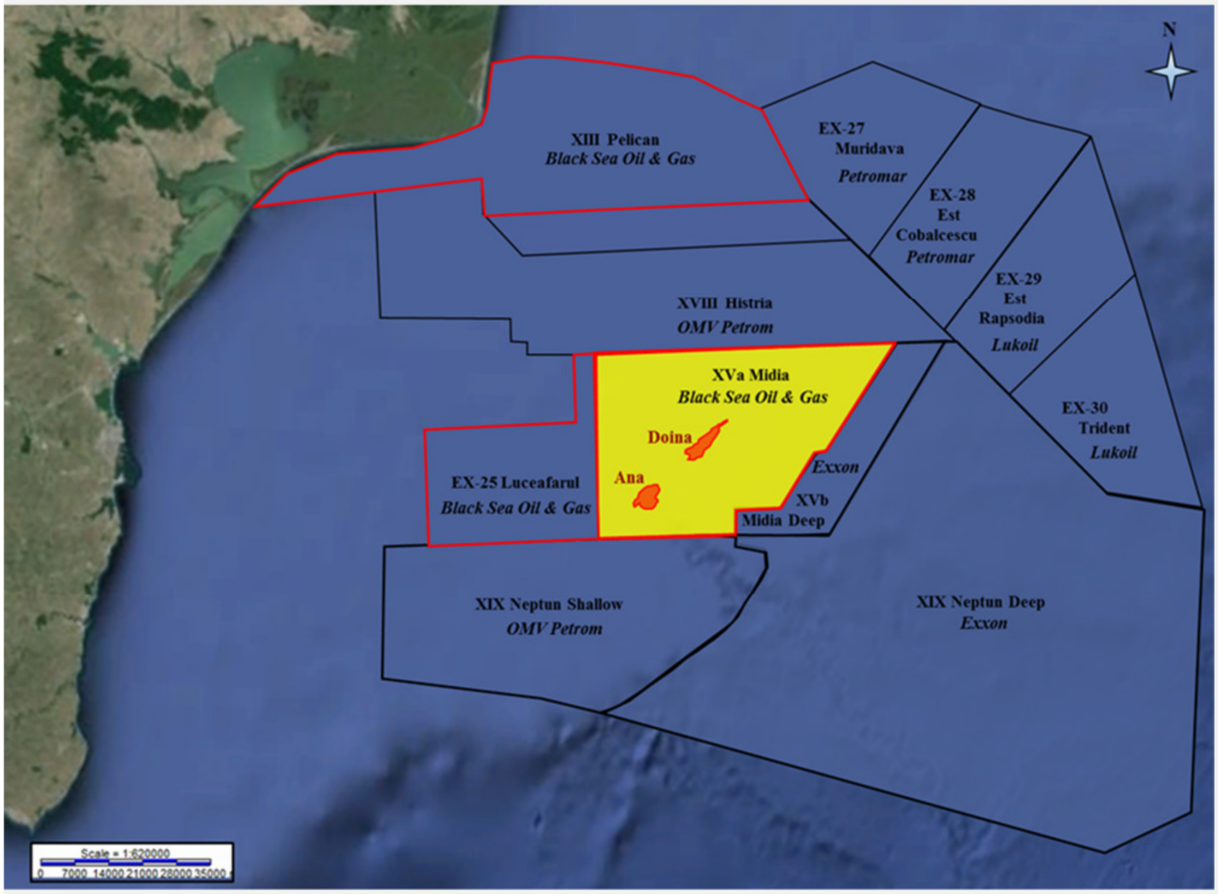

BlackSea
oil & gas

Midia Gas Development

Drill Cuttings Disposal- Best Practicable Environmental Option

2 April 2019

Project No: 0497814

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2 April 2019

Midia Gas Development

Drill Cuttings Disposal- Best Practicable Environmental Option

MIrvine

Mark Irvine
Technical Director

M. R. Cobb

Michael Cobb
Principal Consultant

ERM's Edinburgh Office
6th Floor
102 West Port
Edinburgh
EH3 9DN

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Acronyms and Abbreviations

Name	Description
BMP	Biodiversity Management Plan
BPEO	Best Practicable Environmental Option
BSOG	Black Sea Oil & Gas
CAPEX	Capital Expenditure
CHARM	Chemical Hazard and Risk Management
CO_2e	Carbon Dioxide Equivalent
CORMIX	Cornell Mixing Zone Expert System
EBRD	European Bank of Reconstruction and Development
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
GHG	Greenhouse Gas
GIIP	Good International Industry Practice
HGV	Heavy Goods Vehicle
HOCNF	Harmonised Offshore Chemical Notification Format
HQ	Hazard Quotient
IFC	International Finance Corporation
LECS	Lender Environmental and Social Consultant
MGD	Midia Gas Development
MMSCMD	Million standard cubic metres per day
MODU	Mobile Offshore Drilling Unit
MSL	Mean Sea Level
NADF	Non-aqueous drilling fluid
OCNS	Offshore Chemical Notification Scheme
PLONOR	Poses Little Or NO Risk to the environment
PSA	Particle Size Analysis
PSV	Platform Supply Vessel
THC	Total Hydrocarbon
TOC	Total Organic Carbon
WBDF	Water based drilling fluid
WBM	Water Based Mud

1. INTRODUCTION

1.1 Background

Black Sea Oil & Gas SRL (BSOG) is the operators of petroleum exploration, development and exploitations of the Midia XV (shallow) Block, offshore Romania. The Ana and Doina fields are located in the western Black Sea, approximately 105 and 120 kilometres to the east of Constanta respectively.

BSOG intends to develop the Midia Gas Development (MGD) project (the Project) to produce natural gas from the Ana and Doina fields and export the gas by a 126 km pipeline to a receiving station in Romania for processing and domestic consumption and further export to other European Union countries. Up to four new wells (one vertical and three deviated) from the same location are planned for the Ana field and one new vertical well in the Doina field with drilling scheduled to be undertaken over a 210 day period in 2020-2021. The Ana well site is in 69.2 m of water and the Doina well site is in 84.3 m of water. The two well sites are approximately 18 km apart. Previously two wells have been drilled in the Ana field and four wells drilled in the Doina field.

The fields are predicted to have an overall production life of 10 to 15 years with a predicted peak production rate of approximately 3.115 million standard cubic metres per day (MMSCMD). Front End Engineering Design (FEED) has been undertaken and the Project is ready to enter the Engineering Procurement Construction (EPC) phase.

