mediterranean Ltd. (herein referred to as NEML) for the purpose of developing an Environmental Impact Assessment (EIA) for the Leviathan development project. In order to comply with the guidelines provided by the Israeli Ministry of Environmental Protection (MoEP) it will be necessary to include oil spills modelling within the EIA. Genesis propose to utilise the industry standard oil spills software titled OSCAR (Oil Spill Contingency And Response).

In order to comply with MoEP guidelines (specifically Guideline 4.2.7) the following technical note has been developed in order to enable model approval from MoEP, specifically from the Marine and Coastal Division.

For ease of review headings within this note cross reference the relevant guidelines provided in the following document: "Instructions for Preparation of an Environmental Impact Document in the Economic Waters for the Installation, Operation and Maintenance of Submarine Systems and Laying of Pipelines in the Leviathan Field Development Project (Leases I/14 and I/15)", as provided by the State of Israel to NEML.

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2.0 GENERAL (GUIDELINE 4.2.7.1)

2.1 Name of Model (Guideline 4.2.7.1.1)

The model requiring approval is the "Oil Spills Contingency and Response Model" (OSCAR). This is an industry standard modelling software used throughout the oil and gas industry for the purpose of assessing the impact and response effectiveness of oil spill events.

The OSCAR model is the end product of an industry funded research and development project performed by The Foundation for Scientific and Industrial Research (herein referred to as SINTEF). OSCAR was initially developed during the 1990's and has been subject to continual improvement since, with continued input from major industry sponsors including Statoil, BP, Total, Shell and ExxonMobil.

2.2 Brief Description of the Model (Guideline 4.2.7.1.2)

The Oil Spill Contingency and Response Model (OSCAR) is the end product of an industry funded development by SINTEF. SINTEF is an applied chemistry, non-profit, research institute headquartered in Norway. OSCAR utilizes advanced numerical modelling methods to analyse both the physical and chemical processes, which determine a specific oil spills fates and effects, during an accidental release of oil to the marine environment. OSCAR models provide the ability to compare contingency plans as well as to forecast oil spill behaviour in the marine environment.

The OSCAR model is a state of the art, three-dimensional oil spill model. The key components of the system are a data-based oil weathering model, a three-dimensional oil trajectory and chemical fates model, an oil spill combat model, and tools for exposure assessment within GIS polygons (delineating, for example, sensitive environmental resource areas).

Over 20 years of SINTEF research and on-going development is being continually implemented into OSCAR to ensure it continues to improve and expand its capabilities. Development of OSCAR was supported by international oil majors including Statoil, BP, Total, Shell and ExxonMobil who requested that a modelling tool be developed to address accidental hydrocarbon release into the marine environment. Current focus in OSCAR is on underwater gas release modelling and behaviour and response of oil in arctic environments.

Researchers at SINTEF have been studying the weathering of surface oil for over 15 years, as summarized by Daling et al. (1999). Up to the late 90's, the focus of oil spills research had been on development of a relatively realistic model representation of the formation and composition of the water-accommodated fraction (WAF) of oil for both treated and untreated slicks. The SINTEF work funded over 3 years (1997 to 2000) by US Mineral Management Service (MMS), under the Advanced Management for Oil Spills (AMOS) Program looked to capture advancements in predictive modelling of oil spills. Discussions concerning oil spill contingency planning had so far been concentrated around the fate and behaviour of oil on the sea surface and the risk of stranding on shore. AMOS recognised that an increasing amount of oil was being extracted from underwater installations with a real risk of underwater releases. Light oils and condensates show a high tendency for natural dispersion into the water column under rough weather conditions. OSCAR uses an oil weathering model to simulate the chemical and physical processes (dispersion, dissolution, evaporation, degradation, etc.) that influence the toxicological parameters of the oil spill's plume as it

moves through the water. An integrated tactical response model depicts response activities, such as booming, skimming, dispersant application and in-situ burning. OSCAR tracks all of these activities and displays them in a graphical user interface. The work conducted under the AMOS Program ensured OSCAR became a state of the art, world leader in predictive oil spills modelling.

