CHEMICAL SAFETY REPORT

Substance Name: Renewable hydrocarbons (diesel type fraction) / Renewable hydrocarbons (Alkanes, C10-20-branched and linear)
Common Name: Hydrotreated Vegetable Oil (HVO)
EC Number: 618-882-6
CAS Number: 928771-01-1
Registrant's Identity: Nouryon Salt B.V. (Location Haaksbergen)

Table of Contents

List of Tables

Part A

1. SUMMARY OF RISK MANAGEMENT MEASURES

Please refer to the Exposure Scenarios and its Contributing Scenarios as described in Chapter 9 of this CSR.

2. DECLARATION THAT RISK MANAGEMENT MEASURES ARE IMPLEMENTED

All the operational conditions and risk management measures listed in Chapter 9 are implemented at Nouryon.

3. DECLARATION THAT RISK MANAGEMENT MEASURES ARE COMMUNICATED

All risk management measures are communicated internally as this CSA is solely applicable to own uses.

Part B

1. IDENTITY OF THE SUBSTANCE AND PHYSICAL AND CHEMICAL PROPERTIES

1.1. Name and other identifiers of the substance

The substance Renewable hydrocarbons (diesel type fraction) is a UVCB (organic) having the following characteristics and physical–chemical properties (see the IUCLID dataset for further details).
The following public name is used:

Table 1.1. Substance identity

EC number:	618-882-6
CAS number:	928771-01-1
CAS name:	Alkanes, C10-20-branched and linear
Synonyms:	common name: HVO
Molecular formula:	C10-20 & H22-42

Remarks:
No molecular weight is available as the substance is a UVCB.

1.2. Composition of the substance

Overall information on composition:

Composition	Related composition(s)
Renewable hydrocarbons (Alkanes, C10-20-branched and linear) (CAS 928771-01-1 EC 618-882-6) used as blanketing fluid in salt mining (legal entity composition of the substance)	Renewable hydrocarbons (Alkanes, C10-20-branched and linear) – Composition as described by Nouryon
Renewable hydrocarbons (Alkanes, C10-20-branched and linear) – Composition as described by Nouryon (composition provided by Nouryon)	

Name: Renewable hydrocarbons (Alkanes, C10-20-branched and) (CAS 928771-01-1, EC 618-882-6) used as blanketing fluid in salt mining

State/form: liquid
Degree of purity: <=100 % (w/w)
Description: Composition as described in the SDS provided by the supplier. NOURYON applies a solution mining technology in Haaksbergen (Netherlands) to produce brine as a raw material for its salt plants. In a single well, through concentric pipes water is injected in the inner pipe down into a subsurface salt rock layer to dissolve the salt. Brine is then pumped up to the surface and transported via another pipeline to the salt production site. In an outer annular pipe, a thin layer of protective fluid (blanketing fluid which in this case is HVO) is injected at the top surface of the brine, creating a barrier between the brine/water solution and the salt rock roof of the cavern, therefore controlling the development of the cavern. In the borehole, the concentric tubes are isolated from the different geological layers by a cement envelope. At the surface, the cap system guarantees the full control of the different fluids. The junction with the cavern in the salt rock layer also guarantees that the well is tight. HVO is a mixture of renewable raw material fuel and additives (CAS 928771-01-1, REACH Nr: 01-2119450077-42-0000 / -0001 / -0002) with a classification of Asp Tox.1 -H304. It

contains middle distillate-range iso and n-paraffinic hydrocarbons, total aromatics at maximum of 0.2%w (of which PAH less than 0.05%w); Renewable hydrocarbons (Alkanes, C10-20-branched and linear). The environmental risk assessment has been conducted using the PetroRisk model which uses the hydrocarbon block approach. Compositional information required in the model input was provided by Nouryon using the analytical method GCxGC-MS/FID (see Annex I).

Table 1.2. Constituents (Renewable hydrocarbons (Alkanes, C10-20-branched and linear)(CAS 928771-01-1, EC 618-882-6) used as blanketing fluid in salt mining)

Constituent	Typical concentration	Concentration range	Remarks
Renewable hydrocarbons (Alkanes, C10-20-branched and linear)	<=100 % (w/w)	<=100 % (w/w)	

<u>Name: Renewable hydrocarbons (Alkanes, C10-20-branched and linear) – Composition as described by Nouryon</u>

State/form: liquid
Degree of purity: 100 % (w/w)
Description: Typical composition based upon GCxGC – FID Analysis in % as described in the analytical report performed by Nouryon (see Annex I).

Table 1.3. Constituents (Renewable hydrocarbons (Alkanes, C10-20-branched and linear) – Composition as described by Nouryon)

Constituent	Typical concentration	Concentration range	Remarks
C1-C9 branched and linear hydrocarbons EC no.:		>=0 - <=0.1 % (w/w)	
C9 branched and linear hydrocarbons EC no.:		>=0 - <=0.1 % (w/w)	
C10 branched and linear hydrocarbons EC no.:		>=0 - <=0.5 % (w/w)	
C11 branched and linear hydrocarbons EC no.:		>=0 - <=0.5 % (w/w)	
C12 branched and linear hydrocarbons EC no.:		>=0 - <=0.5 % (w/w)	
C13 branched and linear hydrocarbons EC no.:		>=0.25 - <=1 % (w/w)	
C14 branched and linear hydrocarbons EC no.:		>=0.5 - <=1.5 % (w/w)	
C15 branched and linear hydrocarbons EC no.:		>=7.5 - <=12.5 % (w/w)	
C16 branched and linear hydrocarbons EC no.:		>=25 - <=30 % (w/w)	
C17 branched and linear hydrocarbons EC no.:		>=15 - <=25 % (w/w)	
C18 branched and linear hydrocarbons EC no.:		>=35 - <=45 % (w/w)	
C19 branched and linear hydrocarbons EC no.:		>=0 - <=0.5 % (w/w)	
C20 branched and linear hydrocarbons EC no.:		>=0 - <=0.5 % (w/w)	
> C201 branched and		>=0 - <=0.5 % (w/w)	

linear hydrocarbons EC no.:			
Normal alkanes or paraffins (n-P) EC no.:		>=10 - <=20 % (w/w)	
Branched alkanes or paraffins (i-P) EC no.:		>=80 - <=90 % (w/w)	
Mono-naphthenics (m-N) EC no.:		>=0 - <=0.5 % (w/w)	
Mono-aromatics (MoAr) EC no.:		<0.05 % (w/w)	
Di-aromatics (DiAr) EC no.:		<0.05 % (w/w)	
Polycyclic aromatic hydrocarbons (PAHs) EC no.:		<0.05 % (w/w)	

1.3. Physicochemical properties

Table 1.4. Physicochemical properties

Property	Value used for CSA / Discussion	Description of key information
Physical state	**liquid at 20°C and 101.3 kPa**	The substance is a clear liquid.
Melting / freezing point	**-20°C at 101.3 kPa**	A value of <-20 °C at 1013 hPa was reported in the Safety Data Sheet received from the supplier, tested with BS4633 & EC method A1. This was also reported in the REACH disseminated dossier.
Boiling point	**242°C at 101.3 kPa**	A range was reported on the Safety Data Sheet received from the supplier: 180 - 230 °C at 1013 hPa, tested with EN ISO 3405. The REACH disseminated dossier reports a boiling point range of 127 to 286°C at 1004.4 to 1011.5 hPa, tested with EU method A2. The REACH disseminated dossier also indicates that for Chemical Safety Assessment purposes (fugacity and EUSES models), the boiling point weighted average 242°C calculated based on the carbon number frequency is used. This value is therefore also used in this Chemical Safety Assessment.
Relative density	**0.772 at 20°C**	A range of 0.77 - 0.79 at 15 and 4 °C was reported on the Safety Data Sheet of the supplier, tested with EN ISO 12185 & EC A3. The lower limit of the range was used as a worst-case for the Chemical Safety Assessment and was also reported in the REACH disseminated dossier (0.772 at 20 +/- 0.5 °C).
Vapour pressure	**245 Pa at 45°C**	A value of 0.087 kPa at 25 °C was reported in the Safety Data Sheet of the supplier, tested with EC method A4.

		Based on the study results in the REACH disseminated dossier the vapour pressure at higher temperatures can be calculated: 113 Pa at 30 °C, 191 Pa at 40 °C and 245 Pa at 45 °C. The value at 30 °C may be used for the Chemical Safety Assessment as this represents the maximum possible average temperature on one day in The Netherlands best. However, as a worst-case the value of 245 Pa at 45 °C is used (maximum temperature of HVO in the cavern). Regarding the environmental risk assessment, a predicted vapour pressure of 20.4 Pa is used in PetroRisk modelling. As this has limited impact on the assessment, a worst-case value of 245 Pa is reported in the CSA.
Partition coefficient n-octanol/water (log value)	**Log Kow (Log Pow): 8.4 at 20°C**	A value of >6.5 was reported in the Safety Data Sheet of the supplier, tested with EC method A8. The disseminated REACH dossier reports a range of 4.7 - 10.2 with the weighted average being 8.4 at 20 °C, determined with a calculation on the individual components of the UVCB via KOWWIN. The latter value is considered to be more reliable and is therefore used.
Water solubility	**0.075mg/L at 25°C**	A value of approximately 0.075 mg/l in water at 25 °C was reported in the Safety Data Sheet of the supplier. This is a calculated value using WSKOWWIN as reported in the REACH disseminated dossier. As part of the environmental risk assessment, a predicted value of 0.078 mg/L was used in the PetroRisk model. This is an overconservative assumption as solubility is expected to be lower when in contact with Brine.
Flash point	**64°C at 1013 hPa**	A flashpoint of >61 °C was reported on the Safety Data Sheet of the supplier, tested with EN ISO 2719 & EC method A9. The disseminated REACH dossier indicates an exact value of 64 °C in accordance with the same method.
Autoflammability / self-ignition temperature	**204°C at 1013 hPa**	A value of 204 °C was reported in the Safety Data Sheet of the supplier, tested with EC method A15. The REACH disseminated dossier reports

		the same value.
Flammability	**not classified**	Based on the flashpoint of 64 °C the substance is considered to be non-flammable.
Explosive properties	**non explosive**	The substance was considered to be non-explosive as reported on the Safety Data Sheet of the supplier, testing with EC method A14.
Oxidising properties	**non oxidising**	The supplier Safety Data Sheet indicates that the substance does not meet the criteria for classification as oxidising.
Viscosity	**Viscosity: 4mm²/s (static) at 20°C**	A value for kinematic viscosity of 4.0 mm2/s at 20 °C and 2.6 mm2/s at 40°C is reported on the Safety Data Sheet of the supplier, tested with the OECD 114 method. A value for dynamic viscosity of ≤5 mPa*s at 20°C is also reported.

Discussion of physicochemical properties

The collection of this data was for a downstream Chemical Safety Assessment / Chemical Safety Report (CSA/CSR). Therefore, only the relevant data to conduct the DU-CSR were gathered. The main sources of information included a SDS provided by the supplier and verified using the REACH Registration dossier, and the substance composition received and analysed by Nouryon.

The environmental risk assessment has been conducted using the PETRORISK model, meaning all phys-chem input are based on predicted values from the model instead of measured data.

The assessment is a tier-1 approach, this means that all the chosen values are worst-case and that the generate values are not realistic values but a way to demonstrate without refinements that there is no risk or that the risks are controlled so that the activity can be considered as safe according to the REACH legislation.

2. MANUFACTURE AND USES

Cumulative tonnages:
- Cumulative tonnage for uses at industrial sites: <=1800 tonnes/year (Storage on salt mining site)
- Cumulative tonnage for widespread uses by professional workers: <=0 tonnes/year
- Cumulative tonnage for consumer uses: <=0 tonnes/year
- Cumulative tonnage for service life: <=0 tonnes/year

2.1. Manufacture

No information available on manufacture.

2.2. Identified uses

	Uses at industrial sites
IW-1	**Storage on salt mining site** Further description of the use: HVO is stored in a 300-cubic-meter sealed tank storage with a vent at roof level. From/to this tank oil is pumped into/from a tank truck that is used to transport the oil to/from the wells where it is pumped in/out to adjust the levels for blanketing as needed or to allow maintenance (also see the pumping and maintenance exposure scenarios). The storage tank is set with all the required technical/control/management safety measures required by the petroleum industry standards. Contributing activity/technique for the environment: **- STORAGE (in a sealed tank above ground) (ERC4)** Contributing activity/technique for the workers : **- Storage (in a tank with vent above ground) (PROC 2)** **Product Category used:** PC 0: Other: HVO used as blanketing fluid in salt mining. **Sector of end use:** SU 2a: Mining (without offshore industries) use reported by Downstream user according to REACH Article 38 Tonnage of substance for that use: <=300 tonnes/year STORAGE (tank maximum capacity): Initial value: 257 t/y Initial value + 10% (to consider any possible increase or variations): 283 t/y Final value used in the CSA (simplification to an upper value): 300 t/y Substance supplied to that use: as such
IW-2	**Pumping activities on salt mining site** Further description of the use: **Pumping to adjust the HVO level in the caverns** Typically, during normal salt production, the HVO levels are monitored by means of a pressure device. Because of the flat shape of the caverns, adjustments occur weekly. The operator can go from one well "salt house" to another to adjust the levels. All equipment is connected hermetically to avoid leakages or spills and the installation has impervious flooring to collect any loss. **Pumping for maintenance** Prior to the opening of the well for maintenance (see the corresponding Contributing Scenario) all HVO is drained from the cavern. This is done by using the pressure in the cavern that pushes HVO out towards the tank truck. After the maintenance HVO is pumped back into the cavern by using the tank car with an onboard pump. All equipment is connected hermetically so to avoid leakages or spills and the installation has impervious flooring to collect any loss. Temperatures above ground are typically in the range of 20-25 °C and with a maximum of 30 °C. A worst-case temperature of 45 °C is adopted for risk assessment based on maximum cavern temperature. **Removal of oil at the end of salt production by a cavern** Pumping activities are the same as for e.g. maintenance. The removed HVO is reused in other caverns that are starting up or are already in production. No HVO is disposed as waste.

	Description of abandonment of cavern When a cavern has reached its maximum size production is stopped, oil removed, and the cavern is given time to stabilize (homogeneous temperature and full saturation of the brine) during several months to years. Final well and cavern measurements are conducted to assess (size and shape by sonar imaging, integrity by means of pressure testing, cement bonding logging to check cement connection. A plug-and-abandon plan is developed indicating where plugs will be placed to secure vertical isolation from water layers. This plan also provides information on decommissioning of well pad, tiny house, pipelines and other infrastructure. After the Supervising Authority (SodM) has approved the plan the casing is milled and cement plugs are put in place. The vertical piping is removed, the well cut off at 3 m subsurface and the soil quality is restored. A final report is sent to SodM. Contributing activity/technique for the environment : **- PUMPING (above ground activities) (ERC4)** Contributing activity/technique for the workers : **- Pumping of HVO to/from tanker truck (large, medium, small) and in/out of storage tank (PROC 8b)** **- Pumping of HVO in/out of storage tank and into underground cavern (PROC 8b)** **Product Category used:** PC 0: Other: HVO used as blanketing fluid in salt mining **Sector of end use:** SU 2a: Mining (without offshore industries) use reported by Downstream user according to REACH Article 38 Tonnage of substance for that use: <=850 tonnes/year PUMPING (large volume pumping volumes for maintenance of a cavern all 5 years, and small pumping volumes for adjustments of the blanketing in the caverns): Initial value: 770 t/y Initial value + 10% (to consider any possible increase or variations): 847 t/y Final value used in the CSA (simplification to an upper value): 850 t/y Substance supplied to that use: as such
IW-3	**Maintenance activities (work-over) on salt mining site** Further description of the use: HVO first needs to be removed from the cavern (see pumping exposure scenario) before the well can be opened for maintenance (work-over). After the removal of the well head, brine is collected and reused in the plant. The production strings are then pulled out. Only the outer string can be contaminated with a very thin layer of HVO, however, usually there is HVO present as when it is pushed up in the outer annular pipe, brine replaces its volume. If any HVO would come out it is collected in the containment box and by means of a vacuum tank. At the end of the maintenance activities the tubes are run in the well again and the wellhead is replaced at the top. When all is fixed a handover is done to the production organisation and HVO is put back into the cavern again by using the tank car (see pumping contributing scenario). Note that when the salt production ceases in one cavern, the activities performed can be seen as equivalent to this maintenance activity , therefore abandonment is covered by this maintenance exposure scenario. Contributing activity/technique for the environment : **- TUBING MAINTENANCE (above ground activities) (ERC4)** Contributing activity/technique for the workers : **- Tubing maintenance (above ground activity) (PROC28)** **Product Category used:** PC 0: Other: HVO used as blanketing fluid in salt mining **Sector of end use:** SU 2a: Mining (without offshore industries) use reported by Downstream user according to REACH Article 38 Tonnage of substance for that use: <=50 tonnes/year MAINTENANCE (non-realistic worst-case assumption: 5% of the volume that is pumped before and after maintenance): Initial value: 38.5 t/y Initial value + 10% (to consider any possible increase or variations): 42.4 t/y Final value used in the CSA (simplification to an upper value): 50 t/y Substance supplied to that use: as such
IW-4	**Blanketing fluid in salt mining** Further description of the use:

	Nouryon applies solution mining technology to produce brine as raw material for their salt plants in Hengelo and Delfzijl (Netherlands). With this technology, through concentric pipes, water (in the tube placed in the middle) is injected in a subsurface salt layer, brine pumped out (in the inner tube) to the surface and transported by pipelines, and oil (in the outside tube) distributed as a thin layer on the top of the brine to control the cavern roof dissolution. With the aim to control the development of the caverns, HVO will be used as a blanket material in the Haaksbergen caverns to create a barrier between the brine/water solution and the roof of the cavern. In the borehole, the concentric tubes are isolated from the different geological layers by a cement envelope. At the surface, the cap system guarantees the full control of the different fluids. The junction with the cavern in the salt rock layer also guarantees that the well is tight. For further details one can read the SPERC NOURYON 7.1c.v1 background document, which contents schematics of the cavern and well settings. Contributing activity/technique for the environment : **- BLANKETING FLUID in the confined system composed of the underground cavern and the well that relate it to the surface (ERC7)** Contributing activity/technique for the workers : **- Use as blanketing fluid in the cavern underground (PROC 1)** **- Presence of HVO layer on brine (during salt production above ground) (PROC 10)** **- Quality control of the HVO product (PROC 15)** **Product Category used:** PC 0: Other: HVO used as blanketing fluid to isolate brine from halide at the top of salt caverns. **Sector of end use:** SU 2a: Mining (without offshore industries) **Technical function of the substance:** barrier (sealant) use reported by Downstream user according to REACH Article 38 Tonnage of substance for that use: <=600 tonnes/year BLANKETING: Initial value: 535 t/y Initial value + 10% (to consider any possible increase or variations): 589 t/y Final value used in the CSA (simplification to an upper value): 600 t/y Substance supplied to that use: as such

3. CLASSIFICATION AND LABELLING

3.1. Classification and labelling according to CLP / GHS

Substance: HVO
Implementation: EU
The substance is classified as follows:

Table 3.1. Classification and labelling according to CLP / GHS for physicochemical properties

Hazard class	Hazard category	Hazard statement	Reason for no classification
Explosives:			data conclusive but not sufficient for classification
Desensitised explosives:			data lacking
Flammable gases and chemically unstable gases:			data conclusive but not sufficient for classification
Flammable aerosols:			data conclusive but not sufficient for classification
Oxidising gases:			data conclusive but not sufficient for classification
Gases under pressure:			data conclusive but not sufficient for classification
Flammable liquids:			data conclusive but not sufficient for classification
Flammable solids:			data conclusive but not sufficient for classification
Self-reactive substances and mixtures:			data conclusive but not sufficient for classification
Pyrophoric liquids:			data conclusive but not sufficient for classification
Pyrophoric solids:			data conclusive but not sufficient for classification
Self-heating substances and mixtures:			data conclusive but not sufficient for classification
Substances and mixtures which in contact with water emit flammable gases:			data conclusive but not sufficient for classification
Oxidising liquids:			data conclusive but not sufficient for classification
Oxidising solids:			data conclusive but not sufficient for classification
Organic peroxides:			data conclusive but not sufficient for classification

Corrosive to metals:			data conclusive but not sufficient for classification

Table 3.2. Classification and labelling according to CLP / GHS for health hazards

Hazard class	Hazard category	Hazard statement	Reason for no classification
Acute toxicity - oral:			data conclusive but not sufficient for classification
Acute toxicity - dermal:			data conclusive but not sufficient for classification
Acute toxicity - inhalation:			data conclusive but not sufficient for classification
Skin corrosion / irritation:			data conclusive but not sufficient for classification
Serious damage / eye irritation:			data conclusive but not sufficient for classification
Respiratory sensitisation:			data conclusive but not sufficient for classification
Skin sensitisation:			data conclusive but not sufficient for classification
Aspiration hazard:	Asp. Tox. 1	H304: May be fatal if swallowed and enters airways.	
Reproductive Toxicity:			data conclusive but not sufficient for classification
Reproductive Toxicity: Effects on or via lactation:			data conclusive but not sufficient for classification
Germ cell mutagenicity:			data conclusive but not sufficient for classification
Carcinogenicity:			data conclusive but not sufficient for classification
Specific target organ toxicity – single exposure:			data conclusive but not sufficient for classification
Specific target organ toxicity – repeated exposure:			data conclusive but not sufficient for classification

Table 3.3. Classification and labelling according to CLP / GHS for environmental hazards

Hazard class	Hazard category	Hazard statement	Reason for no classification
Hazards to the aquatic environment (acute/short-term):			data conclusive but not sufficient for classification
Hazards to the aquatic environment (chronic/long-term):			data conclusive but not sufficient for classification
M-Factor acute:			
M-Factor chronic:			
Hazardous to the ozone			data conclusive but not

layer:			sufficient for classification

Labelling

Signal word: Danger

Hazard pictogram:

GHS08: health hazard

Hazard statements:

H304: May be fatal if swallowed and enters airways.