The Project is part-financed by the European Bank for Reconstruction and Development (EBRD) and as such BSOG must implement the EBRD Performance Requirements (PRs) which are designed to assist the implementation of good international industry practices (GIIP) relating to sustainable development.

Following a review of the Project Environmental and Social Impact Assessment (ESIA) by the lender's environmental and social consultant (LESC), the EBRD have highlighted further work that is required to update the ESIA justifying the decision for sea disposal of drill cuttings and associated water based drilling fluids (also termed water based mud, WBM, or water based drilling fluid, WBDF). *Table 1.1* provides an overview of the LESC comments on the assessment of drill cuttings disposal.

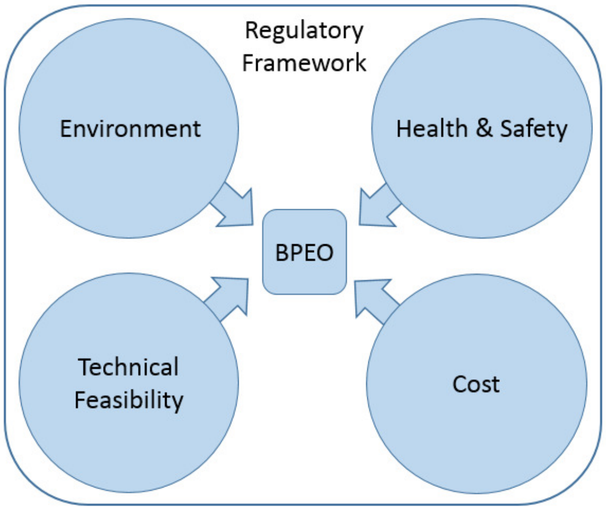
Table 1.1 Summary of LESC Comments on Drill Cuttings Disposal

Issue	Action Required
Drill Cutting Disposal: The assessment of the most environmentally defensible disposal route for the drilling cuttings has not been assessed in the ESIA.	Evaluate the alternatives available for the disposal of cuttings, including bringing ashore for treatment and disposal, and determine the best approach for their disposal.
Drill Cutting Disposal: If disposal at sea is demonstrated to be the most feasible and environmentally acceptable option a drilling cuttings management plan needs to be developed.	Develop a drilled cuttings and fluid disposal plan should be prepared, taking into account currents, cuttings and fluid dispersion approaches, water-based drilling fluid chemical selection, environmental risk, and monitoring of biodiversity.

1.2 Purpose of this Report

This report forms an Additional Impact Assessment covering the gaps in the ESIA raised by the LESC, in relation to the assessment of drill cuttings disposal options. The approach taken is to perform a Best Practical Environmental Option (BPEO) study to identify the preferred option taking into account technical, environmental, health & safety, costs (as illustrated in *Figure 1.1*).

Figure 1.1 Overview of BPEO



The findings of the report will be used to inform the development of a drill cuttings management plan as part of the overall Project Environmental and Social Management Plan (ESMP). This will include recommendations for any monitoring that may be required and link to the overall Project Biodiversity Management Plan (BMP).

2. APPROACH TO THE ASSESSMENT

2.1 Best Practicable Environmental Option

The BPEO concept was developed by the UK Royal Commission on Environmental Pollution between 1976 and 1988 when it was introduced into UK environmental protection, pollution control and waste management legislation. It is a strategic decision making tool and is site and project specific with local regulations, environmental conditions and available technologies influencing the preferred option. The level of detail required for a BPEO assessment depends on the complexity of the different options, however, as the purpose of the process is to assess the relative performance of the different options under consideration, detailed quantitative analysis for all criteria is not required.

2.2 BPEO Stages

The following stages have been undertaken in this BPEO study:

- Details of the proposed drilling activities, type and constituents of the drilling fluids and quantities of drill cuttings to be generated are provided.
- The alternative drill cuttings management and disposal options are presented including reinjection, sea disposal, land disposal (ship to shore for re-use, recycling or disposal).
- A summary is provided of the environmental sensitivities at the drilling sites.
- The findings of an analysis of drill cuttings dispersion modelling for the Ana and Doina sites is presented.
- An assessment of each disposal option is presented considering the following criteria:
  - Regulatory requirements
  - Technical feasibility;
  - Environmental considerations;
  - Cost considerations; and
  - Health & safety considerations.
- The preferred option is identified along with relevant mitigation and management approaches.

3. DRILLING OPERATIONS

3.1 Drilling Programme

The mobile offshore drilling unit (MODU) GSP Uranus, a jack-up rig, has been contracted to undertake the drilling of the five MGD Project wells. A drill string comprising a drill bit at the end of a series of hollow steel pipe sections is rotated from the MODU and the pieces of rock broken up by the drill bit (known as cuttings) are removed from the well by circulating drilling fluids from the MODU through the drill string and back to the MODU via the annulus (the space between the drilled hole and the drill string). With a connection in place from the top of the well to the MODU (ie a casing or riser), the returned cuttings and fluids are processed through solids control equipment to separate the fluids and cuttings so that the fluids can be reused.

The amount of cuttings and WBDF which will be generated through the drilling of the Ana and Doina wells has been estimated (Table 3.1) based upon the internal diameter (ID) and length of each well sections. The duration over which these cuttings would be generated has been estimated.