OSCAR is used by numerous consultancies presenting a global reach. OSCAR has been widely accepted for use in North and South America, Europe, Australia and Asia as the tool of choice for conducting oil spills modelling. Additionally OSCAR was used by the USEPA during the Deepwater Horizon blowout in order to provide real time analysis of the slick in order to assist with response efforts and best utilise resources.

2.3 Reasons for Adapting the Proposed Eastern Mediterranean Sea (Oil) Spill Simulation Model (Guideline 4.2.7.1.3)

Genesis propose using OSCAR for oil spill modelling on the Leviathan production system due to its extensive application record and strong performance when benchmarked against real world spill events. As an internationally recognized (and recommended) spill modelling software, use of OSCAR is considered to provide credible and robust oil spill predictions and will enable detailed analysis of accidental spill events associated with the Leviathan development project.

Further, Genesis' in house expertise in using OSCAR will ensure the model is applied appropriately and in a manner that is most conducive to accurate modelling.

2.4 Examples from Around the World for use in the Proposed Spill Simulation Model (Guideline 4.2.7.1.4)

As stated previously, OSCAR is an industry recognised modelling software that was developed as part of an industry funded research and development project. This has led to OSCAR being applied across a wide range of geographic locations. Of particularly note is Norway, where the Norwegian government require that all oil spill modelling be performed with the SINTEF OSCAR package. Norway is typically viewed to have one of the most progressive and proactive regulatory frameworks in the world and as such, endorsement from the Norwegian regulator is considered particularly noteworthy. In addition to the aforementioned endorsement from the Norwegian regulator, a number of specific examples of the use of OSCAR are highlighted below:

- Response planning for frontier exploration activity offshore Namibia (Reed M et al, 1999);
- Spill modelling for pipelines and wells on the Shah Deniz Ph. 2 development (Azerbaijan);
- Spill modelling for spills and well blowouts on the Sea Lion project (Falkland Islands);
- Spill modelling for pipeline release on the West Nile Delta project (Egypt);
- Spill modelling for frontier exploration on the North Uist exploration (UK) (Oil & Gas UK, 2012);
- Spill modelling for development drilling on the Western Isles Development (UK) (Oil & Gas UK, 2012);

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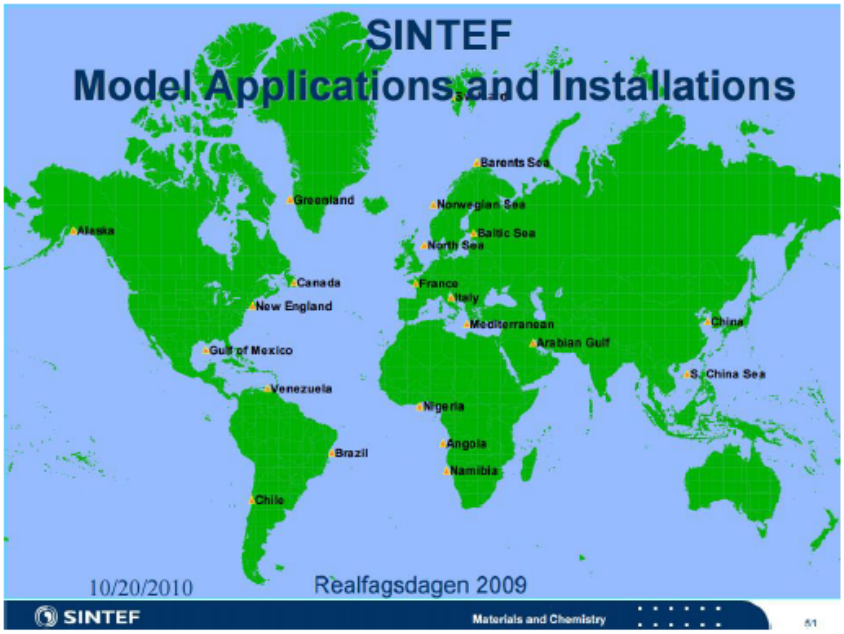
- Spill modelling for development drilling on the Flyndre & Cawdor project (UK) (Maersk, 2011);
- Spill modelling for frontier exploration activity offshore Tanzania;

SINTEF have previously published the map provided in Figure 2-1 showing the global regions where the OSCAR simulation package has been applied. It should be noted that this map is from 2010 and as such doesn't include a number of the more recent applications (e.g. East Africa and the Falkland Islands).