Precautionary statements:

P301+P310: IF SWALLOWED: Immediately call a POISON CENTER/doctor/…

P331: Do NOT induce vomiting.

P405: Store locked up.

P501: Dispose of contents/container to ...

P102: Keep out of reach of children.

Additional labelling requirements (CLP supplemental hazard statement):

EUH066: Repeated exposure may cause skin dryness or cracking.

4. ENVIRONMENTAL FATE PROPERTIES

General discussion of environmental fate and pathways:

The collection of this data was for a downstream Chemical Safety Assessment / Chemical Safety Report (CSA/CSR). Therefore, only the relevant data to conduct the DU-CSR were gathered. The main sources of information included a SDS provided by the supplier and verified using the REACH Registration dossier, and the substance composition received and analysed by Nouryon.

The environmental risk assessment has been conducted using the PetroRisk model, meaning all phys-chem input are based on predicted values from the model instead of measured data.

The assessment is a tier-1 approach, this means that all the chosen values are worst-case and that the generate values are not realistic values but a way to demonstrate without refinements that there is no risk or that the risks are controlled so that the activity can be considered as safe according to the REACH legislation.

4.1. Degradation

4.1.1. Abiotic degradation

4.1.1.1. Hydrolysis

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.1.1.2. Photo-transformation/photolysis

4.1.1.2.1. Photo-transformation in air

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.1.1.2.2. Photo-transformation in water

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.1.1.2.3. Photo-transformation in soil

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.1.2. Biodegradation

4.1.2.1. Biodegradation in water

4.1.2.1.1. Screening tests

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.1.2.1.2. Simulation tests (water and sediments)

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.1.2.1.3. Summary and discussion of biodegradation in water and sediment

Discussion (screening testing)

The following information is taken into account for any hazard / risk / persistency assessment:

The following information is required for CHESAR, however not taken into account for the environmental exposure assessment performed in PetroRisk. As reported in the disseminated dossier, ready biodegradability of the test material was determined in a GLP compliant laboratory according to OECD Guideline 301B (Ready biodegradability; CO2 Evolution Test). As a result, the test material was found readily biodegradable.

Value used for CSA:
Biodegradation in water: readily biodegradable

4.1.2.2. Biodegradation in soil

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.2. Environmental distribution

4.2.1. Adsorption/desorption

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

Discussion

The following information is taken into account for any environmental exposure assessment:

The following information is required for CHESAR, however not taken into account for the environmental exposure assessment performed in PetroRisk. As reported in the disseminated dossier, the adsorption coefficient of the test material was determined in GLP compliant laboratory according to EU Method C.19 Adsorption Coefficient of Commission Regulation (EC) No 440/2008 of 30 May 2008. The Koc was > 427000 (LogKoc > 5.63).

Value used for CSA:
Koc at 20°C: 427000

4.2.2. Volatilisation

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.2.3. Distribution modelling

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.3. Bioaccumulation

4.3.1. Aquatic bioaccumulation

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.3.2. Terrestrial bioaccumulation

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

4.3.3. Summary and discussion of bioaccumulation

Aquatic bioaccumulation
The following information is taken into account for any environmental exposure assessment:

The following information is required for CHESAR, however not taken into account for the environmental exposure assessment performed in PetroRisk. As reported in the disseminated dossier, bioconcentration factors (BCFs) of the main HVO components were determined using BCFWIN program developed by U.S. Environmental Protection Agency. The BCFs ranged from 3.2 to 1949.8 with the weighted average being 116.3.

Value used for CSA:
BCF: 116.3L/kg ww

4.4. Secondary poisoning

Based on the available information, there is no indication of a bioaccumulation potential and, hence, secondary poisoning is not considered relevant (see CSR chapter 7.5 “PNEC derivation and other hazard conclusions)”).

5. HUMAN HEALTH HAZARD ASSESSMENT

5.1. Toxicokinetics (absorption, metabolism, distribution and elimination)

5.1.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.1.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.2. Acute toxicity

5.2.1. Non-human information

5.2.1.1. Acute toxicity: oral

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.2.1.2. Acute toxicity: inhalation

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.2.1.3. Acute toxicity: dermal

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.2.1.4. Acute toxicity: other routes

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.2.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.3. Irritation

5.3.1. Skin

5.3.1.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.3.1.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.3.2. Eye

5.3.2.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.3.2.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.3.3. Respiratory tract

5.3.3.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.3.3.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.4. Corrosivity

5.4.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.4.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.5. Sensitisation

5.5.1. Skin

5.5.1.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.5.1.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.5.2. Respiratory system

5.5.2.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.5.2.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.6. Repeated dose toxicity

5.6.1. Non-human information

5.6.1.1. Repeated dose toxicity: oral

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.6.1.2. Repeated dose toxicity: inhalation

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.6.1.3. Repeated dose toxicity: dermal

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.6.1.4. Repeated dose toxicity: other routes

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.6.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.7. Mutagenicity

5.7.1. Non-human information

5.7.1.1. In vitro data

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.7.1.2. In vivo data

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.7.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.8. Carcinogenicity

5.8.1. Non-human information

5.8.1.1. Carcinogenicity: oral

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.8.1.2. Carcinogenicity: inhalation

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.8.1.3. Carcinogenicity: dermal

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.8.1.4. Carcinogenicity: other routes

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this

DU risk assessment is included in the relevant sections of this CSR.

5.8.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.9. Toxicity for reproduction

5.9.1. Effects on fertility

5.9.1.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.9.1.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.9.2. Developmental toxicity

5.9.2.1. Non-human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.9.2.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.10. Other effects

5.10.1. Non-human information

5.10.1.1. Neurotoxicity

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.10.1.2. Immunotoxicity

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.10.1.3. Specific investigations: other studies

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.10.1.4. Additional toxicological effects

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.10.2. Human information

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.11. Derivation of DNEL(s) and other hazard conclusions

5.11.1. Overview of typical dose descriptors for all endpoints

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for "Renewable hydrocarbons (Alkanes, C10-20-branched and linear)". Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

5.11.2. Selection of the DNEL(s) or other hazard conclusions for critical health effects

Table 5.1. Hazard conclusions for workers

Route	Type of effect	Hazard conclusion	Most sensitive endpoint
Inhalation	Systemic effects - Long-term	DNEL (Derived No Effect Level) 147mg/m³	repeated dose toxicity
Inhalation	Systemic effects - Acute	no hazard identified	
Inhalation	Local effects - Long-term	no hazard identified	
Inhalation	Local effects - Acute	no hazard identified	
Dermal	Systemic effects - Long-term	DNEL (Derived No Effect Level) 42mg/kg bw/day	repeated dose toxicity
Dermal	Systemic effects - Acute	no hazard identified	
Dermal	Local effects - Long-term	no hazard identified	
Dermal	Local effects - Acute	no hazard identified	
Eyes	Local effects	no hazard identified	

Inhalation Systemic effects - Long-term

Dose descriptor starting point: NOAEC
Overall Assessment Factor: 6
Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Inhalation Systemic effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Inhalation Local effects - Long-term

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Inhalation Local effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Dermal Systemic effects - Long-term

Dose descriptor starting point: NOAEL
Overall Assessment Factor: 24
Further explanation on hazard conclusions:

DNEL as reported in the REACH disseminated dossier.

Dermal Systemic effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Dermal Local effects - Long-term

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Dermal Local effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Table 5.2. Hazard conclusions for the general population

Route	Type of effect	Hazard conclusion	Most sensitive endpoint
Inhalation	Systemic effects - Long-term	DNEL (Derived No Effect Level) 94mg/m³	repeated dose toxicity
Inhalation	Systemic effects - Acute	no hazard identified	
Inhalation	Local effects - Long-term	no hazard identified	
Inhalation	Local effects - Acute	no hazard identified	
Dermal	Systemic effects - Long-term	DNEL (Derived No Effect Level) 18mg/kg bw/day	repeated dose toxicity
Dermal	Systemic effects - Acute	no hazard identified	
Dermal	Local effects - Long-term	no hazard identified	
Dermal	Local effects - Acute	no hazard identified	
Oral	Systemic effects - Long-term	DNEL (Derived No Effect Level) 18mg/kg bw/day	repeated dose toxicity
Oral	Systemic effects - Acute	no hazard identified	
Eyes	Local effects	no hazard identified	

Inhalation Systemic effects - Long-term

Overall Assessment Factor: 10

Further explanation on hazard conclusions:

DNEL as reported in the REACH disseminated dossier.

Inhalation Systemic effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Inhalation Local effects - Long-term

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Inhalation Local effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Dermal Systemic effects - Long-term

Modified dose descriptor starting point: NOAEL

Overall Assessment Factor: 40

Further explanation on hazard conclusions:

DNEL as reported in the REACH disseminated dossier.

Dermal Systemic effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Dermal Local effects - Long-term

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Dermal Local effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

Oral Systemic effects - Long-term

Dose descriptor starting point: NOAEL

Overall Assessment Factor: 40

Further explanation on hazard conclusions:

DNEL as reported in the REACH disseminated dossier.

Oral Systemic effects - Acute

Further explanation on hazard conclusions:

Conclusion as reported in the REACH disseminated dossier.

6. HUMAN HEALTH HAZARD ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES

6.1. Explosivity

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

Discussion

The following information is taken into account for any hazard / risk assessment:

The substance was considered to be non-explosive as reported on the Safety Data Sheet of the supplier, testing with EC method A14.

Value used for CSA:
Explosiveness: non explosive

Classification according to GHS

Name: HVO

Classification: data conclusive but not sufficient for classification

6.2. Flammability

Flammability

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

Discussion

The following information is taken into account for any hazard / risk assessment:
Flammability
Key value for chemical safety assessment: Flammability: not classified

Based on the flashpoint of 64 °C the substance is considered to be non-flammable.

Flash Point

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

Discussion

The following information is taken into account for any hazard / risk assessment:

A flashpoint of >61 °C was reported on the Safety Data Sheet of the supplier, tested with EN ISO 2719 & EC method A9.

The disseminated REACH dossier indicates an exact value of 64 °C in accordance with the same method.

Classification according to GHS

Name: HVO

Classification (gas): data conclusive but not sufficient for classification
Classification (liquid): data conclusive but not sufficient for classification
Classification (solid): data conclusive but not sufficient for classification

6.3. Oxidising potential

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

Discussion

The following information is taken into account for any hazard / risk assessment:

The supplier Safety Data Sheet indicates that the substance does not meet the criteria for classification as oxidising.

Value used for CSA:
Oxidising properties: non oxidising

Classification according to GHS

Name: HVO

Classification (gas): data conclusive but not sufficient for classification
Classification (liquid): data conclusive but not sufficient for classification
Classification (solid): data conclusive but not sufficient for classification

7. ENVIRONMENTAL HAZARD ASSESSMENT

7.1. Aquatic compartment (including sediment)

7.1.1. Fish

7.1.1.1. Short-term toxicity to fish

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.1.1.2. Long-term toxicity to fish

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.1.2. Aquatic invertebrates

7.1.2.1. Short-term toxicity to aquatic invertebrates

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.1.2.2. Long-term toxicity to aquatic invertebrates

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.1.3. Algae and aquatic plants

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.1.4. Sediment organisms

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.1.5. Other aquatic organisms

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.2. Terrestrial compartment

7.2.1. Toxicity to soil macro-organisms

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.2.2. Toxicity to terrestrial plants

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.2.3. Toxicity to soil micro-organisms

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.2.4. Toxicity to other terrestrial organisms

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.3. Atmospheric compartment

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.4. Microbiological activity in sewage treatment systems

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.5. Non compartment specific effects relevant for the food chain (secondary poisoning)

7.5.1. Toxicity to birds

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.5.2. Toxicity to mammals

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

7.6. PNEC derivation and other hazard conclusions

7.6.1. PNEC derivation and other hazard conclusions

Table 7.1. Hazard assessment conclusion for the environment

Compartment	Hazard conclusion	Remarks/Justification
Freshwater	PNEC aqua (freshwater): 0.01mg/L Intermittent releases: 0.1mg/L	Assessment factor: 100 Extrapolation method: assessment factor PNEC aqua (freshwater) PNEC as reported in the REACH disseminated dossier.
Marine water	PNEC aqua (marine water): 0.01mg/L Intermittent releases:	Assessment factor: 100 Extrapolation method: assessment factor PNEC aqua (marine water) PNEC as reported in the REACH disseminated dossier.
Sediments (freshwater)	PNEC sediment (freshwater): 3.81mg/kg sediment dw	Extrapolation method: equilibrium partitioning method PNEC sediment (freshwater) PNEC as reported in the REACH disseminated dossier.
Sediments (marine water)	PNEC sediment (marine water): 3.73mg/kg sediment dw	Assessment factor: 100 Extrapolation method: assessment factor PNEC sediment (marine water) PNEC as reported in the REACH disseminated dossier.
Sewage treatment plant	PNEC STP: 10mg/L	Assessment factor: 100 Extrapolation method: assessment factor PNEC STP PNEC as reported in the REACH disseminated dossier.
Soil	PNEC soil: 761mg/kg soil dw	Extrapolation method: equilibrium partitioning method PNEC soil PNEC as reported in the REACH disseminated dossier.
Air	no hazard identified:	Conclusion as reported in the REACH disseminated dossier.
Secondary poisoning	no potential for bioaccumulation:	

Conclusion on environmental classification

According to the CLP regulation Table 4.1.0., a substance is categorized as hazardous for aquatic environment if LC50 > 10 to < 100 mg/l (Chronic Category 3) or if it is lipophilic (log Kow ≥ 4) and not rapidly biodegradable (”Safety net” classification, Chronic Category 4). Since LC50 of all the acute toxicity tests was ≥ 100 mg/l and the test material was found readily biodegradable in OECD CO2 evolution test 301B, the test material is not classified as hazardous to aquatic environment.

General discussion
HVO is not classified as ”Toxic” or ”Harmful”, hence no formal assessment of secondary poisoning is required. However, a PNECoral has been derived for the record, which demonstrates no concern with regard to possible secondary poisoning.

The collection of this data was for a downstream Chemical Safety Assessment / Chemical Safety Report (CSA/CSR). Therefore, only the relevant data to conduct the DU-CSR were gathered. The main sources of information included a SDS provided by the supplier and verified using the REACH Registration dossier, and the substance composition received and analysed by Nouryon.

The environmental risk assessment has been conducted using the PetroRisk model, meaning all phys-chem input are based on predicted values from the model instead of measured data.

The assessment is a tier-1 approach, this means that all the chosen values are worst-case and that the generate values are not realistic values but a way to demonstrate without refinements that there is no risk or that the risks are controlled so that the activity can be considered as safe according to the REACH legislation.

8. PBT AND vPvB ASSESSMENT

8.1. Assessment of PBT/vPvB Properties

8.1.1. PBT/vPvB criteria and justification

This information is not required in a downstream user CSR and is considered to be included in the registration dossier for “Renewable hydrocarbons (Alkanes, C10-20-branched and linear)”. Relevant information for this DU risk assessment is included in the relevant sections of this CSR.

8.1.2. Summary and overall conclusions on PBT or vPvB properties

Overall conclusion: Based on the assessment described in the subsections above the submission substance is not a PBT / vPvB substance.

Justification:

The substance does not fulfil any of the criteria according to Annex XIII, and therefore does not require classification as PBT compound.

8.2. Emission characterisation

9. EXPOSURE ASSESSMENT (and related risk characterisation)

The sections 9 and 10 of this CSR have been generated with Chesar 3.5.

9.0. Introduction

9.0.1. Overview on uses

See the description of the various uses in section 2 of the CSR.
This is a downstream user CSA/CSR. There is no need to assess the Manufacture / Import stage. The use as blanketing fluid in salt mining is a future use which will take place at the Haaksbergen site in the Netherlands. These activities comprise of:

- storage in a tank on site,
- pumping in/out of the caverns and from/to the tank or truck,
- the maintenance of the wells,
- the blanketing use in the caverns underground.

HVO is used as a blanketing fluid in the underground caverns to protect the roof of the caverns during salt production. Once a cavern is no longer in production, HVO is recovered and pumped into a tanker truck for reuse in another cavern or stored in a tank for later reuse.
HVO is stored in an above ground oil tank, placed in a bun with impervious flooring. In case of leakage or collapse the substance will be captured.
At the Haaksbergen site the transfer to and from the caverns is done using dedicated trucks with on board high-pressure pumps.
Regular additions of HVO levels will take place to preserve the cavern's roof integrity. Oil levels are being monitored by a control system. Depending on the level measured, HVO is added to or removed from the cavern. On a routine basis the field operator checks the HVO levels and provides the crew with information on which caverns need to be partially drained or supplied. The frequency varies with the maturity of the well. As a worst case in total 10 m3/day is used.

9.0.2. Assessment entity groups

Not applicable

9.0.3. Introduction to the assessment for the environment

9.0.3.1. Tonnage

Assessed tonnage: 0 tonnes/year based on:

Tonnage supplied per market sector:

Use as blanketing fluid in salt mining - Haaksbergen site: 1800 tonnes/year
The following table provides the tonnage per use and the local tonnages used in the assessment for each environmental contributing activity. The local tonnage corresponds to a tonnage for uses taking place at industrial sites and to a tonnage assumed for a town of 10,000 inhabitants for widespread uses.

Table 9.1. Tonnage for assessment

ES#	Exposure scenario (ES) name and related environmental contributing scenarios	Tonnage per use (t/year)	Daily local tonnage (t/day)	Annual local tonnage (t/year)
ES1 (IS)	Storage on salt mining site	300		
	- STORAGE (in a sealed tank above ground) (ERC 4)		0.8	300
ES2 (IS)	Pumping activities on salt mining site	850		
	- PUMPING (above ground activities) (ERC 4)		2.3	850

ES#	Exposure scenario (ES) name and related environmental contributing scenarios	Tonnage per use (t/year)	Daily local tonnage (t/day)	Annual local tonnage (t/year)
ES3 (IS)	Maintenance activities (work-over) on salt mining site	50		
	- TUBING MAINTENANCE (above ground activities) (ERC 4)		0.5	50
ES4 (IS)	Blanketing fluid in salt mining	600		
	- BLANKETING FLUID in the confined system composed of the underground cavern and the well that relate it to the surface (ERC 7)		1.6	600

9.0.3.2. Scope and type of assessment for the environment

The scope of exposure assessment and type of risk characterisation required for the environment are described in the following table based on the hazard conclusions presented in section 7.

Table 9.2. Type of risk characterisation required for the environment

The environmental risk assessment is conducted using the Hydrocarbon Block (HB) method. PNEC is derived with the Target Lipid Model (TLM) for the representative structure assigned to the hydrocarbon block. The following PNEC listed below is from the disseminated dossier however was not used in the environmental assessment performed in PetroRisk (V.7.04) for the reasons mentioned above.