Table 3.1 Estimated Quantities of Cuttings and WBDF to be Generated

Well	Well Section ID (inches)	Section Length (m)	Hole Volume (m^3)	Dry Cuttings (m^3)	Cuttings & WBDF (m^3)	Total (Tonnes)	Cuttings Generation (Days)
Ana-100 Vertical Well	26"	67	23.0	18.4	36.9	70.1	0.33
	17 1/2"	270	41.9	33.5	67.0	127.4	1.33
	12 1/4"	692	52.0	41.6	83.3	158.2	1.75
	16"	32	4.1	3.3	6.6	12.6	0.41
	Drilling duration 24 days						
Ana-101 Deviated Well	26"	67	23.0	18.4	36.9	70.1	0.33
	17 1/2"	382	59.3	47.4	94.9	180.2	1.67
	12 1/4"	919	69.1	55.3	110.6	210.1	3.58
	16"	37	4.8	3.8	7.7	14.6	0.42
	Drilling duration 26 days						
Ana-102 Deviated Well	26"	67	23.0	18.4	36.9	70.1	0.33
	17 1/2"	335	52.0	41.6	83.2	158.1	1.67
	12 1/4"	955	71.8	57.5	114.9	218.3	3.33
	16"	36	4.7	3.7	7.5	14.2	0.42
	Drilling duration 26 days						
Ana-103 Deviated Well	26"	67	23.0	18.4	36.9	70.1	0.33
	17 1/2"	286	44.4	35.5	71.0	134.9	1.46
	12 1/4"	934	70.2	56.2	112.4	213.5	3.50
	16"	50	6.5	5.2	10.4	19.7	0.42
	Drilling duration 26 days						
Doina-100 Vertical Well	* 36"	67	44.3	35.4	70.8	134.6	No data
	17 1/2"	490	76.0	60.8	121.7	231.2	1.33
	12 1/4"	450	33.8	27.1	54.1	102.9	1.96
	16"	25	3.2	2.6	5.2	9.8	0.33
	Drilling duration 26 days						
Totals				548.7 m^3	1098.1 m^3	2086.1 T	24.9 days

Source: Xodus 2018.

Note: * 36” Riserless section – discharge directly to seabed from the top of the well.

3.2 Drilling Fluids

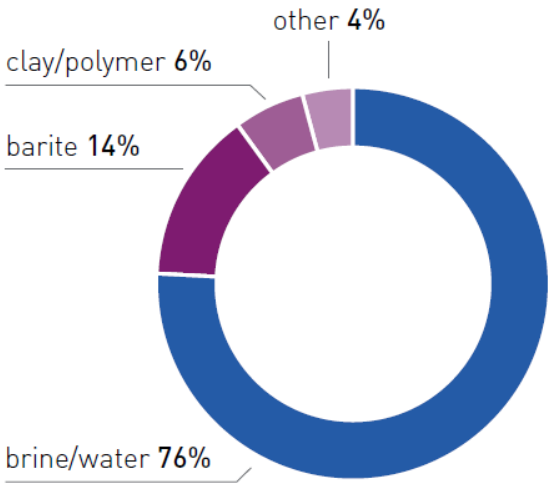
Drilling fluids are mixtures of fine-grained solids, inorganic salts, and organic compounds dissolved or dispersed in a base fluid which may be water or an organic liquid. Two main types of drilling fluids exist, classified according to their base fluid.

- Water-based drilling fluids (WBDF) – based on fresh or saltwater; and
- Non-aqueous drilling fluids (NADF) – based on oil or synthetic fluids.

The type of fluid selected depends on anticipated well conditions or on the specific section of the well being drilled.

WBDF are formulated mixtures of clays, natural and synthetic organic polymers, mineral weighting agents (eg barite or calcium carbonate), and other additives dissolved or suspended in fresh water, seawater, brine, saturated brine, or a formate brine (IOGP, 2016b). Figure 3.1 provides an illustration of the composition of a typical WBDF.

Figure 3.1 Composition in Weight Percent of Typical WBDF



Source: IOGP, 2016a

A number of additives are used to modify the physical properties of drilling fluids to deliver the functional requirements for each well section. Table 3.2 provides an overview of the types of additives typically used in WBDF.

Table 3.2 Types of WBDF Additives

Category	Example
Weighting materials	Barite, calcium carbonate, ilmenite or hematite
Viscosifiers	Clay, organic polymers
Filtrate reducers	Starch, clay, lignite, polymers
pH control	Inorganic acids and bases, most often caustic soda
Shale control	Soluble salts such as potassium chloride (KCl), amines, glycols)
Lost circulation materials	Inert insoluble solids such as calcium carbonate, ground nut shells, graphite, mica and cellulose fibres
Lubricants	Water-based lubricants, glycols and beads
Emulsifiers, surfactants	Detergents, soaps, organic fatty acids
Thinners	Lignite, lignosulfonates, polymers
Flocculants	Inorganic salts, acrylamide polymers
Bactericides	glutaraldehyde, triazine disinfectants
Pipe-freeing agents	Water-based lubricants, enzymes, surfactants
Defoamers	alcohols, silicones, aluminium stearate, alkyl phosphates
Calcium reducers	Sodium carbonate, bicarbonate, polyphosphates
Corrosion inhibitors	Amines, phosphates
Temperature stability	Acrylic or sulfonated polymers, lignite, lignosulfonate

Source: IOGP, 2016b.

3.3 MGD Water Based Drilling Fluids

For the MGD project WBDF will be used for all wells. Table 3.3 presents a list of the proposed drilling additives, together with information on their rating (see Box 3.1 for further information), which will be used to formulate the WBDF for the Ana and Doina wells.

Table 3.3 Proposed MGD well WBDF Additives

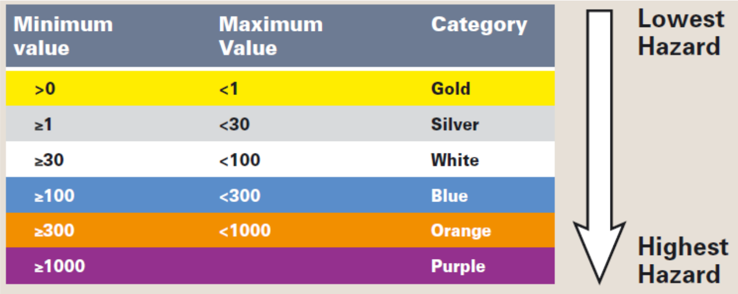
Product Name	Category	Rating (Hazard Quotient, PLONOR or OCNS Group)
AVALIG NE	Thinner and deflocculant	OCNS Group E
AVACARB	Weighting material	PLONOR, OCNS Group E
AVACID 50	Biocide	HQ Band Gold; No substitution warning
AVAGEL	Viscosifier	PLONOR, OCNS Group E
AVAGUM	Viscosifier	PLONOR, OCNS Group E
AVAMICA F-M-C	Lost circulation material	PLONOR, OCNS Group E
AVATENSIO NS	Surfactant / Stuck Pipe Agent	HQ Band Silver, Substitution warning
Calcium Carbonbate	Weighting material	PLONOR, OCNS Group E
Caustic Soda	pH control	OCNS Group E
Citric Acid	pH control	PLONOR, OCNS Group E
AVAGREENLUBE	Lubricant	HQ Band Gold
GRANULAR F-M-C	Lost circulation material	PLONOR, OCNS Group E
INCORR	Corrosion inhibitor	HQ Band Gold; No substitution warning
INTAFLOW	Lost circulation material	PLONOR, OCNS Group E
INTASOL F-M-C	Lost circulation material	PLONOR, OCNS Group E
Potassium Chloride	Shale Inhibitor / Encapsulator	PLONOR, OCNS Group E
Sodium Bicarbonate	Brine (Completion)	PLONOR, OCNS Group E
Sodium Carbonate–Soda Ash	Scale Dissolver	PLONOR, OCNS Group E
AVADEFOAM NS	Defoamer	HQ Band Gold
VICTOSAL	Viscosifier	PLONOR, OCNS Group E
VISCO 83 XLV	Viscosifier	PLONOR, OCNS Group E
VISCO XC 84	Viscosifier	PLONOR, OCNS Group E