Figure 2-1: Global Application of SINTEF OSCAR (SINTEF, 2010)



Amongst the oil majors, BP actively state that the SINTEF OSCAR model is their preferred oil spill fate and trajectory modelling package (BP, 2015). In light of BP's experience following the Deepwater Horizon spill which provided a unique opportunity to verify model performance, this endorsement is considered particularly noteworthy.

3.0 METEOROLOGICAL-PHYSICAL CONDITIONS AND VARIABLES (GUIDELINE 4.2.7.2)

The following meteorological-physical data will be used within the SINTEF OSCAR model when simulating oil spill scenarios from the Leviathan development project:

- Winds: Wind data for the Eastern Mediterranean region has been provided to Genesis by NEML. This data is derived from the global Climate Forecast System (CFS) databases managed by the National Oceanic and Atmospheric Administration (NOAA).
- Currents: Current data for the Eastern Mediterranean region has been provided to Genesis by NEML. This data is derived from the HYCOM (Consortium for Data Assimilative Modelling) databases which themselves utilise data from the Navy Coupled Ocean Data Assimilation (NCODA) analysis system

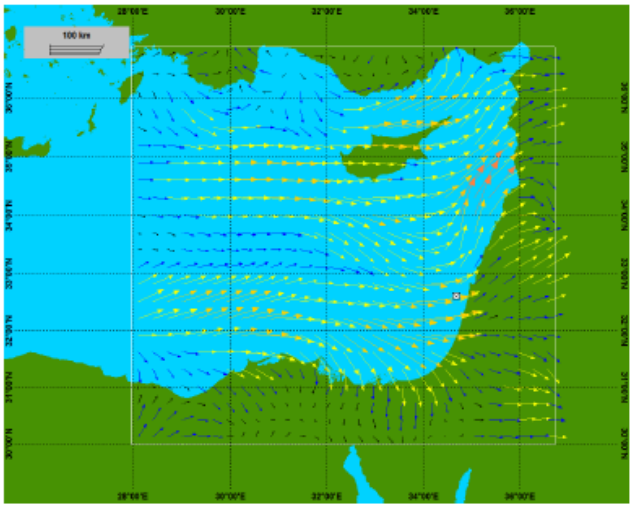
Both the HYCOM and CFS databases are global data banks of climate data developed and maintained in order to serve the data requirements of international scientists modelling both atmospheric, and oceanic phenomena.

3.1 Conditions of Edge of Model

The wind grids to be used within OSCAR for the purpose of modelling spills arising from the Leviathan development cover almost the entirety of the eastern Mediterranean Sea, extending from the coastline in the east (approx. latitude of 34-36°) to a western limit of approximately 28° longitude. An example wind grid is provided in Figure 3-1 for reference.

The wind grids applied in OSCAR are two dimensional (planar) with wind speeds provided based on an elevation of 10 m above sea level.