Protection target	Risk characterisation type	Hazard conclusion (see section 7)
Fresh water	Quantitative	PNEC aqua (freshwater) = 0.01 mg/L
Sediment (freshwater)	Quantitative	PNEC sediment (freshwater) = 3.81 mg/kg sediment dw
Marine water	Quantitative	PNEC aqua (marine water) = 0.01 mg/L
Sediment (marine water)	Quantitative	PNEC sediment (marine water) = 3.73 mg/kg sediment dw
Sewage Treatment Plant	Quantitative	PNEC STP = 10 mg/L
Air	Not needed	No hazard identified
Agricultural soil	Quantitative	PNEC soil = 761 mg/kg soil dw
Predator's prey (freshwater)	Not needed	No potential for bioaccumulation, as the substance is not a PBT
Predator's prey (marine water)	Not needed	No potential for bioaccumulation, as the substance is not a PBT
Top predator's prey (marine water)	Not needed	No potential for bioaccumulation, as the substance is not a PBT
Predator's prey (terrestrial)	Not needed	No potential for bioaccumulation, as the substance is not a PBT

9.0.3.3. Fate and distribution parameters

Physicochemical properties used for exposure estimation

The following substance properties are used in the fate estimation done by EUSES. They correspond to the "value used for CSA" reported in sections 1 and 4.

Table 9.3. Substance key phys-chem and fate properties

Substance property	Value
Molecular weight	-
Melting point at 101 325 Pa	-20 °C
Vapour pressure	245 Pa at 45 °C

Substance property	Value
Partition coefficient (Log Kow)	8.4 at 20 °C
Water solubility	0.075 mg/L at 25 °C
Biodegradation in water: screening tests	readily biodegradable
Bioaccumulation: BCF (aquatic species)	116.3 L/kg ww
Adsorption/Desorption: Koc at 20 °C	4.27E5

Fate (release percentage) in the modelled biological sewage treatment plant

Since the substance does not enter a sewage treatment plant, the following scenario does not need to be assessed.

9.0.3.4. Comments on assessment approach for the environment

The regional concentrations are reported in section 10.2.1.1. The local Predicted Exposure Concentrations (PECs) reported for each contributing scenario correspond to the sum of the local concentrations (Clocal) and the regional concentrations (PEC regional).
NOURYON applies a solution mining technology in Haaksbergen (Netherlands) to produce brine as a raw material for its salt plants. In a single well, through concentric pipes, water is injected in the inner pipe down into a subsurface salt rock layer to dissolve the salt. Brine is then pumped up to the surface and transported via a another pipeline to the salt production site. In an outer annular pipe, a thin layer of protective fluid (blanketing fluid which in this case is HVO) is injected at the top surface of the brine, creating a barrier between the brine/water solution and the salt rock roof of the cavern, therefore controlling the development of the cavern. In the borehole, the concentric tubes are isolated from the different geological layers by a cement envelope. At the surface, the cap system guarantees the full control of the different fluids. The junction with the cavern in the salt rock layer also guarantees that the well is tight.
HVO is a mixture of renewable raw material fuel and additives (CAS 928771-01-1, REACH Nr: 01-2119450077-42-0000 / -0001 / -0002) with a classification of Asp Tox.1 -H304. It contains middle distillate-range iso and n-paraffinic hydrocarbons, total aromatics at maximum of 0.2%w (of which PAH less than 0.05%w); Renewable hydrocarbons (Alkanes, C10-20-branched and linear); Alkanes, C10-20branched and linear. The environmental risk assessment has been conducted using the PetroRisk model which uses the hydrocarbon block approach. Compositional information required in the model input was provided by Nouryon using the analytical method GCxGC-MS/FID..
As part of the model, calculations are based on hydrocarbon blocks and values are derived from a library containing the physical properties and PNEC for the various structures. The differences in phsy-chem properties such as vapour pressure and water solubility compared to the measured data are not expected to affect the overall environmental risk assessment.
The quantities supplied each year are very low compared to the large amount present and (re)used on-site. Nevertheless, exposures, if they occur, will be related to the total volume handled during each stage of the salt mining activity. Therefore, a theoretical “total (re)used” quantity was proposed in the life cycle tree, which is different from the supplied quantity but corresponds to the sum of quantities used in each step. Data and calculations were made as follows:
The annual tonnage is much lower (the annual supply is 120t), however for the environmental assessment the whole volume present and potentially usable on-site was used as reference.
See details in section “9.0.3.4. Comments on assessment approach for the environment” and the data and calculations presented hereafter for the Haaksbergen site.

	STORAGE (maximum tank capacity)	**PUMPING (maintenance + adjustments)**	**MAINTENANCE 5% of the pumped volume of all maintenances**	**BLANKETING (whole maximum volume in caverns)**	**TOTAL (re)used**
Total on-site (re)used quantities (t/y)	257	770	38.5	385 + 150	1600.5
Total on-site (re)used quantities	283	847	42.5	1848589	1761.5

(t/y) taken into account a 10% growth					
Total on-site (re)used quantities (t/y) taken into account a 10% growth & simplified with an upper value	300	850	50	600	1800

All these uses take place on the same site.

9.0.3.5. Scope and type of assessment for man via environment

The exposure assessment for man via environment is not needed.
As summarized in the disseminated dossier, HVO does not fulfil any of the criteria according to Annex XIII, and therefore does not require classification as PBT compound. The exposure assessment for man via the environment is not required, as the substance is not classified for long-term hazard in human (as carcinogen, mutagen, or toxic to reproduction, or as STOT RE1/2). In addition, the substance is readily biodegradable, and thus is not expected to persist, bioaccumulate or biomagnify in the food chain.

9.0.3.6. Comments on assessment approach for man via the environment

The exposure assessment for man via the environment is not required

9.0.4. Introduction to the assessment for workers

9.0.4.1. Scope and type of assessment for workers

The scope of exposure assessment and type of risk characterisation required for workers are described in the following table based on the hazard conclusions presented in section 5.11.

Table 9.4. Type of risk characterisation required for workers

Route	Type of effect	Risk characterisation type	Hazard conclusion (see section 5.11)
Inhalation	Systemic effects - long term	Quantitative	DNEL (Derived No Effect Level) = 147 mg/m³
	Systemic effects - acute	Not needed	No hazard identified
	Local effects - long term	Not needed	No hazard identified
	Local effects - acute	Not needed	No hazard identified
Dermal	Systemic effects - long term	Quantitative	DNEL (Derived No Effect Level) = 42 mg/kg bw/day
	Systemic effects - acute	Not needed	No hazard identified
	Local effects - long term	Not needed	No hazard identified
	Local effects - acute	Not needed	No hazard identified
Eye	Local effects	Not needed	No hazard identified

9.0.4.2. Comments on assessment approach for workers

Assessment approach related to toxicological hazard:

The worker exposure was assessed quantitively for the long term systemic inhalation and long term systemic dermal route. For these routes the information in the REACH disseminated dossier and SDS of the supplier was used, which contain phys-chem parameters and DNELs. All relevant information from the dossier and SDS that has been used for the exposure assessment is reported in this CSR.

Specifically for the parameter vapour pressure it was decided to use the value at 45 °C, as the temperature of HVO in the cavern can be up to 45 °C as a maximum. Even though at the Haaksbergen location the average day temperature above ground is normally well below 30 °C, the vapour pressure at 45 °C was used as a worst-case value for all worker assessments. The vapour pressure was calculated using the equation as reported in the vapour pressure study in the disseminated REACH dossier. The resulting vapour pressure is 245 Pa.

For the inhalation route, the exposure was estimated using the Advanced REACH Tool (ART; version 1.5). Molecular weight is normally required for an assessment for the inhalation route with ECETOC TRA, but as only ART is used the omission of this parameter is not an issue. For each of the worker contributing scenarios the activity duration is set at 8 hours (full shift length). The 90th percentile of the full shift exposure estimate is used for the risk assessment. The risk characterisation ratios are calculated by dividing the exposure estimate with the long-term systemic inhalation DNEL.

For all contributing scenarios in which dermal contact is even remotely possible during normal operations, the dermal exposure is estimated using the ECETOC TRA dermal model as implemented in Chesar 3.5. If during normal operation dermal contact with HVO is absent (worker activity in the far field) the dermal exposure estimate is considered to be 0 (zero) mg/kg bw/day and therefore the reported ECETOC TRA value is an overestimation. This is applicable for e.g. the HVO storage (in a closed tank with a vent on top) and underground use as blanketing liquid. For other activities which take place (partly) in the far field the ECETOC TRA exposure value will also be an overestimation.

The table below provides an overview of the exposure assessment approach and methods used.

Hazard	**Hazard conclusion**	**Risk characterisation type**	**Exposure model used**	**RCR combined?**
Inhalation, systemic effects - long term	DNEL	Quantitative	ART (v1.5)	Yes
Inhalation, systemic effects – acute	No hazard identified	Not relevant	Not relevant	Not relevant
Inhalation, local - effects long term and acute	No hazard identified	Not relevant	Not relevant	Not relevant
Dermal, systemic effects - long term	DNEL	Quantitative	ECETOC TRA (v3.0)	Yes
Dermal, systemic effects - acute	No hazard identified	Not relevant	Not relevant	Not relevant
Dermal, local effects - long term	No hazard identified	Not relevant	Not relevant	Not relevant
Dermal, local effects - acute	No hazard identified	Not relevant	Not relevant	Not relevant

For the exposure models reasonable worst-case input has been used based on information collected from conversations with Nouryon employees, other available Nouryon documentation and information collected at similar production sites in the Hengelo/Delfzijl area which are currently functional (the Haaksbergen site has not yet been developed so no site visit was possible). The reasonable worst-case input ensures to rule out as much as possible uncertainty in the exposure estimates (and therefore a possible underestimation of the exposure). In addition, the fact that ECETOC TRA is a first-tier instrument with relatively high dermal exposure estimates and the use of the 90th percentile for the full-shift exposure estimate for inhalation within the ART model, allows for the conclusion that uncertainties in the exposure estimates have been taken into account sufficiently.

General information on risk management related to toxicological hazard:

Based on the hazard profile of this substance (H304), entry of the substance into the lungs following ingestion or vomiting should be prevented as this may cause chemical pneumonitis. To prevent this provide proper instructions to the worker (e.g. via the workplace instruction card) that ingestion should be avoided and do not induce vomiting when ingested after all.
A good industrial hygiene program is required for this substance and includes the following:

- Implementation of Occupational Health and Safety management system.
- Application of hierarchy of control in selection risk management options
- Periodic Hazard identification and Risk assessments
- Clear signs
- Training on the use of procedures, applications of risk management measures and PPE (pre-employment, periodically)
- Management supervision
- Good housekeeping practices including cleaning of workplaces, cleaning of spills etc.
- Regular maintenance and pre-start-up inspections
- Clear rules for contractors

Assessment approach related to physicochemical hazard:

The substance is not classified for physicochemical hazards and it is used well below its flashpoint of 64 °C. Therefore no risk assessment these hazards is required.

General information on risk management related to physicochemical hazard:

The substance is not classified for physicochemical hazards, is used well below its flashpoint and therefore no risk management measures are required.

9.0.5. Introduction to the assessment for consumers

Exposure assessment is not applicable as there are no consumer-related uses for the substance.

9.1. Exposure scenario 1: Use at industrial sites - Storage on salt mining site

Market sector: Use as blanketing fluid in salt mining - Haaksbergen site
Product category used: PC 0: Other
Sector of use: SU 2a: Mining (without offshore industries)

Environment contributing scenario(s):		
CS 1	STORAGE (in a sealed tank above ground)	ERC 4
Worker contributing scenario(s):		
CS 2	Storage (in a tank with vent above ground)	PROC 2

Further description of the use:

HVO is stored in a 300-cubic-meter sealed tank storage with a vent at roof level. From/to this tank oil is pumped into/from a tank truck that is used to transport the oil to/from the wells where it is pumped in/out to adjust the levels for blanketing as needed or to allow maintenance (also see the pumping and maintenance exposure scenarios). The storage tank is set with all the required technical/control/management safety measures required by the petroleum industry standards.

9.1.1. Env CS 1: STORAGE (in a sealed tank above ground) (ERC 4)

HVO is stored in an atmospheric 300-cubic-meter sealed tank. No leaks are expected, as the storage tank is placed in a safety retention basin with impermeable flooring. This is an adequate state-of-the-art safety measure. Transfer from tank to oil truck is executed on liquid tight floor.

9.1.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
• Daily use amount at site: <= 0.8 tonnes/day *This value is required for the EUSES calculation but has no real sense on site as the whole volume stays stored all the time – 365 days / year - in the tank.*
• Annual use amount at site: <= 300 tonnes/year *Maximum tank storage capacity.*
• Percentage of EU tonnage used at regional scale: = 100 % *Default value, this is a worst-case.*
Conditions and measures related to biological sewage treatment plant
• Biological STP: None [Effectiveness Water: 0%] *HVO is systematically reused on site and no effluent is directed towards biological STP.* Water explanation: *Not required as no effluent goes to STP.*
Conditions and measures related to external treatment of waste (including article waste)
• Particular considerations on the waste treatment operations: Dedicated recollection infrastructure required *Petroleum products must be recollected for reuse in caverns on the site or taken by a Company specialised in petroleum products waste/recycling.*
Other conditions affecting environmental exposure
• Receiving surface water flow rate: >= 1.8E4 m3/day *Defaults settings in EUSES.*
• Place of use: Outdoor *Storage tank is onsite outdoor on a concrete platform with all safety elements that avoid small or accidental leakages.*
• Discharge rate of effluent: >= 1E6 m3/day *No discharge in water is foreseen because all the oil is collected and re-injected in the caverns. This case can however not be handled by EUSES. Choice is therefore to set it high to reflect the very high dilution that may be expected if some effluents discharges would occur in the receiving water bodies, even this amount is not relevant in the case of this activity, just to allow EUSES to run its calculations. This can be considered as*

equivalent to a zero-effluent case.

9.1.1.2. Releases

The local releases to the environment are reported in the following table. Note that the releases reported do not account for the removal in the modelled biological STP.

Table 9.5. Local releases to the environment

Release	Release estimation method	Explanations
Water	Estimated release factor (Closed system)	**Release factor before on site RMM:** 1E-3% **Release factor after on site RMM:** 1E-3% **Explanation:** Cylindrical closed tank with hermetic loading system, installation in a concrete containment structure, and VOC control measures. Losses by leakages or volatilisation are not expected.
Air	Estimated release factor (Closed system)	**Release factor before on site RMM:** 1E-3% **Release factor after on site RMM:** 1E-3% **Explanation:** Cylindrical closed tank with hermetic loading system, installation in a concrete containment structure, and VOC control measures. Losses by leakages or volatilisation are not expected.
Non agricultural soil	Estimated release factor (Closed system)	**Release factor after on site RMM:** 1E-3% **Explanation:** Cylindrical closed tank with hermetic loading system, installation in a concrete containment structure, and VOC control measures. Losses by leakages or volatilisation are not expected.

Releases to waste

Release factor to external waste: 0 %
Storage is for use, no waste foreseen.

9.1.1.3. Exposure and risks for the environment and man via the environment

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table. The exposure estimates have been obtained withPetroRisk.

Table 9.6. Exposure concentrations and risks for the environment and man via the environment

Protection target	Exposure concentration	Risk quantification
Fresh water	Clocal: 1.59E-4 mg/L (estimated by PetroRISK 7.04)	RCR = 0.0292
Sediment (freshwater)	Clocal: 0.069 mg/kg dw (estimated by PetroRISK 7.04)	RCR = 0.0338
Marine water	Clocal: 1.62E-5 mg/L (estimated by PetroRISK 7.04)	RCR 0.0029
Sediment (marine water)	Clocal: 6.94E-3 mg/kg dw (estimated by PetroRISK 7.04)	RCR = 0.0034
Agricultural soil	Clocal: 1.39E-6 mg/kg dw (estimated by PetroRISK 7.04)	RCR < 0.01

Risk characterisation

No risks were identified related to the whole maximum volume used on site. This is achieved notably by special attention via monitoring of the caverns and wells - to avoid any “chronic” leakage. The assessment does not include incidental/accidental leakages, which were part of the Permitting (MER) assessment.

9.1.2. Worker CS 2: Storage (in a tank with vent above ground) (PROC 2)

This contributing scenario describes the storage of HVO in an outdoor tank above the ground. The tank remains closed at all times (loading/unloading covered by other scenario) but has a vent and therefore cannot be seen as a fully closed system. Therefore, this scenario is modelled with medium level containment. Sampling takes place for quality control irregularly but this is included in another contributing scenario (laboratory work). The tank is positioned in the open field (not near buildings) and the vent is on top of the tank. No workers will work near the roof of the tank for any length of time. The scenario describes an 8 hours activity as if this would be the only work the worker performs on a full working day. No risk management measures are required during the work.

9.1.2.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	ART 1.5 , TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5 , TRA Workers 3.0
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5 , TRA Workers 3.0
Technical and organisational conditions and measures	
• Occupational Health and Safety Management System: Advanced	TRA Workers 3.0
• Surface Contamination/Fugitive Emission Sources: The process is not fully enclosed or the integrity of that enclosure is not regularly monitored but demonstrable and effective housekeeping practices are in place	ART 1.5
• Containment - no extraction: Medium level containment [Effectiveness Inhalation: 99%]	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: No [Effectiveness Dermal: 0%]	TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Outdoor *Source not located close to buildings, but worker is assumed to be within 4 meters distance as a worst-case.*	ART 1.5
• Operating temperature: <= 45 °C *As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.*	ART 1.5 , TRA Workers 3.0
• Activity Class: Activities with open liquid surfaces or open reservoirs - Activities with undisturbed surfaces (no aerosol formation)	ART 1.5
• Open Surface: Surface > 3 m²	ART 1.5

9.1.2.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.7. Exposure concentrations and risks for workers

Route of exposure and type of effects	**Exposure concentration**	**Risk quantification**
Inhalation, systemic, long term	0.064 mg/m³ (ART 1.5)	RCR < 0.01
Dermal, systemic, long term	1.37 mg/kg bw/day (TRA Workers)	RCR = 0.033

Route of exposure and type of effects	Exposure concentration	Risk quantification
Combined routes, systemic, long-term		RCR = 0.033

Remarks on exposure dataset obtained with ECETOC TRA

Explanation: The dermal exposure estimate is based on a worker that is working near the substance in a closed storage tank based on the default ECETOC TRA assessment. However, as the worker is working in the far field of the storage tank, the actual exposure estimate would be 0 mg/kg bw/day and therefore the ECETOC TRA value is considered an overestimation of the exposure.
The vapour pressure at operating temperature (45°C) used for the calculation is 245 Pa (set by the assessor).

Remarks on exposure data from external estimation tools:

ART 1.5:
Explanation: The worker is assumed not to work within the vicinity of the vents of the storage tank and therefore the scenario is modelled with far field exposure only. The predicted 90th percentile full-shift exposure is 0.064 mg/m^3. The inter-quartile confidence interval is 0.029 mg/m^3 to 0.16 mg/m^3.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

9.2. Exposure scenario 2: Use at industrial sites - Pumping activities on salt mining site

Market sector: Use as blanketing fluid in salt mining - Haaksbergen site
Product category used: PC 0: Other
Sector of use: SU 2a: Mining (without offshore industries)

Environment contributing scenario(s):		
CS 1	PUMPING (above ground activities)	ERC 4
Worker contributing scenario(s):		
CS 2	Pumping of HVO to/from tanker truck (large, medium, small) and in/out of storage tank	PROC 8b
CS 3	Pumping of HVO in/out of storage tank and into underground cavern	PROC 8b

Further description of the use:

Pumping to adjust the HVO level in the caverns
Typically, during normal salt production, the HVO levels are monitored by means of a pressure device. Because of the flat shape of the caverns, adjustments occur weekly. The operator can go from one well “salt house” to another to adjust the levels. All equipment is connected hermetically to avoid leakages or spills and the installation has impervious flooring to collect any loss.