Source: Black Sea Oil and Gas; CEFAS Offshore Chemical Notification Scheme Lists of Notified and Ranked Products (updated 26/02/2019).

Box 3.1 Categorisation of Offshore Chemicals

The OSPAR Harmonised Mandatory Control Scheme (HMCS), developed through the OSPAR Decision 2000/2 on a Harmonised Mandatory Control System for the Use and Discharge of Offshore Chemicals (as amended by OSPAR Decision 2005/1) and its supporting Recommendations, was introduced with a view to unifying regulations regarding the use and reduction of the discharge of offshore chemicals across the Northeast Atlantic region. Under the HMCS, a chemical developed for use on an offshore installation will not be permitted to be used without authorisation from the authorities of the intended sector of the North Sea; the first step in the process of authorisation is to complete a Harmonised Offshore Chemical Notification Format (HOCNF) submission.

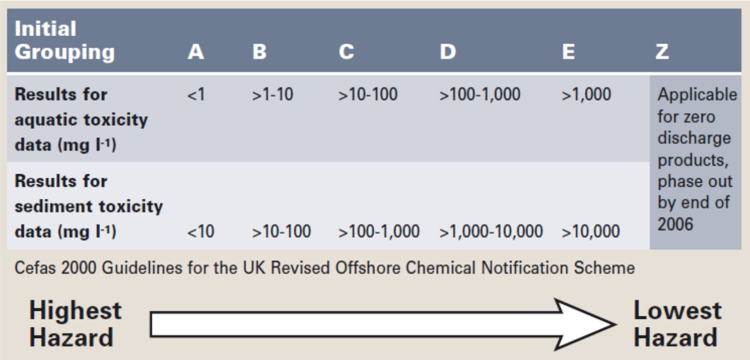
The Offshore Chemical Notification Scheme (OCNS) manages chemical use and discharge by the UK and Netherlands offshore petroleum industries. It ranks chemical products according to Hazard Quotient (HQ), calculated using the Chemical Hazard and Risk Management (CHARM) model, using data from the HOCNF on parameters such as biodegradability and toxicity. The HQ expresses the ratio of the predicted exposure concentration against the no effect concentration (PEC: NEC). Chemicals are then assigned one of six colour codes (Gold, Silver, White, Blue, Orange, and Purple) in increasing order of hazard.



Minimum value	Maximum Value	Category
>0	<1	Gold
≥1	<30	Silver
≥30	<100	White
≥100	<300	Blue
≥300	<1000	Orange
≥1000		Purple

The term PLONOR is used to categorise substances which are included in the OSPAR List of Substances Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONOR) as per OSPAR Agreement 2013-06.

Inorganic chemicals and organic chemicals with functions for which the CHARM model has no algorithms are ranked using the CEFAS (Centre for Environment, Fisheries & Aquaculture Science) OCNS hazard groups (A to E in increasing order of hazard).



Initial Grouping	A	B	C	D	E	Z
Results for aquatic toxicity data (mg l^{-1})	<1	>1-10	>10-100	>100-1,000	>1,000	Applicable for zero discharge products, phase out by end of 2006
Results for sediment toxicity data (mg l^{-1})	<10	>10-100	>100-1,000	>1,000-10,000	>10,000	

Cefas 2000 Guidelines for the UK Revised Offshore Chemical Notification Scheme

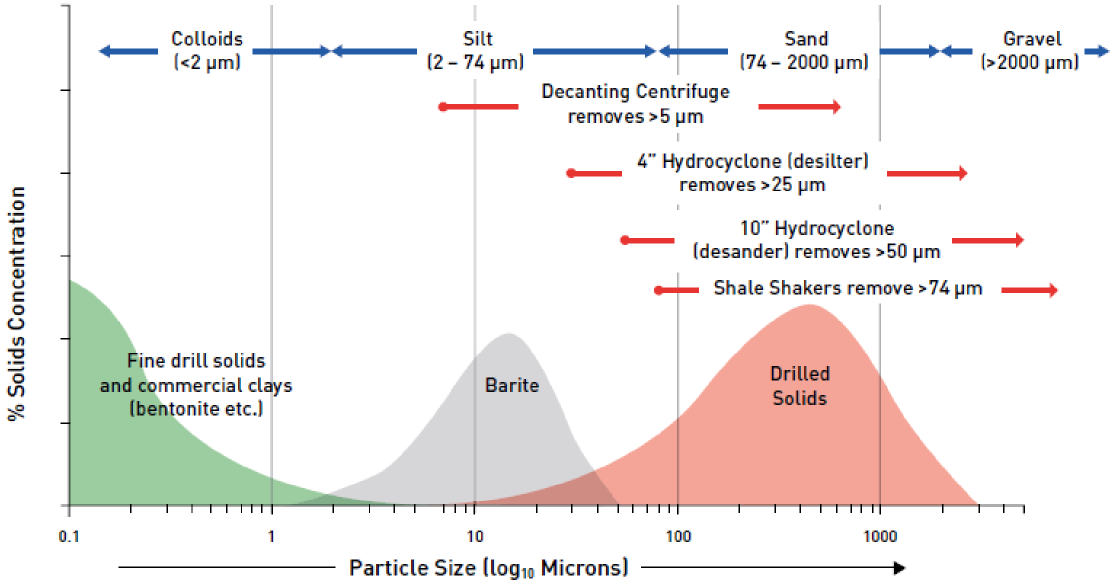
Whilst OSPAR is not directly applicable to the Black Sea, the categorisation of chemicals is considered to be GIIP in the evaluation and selection of chemicals with the lowest hazards to mitigate potential toxicity impacts.