Figure 3-1: Representative Eastern Mediterranean Wind Grid

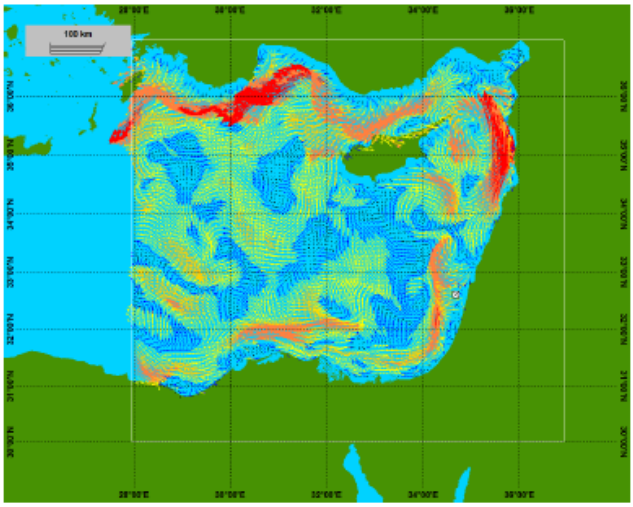


The current grids to be used for OSCAR modelling of accidental spills arising from the Leviathan development cover the entire eastern Mediterranean sea, extending from the eastern shoreline (approx.. longitude of 34-36°) to a western limit at an approximately 28° longitude. An example current grid is provided in Figure 3-2 for reference.

The current grids to be used for modelling associated with the Leviathan development are three dimensional (3D) grids, with an upper boundary 5 m below the sea surface, and extending to a maximum depth of 3,000 m below sea level. Where water depth is less than 3,000 m, the current grid will be bounded by the sea bed at that location.

Surface currents are estimated within the OSCAR model based on boundary interactions between shallow currents and near surface winds.

Figure 3-2: Representative Eastern Mediterranean Current Grid



3.2 Conditions at the Commencement of Model (Guideline 4.2.7.2.2)

The user of the OSCAR model is responsible for defining the start and end times of any oil spills model. Any start time may be specified, given that it lies within the temporal boundaries of the wind and current data being used for the model. If the start time lies within the available environmental data set, then the environmental conditions from this point in time will be taken at model initialization.

3.3 Resolution of Model, both Horizontal and Vertical (Guideline 4.2.7.2.3)

The wind grids to be utilised in the analysis of oil spill events arising from the Leviathan development show a planar resolution of between 0.2° and 0.3° in both the longitudinal and latitudinal directions. This is equivalent to a grid spacing of between 25 and 35 km. There is no vertical resolution of the wind data as wind grids applied in OSCAR are 2D.

The current grids provided for use in OSCAR modelling show a horizontal resolution of approximately 1/12° in the longitudinal direction and 1/15° in the latitudinal direction. This is equivalent to a grid spacing of approximately 7.4 km x 7.4 km. Vertical resolution (spacing between sea current data layers) of the current grid is dependent on depth, and ranges from 5 m close to the surface, to 250 m at the project water depth (~1,700 m), and up to 500 m at the deepest points of the eastern Mediterranean region (3,000 m). Table 3-1 provides the layer depths within the current grids available for the Eastern Mediterranean.

Table 3-1: Current Grid Water Depths (Vertical Resolution)

Layer N^{o}	Water Depth (m)
0	0
1	5
2	10
3	20
4	30
5	50
6	75
7	100
8	125
9	150
10	200
11	250
12	300
13	400
14	500
15	600
16	700
17	800
18	900
19	1000
20	1100
21	1200
22	1300
23	1400
24	1500
25	1750
26	2000
27	3000

In addition to the resolutions of the input data (wind and current), the model user is responsible for defining the modelling resolution applied within the specific scenario being considered. The following limitations apply to the OSCAR model when specifying the modelling resolution:

- Maximum number of grid cells in the horizontal grid of 1 million (specifically 1,000 cells north by 1,000 cells east); and,
- Maximum number of layers in the vertical grid of 100.

Final modelling resolution will be determined by preliminary modelling runs, but the limits within OSCAR are sufficient to enable the entire eastern Mediterranean region (up to 28° longitude) to be modelled with a horizontal cell sizing of 750 m by 700 m (north by east). The maximum water depth in the project area is 1,710 m, which enables a vertical resolution of 17.1 m within the aforementioned model limits.