Pumping for maintenance
Prior to the opening of the well for maintenance (see the corresponding Contributing Scenario) all HVO is drained from the cavern. This is done by using the pressure in the cavern that pushes HVO out towards the tank truck. After the maintenance HVO is pumped back into the cavern by using the tank car with an onboard pump. All equipment is connected hermetically so to avoid leakages or spills and the installation has impervious flooring to collect any loss. Temperatures above ground are typically in the range of 20-25 °C and with a maximum of 30 °C. A worst-case temperature of 45 °C is adopted for risk assessment based on maximum cavern temperature.

Removal of oil at the end of salt production by a cavern
Pumping activities are the same as for e.g. maintenance. The removed HVO is reused in other caverns that are starting up or are already in production. No HVO is disposed as waste.

Description of abandonment of cavern
When a cavern has reached its maximum size production is stopped, oil removed, and the cavern is given time to stabilize (homogeneous temperature and full saturation of the brine) during several months to years. Final well and cavern measurements are conducted to assess (size and shape by sonar imaging, integrity by means of pressure testing, cement bonding logging to check cement connection. A plug-and-abandon plan is developed indicating where plugs will be placed to secure vertical isolation from water layers. This plan also provides information on decommissioning of well pad, tiny house, pipelines and other infrastructure. After the Supervising Authority (SodM) has approved the plan the casing is milled and cement plugs are put in place. The vertical piping is removed, the well cut off at 3 m subsurface and the soil quality is restored. A final report is sent to SodM.

9.2.1. Env CS 1: PUMPING (above ground activities) (ERC 4)

Pumping in or out of the salt caverns in large volumes is conducted when a new cavern is started, or the cavern salt production activity stops, as also before and after maintenance activities. This contributing scenario also covers the pumping of small volumes that are conducted to adjust the level of the blanketing layer in the caverns (see “further description of the use” for additional details).

9.2.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
• Daily use amount at site: <= 2.3 tonnes/day *Pumping activities can be to move small volumes notably to adjust the oil level in the caverns, but also*

larger volumes when all the oil of a cavern must be removed for maintenance..
• Annual use amount at site: <= 850 tonnes/year *This is an average yearly quantity of oil pumped to manage the salt production of all the caverns of the site. Some variations are acceptable without a significant impact on the CSA outcomes.*
• Percentage of EU tonnage used at regional scale: = 100 % *Default value, this is a worst-case.*
Conditions and measures related to biological sewage treatment plant
• Biological STP: None [Effectiveness Water: 0%] *HVO is systematically reused on site and no effluent is directed towards biological STP.* Water explanation: *Not required as no effluent goes to STP.*
Conditions and measures related to external treatment of waste (including article waste)
• Particular considerations on the waste treatment operations: Dedicated recollection infrastructure required *Petroleum products must be recollected for reuse in caverns on the site or taken by a Company specialised in petroleum products waste/recycling.*
Other conditions affecting environmental exposure
• Receiving surface water flow rate: >= 1.8E4 m3/day *Defaults settings in EUSES.*
• Place of use: Outdoor *Pumping activities are transfers of HVO between the tank truck and the storage tank or the caverns. They thus take place onsite outdoor on a concrete platform with all safety elements that avoid small or accidental leakages.*
• Discharge rate of effluent: >= 1E6 m3/day *No discharge in water is foreseen because all the oil is collected and re-injected in the caverns. This case can however not be handled by EUSES. Choice is therefore to set it high to reflect the very high dilution that may be expected if some effluents discharges would occur in the receiving water bodies, even this amount is not relevant in the case of this activity, just to allow EUSES to run its calculations. This can be considered as equivalent to a zero-effluent case.*

9.2.1.2. Releases

The local releases to the environment are reported in the following table. Note that the releases reported do not account for the removal in the modelled biological STP.

Table 9.8. Local releases to the environment

Release	Release estimation method	Explanations
Water	Estimated release factor (Closed system)	**Release factor before on site RMM:** 0.01% **Release factor after on site RMM:** 0.01% **Explanation:** Pumping activities were handled by trained staff. All connections between tank, tank trucker, well valves, etc, are state-of-the-art devices guaranteeing absence of losses. Moreover, all activities take place on concrete platforms with retention basins.
Air	Estimated release factor (Closed system)	**Release factor before on site RMM:** 0.1% **Release factor after on site RMM:** 0.1% **Explanation:** Pumping activities were handled by trained staff. All connections between tank, tank trucker, well valves, etc, are state-of-the-art devices guaranteeing absence of losses. Moreover, all activities take place on concrete platforms with retention basins.
Non agricultural soil	Estimated release factor (Closed system)	**Release factor after on site RMM:** 0.01% **Explanation:**

Release	Release estimation method	Explanations
		Pumping activities were handled by trained staff. All connections between tank, tank trucker, well valves, etc, are state-of-the-art devices guaranteeing absence of losses. Moreover, all activities take place on concrete platforms with retention basins.

Releases to waste

Release factor to external waste: 0 %
Pumping is for use, no waste foreseen.

9.2.1.3. Exposure and risks for the environment and man via the environment

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table. The exposure estimates have been obtained withPetroRisk.

Table 9.9. Exposure concentrations and risks for the environment and man via the environment

Protection target	Exposure concentration	Risk quantification
Fresh water	Clocal: 1.37E-3 mg/L (estimated by PetroRisk 7.04)	RCR = 0.248
Sediment (freshwater)	Clocal: 0.590 mg/kg dw (estimated by PetroRisk 7.04)	RCR = 0.288
Marine water	Clocal: 1.37E-4 mg/L (estimated by PetroRisk 7.04)	RCR = 0.025
Sediment (marine water)	Clocal: 0.059mg/kg dw (estimated by PetroRisk 7.04)	RCR = 0.029
Agricultural soil	Clocal: 3.01E-7 mg/kg dw (estimated by PetroRisk 7.04)	RCR < 0.01

Risk characterisation

No risks were identified related to the whole maximum volume used on site. This is achieved notably by special attention via monitoring of the caverns and wells - to avoid any “chronic” leakage. The assessment does not include incidental/accidental leakages, which were part of the Permitting (MER) assessment.

9.2.2. Worker CS 2: Pumping of HVO to/from tanker truck (large, medium, small) and in/out of storage tank (PROC 8b)

This contributing scenario covers the transfer of virgin or used HVO from a variable size tanker truck into a fixed storage tank and vice versa by pumping it via bottom loading (100-1000 L/minute). All hoses are fitted with dry-break couplings and therefore the transfer of HVO through the hose can be considered fully closed (high level containment). However as neither the tanker nor the storage tank are fitted with vapour recovery systems some expulsion losses will be present. These are considered not significant for human exposure, due to the limited amount lost and the emission on top of the tank. When coupling/uncoupling, the worker can be exposed to residual product on the coupling from a limited surface (0.3-1 m2) for a limited amount of time (near field exposure, so inside the breathing zone). All activities are performed outdoor and during transfer of the product the worker will not be working in the near field (potential exposure outside the breathing zone). The scenario describes an 8 hours activity as if this would be the only work the worker performs on a full working day. No risk management measures are required during the work.

9.2.2.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	ART 1.5 , TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5 , TRA Workers 3.0

	Method
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5 , TRA Workers 3.0
Technical and organisational conditions and measures	
• Occupational Health and Safety Management System: Advanced	TRA Workers 3.0
• Surface Contamination/Fugitive Emission Sources: The process is not fully enclosed or the integrity of that enclosure is not regularly monitored but demonstrable and effective housekeeping practices are in place	ART 1.5
• Containment - no extraction: High level containment [Effectiveness Inhalation: 99.9%] *Only applicable to the bottom loading activity (dry-break coupling).*	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: No [Effectiveness Dermal: 0%]	TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Outdoor *Storage tank is located close to buildings and the worker is assumed to be within 4 meters distance.*	ART 1.5
• Operating temperature: <= 45 °C *As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.*	ART 1.5 , TRA Workers 3.0
• Activity Class: Transfer of liquid products - Bottom loading *Duration of this activity is assumed to be 450 minutes on an 8 hour working day.*	ART 1.5
• Bottom Loading - Activity: Transfer of liquid product with flow of: 100 - 1000 L/minute	ART 1.5
• Activity Class - 2: Handling of contaminated objects *Duration of this activity is assumed to be 30 minutes on an 8 hour working day.*	ART 1.5
• Handling of Contaminated Objects - Activity: Activities with treated/contaminated objects (surface 0.3 - 1 m²)	ART 1.5
• Handling of Contaminated Objects - Level of contamination of the surface of the objects: Contamination > 90 % of surface	ART 1.5

9.2.2.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.10. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk quantification
Inhalation, systemic, long term	3.9 mg/m³ (ART 1.5)	RCR = 0.027
Dermal, systemic, long term	13.71 mg/kg bw/day (TRA Workers)	RCR = 0.326
Combined routes, systemic, long-term		RCR = 0.353

Remarks on exposure dataset obtained with ECETOC TRA

The vapour pressure at operating temperature (45°C) used for the calculation is 245 Pa (set by the assessor).

Remarks on exposure data from external estimation tools:

ART 1.5:
Explanation: The worker is assumed not to work within the vicinity of the transfer of liquids and therefore this activity is modelled with far field exposure. Coupling and uncoupling of hoses does take place in the breathing zone of the worker (near field exposure).

The predicted 90th percentile full-shift exposure is 3.9 mg/m³. The inter-quartile confidence interval is 1.7 mg/m³ to 9.4 mg/m³.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

9.2.3. Worker CS 3: Pumping of HVO in/out of storage tank and into underground cavern (PROC 8b)

This contributing scenario covers the following: 1) transfer of virgin or used HVO from a tanker into the underground cavern and vice versa by pumping, and 2) transfer of used HVO from the brine tank (presence of HVO layer is described in another scenario) into a tank truck. Both activities are performed via submerged loading with a transfer rate of 100-1000 L/minute. All hoses are fitted with dry-break couplings and therefore the transfer of HVO through the hose can be considered fully closed (high level containment). However as neither the tanker nor the storage tank are fitted with vapour recovery systems some expulsion losses will be present. These are considered not significant for human exposure, due to the limited amount lost and the emission on top of the tank. When coupling/uncoupling, the worker can be exposed to residual product on the coupling from a limited surface (0.3-1 m2) for a limited amount of time (near field exposure, so inside the breathing zone). During transfer of the product the worker will not be working in the near field (potential exposure outside the breathing zone). The activities are performed indoor (in a “salt house”) and outdoor, meaning worst-case indoor is used for modelling. The scenario describes an 8 hours activity as if this would be the only work the worker performs on a full working day. No risk management measures are required during the work.

9.2.3.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	ART 1.5 , TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5 , TRA Workers 3.0
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5 , TRA Workers 3.0
Technical and organisational conditions and measures	
• Dispersion - Indoors: Ventilation rate of the general ventilation system in the work area: Only good natural ventilation	ART 1.5
• Occupational Health and Safety Management System: Advanced	TRA Workers 3.0
• Surface Contamination/Fugitive Emission Sources: The process is not fully enclosed or the integrity of that enclosure is not regularly monitored but demonstrable and effective housekeeping practices are in place	ART 1.5
• Containment - no extraction: High level containment [Effectiveness Inhalation: 99.9%] *Only applicable to the transfer of liquids activity (dry-brake coupling).*	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: No [Effectiveness Dermal: 0%]	TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Indoor and outdoor *Majority of the activity takes place outdoor, but pumping into the cavern takes place in a “salt house”.*	ART 1.5
• Dispersion - Indoor: Room size of the work area: 30 m3	ART 1.5
• Operating temperature: <= 45 °C	ART 1.5 , TRA

	Method
As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.	Workers 3.0
• Activity Class: Transfer of liquid products - Falling liquids *Duration of this activity is assumed to be 450 minutes on an 8 hour working day. Falling of liquids is a worst-case activity as all transfers are through closed piping.*	ART 1.5
• Falling Liquids - Activity: Transfer of liquid product with flow of: 100 - 1000 l/minute	ART 1.5
• Falling Liquids - Level of containment of the process: Open process	ART 1.5
• Transfer Loading Type: Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation	ART 1.5
• Activity Class - 2: Handling of contaminated objects *Duration of this activity is assumed to be 30 minutes on an 8 hour working day.*	ART 1.5
• Handling of Contaminated Objects - Activity: Activities with treated/contaminated objects (surface 0.3 - 1 m²)	ART 1.5
• Handling of Contaminated Objects - Level of contamination of the surface of the objects: Contamination > 90 % of surface	ART 1.5

9.2.3.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.11. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk quantification
Inhalation, systemic, long term	31 mg/m³ (ART 1.5)	RCR = 0.211
Dermal, systemic, long term	13.71 mg/kg bw/day (TRA Workers)	RCR = 0.326
Combined routes, systemic, long-term		RCR = 0.537

Remarks on exposure dataset obtained with ECETOC TRA

The vapour pressure at operating temperature (45°C) used for the calculation is 245 Pa (set by the assessor).

Remarks on exposure data from external estimation tools:

ART 1.5:
Explanation: The worker is assumed not to work within the vicinity of the transfer of liquids and therefore this activity is modelled with far field exposure. Coupling and uncoupling of hoses does take place in the breathing zone of the worker (near field exposure).
The predicted 90th percentile full-shift exposure is 31 mg/m³. The inter-quartile confidence interval is 15 mg/m³ to 66 mg/m³.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

9.3. Exposure scenario 3: Use at industrial sites - Maintenance activities (work-over) on salt mining site

Market sector: Use as blanketing fluid in salt mining - Haaksbergen site
Product category used: PC 0: Other
Sector of use: SU 2a: Mining (without offshore industries)

Environment contributing scenario(s):		
CS 1	TUBING MAINTENANCE (above ground activities)	ERC 4
Worker contributing scenario(s):		
CS 2	Tubing maintenance (above ground activity)	PROC 28

Further description of the use:

HVO first needs to be removed from the cavern (see pumping exposure scenario) before the well can be opened for maintenance (work-over). After the removal of the well head, brine is collected and reused in the plant. The production strings are then pulled out. Only the outer string can be contaminated with a very thin layer of HVO, however, usually there is HVO present as when it is pushed up in the outer annular pipe, brine replaces its volume. If any HVO would come out it is collected in the containment box and by means of a vacuum tank. At the end of the maintenance activities the tubes are run in the well again and the wellhead is replaced at the top. When all is fixed a handover is done to the production organisation and HVO is put back into the cavern again by using the tank car (see pumping contributing scenario).

Note that when the salt production ceases in one cavern, the activities performed can be seen as equivalent to this maintenance activity , therefore abandonment is covered by this maintenance exposure scenario.

9.3.1. Env CS 1: TUBING MAINTENANCE (above ground activities) (ERC 4)

During the workover period, HVO is removed and tubes are taken out, checked, renewed or repaired if needed, before placing these back in the wellbore. When tubing maintenance is finished, HVO is reinjected into the well, but this part is covered by the Contributing Scenario “Pumping (above ground activities)”.

9.3.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
• Daily use amount at site: <= 0.5 tonnes/day *Usually, no HVO remains after all the substance is pumped from the cavern. This value was calculated from the yearly tonnage divided 100 days/year.*
• Annual use amount at site: <= 50 tonnes/year *This value corresponds to the worst-case non-realistic assumption that 5% of the HVO remains on tubes after pumping the oil out of the cavern.*
Conditions and measures related to biological sewage treatment plant
• Biological STP: None [Effectiveness Water: 0%] *HVO is systematically reused on site and no effluent is directed towards biological STP.* Water explanation: *Not required as no effluent goes to STP.*
Conditions and measures related to external treatment of waste (including article waste)
• Particular considerations on the waste treatment operations: Dedicated recollection infrastructure required *Petroleum products must be recollected for reuse in caverns on the site or taken by a Company specialised in petroleum products waste/recycling.*
Other conditions affecting environmental exposure
• Receiving surface water flow rate: >= 1.8E4 m3/day *Defaults settings in EUSES.*
• Place of use: Outdoor *Maintenance activities take place onsite outdoor around the well on a concrete platform with all safety*

elements that avoid small or accidental leakages.
• Discharge rate of effluent: >= 1E6 m3/day *No discharge in water is foreseen because all the oil is collected and re-injected in the caverns. This case can however not be handled by EUSES. Choice is therefore to set it high to reflect the very high dilution that may be expected if some effluents discharges would occur in the receiving water bodies, even this amount is not relevant in the case of this activity, just to allow EUSES to run its calculations. This can be considered as equivalent to a zero-effluent case.*

9.3.1.2. Releases

The local releases to the environment are reported in the following table. Note that the releases reported do not account for the removal in the modelled biological STP.

Table 9.12. Local releases to the environment

Release	Release estimation method	Explanations
Water	Estimated release factor (Maintenance procedures)	**Release factor before on site RMM:** 0.1% **Release factor after on site RMM:** 0.1% **Explanation:** Tubing maintenance activities were handled by trained staff. All procedures take place on concrete platforms with retention basins, and all losses are recovered and reuse in the caverns.
Air	Estimated release factor (Maintenance procedures)	**Release factor before on site RMM:** 0.2% **Release factor after on site RMM:** 0.2% **Explanation:** Tubing maintenance activities were handled by trained staff. All procedures take place on concrete platforms with retention basins, and all losses are recovered and reuse in the caverns.
Non agricultural soil	Estimated release factor (Maintenance procedures)	**Release factor after on site RMM:** 0.1% **Explanation:** Tubing maintenance activities were handled by trained staff. All procedures take place on concrete platforms with retention basins, and all losses are recovered and reuse in the caverns.

Releases to waste

Release factor to external waste: 0 %
Blanketing is for use, no waste foreseen during the mining activity, which will continue in the coming years. If in case activity ceases and HVO is not reused on another site, it will be processed as waste or for reuse by a specialised Company

9.3.1.3. Exposure and risks for the environment and man via the environment

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table. The exposure estimates have been obtained with PetroRisk.

Table 9.13. Exposure concentrations and risks for the environment and man via the environment

Protection target	Exposure concentration	Risk quantification
Fresh water	Clocal: 8.09E-4 mg/L (estimated by PetroRisk 7.04)	RCR = 0.146
Sediment (freshwater)	Clocal: 0.347 mg/kg dw (estimated by PetroRisk 7.04)	RCR = 0.169
Marine water	Clocal: 8.08E-5 mg/L (estimated by PetroRisk 7.04)	RCR= 0.0146
Sediment (marine water)	Clocal: 0.035 mg/kg dw (estimated by PetroRisk 7.04)	RCR = 0.0169
Agricultural soil	Clocal: 1.77E-7 mg/kg dw (estimated by PetroRisk 7.04)	RCR < 0.01

Risk characterisation

No risks were identified related to the whole maximum volume used on site. This is achieved notably by special attention via monitoring of the caverns and wells - to avoid any “chronic” leakage. The assessment does not include incidental/accidental leakages, which were part of the Permitting (MER) assessment.

9.3.2. Worker CS 2: Tubing maintenance (above ground activity) (PROC 28)

This contributing scenario describes the inspection and maintenance of the tubing used in the cavern for injecting and extracting the blanketing fluid. During periodic maintenance (work-over) the tubes are removed from the drilling hole and inspected outdoors above ground. At the Hengelo site maintenance occurs regularly with over 30 weeks of maintenance per year. Before removing the tubing from the well, the cavern is depressurized and both blanketing fluid and brine are then removed. Therefore, the remaining contamination on the tubes will be limited (brine will be pumped up eventually when removing HVO). There are two types of tubes in contact with HVO (typical length of 10 meters for each piece), 7 and 9-5/8 inch. As exact information on remaining residue on the tubes is not available, we assume worst-case 10-90% of the tube is contaminated with HVO when handled above ground. The scenario describes an 8 hours activity as if this would be the only work the worker performs on a full working day. No risk management measures are required during the work.