Inset Figures Source: CEFAS (2007).

3.4 Drill Cuttings Treatment

The fraction of solids removed from the returned WBDF depends of the type and efficiency of the solids controls equipment available on the MODU. Figure 3.2 provides an illustration of the ability of solids control equipment to remove various particle sizes of cuttings.

Figure 3.2 Particle Sizes and Solids Removal Equipment



Source: IGOP, 2016a

Conventional solids control equipment comprises shale shakers and hydrocyclones. Shale shakers separate solids from the drilling fluids using a vibrating screen, and remove the majority of cuttings. Hydrocyclones further remove finer solids from the drilling fluids using centrifugal force induced by the drilling fluid flow. When a shale shaker is used below a hydrocyclone to minimise fluid loss, this combination is called a ‘mud cleaner’.

Separated cuttings are therefore comprised of the rock which has been drilled, together with any retained drilling fluids post-solids treatment.

3.5 MGD Cuttings Treatment

The solids control equipment on the MODU comprises shale shakers, hydrocyclones and a mud cleaner. There are no secondary treatment technologies onboard the MODU.

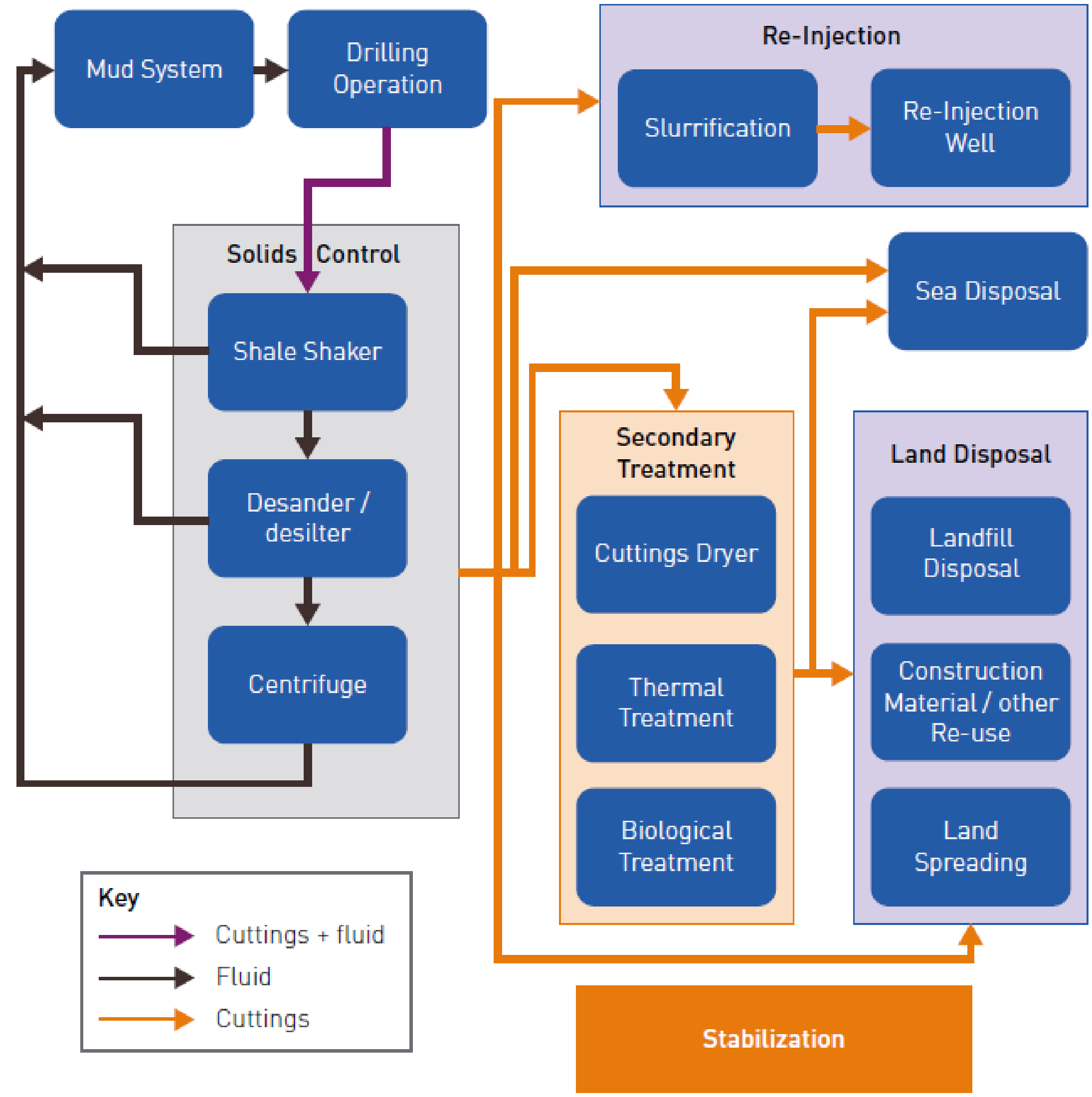
4. DRILLING WASTE MANAGEMENT OPTIONS

For drill cuttings generated from offshore wells there are three main disposal options.

- Sea disposal.
- Land disposal.
- Reinjection into existing or new wells.

Figure 4.1 provides an overview of these options and the type of treatment typically used (ie solids control only, or solids control and secondary treatment).

Figure 4.1 Management Options for Drill Cuttings



Source: IOGP, 2016a

Secondary treatment technologies, such as cuttings dryers, thermal treatment and biological treatment to further treat cuttings to facilitate their management or disposal and are suitable for organics such as cuttings contaminated with NADF or with reservoir hydrocarbons. For this project there is no condensate of oil in the gas reservoirs so there will be no hydrocarbons in the drill cuttings.

The sections below provide an overview of the typical disposal routes.