It is not expected that the entire eastern Mediterranean region will be affected by an oil spill from the Leviathan development, and as such it is likely that a smaller grid area will be suitable and thus a higher resolution (smaller grid cells) may be used if required.

3.4 Characteristics of Starting Data for Model: Winds, Currents, Sea Level, Temperature, Salinity etc. (Guideline 4.2.7.2.4)

The OSCAR simulation package allows the user to define a wide range of environmental parameters prior to oil spill simulation. Aside from wind and current data (which are discussed above), the following environmental parameters must be defined when modelling oil spill scenarios:

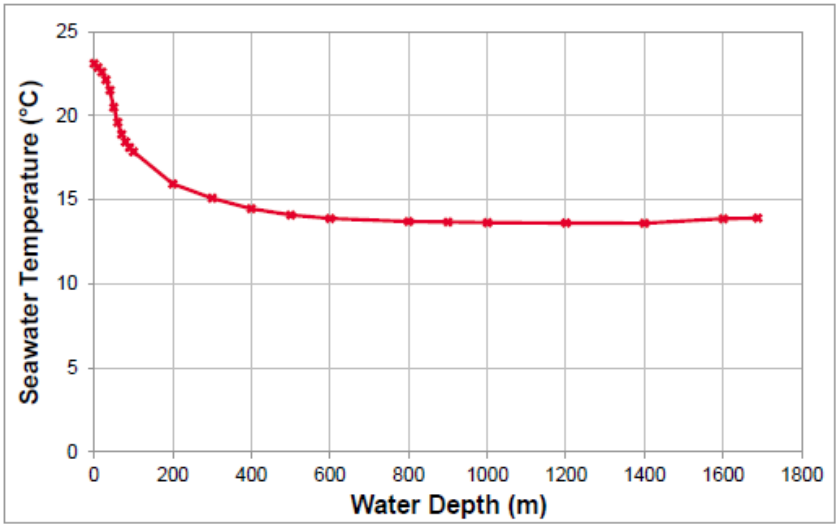
- Water Salinity;
- Sea Temperature profile (based on depth); and,
- Air Temperature;

For the purpose of the proposed modelling the parameters detailed in Table 3-2 and Figure 3-3 will be specified within the OSCAR model. The parameters in Table 3-2 are taken from the Leviathan Production Platform (LPP) Metocean Data report (Noble Energy, 2016), while the seawater temperature profile is derived from a combination of the aforementioned report (water depths of 0 – 100 m), and the Leviathan Metocean Report (Noble Energy, 2012) for water depths of greater than 100 m.

Table 3-2: Environmental Parameters for Implementation in OSCAR

Parameter	Units	Value
Water Salinity	ppt	39.1
Air Temperature	°C	21

Figure 3-3: Seawater Temperature Profile



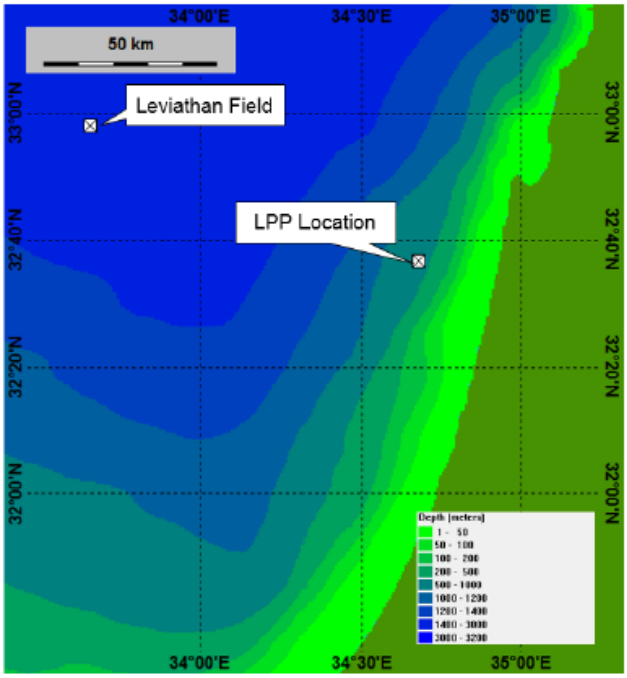
3.5 Bathymetry (Guideline 4.2.7.2.5)

The OSCAR model determines water depth at any given location based on a range of regional/global depth databases that are available within the model. Databases available are as follows:

- Synthetic Bathymetric Profiling System (Synbaps);
- Sea Topo 8.2;
- International Bathymetry Chart of the Arctic Ocean (IBCAO).