9.3.2.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 90 % *The substance handled is assumed to be diluted to a certain extent (50-90%) while removing the fluids from the tubing before maintenance is started.*	ART 1.5 , ECETOC TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5 , ECETOC TRA Workers 3.0
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5 , ECETOC TRA Workers 3.0
Technical and organisational conditions and measures	
• Occupational Health and Safety Management System: Advanced	ECETOC TRA Workers 3.0
• Surface Contamination/Fugitive Emission Sources: The process is not fully enclosed or the integrity of that enclosure is not regularly monitored but demonstrable and effective housekeeping practices are in place	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: No [Effectiveness Dermal: 0%]	ECETOC TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Outdoor *Source not located close to buildings, but worker is assumed to be within 4 meters distance.*	ART 1.5
• Operating temperature: <= 45 °C *As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.*	ART 1.5 , ECETOC TRA Workers 3.0
• Activity Class: Handling of contaminated objects *Exposure from both the objects that are actually handled as well as objects already removed and placed at a certain distance is calculated. This is a worst-case assumption.*	ART 1.5
• Handling of Contaminated Objects - Activity: Activities with treated/contaminated objects (surface > 3 m^2)	ART 1.5
• Handling of Contaminated Objects - Level of contamination of the surface of the	ART 1.5

	Method
objects: Contamination 10-90 % of surface *This level of contamination is a worst-case assumption as most of the oil will run of the piping when the oil is removed from the cavern.*	

9.3.2.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.14. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk quantification
Inhalation, systemic, long term	41 mg/m³ (ART 1.5)	RCR = 0.279
Dermal, systemic, long term	13.71 mg/kg bw/day (ECETOC TRA Workers 3.0)	RCR = 0.326
Combined routes, systemic, long-term		RCR = 0.605

Remarks on exposure data from external estimation tools:

ECETOC TRA Workers 3.0:
Explanation: This activity is modelled as PROC8a in ECETOC TRA, as PROC28 is not yet included in this model.

ART 1.5:
Explanation: The worker is assumed to work within the vicinity of other hoses to be maintained as well and therefore the scenario a secondary source exposure is added with the same parameters (additional far field exposure).
The predicted 90th percentile full-shift exposure is 41 mg/m³. The inter-quartile confidence interval is 18 mg/m³ to 98 mg/m³.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

9.4. Exposure scenario 4: Use at industrial sites - Blanketing fluid in salt mining

Market sector: Use as blanketing fluid in salt mining - Haaksbergen site
Product category used: PC 0: Other
Sector of use: SU 2a: Mining (without offshore industries)

Environment contributing scenario(s):		
CS 1	BLANKETING FLUID in the confined system composed of the underground cavern and the well that relate it to the surface	ERC 7
Worker contributing scenario(s):		
CS 2	Use as blanketing fluid in the cavern underground	PROC 1
CS 3	Presence of HVO layer on brine (during salt production above ground)	PROC 10
CS 4	Quality control of the HVO product	PROC 15

Further description of the use:

Nouryon applies solution mining technology to produce brine as raw material for their salt plants in Hengelo and Delfzijl (Netherlands). With this technology, through concentric pipes, water (in the tube placed in the middle) is injected in a subsurface salt layer, brine pumped out (in the inner tube) to the surface and transported by pipelines, and oil (in the outside tube) distributed as a thin layer on the top of the brine to control the cavern roof dissolution. With the aim to control the development of the caverns, HVO will beused as a blanket material in the Haaksbergen caverns to create a barrier between the brine/water solution and the roof of the cavern. In the borehole, the concentric tubes are isolated from the different geological layers by a cement envelope. At the surface, the cap system guarantees the full control of the different fluids. The junction with the cavern in the salt rock layer also guarantees that the well is tight. For further details one can read the SPERC NOURYON 7.1c.v1 background document, which contents schematics of the cavern and well settings.

9.4.1. Env CS 1: BLANKETING FLUID in the confined system composed of the underground cavern and the well that relate it to the surface (ERC 7)

Salt mining is conducted in underground salt layers that progressively becomes cavities filled with brine and are later called “caverns”. HVO is used as blanketing fluid to avoid the transformation of the salt rock into brine at the roof of the cavern, thus controlling the growth and structure of the cavern. In Haaksbergen HVO is removed, usually every 2 years for maintenance (see Pumping and Maintenance Exposure Scenarios). Some HVO can also be added to adjust the blanketing level along the cavern growth. Caverns within the geological structure of the halite dome/pillow can be considered as a fully confined space as halite is a barrier in which HVO diffusion can be considered as not significant. Blanketing is essential to control the salt extraction and maintain the integrity of the structure of the caverns, preventing any weakness in the structure that may lead to collapse under the pressure of the above geological layers. Diffusion and other means of emissions are discussed in an in-house SpERC (SpERC NOURYON 7.1c.v1; included in Annex II to this CSR).

9.4.1.1. Conditions of use

Amount used, frequency and duration of use (or from service life)
• Daily use amount at site: <= 2.3 tonnes/day *This is use is all along the 365 days of the year as the oil remains in the caverns. This daily quantity is derived to conduct the EUSES calculations but does not have sense in the daily work on-site.*
• Annual use amount at site: 850 tonnes/year *This is the maximum annual quantity that can be found in the caverns. This figure is derived from the maximum size of the active caverns and a 10% growth of the mining activity.*
• Percentage of EU tonnage used at regional scale: = 100 % *Default value, this is a worst-case.*
Conditions and measures related to biological sewage treatment plant
• Biological STP: None [Effectiveness Water: 0%]

HVO is systematically reused on site and no effluent is directed towards biological STP. Water explanation: *Not required as no effluent goes to STP.*
Conditions and measures related to external treatment of waste (including article waste)
• Particular considerations on the waste treatment operations: Closed system required to minimise release to the environment. *Regarding the confined system according to mining and petroleum industrial standards, no waste is expected. If some petroleum product waste is generated, it must be recollected for reuse in caverns on the site or taken by a Company specialised in petroleum products waste/recycling.*
Other conditions affecting environmental exposure
• Receiving surface water flow rate: >= 1.8E4 m3/day *Defaults settings in EUSES.*
• Discharge rate of effluent: >= 1E6 m3/day *No discharge in water is foreseen because all the HVO is collected and re-injected in the caverns. This case can however not be handled by EUSES. Choice is therefore to set it high to reflect the very high dilution that may be expected if some effluents discharges would occur in the receiving water bodies, even this amount is not relevant in the case of this activity, just to allow EUSES to run its calculations. This can be considered as equivalent to a zero-effluent case.*
• Place of use: Indoor/Outdoor *Only the upper part of the well is connected to the surface, so truly outdoor. Other parts, well with a cement coating and cavern in a salt-rock shell can be considered as indoor or at least as not directly accessible by workers and not directly in contact with the environmental compartments (water/air/soil).*

9.4.1.2. Releases

The local releases to the environment are reported in the following table. Note that the releases reported do not account for the removal in the modelled biological STP.

Table 9.15. Local releases to the environment

Release	**Release estimation method**	**Explanations**
Water	Estimated release factor (SPERC NOURYON 7.1c.v1)	**Release factor before on site RMM:** 0.01% **Release factor after on site RMM:** 0.01% **Explanation:** Confinement is required for the brine extraction that is pumped and transported by tubes to the salt production facility. HVO is used as blanketing fluid in the cavern and its containment is also paramount to avoid brine contamination and losses that may perturb the cavern structure. The tubes are concentric (brine in the central tube, water in the middle tube, oil in the outside tube) and surrounded by a hermetic cement envelop (tightness confirmed by Mechanical Integrity Test, MIT). All connections are with safety valves, and inspections are conducted on all the systems. The well goes down into the salt rock layer, in which the cavern grows progressively when water dissolves the halite and so transform it into brine. The cavern itself is a confined space in the salt rock layer and its anhydrite caprock. The extraction points are chosen in areas where the salt is of high quality – without impurities undesirable for this raw material essentially used for fine chemistry – and the conditions to grow a cavern ideal, notably with low risks regarding the geological faults. This release factor was estimated from the possible “chronic leakages” that may not be detected in the cavern or well and lead to a partial migration towards the surface water bodies or soil layers, and so cannot be handled as incidental leakages, the risks related to these last ones being assessed under the

Release	Release estimation method	Explanations
		Permitting (IED Regulation and its transposition into the national legislation). Please see further explanations and justifications in the SPERC NOURYON 7.1c.v1 supporting document.
Air	Estimated release factor (SPERC NOURYON 7.1c.v1)	**Release factor before on site RMM:** 0% **Release factor after on site RMM:** 0% **Explanation:** The salt caverns and wells are confined so that no direct releases to air are expected. Please see further explanations and justifications in the SPERC NOURYON 7.1c.v1 supporting document.
Non agricultural soil	Estimated release factor (SPERC NOURYON 7.1c.v1)	**Release factor after on site RMM:** 0.01% **Explanation:** Same explanation as for Water release route. Please see further explanations and justifications in the SPERC NOURYON 7.1c.v1 supporting document.

Releases to waste

Release factor to external waste: 0 %
No risks were was identified related to the whole maximum volume used on site. This is achieved notably by special attention via monitoring of the caverns and wells - to avoid any "chronic" leakage. The assessment does not include incidental/accidental leakages, which were part of the Permitting (MER) assessment.

9.4.1.3. Exposure and risks for the environment and man via the environment

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table. The exposure estimates have been obtained with PetroRisk.

Table 9.16. Exposure concentrations and risks for the environment and man via the environment

Protection target	Exposure concentration	Risk quantification
Fresh water	Clocal: 3.21E-4 mg/L (estimated by PetroRisk 7.04)	RCR = 0.059
Sediment (freshwater)	Clocal: 0.139 mg/kg dw (estimated by PetroRisk 7.04)	RCR = 0.068
Marine water	Clocal: 3.23E-5mg/L (estimated by PetroRisk 7.04)	RCR = 0.006
Sediment (marine water)	Clocal: 0.014 mg/kg dw (estimated by PetroRisk 7.04)	RCR = 0.007
Agricultural soil	Clocal: 2.13E-7 mg/kg dw (estimated by PetroRisk 7.04)	RCR < 0.01

Risk characterisation

No risks were identified related to the whole maximum volume used on site. This is achieved notably by special attention via monitoring of the caverns and wells - to avoid any "chronic" leakage. The assessment does not include incidental/accidental leakages, which were part of the Permitting (MER) assessment.

9.4.2. Worker CS 2: Use as blanketing fluid in the cavern underground (PROC 1)

This contributing scenario describes the actual functional use of HVO in the cavern as blanketing fluid. When HVO is in the cavern, no exposure to workers is possible. Especially from a worker exposure point of view, the cavern can be seen as closed system without any breaches. The oil is in a cavern far underground. At the surface all pipes are closed. Valves in the piping are also closed. The scenario describes an 8 hours activity as if this would be the only work the worker performs on a full working day. No risk management measures are required during the work.

9.4.2.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	ART 1.5, TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5, TRA Workers 3.0
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5, TRA Workers 3.0
Technical and organisational conditions and measures	
• Occupational Health and Safety Management System: Advanced	TRA Workers 3.0
• Local exhaust ventilation: No [Effectiveness Inhalation: 0%, Dermal: 0%]	ART 1.5
• Surface Contamination/Fugitive Emission Sources: The process is fully enclosed and the integrity of that enclosure is regularly monitored	ART 1.5
• Containment - no extraction: High level containment [Effectiveness Inhalation: 99.9%]	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Respiratory protection: No [Effectiveness Inhalation: 0%]	ART 1.5
• Dermal protection: No [Effectiveness Dermal: 0%]	TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Outdoor *Source not located close to buildings and the worker is assumed to be further away than 4 meters distance (cavern is fully closed).*	ART 1.5
• Operating temperature: <= 45 °C *As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.*	ART 1.5, TRA Workers 3.0
• Activity Class: Activities with open liquid surfaces or open reservoirs - Activities with undisturbed surfaces (no aerosol formation)	ART 1.5
• Open Surface: Surface > 3 m²	ART 1.5

9.4.2.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.17. Exposure concentrations and risks for workers

Route of exposure and type of effects	**Exposure concentration**	**Risk quantification**
Inhalation, systemic, long term	1.9E-3 mg/m³ (ART 1.5)	RCR < 0.01
Dermal, systemic, long term	0.034 mg/kg bw/day (TRA Workers)	RCR < 0.01
Combined routes, systemic, long-term		RCR < 0.01

Remarks on exposure dataset obtained with ECETOC TRA

Explanation: The dermal exposure estimate is based on a worker that is working near the substance in a closed system based on the default ECETOC TRA assessment. However, as the worker cannot be working near the cavern, the actual exposure estimate would be 0 mg/kg bw/day and therefore the ECETOC TRA value is considered an overestimation of the exposure.
The vapour pressure at operating temperature (45°C) used for the calculation is 245 Pa (set by the assessor).

Remarks on exposure data from external estimation tools:

ART 1.5:
Explanation: The worker cannot enter a cavern as it is fully closed and therefore the scenario is modelled with far field exposure only. The predicted 90th percentile full-shift exposure is 0.0019 mg/m³. The inter-quartile confidence interval is 0.00084 mg/m³ to 0.0045 mg/m³.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

9.4.3. Worker CS 3: Presence of HVO layer on brine (during salt production above ground) (PROC 10)

This contributing scenario describes the presence of a HVO layer on brine that has been mined from the salt cavern and is pumped into an outdoor open tank, which is part of the standard salt mining process. A few times a year blanketing fluid is pumped up with the brine because of unexpected turbulence in the cavern. When the brine is stored, the HVO then floats on the surface of the tank. Exposure of workers to this layer can occur but only to a limited extent, with a maximum of 15 minutes/day in the near field (inside breathing zone) when inspecting the tank (this is assumed a worst-case situation as the worker will actually not come within 1 meter of the source). The remainder of the working day the worker will be working far field. The scenario describes an 8 hours activity as if this would be the only work the worker performs on a full working day. No risk management measures are required during the work.

9.4.3.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	ART 1.5 , TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5 , TRA Workers 3.0
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5 , TRA Workers 3.0
Technical and organisational conditions and measures	
• Occupational Health and Safety Management System: Advanced	TRA Workers 3.0
• Surface Contamination/Fugitive Emission Sources: The process is not fully enclosed or the integrity of that enclosure is not regularly monitored but demonstrable and effective housekeeping practices are in place	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: No [Effectiveness Dermal: 0%]	TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Outdoor *Source not located close to buildings and worker is assumed to be at least at 4 meters distance.*	ART 1.5
• Operating temperature: <= 45 °C *As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.*	ART 1.5 , TRA Workers 3.0
• Activity Class: Activities with open liquid surfaces or open reservoirs - Activities with undisturbed surfaces (no aerosol formation) *This activity is split into 15 minutes of inspection of the tank (near field) and 465 minutes of work from a distance (far field).*	ART 1.5

	Method
• Open Surface: Surface > 3 m²	ART 1.5

9.4.3.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.18. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk quantification
Inhalation, systemic, long term	7.8 mg/m³ (ART 1.5)	RCR = 0.053
Dermal, systemic, long term	27.43 mg/kg bw/day (TRA Workers)	RCR = 0.653
Combined routes, systemic, long-term		RCR = 0.706

Remarks on exposure dataset obtained with ECETOC TRA

The vapour pressure at operating temperature (45°C) used for the calculation is 245 Pa (set by the assessor).

Remarks on exposure data from external estimation tools:

ART 1.5:
Explanation: The predicted 90th percentile full-shift exposure is 7.8 mg/m³. The inter-quartile confidence interval is 3.5 mg/m³ to 19 mg/m³.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

9.4.4. Worker CS 4: Quality control of the HVO product (PROC 15)

This contributing scenario describes the quality control that is performed on-site and which consists of 4 activities: 1) sampling of HVO from storage tank (open process), 2) presence of the laboratory technician near the storage tank (which is a closed system), 3) handling of the product in the laboratory, and 4) pipetting of HVO (via the wall of the container, modelled as submerged). Quality control is done in all stages of salt mining; before HVO is brought into the cavern or when it has returned. Work is performed partly outdoor (sampling) and indoor (laboratory work), in the latter case in a small workroom (100 m3) with general ventilation (at least 3 ACH) present. The scenario describes an 8 hours activity as if this would be the only work the technician performs on a full working day. No risk management measures are required during the work.

9.4.4.1. Conditions of use

	Method
Product (article) characteristics	
• Percentage (w/w) of substance in mixture/article: <= 100 %	ART 1.5 , TRA Workers 3.0
• Physical form of the used product: Liquid	ART 1.5 , TRA Workers 3.0
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: <= 8 h/day	ART 1.5 , TRA Workers 3.0
Technical and organisational conditions and measures	
• Occupational Health and Safety Management System: Advanced	TRA Workers 3.0
• Surface Contamination/Fugitive Emission Sources: The process is not fully enclosed or the integrity of that enclosure is not regularly monitored but demonstrable and effective housekeeping practices are in place	ART 1.5
• Dispersion - Indoors: Ventilation rate of the general ventilation system in the work	ART 1.5

	Method
area: 3 ACH *Applicable to the activities inside the laboratory (indoor).*	
• Containment - no extraction: Medium level containment [Effectiveness Inhalation: 99%] *Only applicable to the storage tank (activity with undisturbed surface).*	ART 1.5
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: No [Effectiveness Dermal: 0%]	TRA Workers 3.0
Other conditions affecting workers exposure	
• Place of use: Indoor and outdoor *Outdoor sampling takes place close to buildings.* *Laboratory work is done indoors.*	ART 1.5
• Dispersion - Indoor: Room size of the work area: 100 m3 *Applicable to the activities inside the laboratory (indoor).*	ART 1.5
• Operating temperature: <= 45 °C *As a worst-case approach, the maximum temperature in the cavern is selected as operating temperature.*	ART 1.5 , TRA Workers 3.0
• Activity Class - 1: Transfer of liquid products - Falling liquids *Sampling for QC. Duration of this activity is assumed to be 15 minutes on an 8 hour working day.*	ART 1.5
• Falling Liquids - Activity 1: Transfer of liquid product with flow of: 0.1 - 1 l/minute	ART 1.5
• Falling Liquids - Level of containment of the process: Handling that reduces contact between product and adjacent air	ART 1.5
• Transfer Loading Type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely	ART 1.5
• Activity Class - 2: Activities with open liquid surfaces or open reservoirs - Activities with undisturbed surfaces (no aerosol formation) *Duration of this activity is assumed to be 15 minutes on an 8 hour working day.*	ART 1.5
• Open Surface: Surface > 3 m²	ART 1.5
• Activity Class - 3: Activities with open liquid surfaces or open reservoirs - Activities with agitated surfaces *Duration of this activity is assumed to be 435 minutes on an 8 hour working day.*	ART 1.5
• Open Surface - other activities: Surface < 0.1 m²	ART 1.5
• Activity Class - 4: Transfer of liquid products - Falling liquids *Duration of this activity is assumed to be 15 minutes on an 8 hour working day.*	ART 1.5
• Falling Liquids - Activity 4: Transfer of liquid product with flow of: < 0.1 l/minute	ART 1.5
• Falling Liquids - Level of containment of the process 4: Open process	ART 1.5
• Transfer Loading Type 4: Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation	ART 1.5

9.4.4.2. Exposure and risks for workers

The exposure concentrations and risk characterisation ratios (RCR) are reported in the following table.

Table 9.19. Exposure concentrations and risks for workers

Route of exposure and type of effects	Exposure concentration	Risk quantification
Inhalation, systemic, long term	52 mg/m³ (ART 1.5)	RCR = 0.354
Dermal, systemic, long term	0.34 mg/kg bw/day (TRA Workers)	RCR < 0.01
Combined routes, systemic, long-		RCR = 0.362

Route of exposure and type of effects	Exposure concentration	Risk quantification
term		

Remarks on exposure dataset obtained with ECETOC TRA

The vapour pressure at operating temperature (45°C) used for the calculation is 245 Pa (set by the assessor).

Remarks on exposure data from external estimation tools:

ART 1.5:
Explanation: The predicted 90th percentile full-shift exposure is 52 mg/m³. The inter-quartile confidence interval is 23 mg/m³ to 130 mg/m³.

Risk characterisation

When taking into account the conditions of use and risk management measures imposed in this contributing scenario, the risk is considered to be controlled.

10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1. Human health

10.1.1. Workers

No assessment of combined use is required for the worker activities included in this CSR as all scenarios have been modelled with an 8 hours duration. As this is a normal working day length in accordance with the Dutch Labour Act, all scenarios can be combined as long as this 8 hours working day is respected.

10.1.2. Consumer

An assessment is not applicable as there are no consumer-related uses for the substance.

10.2. Environment (combined for all emission sources)

10.2.1. All uses (regional scale)

10.2.1.1. Total releases

The total releases to the environment from all the exposure scenarios covered are presented in the table below. This is the sum of the releases to the environments from all exposure scenarios addressed.