4.1.1 Sea Disposal

Technically the simplest, this option involves direct disposal of WBDF drill cuttings, following treatment using solid control equipment, from the MODU; no cuttings storage facilities are required on the MODU. At the end of drilling, the WBDF remaining in the well bore is circulated out with brine, as part of the well completion activities, and discharged overboard. Because of their low toxicity, both used WBDF and WBDF cuttings are permitted for discharge to offshore water in most countries based on environmental discharge criteria for local marine habitats (IOGP, 2016b). Discharge criteria[1], may include WBDF chemical categorisation, distances from shore, hydrocarbon contamination (eg OSPAR <1% oil contamination by dry weight) or toxicity limits (either determine by a toxicity test on the waste or via the approval process for offshore drilling chemicals). It is noted here the disposal of WBDF is permitted in Romania and that the project already has a construction permit based on sea disposal of WBDF. It is also noted that there is not expected to be any oil contamination on the cuttings as the compositional analysis of reservoir samples from the Ana 1, Ana 2 and Doina 4 exploration wells returned an average 99.8% dry methane gas with no condensate or oil fractions.

4.1.2 Land Disposal

This option involves the temporary storage of cuttings on the MODU prior to transportation to shore for potential further treatment, re-use or disposal. The following steps are typically involved which are additional to the processing of drill cuttings and WBDF through the MODU's solids control equipment.

- Treated cuttings (ex-solids control) are either:
  - stored in cuttings bins or skips,
  - ground and mixed with water (slurrification) and pumped into tanks, or
  - blown using compressed air (pneumatic transport) into tanks.
- Storage containers are either offloaded by crane to a Platform Supply Vessel (PSV) or tanks pumped by vacuum into tanks on PSV (Figure 4.2).
- PSV transports the cuttings to shore.
- Cuttings are offloaded from the PSV (crane or vacuum) at the port.
- Cuttings (and possibly containers if not emptied at the port) are loaded into trucks.
- Trucks transport the cuttings to a land disposal or treatment facility.
- Empty containers (if not emptied at the port) are transported back to the port by truck and ultimately back to the rig by boat.

Once the cuttings are returned to land there are a number of options for treatment or disposal, including potential secondary treatment if there is organic content in the cuttings (drying, thermal treatment or biological treatment), prior to final reuse or disposal.

An additional form of treatment which may be undertaken prior to re-use or disposal is stabilisation, which involves physical or chemical immobilisation, to convert wastes to a chemically stable form to allow the re-use of the cuttings or reduce the potential impacts from leaching of contaminants.

Land disposal options include the following.

- Disposal to a landfill in line with local regulatory requirements (ie landfill categorised for hazardous, non-hazardous or inert waste depending on nature of cuttings). Whilst low-cost and technically relatively simple, the waste remains in situ and engineering and landfill management may be required to prevent potential groundwater contamination.
- Use of stabilised cuttings as fill material, road material, daily cover material at landfill sites or use as an aggregate or filler in concrete, brick or block manufacture.

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[1] As defined in local regulations, or Good International Industry Practice guidelines, such as the WBG/IFC Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (2015).

- Direct application to land, if permitted by local regulations, intended to be incorporated into the natural soil structure. Whilst low cost, the main constraints are the salt and potential contaminant levels (eg metals).

Figure 4.2 Offshore Cuttings Transportation (Skip and Ship and Transfer Hose and Tanks)

Source: IOGP, 2016a

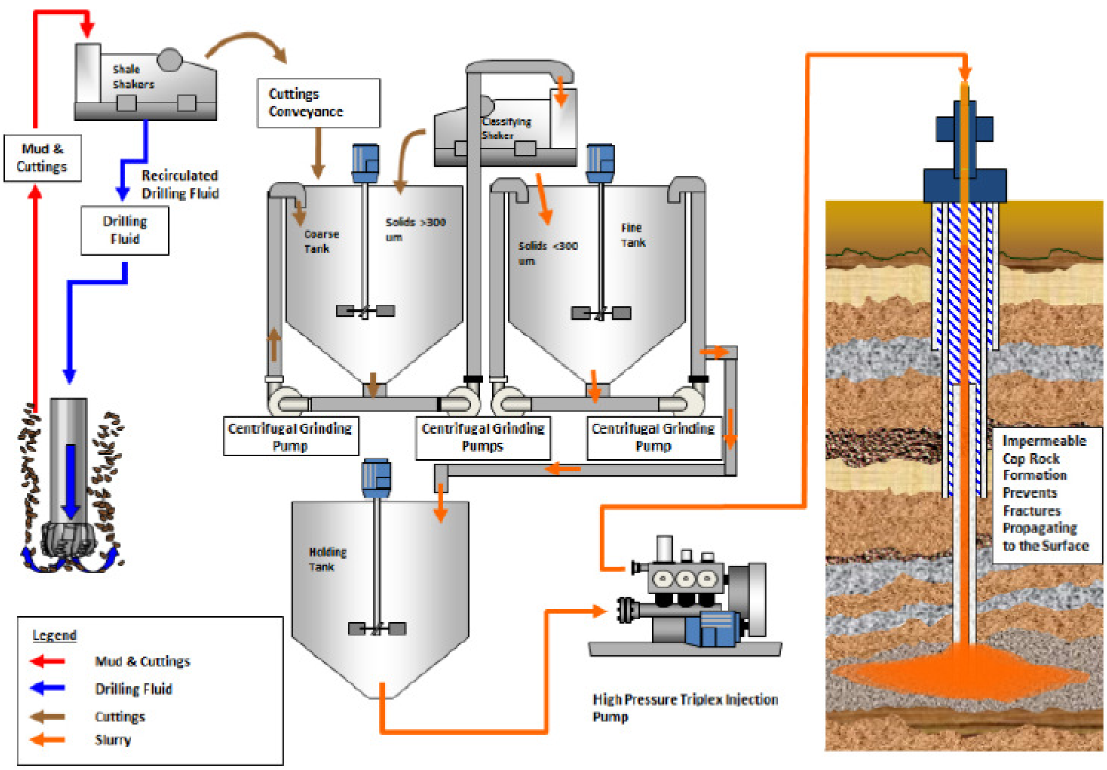
4.1.3 Reinjection

Offshore reinjection involves the conversion of the drill cuttings into a slurry to reduce particle size to allow injection into suitable, permeable subsurface formations (these need to be isolated at a safe depth to prevent contamination of the reservoirs or migration to the surface. The slurrified cuttings can either be injected into a dedicated (ie purpose drilled) disposal well, injected down the well annulus of an existing production or water injection well, or injected down the well annulus whilst drilling. Reinjection relies upon the availability of a suitable formation to receive the cuttings. Additional equipment (cuttings transport system, slurrification system, slurry storage tanks and pumps, and re-injection system are required for this option (see Figure 4.3). Additional resources (fuel, manpower, time) are also required.