The Sea Topo 8.2 database covers the entirety of the Mediterranean region and will be used for this work. The area bathymetry, as predicted by the Sea Topo database, is provided in Figure 3-4 for reference.

Figure 3-4: Area Bathymetry as per Sea Top 8.2 Database



4.0 CHEMICAL VARIABLES (GUIDELINE 4.2.7.3)

4.1 Type of Oil (Guideline 4.2.7.3.1)

The OSCAR modelling package includes a database of over 130 crude oils and condensates from around the world. Based on previous analysis of Leviathan condensate properties (API gravity, viscosity, pour point, wax and asphaltine content) the "Kristin 2006 13°C" oil assay will be used for modelling the condensate phase of any spills from the Leviathan production system. This selection is based on matching those properties that are most important for determining oil spreading and dispersion behaviour, especially specific gravity, viscosity and pour point.

Kristin is a gas condensate field developed by Statoil in the Norwegian Sea. A comparison of the Kristin oil properties from the OSCAR database, and the condensate assay for the Leviathan condensate is provided in Table 4-1 below. This comparison shows that the specific gravity and pour point of the two assays provide a relatively good match (within 10%), however viscosity and asphaltene content show greater variation between the two assays. On balance, the Kristin condensate assay is considered to provide a good representation of Leviathan condensate for oil spill modelling purposes.

Table 4-1: Comparison of Leviathan and Kristin Condensate Properties

Condensate property	Value supplied	Oil analogues from OSCAR database & comparison to Leviathan Condensate	
Condensate Type	Leviathan Condensate	Kristin 2006 13°C	Percentage Variation
Specific gravity	0.8781	0.794 More buoyant	-9.6%
Viscosity	2.57	2.0 Dispersion will be slightly faster. Sheen will spread slightly quicker.	-22.2%
Pour Point	-36 °C	-39 °C	-8.3%
Asphaltene content	0.05%	0.04% Similar persistence	-20%
Hydrocarbon composition	Mainly C8 - C16	24% C25+ Heavier; less volatile	N/A

4.2 Quantity of Oil Emitted per Unit of Time (Guideline 4.2.7.3.2)

The rate of oil discharge from a release location is defined by the user in the OSCAR model, but may fundamentally take any value, for any period of time. Further, the OSCAR model includes the "DeepBlow" module that has been specifically developed, by SINTEF, to increase modelling accuracy of multiphase discharges from subsea sources. This allows the user to account for the effects of simultaneous release of gas and condensate from a single location, as will be the case in the event of a loss of containment from the Leviathan production system.

The rate of oil discharged from the Leviathan production system will be a function of the discharge scenario being assessed. Following scenario identification, NEML will provide an engineering assessment of the gas discharge rate associated with the scenario. Based on the gas discharge rate, and a maximum (worst case) Oil Gas Ratio (OGR) of 5 bbl of condensate per MMscf of gas, the rate of oil emitted per unit of time will be determined and modelled.

A description of the discharge scenario, and the events leading up to it, will be included in the production EIA for the Leviathan development.

5.0 CALIBRATION AND VERIFICATION OF THE MODEL (GUIDELINE 4.2.7.4)

The following sections provide an overview of the calibration and verification work that has been previously performed on the OSCAR model, and a short justification of the validity of the wind and current data to be used when modelling oil spills from the Leviathan project. The intention of this section is to satisfy the ministerial requirements associated with Guidelines 4.2.7.4.1, through to 4.2.7.4.5.