Table 10.1. Total releases to the environment per year from all life cycle stages

Release route	Total releases per year
Water	437 kg/year
Air	1.54E4 kg/year
Soil	545 kg/year

10.2.2. Regional assessment

The regional predicted environmental concentration (PEC regional) and the related risk characterisation ratios when a PNEC is available are presented in the table below. The exposure to man via the environment from regional exposure and the related risk characterisation ratios are also provided (when relevant). The exposure concentration for human via inhalation is equal to the PEC air.
The exposure estimates have been obtained with PetroRisk.

Table 10.2. Predicted regional exposure concentrations (Regional PEC) and risks for the environment

Protection target	Regional PEC	Risk characterisation
Fresh water	**Regional PEC:** 2.4E-6 mg/L (estimated by PetroRisk 7.04)	3.8E-04
Sediment (freshwater)	**Regional PEC:** 2.7E-4 mg/kg dw (estimated by PetroRisk 7.04)	1.8E-04
Marine water	**Regional PEC:** 1.1E-8 mg/L (estimated by PetroRisk 7.04)	2.6E-06
Sediment (marine water)	**Regional PEC:** 1.4E-6 mg/kg dw (estimated by PetroRisk 7.04)	1.1E-06
Agricultural soil	**Regional PEC:** 2.1E-6 mg/kg dw (estimated by PetroRisk 7.04)	1.2E-06

Remarks on risk characterisation for regional concentrations:

The environmental assessment does not cover leakage incidents/accidents that fall under the scope of the

Industrial Emissions Directive (IED, Directive 2010/75/EU) and its national transposition legal texts (notably in the context of a permit application it will need to be assessed there), but only the remaining environmental exposures that may be associated to the day to day use and re-use of HVO as blanketing fluid in the solution salt mining. To clearly distinguish the objective covered by this Chemical Safety Assessment, the term "chronic" may be used in this assessment to qualify emissions (leakages, releases, exposures).
The above ground activities consist of storage, pumping and maintenance activities. Measures are taken to avoid any emission into the environment. Most of the transfers are in closed systems and all of the collected oil is systematically reused in the caverns.
The system composed of the cavern and the well should be considered as a confined environment, because the upper part is fully closed with a system that follows conception and management industrial standards of the mining sector, and its bottom part is within halite geological layers that are known as impermeable barriers to oil (that is one mean to localise the oil deposits that are trapped under the salt layers). Underground, the caverns are at depths of between700 to 950 m, have a horizontal shape due to the geological salt-rock layer structures, and are covered by several geological layers, some which are impermeable or with very low permeability (e.g. anhydrite caprock). The faults are studied in this area to guarantee the integrity of the caverns. Moreover, salt healing processes and fine clay intrusions are known to compensate for the presence of small faults. If significant leakages appear, they will be identified through the cavern growth monitoring. If small "chronic" leakages appear, the risks related to their migration upward and that they reach the underground water level are low. If some contamination of the groundwater occurs by these small leakages, some transfers could then be possible to other environmental compartments; however, it can then also be expected that the natural concentrations would be very low and the biodegradation processes efficient.
In conclusion, the risks of contamination at the regional level from small undetectable leakages can be considered as very low, even when all exposure scenarios are combined.

10.2.3. Local exposure due to all widespread uses

Not relevant as there are not several widespread uses covered in this CSR.

10.2.4. Local exposure due to combined uses at a site

Regarding the low risk associated to each of these contributing scenarios, there is no concern, and this can also be considered the case even if in a very worst-case their RCRs are combined: freshwater = 0.483, freshwater sediment = 0.558 (but this value should be interpreted with care because it is generated by combination of several very worst-case values, and in addition there is no direct emissions to water and sediment the only possible path being towards soil or/and groundwater), marine water = 0.048, marine sediment = 0.056, sewage treatment plant = 0 (no release to STP), soil = <0.001.

Environmental Risk	1	2	3	4	Combined
RCR freshwater	0.029	0.249	0.146	0.059	**0.483**
RCR marine	0.003	0.025	0.015	0.006	**0.048**
RCR freshwater sediment	0.034	0.288	0.169	0.068	**0.558**
RCR marine sediment	0.003	0.029	0.017	0.007	**0.056**
RCR agricultural soil	2.05E-06	2.22E-06	1.80E-06	1.92E-06	**7.99E-06**

Annexes

1. Annex: SGS analytical report for HVO

SGS OGC Laboratory Services
Attn : 5.1.2.e [redacted]
5.1.2.e [redacted]
THE NETHERLANDS

The following sample(s) was/were submitted and identified by/on behalf of the client 5.1.2.e [redacted]

SGS Job No.	:	IAC19-03097
Sample identification	:	See following page(s)
Sample Receiving Date	:	10/04/2020
Testing Period	:	15/04/2020 – 16/04/2020

Test Requested	:	Screening GCxGC-MS/FID
Test Method	:	Please refer to next page(s).
Test Result(s)	:	Please refer to next page(s).

5.1.2.e [redacted]
5.1.2.e [redacted]

SGS Belgium NV | Institute for Applied Chromatography Haven 407 Polderdijkweg 16 B-2030 Antwerpen
5.1.2.e [redacted]
Member of the SGS Group (Société Générale de Surveillance)

Sample identification:

SGS reference	Client reference
IAC20-03097.001	6006022 - S00859902

Requested analyses:

- Screening GCxGC-MS/FID
  Test performed by Comprehensive two-dimensional Gas Chromatography – Mass Spectrometry (GCxGC/MS) and Comprehensive two-dimensional Gas Chromatography – Flame Ionization Detection (GCxGC/FID)

Test results: **Screening GCxGC – MS/FID**

Technical performance

General information

Dichloromethane was added to a small amount of the samples and was subsequently analyzed with two-dimensional gas chromatography (GCxGC) followed by a mass spectrometry (MS) detection and a flame ionization (FID) detection.

The gas chromatograph was equipped with a Rxi-1ms column with dimensions 30 m x 0.25 mm x 0.25 µm and a BPX50 column with dimensions 1 m x 0.15 mm x 0.15 µm. Quantification was performed in area percentage by using GCxGC-FID data.

Data interpretation

Data interpretation was done using ‘GC image™’-software.

The chromatogram on which the final results are based were baseline corrected using the GC image™ Rolling Ball algorithm:

Deadband/Datapoints: 5

Filter Window Size: 7

Ball Column 1 radius (min): 2.00

Ball Column 2 radius (sec): 2.00

Ball relative Height (0-100): 5.00

Identification of (groups of) compounds in a sample is done based on the measured GCxGC-MS chromatogram. Quantification of (groups of) compounds in a sample is done based on the corresponding measured GCxGC-FID chromatogram. The quantified result of each (group of) compound(s) is normalized to the combined response of all identified compounds.

GCxGC-MS parameters

Gas chromatograph system: Shimadzu GC-2010

Column Oven Temp.:50.0 ° C

Injection Temp.:250.00 ° C

Injection Mode: Split

Flow Control Mode: Pressure

Pressure:100.0 kPa

Total Flow:37.0 mL/min

Column Flow:1.69 mL/min

Linear Velocity:47.2 cm/sec

Purge Flow:1.5 mL/min

Split Ratio:20.0

High Pressure Injection: OFF

Carrier Gas Saver: OFF

Splitter Hold: OFF

Oven Temperature Program:

Rate	Temperature (° C)	Hold Time (min)
-	50.0	0.00
2.50	100	0.00
3.50	345	20.00

2.2.2: Mass spectrometer system: Shimadzu QP-2010 Ultra

IonSource Temperature: 220.00 ° C

Interface Temperature: 300.00 ° C

Solvent Cut Time: 2.50 min

Detector Gain Mode: Relative

Detector Gain: +0.10 kV

Threshold: 0

[MS Table]

--Group 1 - Event 1--

Start Time: 2.50min

End Time: 100.00min

ACQ Mode: Scan

Event Time: 0.02sec

Scan Speed: 20000

Start m/z: 35.00

End m/z: 300.00

Sample Inlet Unit: GC*GCxGC-FID parameters*

Gas chromatograph system: Shimadzu GC-2010

[Injection Port SPL1]

Injection Mode: Split

Temperature: 250.0 C

Carrier Gas: He

Flow Control Mode: Velocity

Pressure: 160.9 kPa

Total Flow: 78.7 mL/min

Column Flow: 2.44 mL/min

Linear Velocity: 47.2 cm/sec

Purge Flow: 3.0 mL/min

Split Ratio: 30.0

High Pressure Injection: OFF

Total Program Time: 60.00 min

Carrier Gas Saver: ON

  Split Ratio: 5.0

  Time: 1.00

Splitter Hold: OFF

[Column Oven]

Initial Temperature : 50.0 C

Equilibration Time : 0.5 min

Column Oven Temperature Program

Total Program Time : 110.00 min

Rate(C/min)	Temperature(C)	Hold Time(min)
------	50.0	0.00
2.5	100	0.00
3.5	345	20.00

Flame ionization detector: Shimadzu GC-2010

[Detector Channel 1 FID1]

Temperature: 350.0 C

Signal Acquire: Yes

Sampling Rate: 40 msec

Stop Time: 60.00 min

Delay Time: 0.00 min

Subtract Detector: None

Makeup Gas: He

Makeup Flow: 30.0 mL/min

H2 Flow: 40.0 mL/min

Air Flow: 400.0 mL/min

Time Program(6):

Total Program Time 110.00 min

	Time	Device	Event	Value
1	5.00	CON1	Temperature	110.0
2	10.00	CON1	Temperature	130.0
3	15.00	CON1	Temperature	150.0
4	20.00	CON1	Temperature	170.0
5	25.00	CON1	Temperature	190.0
6	30.00	CON1	Temperature	210.0
7	35.00	CON1	Temperature	230.0
8	40.00	CON1	Temperature	250.0
9	45.00	CON1	Temperature	270.0
10	50.00	CON1	Temperature	290.0
11	55.00	CON1	Temperature	310.0
12	60.00	CON1	Temperature	330.0
13	100.00	CON1	Temperature	330.0
14	110.00	CON1	Temperature	90.0

Additional Heater(3): CON1 (90.0 C)

Auto Flame On : Yes

Auto Flame Off : Yes

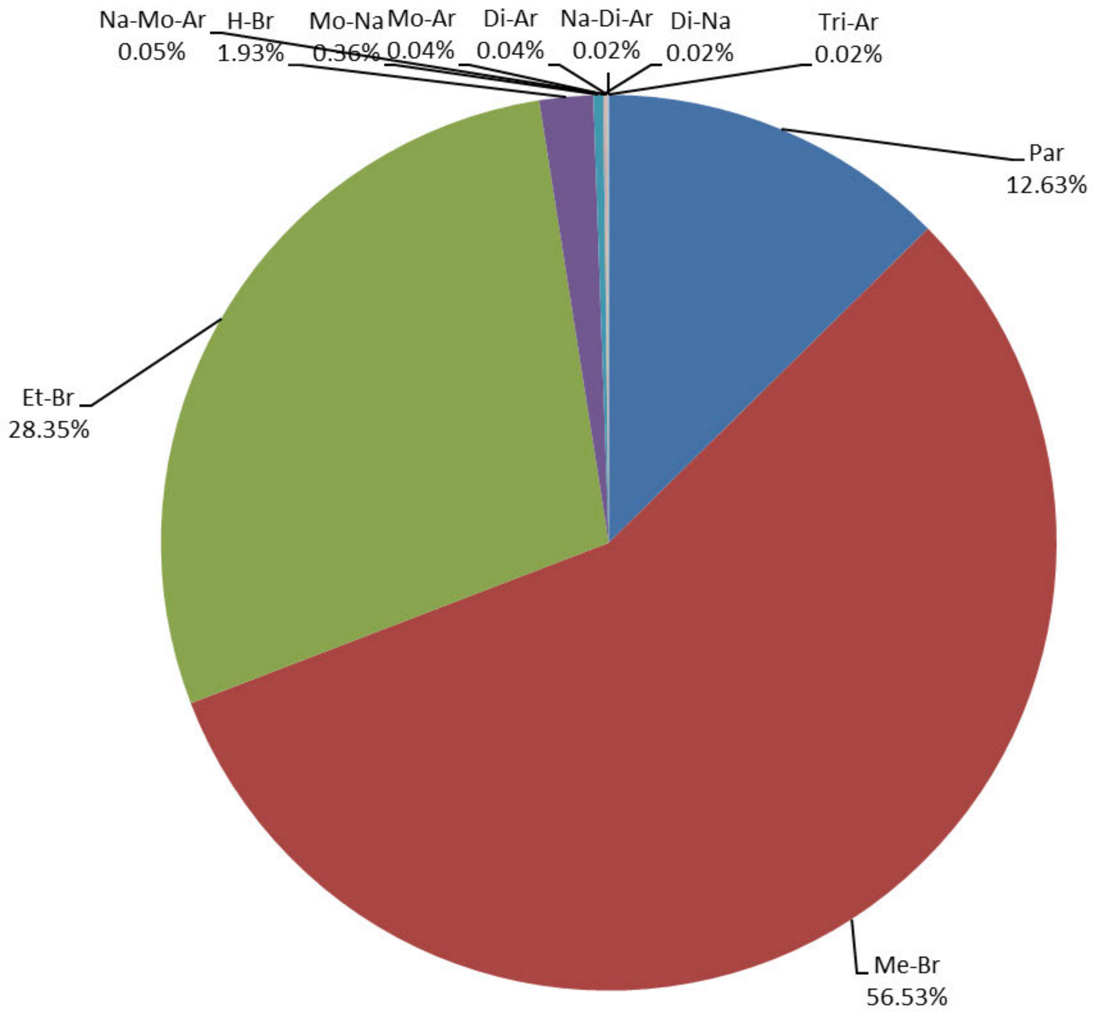
Analytical results

Table 1: IAC20-03097.012 - 6006022 - S00859902

C-nr	Par	Me-Br	Et-Br	H-Br	Mo-Na	Di-Na	Mo-Ar	Na-Mo-Ar	Di-Ar	Na-Di-Ar	Tri-Ar	Tetra-Ar	Others
6													
7					0.04								
8	0.02				0.05								
9	0.04	0.07			0.01								
10	0.06	0.11	0.02		0.01		0.01	0.01					
11	0.06	0.15	0.03		0.01			0.01					
12	0.07	0.22	0.06		<0.01			0.01	0.01				
13	0.07	0.27	0.10		0.02			0.01	<0.01				
14	0.19	0.53	0.18		0.01				0.01				
15	2.00	5.08	1.70	0.23	0.03				0.01		0.01		
16	3.11	17.52	7.83	0.37	0.03						0.01		
17	4.72	8.84	4.00	0.15	0.09						0.01		
18	2.20	23.17	14.22	1.14	0.04						0.01		
19	0.04	0.14	0.05	0.02	<0.01								
20		0.24	0.10	0.02	0.01								
21		0.03	0.01										
22		0.02	0.02										
23		0.02											
24		0.02											
25		<0.01											
26		<0.01											
27		0.04											
28		<0.01											
29		<0.01											
30		<0.01											
31		<0.01											
32		0.01											
33													
Total	**12.63**	**56.53**	**28.35**	**1.93**	**0.36**	**0.02**	**0.04**	**0.05**	**0.04**	**0.02**	**0.02**	**0.00**	**0.00**

C-nr	Carbon number	Di-Na	Di-naphthenics	Results in % w/w (based on the FID respons factors)
Par	Normal paraffins	Mo-Ar	Mono-aromatics	
Me-Br	Methyl branched paraffins	Na-Mo-Ar	Naphthenic-mono-aromatics	
Et-Br	Ethyl branched paraffins	Di-Ar	Di-aromatics	
H-Br	Heavily branched paraffins	Na-Di-Ar	Naphthenic-di-aromatics	
Mo-Na	Mono-Naphthenics	Tri-Ar	Tri-aromatics	
		Tetra-Ar	Tetra-aromatics	

Chart diagram 1: IAC20-03097.012 - 6006022 - S00859902



Chromatogram 1: IAC20-03097.012 - 6006022 - S00859902

*** End of Report ***

2. Annex: SpERC fact sheet for use of HVO in salt mining

SPERC fact sheet and supporting information
SPERC NOURYON 7.1c. v1- *Industrial use of HVO as blanketing fluid in salt mining*

Factsheet: page 1-6 -- Supporting information: page 7-15

SPERC NOURYON 7.1c. v1: Factsheet

1. Identification	
1.1 Title	Industrial use of Hydrotreated Vegetable Oil as blanketing fluid in salt mining
1.2 Code	NOURYON 7.1c.v1
1.3 Responsible	NOURYON B.V.
2. Scope	
Industrial use of the renewable hydrocarbon: Hydrotreated Vegetable Oil (HVO) as a barrier between brine and salt rock to protect the roof of the cavern and to control the growth of the underground caverns from which salt is extracted using the brine solution mining technology. This SPERC covers the HVO present in the caverns and the wells, the whole being considered as a closed system because of the confinement technology used in the well and the natural confinement characteristics of the geological salt layers. This SPERC covers a planned new development by NOURYON B.V. at Haaksbergen and is based upon the experiences gained on their two production locations in the Netherlands: a) Delfzijl site (salt fields: Heiligerlee and Zuidwending) b) Hengelo site (salt field: Twente)	
2.1 Substance/Product domain	
Chemical identification	Applicable to: ✓ The UVCB substance Renewable hydrocarbons (Alkanes, C10-20-branched and linear) ○ Common name: Hydrotreated Vegetable Oil (HVO) ○ REACH Registration number 01-2119450077-42-XXXX ○ EC number: 618-882-6 ○ CAS number: 928771-01-1 ○ IUPAC name: Renewable hydrocarbons (diesel type fraction).
Sub-SPERC	No.
2.2 Process domain	
Related Environmental Release Category	ERC 7 – Industrial use of substances in closed systems
Process description	Assumed used maximum volume: a) 120/t/year/cavern and 600 t/year/site Function & process: Blanketing fluid is used to prevent uncontrolled leaching of a cavern to protect the cavern roof. It is present in the cavern during the caverns life cycle. Volumes are adjusted up and down during the life cycle of the salt cavern. Its specific use is to prevent the cavern roof beingdissolved by water / brine, and to preserve the cavern structure integrity and orientate the horizontal salt mining expansion. Sometimes part of the volume is removed before maintenance of the well. Standard ERCs were used for pumping and maintenance operations and are thus not part of this SpERC. Which only relates to the conditions during the

	functioning of HVO in the cavern-well system that consists of the blanketing fluid in the cavern and the oil in the well tube to maintain the pressure.
Process conditions	Wet process: when in the cavern, the HVO comes into contact but does not dissolve in water or brine, and because of its lower density it moves at the top and acts as a barrier function between brine and the rock salt. Temperatures in the caverns are moderate, at temperatures no higher than 45ºC and at pressures below 245 Pa.
List of Use Descriptors covered by this SPERC	In combination: SU2a – Mining (without offshore activities) PC0 – Others – HVO used as blanketing fluid in salt mining PROC1 - use in closed process, no likelihood of exposure.
3. Operational conditions	
3.1 Conditions of use	
Location	Indoor/outdoor use: the assessment is related to the “well-cavern” system. Underground caverns can be considered as equivalent to indoor conditions, the well upper part is located in a compartment and therefore indoor. The upper part is the only place where direct contact with environmental compartments is possible.
Contact with water	Yes: HVO is used to create a barrier between water / brine and salt rock. However, HVO comprises predominantly of highly hydrophobic components and, therefore, does not dissolve in the brine (or vice versa) but remains as a distinct phase. In addition, the brine is extracted deeper than where the oil/brine interface is located.
Connection to an STP	No: The activity does not generate any effluents with oil that are emitted to sewer systems connected to sewage treatment plant (STP). Hence, considering the risks for STP is not relevant. Any HVO collected by the above ground activities that are required to keep the well-cavern system functioning, is reinjected into the caverns or temporarily stored in a dedicated storage. This storage and all related transfers are not included in this SpERC.
Rigorously contained system with minimisation of release in the Environment	Yes: <u>The geological salt rock layers</u> are known by the oil gas industry sector as traps for the petroleum products. Therefore, the salt rock caverns are confined conditions for the HVO used as blanketing fluid. <u>Between the salt layers and the fresh water ground water level</u> several geological impermeable layers are present that prevent seepage and upward flows. Therefore, HVO contamination of these aquifers or the surface is not expected. A full understanding of a possible flow of oil in these complex geological structures is not straightforward, some concerns could be notably expressed regarding possible geological faults and local variations in the rock structures with small fissures or changes in porosity, at the end conditions allowing an easier path towards the surface. However, taking into account a number of factors including the fact that these caverns are not built in unsuitable geological areas, the depth at which these are developed and that salt rock is

	known to have self-healing properties, this SPERC only applies if a geological study of the site underground has been conducted. More specifically that a study has been done for each cavern guaranteeing integrity of the cavern and confinement properties of each cavern. Moreover, in a precautionary approach, the presence of some weaknesses of this kind were considered when deriving the release factors. Wells' structure and state-of-the art apparatus, as regular monitoring, including inspections, also guarantee the full integrity of this part from which leakages must be avoided.
Further conditions impacting on releases to the environment	The monitoring of the cavern shape, pressure and integrity is part of the operational conditions that guarantee the absence of leakages. The mining and petroleum industry sectors best available technologies will be used to guarantee that the well is not a weak point regarding small long-term leakages. A combination of routine monitoring (e.g. pressure) and regular inspections is, therefore, required to demonstrate well, as well as, cavern integrity
3.2 Waste handling and disposal	
Waste disposal	A closed system is required to minimise release to the environment. If some HVO waste is generated, it will be recollected for reinjection into the caverns on the site, temporarily stored in a dedicated storage or taken by a Company specialised in petroleum products waste handling and recycling.
Suitable treatment	When activity ceases, the HVO is pumped up to be reused in another cavern or handled by a specialised company in order to be reused e.g. as fuel or handled as hazardous waste.
4. Obligatory RMMs on-site	
4.1 Air	
RMM limiting release	In the petroleum industry, for vapour pressures in the range 100-1000 Pa, the air emission fraction are less than 1%. In confined systems such air emissions can even be considered as negligible. Most of the HVO is in the confined area of the cavern and the only possible volatilisation can then be through the surface plugin system, which is tight, and has a very small interface compared to the whole used volume. Moreover, it is expected that the best available techniques recognised by the oil and gas industry for well and surface plugin systems are used. Therefore, an RMM efficiency abatement of 100% can be stated.
RMM efficiency	100% (0% release)
4.2 Water	
RMM limiting release	No direct release to water is expected because the surface plugin system is built on a concrete surface with a collecting basin and the best available techniques recognised by the oil and gas industry for well and surface plugin systems are used. Moreover, any collected releases are reinjected in the caverns. In the petroleum industry, for water solubilities below 1 mg/l, the emission fraction appear to be less than 0.0001%.