Whilst cuttings reinjection may offer safety benefits over alternative disposal options such as skip and ship via removal of the large number of lifting operations, and result in zero discharge to the surface environment, there are a number of important challenges which limit its use.

- Availability of suitable formations for injection.
- Ensuring proper containment of injected cuttings.
- Avoidance of wellbore plugging, corrosion or erosion.
- Reliability of surface equipment.
- Regulatory and permitting issues.

Figure 4.3 Cuttings Reinjection Process



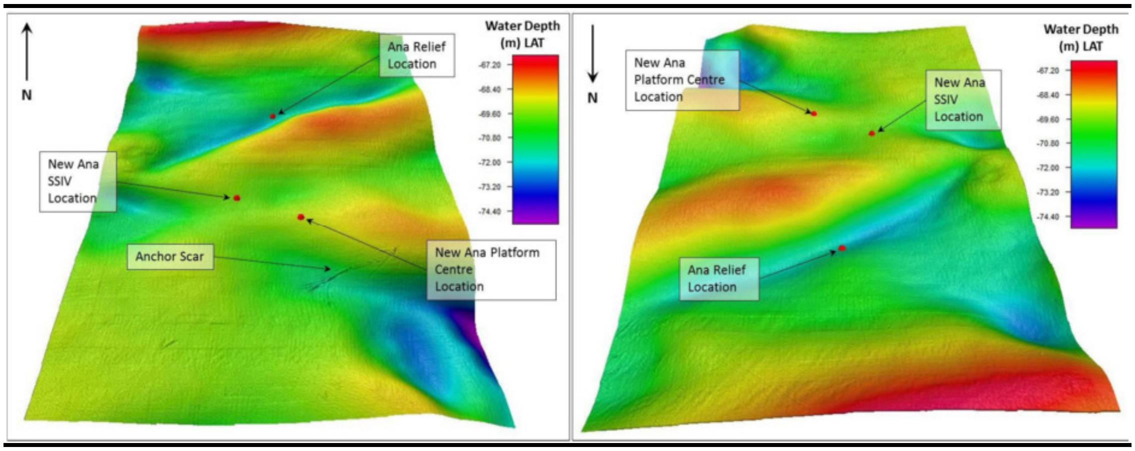
Source: IOGP (2016a)

5. ENVIRONMENTAL CONDITIONS AT THE DRILLING SITES

5.1 Bathymetry and Seabed Features

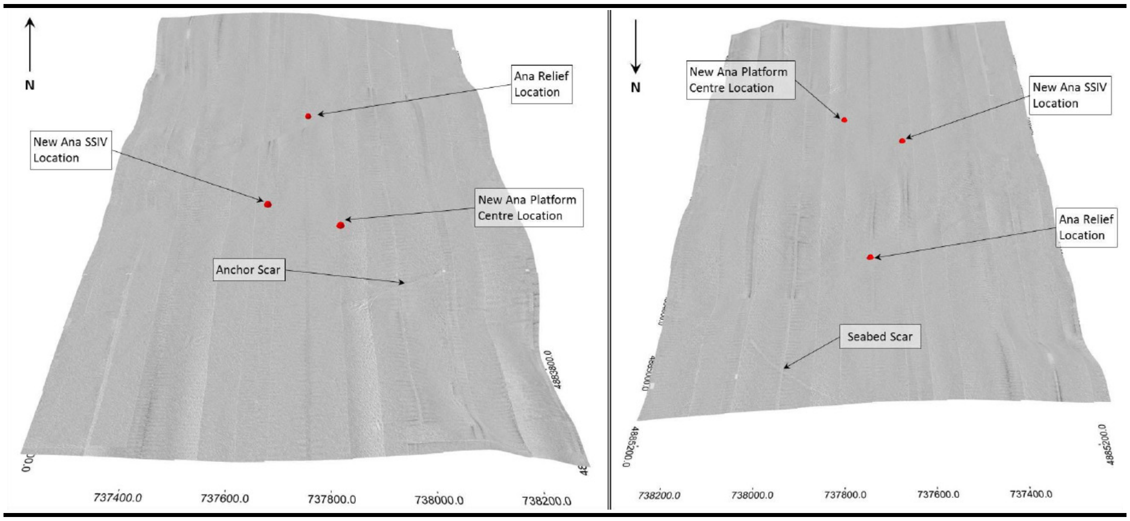
Water depths at MGD Project location range from approximately 70 m at the Ana wells site to around 84 m at the Doina well site. The seabed topography at the Ana site exhibits a hummocky terrain across the site of a dune-like appearance. It is likely that this undulating terrain is a consequence of relict sedimentary bedforms, such as sand bars deposited in periods of lower sea level, overlying sediments from past deltaic environmental conditions within this area. *Figure 5.1* presents the bathymetry at the Ana site. Side scan sonar data across the Ana site exhibits relatively uniform reflectivity with little evidence for surficial variations in sediment type, and some seabed scars that may be attributed to fishing and/or developments related to the nearby wells, such as Ana-1 Well *Figure 5.2*).

Figure 5.1 Ana Site Bathymetry



Source: MG3 (2017a)

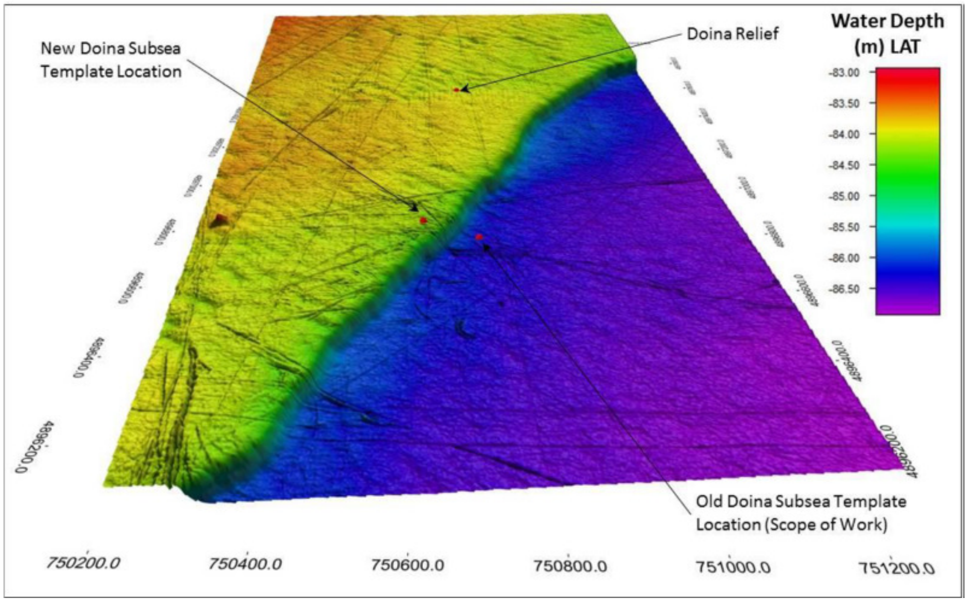
Figure 5.2 Ana Field Side Scan Sonar Image Mosaic