5.1 Model Calibration and Verification

Since its initial development the OSCAR model has been subject to continued development through further research and calibration of the model against real world oil spills (deliberate and accidental).

Scientific papers are available which detail how the OSCAR model was calibrated against both experimental and accidental oil spill events during its initial development (Reed M et al, 1996). The majority of the documented calibration work was performed in the nineties following the initial development of the model and concluded that the model provides a good estimate of surface oil drift, direction of drift, and oil coverage. Of particular note is the verification work performed following the 1992 Statfjord oil spill in the Norwegian Sea, where approximately 5,600 bbls of crude were spilled, which showed the models capacity to simulate larger spills and response actions while retaining much of the accuracy seen from previous calibration on small scale experimental spills.

Subsequent to the initial development and testing of OSCAR, SINTEF developed the DeepBlow model in order to allow the effects of deepwater hydrocarbon spills to be modelled. The DeepBlow model has been verified against experimental releases of oil and gas as detailed in the scientific paper "DeepSpill – Field Study of a Simulated Oil and Gas Blowout in Deep Water" (Johansen et al, 2003). The experimental releases used for verification of the DeepBlow model included a total of four releases at a water depth of approximately 850 m, subsequent analysis indicated good performance of the model in comparison to the observed impacts during the experimental releases. The DeepBlow model was subsequently incorporated into the OSCAR model.

During the Deepwater Horizon explosion and subsequent well blowout the OSCAR simulation package was applied by a range of scientific groups to provide daily slick forecasting and assessment of dispersion effectiveness. Users of OSCAR during this incident included the US Government (through the National Oceanic and Atmospheric Administration NOAA) who used the model to assess the daily spreading of sub-surface and surface oil. Since the Deepwater Horizon event, BP have made OSCAR their preferred oil spill fate and trajectory model and have applied it for a range of projects, including their frontier exploration campaign in the Great Australian Bight (BP, 2015), an area of substantial wilderness and natural beauty.

Further calibration/validation of the OSCAR model, specifically for Eastern Mediterranean conditions will not be carried out as part of this work.

5.2 Metocean Data Calibration and Verification

The wind and current data to be applied in the OSCAR modelling of oil spills arising from the Leviathan development project has been provided by NEML. The origin of this data is the

Climate Forecast System (CFS – Wind Data) and the Consortium for Data Assimilative Modelling (HYCOM – Current Data).

The CFS is a medium to long range numerical weather prediction model which is managed and run by the National Centres for Environmental Prediction (NCEP) which is itself a US Government organisation. As the CFS forms part of a National Government Organisation it is considered a given that model predictions, and subsequent datasets have been subject to appropriate calibration and verification against observed weather patterns.

The HYCOM consortium is a multi-institutional project, sponsored by the National Ocean Partnership Program (NOPP) as part of the US Global Ocean Data Assimilation Experiment (GODAE). GODAE includes real-time and historical oceanographic observations which are collated by the HYCOM project to form a coherent data set available to environmental scientists. The GODAE project has significant ties to both NASA and the US Navy and as such calibration and verification of this data by these organisations is considered a given, particularly as the databank is based on real-time oceanographic observations.

No further validation of wind or current data is considered necessary for this work.

6.0 SCENARIOS FOR EXAMINATION (GUIDELINE 4.2.7.5)

The selected oil spill scenario(s) (to be determined) will be assessed based on the four climate states requested in the Leviathan Production EIA guidelines (guideline 4.2.4). Specifically these climate states are:

- Extreme Winter Wave Storm: 09/12/2010 – 08/01/2011
- Winter Wave Storm: 26/01/2008 – 14/02/2008
- Summer Swell: 17/07/2008 – 16/08/2008
- Spring and Autumn: 25/09/2007 – 25/10/2007

All of the above climate states are covered by the aforementioned wind and current data sets. As such no additional data will be required to study these specific time periods.

7.0 REFERENCES

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