	When leakage incidents can occur along the wellbore or from the cavern, these risks and their mitigation measures are assessed under the Industrial activity Permitting. Any remaining fugative leakage risks, which cannot be identified as incidents, were assessed in this SPERC and the uncertainties related to the confinement conditions taken into account when deriving this RMM efficiency towards surface water. Based on a weight of evidence approach it is concluded that under worst case emission calculations, the emissions are demonstrated to be well below 0.01%. Therefore, the proposed RMM efficiency abatement is 99.99%.
RMM efficiency	99.99% (0.01% release used for calculation)
4.3 Soil	
RMM limiting release	Reasoning is the same as for water. The proposed RMM efficiency abatement 99.99% is based upon the monitoring of existing well-cavern systems that have demonstrated any leakage above 10 L/year/cavern is detected. These are, then subsequently repaired.
RMM efficiency	99.99% (0.01% release)
5. Exposure assessment inputs	
5.1 Substance use rate and emissions	
Annual used amount	Haaksbergen site: 600 t/y This range covers site with multiple caverns and wells. It is not the supplied volume but the total volume used in all caverns of the site, taking into account the amounts that are reused.
Daily used amount	Daily used tonnage is not a relevant indication because the whole annual volume is used all along the year. For the EUSES calculation, a value of 2.3 t/day was used for the intended Haaksbergen operation.
Fraction of EU tonnage used in region	100% This is a default worst-case assumption, which can thus cover any transfers on longer ranges through notably groundwater.
Fraction of Regional tonnage used locally	Not required. It is not a widespread use and the number of sites is limited (only 1 site) and therefore this value is not required in the assessment.
Number of emission days per year	365 days The HVO is used as the blanketing fluid in the caverns and wells all along the year.
5.2 Release factors	
Release factor in Air	0% This Release Factor describes the total release from the contributing activity to air by taking into account the OC and RMM specified in section 3 and 4. The method and argumentations are provided in the second part of this document.
Release factor in Water	0.01% This Release Factor describes the total release from the contributing activity to air by taking into account the OC and RMM specified in section 3 and 4.

	The method and argumentations are provided in the second part of this document.
Release factor in Soil	0.01% This Release Factor describes the total release from the contributing activity to air by taking into account the OC and RMM specified in section 3 and 4. The method and argumentations are provided in a background document.
6. Scaling	
Scaling can be applied to evaluate compliance of a specific use with the Exposure Scenario as described in the factsheet. Although based upon the use of diesel oil, this SPERC was adapted specifically for the use of HVO as blanketing fluid in salt mining on the new salt mining development in the Netherlands of the downstream user Company NOURYON B.V. For the moment, no scaling is included to adapt this SPERC to other salt mining sites, but this approach could be developed to adapt e.g. to new sites.	

NOURYON 7.1c. v1

Determinant Label	Quali-/ Quanti-tative	Value	Description of Value	Effectiveness in %	Exposure route	Use conditions	Standard Phrase
Indoor/Outdoor use	Qualitative	Covers Indoor and Outdoor use			Air/ water/ soil	E-W-3	Same as “value”
On-site containment of leakages	Qualitative	Typical measures used in the petroleum industry to maintain confined well systems.	-		Air/water/soil	E-W-3	Same as “value”
Further on-site technology	RMM	Monitoring well & cavern integrity through pressure and integrity of the well/cavern by techniques as flow measures, camera verification, echography.	The efficiency of the RMMs depends on the organisational and technological efforts putted on this objective.	99.99 % (0.01% release)	Water/Soil	E-W-3	Same as “value”
Further on-site technology	RMM	Monitoring well & cavern integrity through pressure and integrity of the well/cavern by techniques as flow measures, camera verification, echography.	The efficiency of the RMMs depends on the organisational and technological efforts putted on this objective.	99.99 % (0.01% release)	Water	E-W-3	Same as “value”
External treatment of waste	RMM	Closed system required to minimise release to the environment.	If oil is removed from caverns and not used in new caverns, it should be handled by a waste company or a Company able to transform the oil into a reusable fuel.				Same as “value”

SPERC NOURYON 7.1c. v1: Supporting information

Table of Contents

1. Introduction

The supporting information below is provided, as it forms the basis for the development of SPERC for the new salt mining development by NOURYON B.V. in Haaksbergen, which has similar salt mining technology as Hengelo.

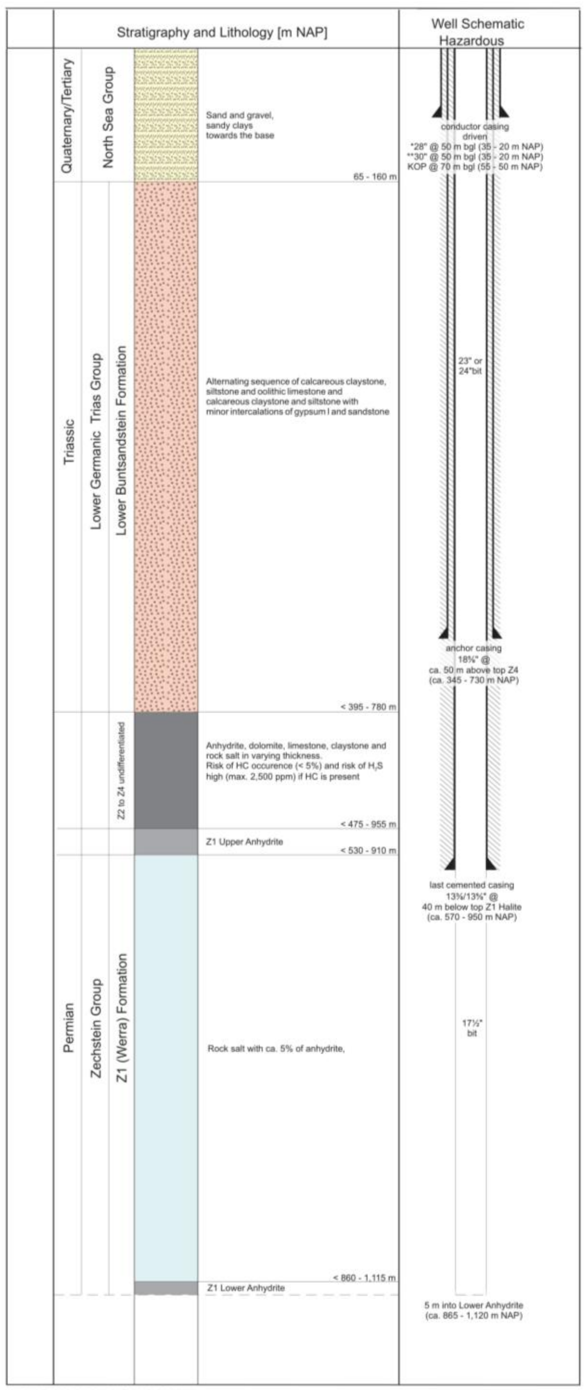
The information provided is based upon the experiences of NOURYON B.V. when operating the salt mining activities in Delfzijl and Hengelo. Their intension is to install the same technology, however, including improvements based upon the state-of-the-art of wet-salt mining that have surfaced since the installation of their aforementioned activities and their experiences gained during these operations.

In addition, this new development intends to apply a blanketing fluid, Hydrotreated Vegetable Oil (HVO) that has a lower water solubility, a lower vapour pressure and higher biodegradability. Therefore, the exposure assessment based upon the SPERC conditions that are based upon the information below have to be considered a worst-case scenario that overestimates the anticipated real-live conditions once the operations are in production.

2. Confined conditions

Settings of the wells follow the standards recommended by the mining and petroleum industrial sectors, e.g. ISO 16530 describes the effectively manage well integrity during the well life cycle, including the design and operation (Figure 1).

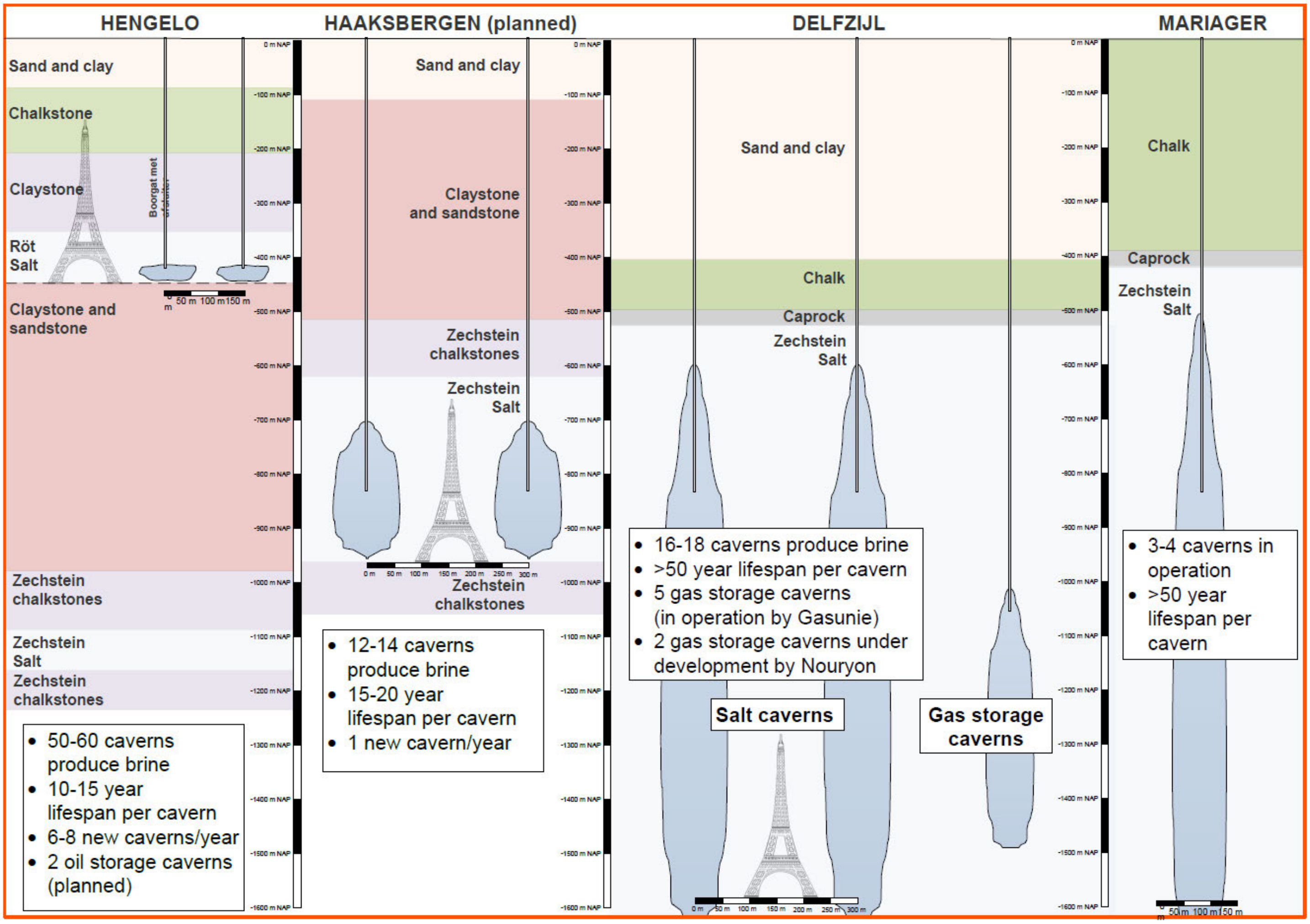
Figure 1: Schematic of the well confined system (Nouryon B.V.)



* vertical well; **deviated well; KOP - Kick off Point

The caverns are within salt layers at different depths depending on the site. The direction of their growth is controlled notably by the blanketing fluid and caverns so remain in the salt rock with several meters of salt rock above them as also a Caprock layer that is also impermeable (Figure 2).

Figure 2: Geological context of the salt mining caverns in the different sites (Nouryon B.V.)



The high ratio of the surface area of the cavern walls to their volume means that cavern shape is irregular, leaving smaller isolated pockets of both brine and diesel. It is well known from geological studies (e.g. Gesellschaft für Anlagenund Reaktorsicherheit mbH, 2011. Sichtung und Bewertung der Standortdaten Gorleben. GRS 276) that oil and brine pockets, up to hundreds of cubic meters, can remain immobile in salt over geologic times. Diesel is immiscible with brine and non-wetting; in addition, its permeation through halite is considerably limited by the high capillary resistance. Faults or fissures or microfractures may increase permeability. However, on one hand caverns and their surroundings are monitored e.g. by 3D sonar or seismic mapping, on the other hand if some failures are present it can be expected that the "salt sealing" and "Clay smear" processes bring back the impermeability (Pei Y., Paton DA., Knipe R.J., 2015. A Review of fault Sealing behaviour and its evaluation in siliciclastic rocks. Earth-Science Reviews, 150. 121 -138). Finally, when the production ceases, the caverns can be used as strategic hydrocarbon storage, indicating that if some conditions are gathered the oil can be considered as fully safe in such tight conditions (Bérest P. and Brouard B., 2003. Safety of Salt Caverns Used for Underground Storage. Oil & Gas Science and Technology – Rev. IFP, Vol. 58, No. 3, pp. 361-384).

The modelling of possible migration towards the surface by e.g. combining a multi-phase flow model and a Geographic Information System that includes a groundwater mapping could be a solution to accurately define cavern by cavern and for the whole site the risks related to groundwater contamination. However, to make such a tool accurate, the task would be very complex (no such specific tool is available at the moment), time consuming, and therefore costly, whereas a “worst-case” approach could be sufficient under the REACH Regulation to answer about the safeness of this Downstream Use (DU) of “Fuels, Diesel” as blanketing fluid in salt mining. The European Chemicals Agency indeed recommends a “tier approach” that begins with a first tier, which is a “worst-case” that combines very conservative assumptions; and, if at this stage the conclusions are that the risks are not significant and/or are correctly managed, no further assessment must be conducted (ECHA, 2011. Guidance on information requirements and chemical safety assessment - Part A: Introduction to the Guidance document. ECHA-2011-G-15-EN). The counterpart of such a simplified approach is that the generated predictions e.g. about emissions - are not realistic but overestimated ones.

The worst-case approach was therefore conducted in the CSA/CSR prepared by NOURYON for both sites in the Netherlands. The derivation of the Release Factors (RF) in this Specific Environmental Release Category (SPERC) document also follows this worst-case approach. In addition, a weight of evidence approach was used to strengthen the confidence in the proposed values.

3. Approach-1: Based on the limit of detection of leakages and worst-case assumptions about migration towards the surface

Warning: All the figures used are worst case, so this all results into an absolute worst case and not into a realistic worst case.

An impact assessment is conducted under the Industrial Emission European Directive and its transposition into the Dutch legislation (environmental Permitting). The Chemical Safety Assessment under REACH therefore focuses on the “chronic” leakages that may occur during a normal activity. The oil level monitoring is a crucial part of the brine production management because it allows the orientation of the salt extraction in the best salt rock qualities, as also guarantees the integrity of the cavern structure. In addition to the monitoring of the cavern shape, oil volumes, and pressure, inspections are also conducted, notably in case of any leakage suspicion. The limit of detection of a leakage is estimated 10 litres per whole volume of the blanketing fluid of one cavern. The weakness can mostly be in the well system and if a leak is detected, measures are taken to repair it. Therefore, in the precautionary approach undetectable leakages are hypothesised and are the only ones that can be considered as worst case input for calculations under this SPERC.

The chosen approach is therefore to simplify the possible leakages into 3 types, near the surface, in between and from the cavern (Figure 3). The closer to the surface, the more emissions can be foreseen to soil and groundwater. In a worst-case approach it is thus hypotheses that if the leakages are at a shallow level, 100% goes into the soil and groundwater, and if the leakages are deeper, a fraction is lost during the migration and only a lower percentage can reach the surface. Indeed, middle distillates as diesel tend, especially when older, to contain low percentages of the lighter molecular weight aromatic group, and so are denser, more viscous, less water soluble, more adsorptive, so much less mobile and linking tightly with the crossed layers. Underground pressure and capillary forces will move the oil upward, but with these losses and in addition, trapping process when reaching the impermeable layers (e.g. in the Muschelkalk formation). It is thus very unlikely that if chronic leakages occur, the oil would reach the groundwater level.

To integrate the three types of chronic leakages, which cannot occur at the same time otherwise the volume would be higher and then the leakages would be detected and repaired, a distribution is proposed. From all this simplified worst-case approach, it can be proposed a release factor to soil or groundwater not higher than 0.01% (

Table 1).

Figure 3: Simplification into 3 types of "chronic" leakages to estimate a release factor to groundwater or soil

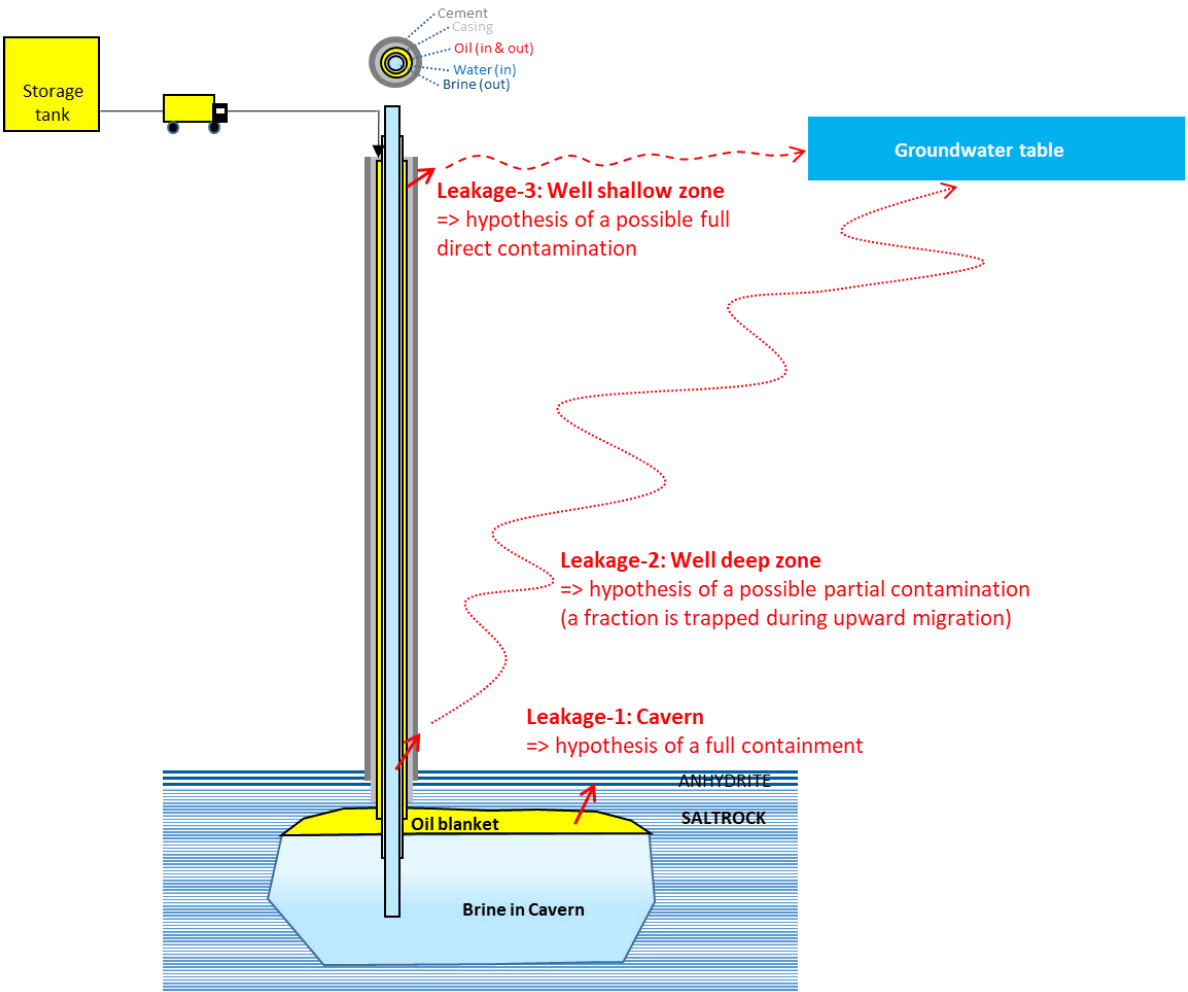


Table 1: Estimation of the release factors from the limit of detection of a "chronic" leakage

Delfzijl (Heiligerlee/Zuidwending)	Case-1	Case-2	Case-3	Note
"Chronic" leakage cases	Shallow level	In between level	cavern level	[1]
Fraction that can potentially reach the groundwater or the soil (very worst-	1.00	0.70	0.50	[2]
Limit of detection of a leakage in a well-cavern system [m3]	0.010	0.010	0.010	[3]
Blanketing oil in one cavern (average) [m3]	89.8	89.8	89.8	[4]
Chronic leakage fraction related to the oil volume in the well-cavern system	1.11E-04	1.11E-04	1.11E-04	[5]
Case by case release factor to groundwater (& surface water) and soil [%]	0.011	0.008	0.006	[6]
Distribution of the non-detected chronic leakages	0.20	0.30	0.50	[7]
Global potential release factor to groundwater (& surface water) and soil [%]	0.007			[8]
Global potential release factor to groundwater (& surface water) and soil [%] - rounded value	**0.01**			-
Hengelo (Twente)	Case-1	Case-2	Case-3	
"Chronic" leakage cases	Shallow level	In between level	cavern level	[1]
Fraction that can potentially reach the groundwater or the soil (very worst-	1.00	0.80	0.50	[2]
Limit of detection of a leakage in a well-cavern system [m3]	0.010	0.010	0.010	[3]
Blanketing oil in one cavern (average) [m3]	94.1	94.1	94.1	[4]
Chronic leakage fraction related to the oil volume in the well-cavern system	1.06E-04	1.06E-04	1.06E-04	[5]
Release factor to groundwater (& surface water) and soil [%]	0.011	0.009	0.005	[6]
Distribution of the non-detected chronic leakages	0.20	0.30	0.50	[7]
Global potential release factor to groundwater (& surface water) and soil [%]	0.007			[8]
Global potential release factor to groundwater (& surface water) and soil [%] - rounded value	**0.01**			-

[1] Cases are presented in Figure 3. Blanketing fluid is used in the caverns, but because of its continuity with the well the assessment considers the “well-cavern” system. From it, in theory, leakages can occur at any level. That is the reason three cases were proposed: immediately in the vicinity of the soil or groundwater, slightly under it, more deeply but above the salt layers, and from the cavern in the salt layer. The different zones are not defined by their exact depths but the worst-case assumption regarding the fraction that could from chronic leakages reach the underground zone that is near the surface.

[2] If oil is released directly near the soil & groundwater level, in a worst-case approach 100% can be considered as reaching these environmental compartments (if other parameters as porosity would be taken into account, such a figure would be impossible to reach). However, the deeper the "chronic" leakage, the lower is the fraction that can reach the surface; this is notably related to adsorption,

viscosity, wettability, capillarity, that govern but also limit the possible flows, and of course it is related to the well-recognised impermeable or of-low-permeability geological layers identified on these sites, that are barriers and traps that will reduce the fraction that can potentially reach the subsurface zone. The caverns are confined in the salt rock layers and covered by an impermeable evaporite layer, however, to take into account a worst-case with some loss of impermeability due to faults or fissures, a chronic leakage from the cavern is also assessed. The statements proposed in this first approach can be considered as a worst-case and if needed can be in the future supported by further refinements and literature references.

[3] The assessment focuses on the "chronic" leakages that may not be detected and handled as incidental/accidental leakages, these last ones being already considered in the impact assessment required under the industrial Permitting legislation. Technically the measures, notably when inspections are conducted, can detect a 10-litre leakage in a well-cavern system. Thus, this value is used as a reference under which the leakage becomes undetectable and lead to “chronic” contamination.

[4] The blanketing total volume is the one of all the caverns of the site.

[5] The leakage fraction is the ratio limit of detection to the oil volume in the cavern.

[6] This is the precedent value transformed into a percentage and rounded to the upper value.

[7] As all leakages do not occur at the same time (otherwise the amount would be detectable as an incident and handled, so not a "chronic" leakage) and do not have the same probability to occur without being detected (well inspection reduce the risks, for the caverns the uncertainties due to the complex shape of the volume make more difficult to know precisely e.g. presence of small faults), a distribution of these cases is taking into account.

[8] This is the weighted estimated release factor. This approach is relevant as this value should represent "chronic" leakages of all the caverns on the site. The release factor is rounded to the upper value.

4. Approach-2: Based on worst-case leakage (normally under the scope of Permitting & out of REACH) and simplified assumptions about migration

Warning: All the figures used are worst case, so this all results into an absolute worst case and not into a realistic worst case.

Based on a leakage incident reported in the Hengelo site (this site can be considered as worst-case notably because caverns are less deep so closer to the groundwater level), without conducting a sophisticated modelling that would need more data, it can be calculated from the measured locations of the leakages and their extensions a theoretical plume with two zones, one called the “core plume” that is fully saturated with oil and another one called “peripherical plume” that is not fully saturated (stated 50% saturated, if other parameters as porosity would be taken into account, such a figure would be impossible to reach) (Figure 4). After taking into account the frequency of this type of leakages and then comparing the calculated quantity to the total quantity of oil used as blanketing fluid in all the caverns of the site, it can be proposed a hypothetical release factor of 0.006% if the receptacle is soil and 0.000004% if the receptacle is groundwater (Table 2).

Figure 4: Summary of the leakage incident case (assessed under Permitting assessment) used as worst-case to derive a release factor (REACH assessment)

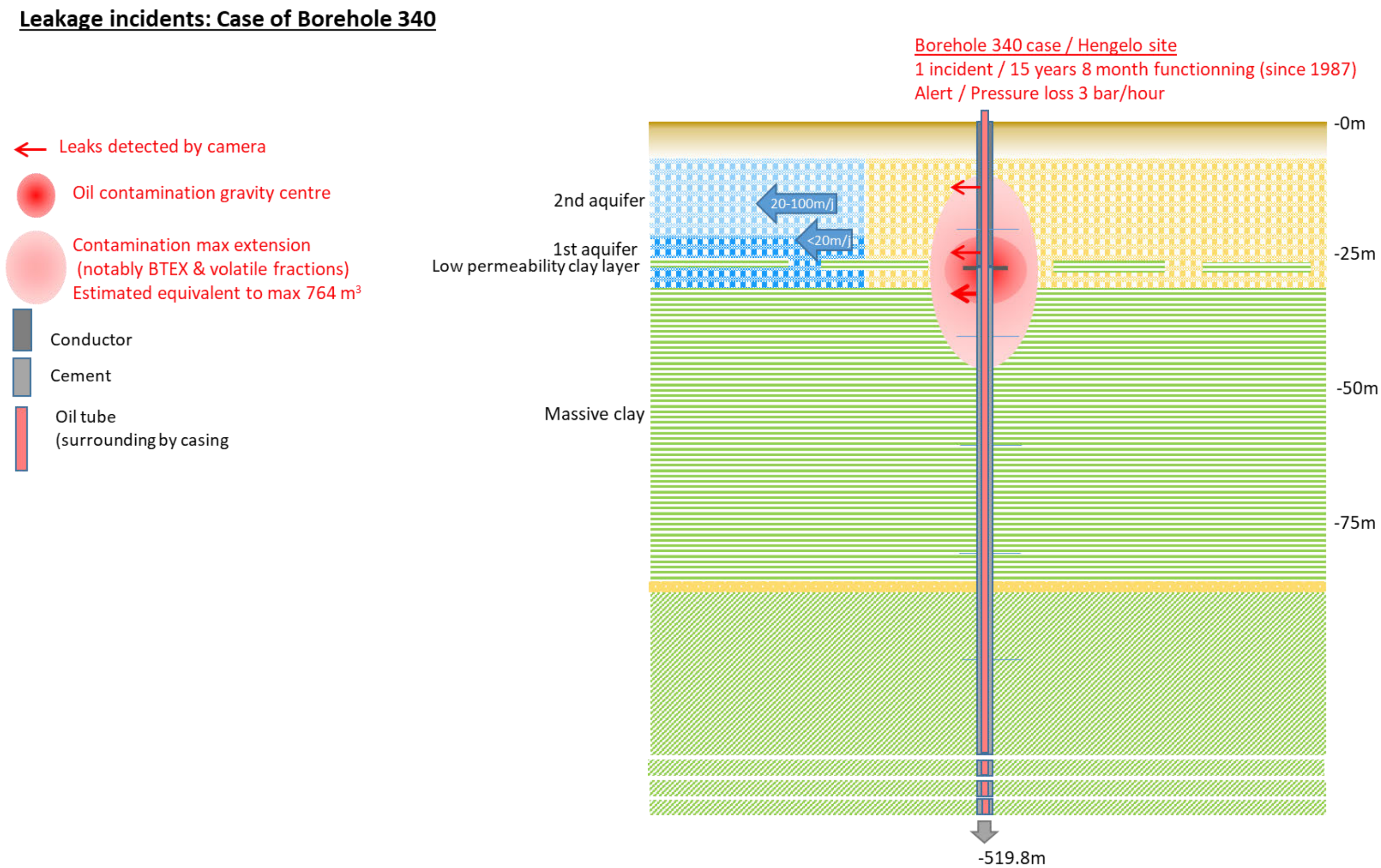


Table 2: Simplified calculation of a release factor based on the leakage case at Hengelo site

All the figures used are worst case, so this all results into an absolute worst case and not into a realistic worst case. The volumes of both plume zones are fully theorical only based on an equal diffusion in all direction (sphere form), this is a non-realistic behaviour but is sufficient for this conservative first assessment approach.

Release to soil hypothesis	*Value Unit*	*References & comments*
Volume of the plume core zone	1001.4 m3	Gravity center of the diesel pollution is between -23 and -31.5 m & with a max horizontal migrration of 15 m
Max possible diesel concentration	0.00002 t/m3	According to Brost et al., 2000, API's Soil and Groundwater Bulletin No. 9.
Saturation	100 %	Worst-case assumption
Maximum possible oil quantity in the plume saturated zone	0.02 t	Volume * Concentration * Saturation
Volume of the plume peripherical zone	6643.2 m3	Extension of the contaminated zone is from -10 to -46.5 m & with a max horizontal migration of 20 m
Max possible diesel concentration	0.00002 t/m3	According to Brost et al., 2000, API's Soil and Groundwater Bulletin No. 9.
Average saturation fraction in the non-oil-saturated zone	50 %	Reasonable worst-case assumption in a 0 to 100% gradient
Oil quantity in the plume non-saturated zone	0.06 t	Volume * Concentration * Saturation
Total oil quantity in the plume	0.08 t	Core + peripherical zone of the plume
Incident yearly frequency per one cavern	0.065 cases/y/cavern	One case reported during the 15.5 years functionning of the Cavern
Incident yearly frequency per all caverns	4.839 cases/y/site	Other cases not reported, worst-case assumption is that the same probability applies to all the caverns of the site
Blanketing oil quantity in all caverns	7053.8 t	Maximum theoritical quantity that could be used for all caverns in the site
Release factor to soil	**0.006** %	Ratio of the hypothetical release to the total blanketing oil for this site
Release to water hypothesis	*Value Unit*	*References & comments*
Volume of the plume	7644.5 m3	Volume of the core + volume of the peripherical zone
Porosity fraction	0.3	Usual accepted porosity for sandy soils
Saturation	100 %	Worst-case assumption
Concentration in water	9.7E-07 t/m3	Maximum water solubility as proposed in the REACH Registration dossier
Maximum possible oil quantity in the plume	0.002 t	Volume * porosity * Concentration * Saturation
Yearly frequency per one cavern	0.067 cases/y/cavern	One case reported during the 15.5 years functionning of the Cavern
Yearly frequency per all cavern	0.133 cases/y/site	Other cases not reported, worst-case assumption is that the same probability applies to all the caverns of the site
Total blanketing oil quantity	7053.8 t	Maximum theoritical quantity that could be used for all caverns in the site
Release factor to water	**0.000004** %	Ratio of the hypothetical release to the total blanketing oil for this site

5. Approach-3: Based on extrapolation from groundwater monitoring data

Warning: All the figures used are worst case, so this all results into an absolute most worst case and not into a realistic worst case.

In groundwater monitoring data were gathered to assess the contaminations due to handling incidents. These are technically outside of the scope of a REACH chemical safety assessment. In this third approach we only used these data to approximate what could be the release factors if these detected contaminations would come from chronic leakages from the caverns or wells. The values indicated as equal to “50 µg/l” or “35 µg/l“ cannot be considered as significant as they correspond to the limit of quantification.

Table 3: Groundwater monitoring data for all wells drilled and taken into operation after 2005 (Hengelo area)

			Concentratie minerale olie in µg/l															
	X	Y	1998	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 (ANTEA)	2016(GEOFOXX)	2017
TWR-431	253031,5	471034,2				50					50			75	50	50		50
TWR-440	252159,1	470756					50				50			35			50	50
TWR-441	252138,8	470944,8					50				50			35			50	50
TWR-442	252157	471089,8					50				50			35			50	50
TWR-445	251646,5	471040,5				50					50			160	50	50	50	50
TWR-446	251499,9	471071,3				50					50			35			50	50
TWR-447	251002,8	470906,9				50						2700	50				110	95
TWR-478	251147,7	470915				50						50			50		50	50
TWR-479	251569,9	471541,2												34000			10000	2100
TWR-482	250509,8	471787,9				50					50			35			50	50
TWR-483	252973,3	472040,6						50			50			35			50	50
TWR-484	253151,3	471966,8						50			50			35			50	50
TWR-485	251124	471638,6					50				50			35			50	50
TWR-486	253581,1	470006,2						50			50			35			50	50
TWR-487	253396,5	469826,6					50				50			35			50	50
TWR-488	253511,7	469738,3					50				50			35			50	50
TWR-489	253694,2	469667,4						50			50			35			50	50
TWR-490	253833,2	469622,7						50			50			53	50		50	50
TWR-491	253972,8	469583,3						85			50			4800			50	3300
TWR-492	254159,7	469539						50			50			35			50	50
TWR-493	254301,2	469507,6						50			50			35			50	50
TWR-494	254442,7	469475,9						50			140	50			50		50	50
TWR-495	254584,7	469446,6							50			50			50		50	50
TWR-496	254633,7	469440,1							50				50				50	50
TWR-497	254729,3	469430								50			50				50	50
TWR-498	254236,8	470488										50			50		50	50
TWR-499	254333,1	470365,7									50			35			50	50
TWR-500	254332,9	470219,3									50			35			50	50
TWR-501	254448,1	470129,5									50			35			50	50
TWR-502	254562,1	470039,8									50			350	400		200	420
TWR-503	254676,1	469949,6									50			35			50	50
TWR-504	254838,7	469900,9								50			50				50	50
TWR-505	253739,2	470242,2								50			50				50	50
TWR-506	253866,7	470171,4								50	50			35			50	50
TWR-507	253973,2	470072,6									50			35			50	50
TWR-508	254063,5	469952,1									50			35			50	50
TWR-509	254196,2	469893												35			50	50
TWR-510	254346,6	469814									50			35			50	50
TWR-511	254480,9	469754,1							50		50			35			50	50
TWR-512	253699,7	469933,9									50			35			50	50
TWR-513	255123,2	469618,6									50			35			50	50
TWR-514	255201,7	469370,5										50			50		50	50
TWR-516	254286	469010,6										50			50		230	310
TWR-517	254293,2	468865,8										50			80		50	50
TWR-520	254544,8	469088,3										50			50		50	50
TWR-521	254513,5	468945,8										50			50		50	50
TWR-523	254853,3	469027,9											50				50	50
TWR-524	254772,3	468904,8											50				50	50
TWR-525	254834	468706,2											50				50	50
TWR-526	249852,3	470011,9											50				50	50
TWR-527	249697,6	470294,5											50				50	50
TWR-528	249385,7	470635,1																50
TWR-529	249261,8	470717,1																50
TWR-530	248945,7	470713,6															50	50
TWR-531	249864	469765,7											50				50	50
TWR-532	249652,3	469935,4											50				50	50
TWR-533	249539,7	470027,9											50				720	290
TWR-534	249412,8	470106											50				50	50
TWR-535	249397,5	470359,4															50	50
TWR-536	249249,6	470383,9															50	50
TWR-537	249096,2	470384,5													50		50	50
TWR-538	248930,6	470438,9											50		50		50	50
TWR-539	248619,5	470455,8													50		50	50
TWR-540	248482,7	470410,7													50		50	50
TWR-541	248344,4	470366,2																50
TWR-542																		
TWR-543																		
TWR-544																		
TWR-545																		
TWR-546																		

No free diesel was found in monitoring wells. The values, therefore, only concern the solubilised fraction, indicating no major contamination. Moreover, among the 248 samples only 10 were contaminated, so 4% of the samples.

It is very complex to propose a release factor from these monitoring data; however, an attempt can be made by using as starting point an average concentration of 243.8 mg/m^3 that represents a worst-case if one considers that oil contaminations are not all the time present. From this concentration, by stating that a groundwater volume 10 meters deep and 25 meters large with a porosity of 0.4 will hold 2500 m^3 groundwater, it can be proposed a total theoretical quantity equal to 0.61 m^3. When comparing this oil quantity to the total blanketing fluid on site, the ratio is 0.000086; this means a hypothetical release factor below 0.01%.

6. Conclusion through a Weight of Evidence approach

Warning: All the figures used are worst case, so this all results into an absolute worst case and not into a realistic worst case.

Table 4: Conclusion about the release factors related to the blanketing use in salt mining

Approach			Release factor %
	1	**Upper estimation soil or water / Chronic leakages (REACH)**	
		Delfzijl (Heiligerlee/Zuidwending)	0.007352
		Hengelo (Twente)	0.007337
	2	**Lower estimation / Incidental leakages (Permitting & not REACH)**	
		Soil (both sites)	0.005761
		Water (both sites)	0.000004
	3	**Extrapolation from groundwater monitoring data**	
		Water (Hengelo site)	0.008642
Conclusion		**Release factor in soil or water for both sites**	**<0.01**