Source: MG3, 2017a

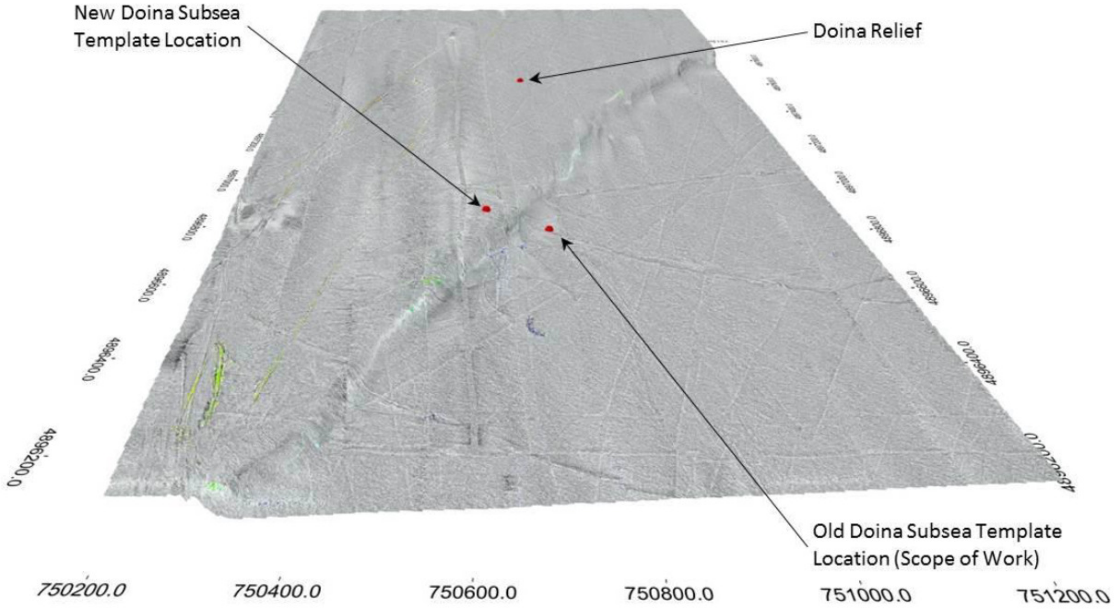
Seabed topography across the Doina site generally shallows gently from southeast, where the deepest water depth within the site is 87 m, to northwest, where water depths shallow to 83 m. The site is bisected northeast to southwest by a prominent escarpment representing a surficial fault expression. To either side of the escarpment the site is generally flat. *Figure 5.3* presents the bathymetry at the Doina site. Side scan sonar imagery of the Doina site (*Figure 5.4*) indicates that it is characterised by widespread scarring of the seabed, which is expected to be as a result of fishing and/or anchor scarring activities, with no observed distinctive debris or obstructions.

Figure 5.3 Doina Site Bathymetry



Source: MG3, 2017b

Figure 5.4 Doina Field Side Scan Sonar Image Mosaic



Source: MG3, 2017b

5.2 Currents

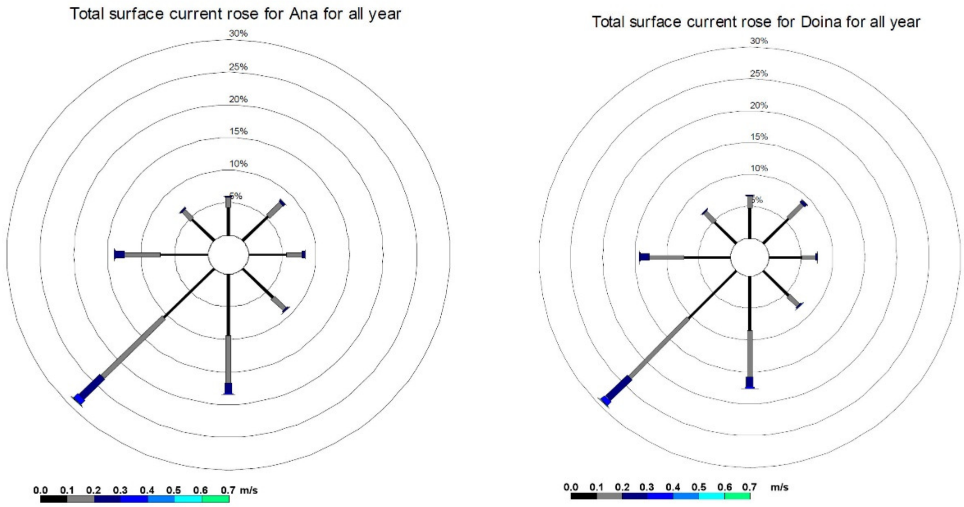
The main circulation mechanism within the Black Sea is the cyclonic ‘Rim Current’ which circulates anticlockwise, approximately following the shelf break, and has a maximum velocity of approximately

0.5 to 1.0 m/s. Within this feature, two smaller cyclonic gyres operate, occupying the eastern and western sectors of the basin. The Rim Current is highly variable, and often barely discernible.

The River Danube freshwater discharges influence the circulation along the entire Romanian Black Sea coast, generating a long-shore current. This current occurs even at low river discharges regardless of wind conditions and is evident in both surface and deeper waters.

Water mass circulation along the Romanian shore is generally north to south with the current speeds ranging from 0.5 m/s at the surface to 0.05 m/s in the bottom layers, depending on winds and the specific location. At Ana and Doina the predominant current directions toward the southwest (see *Figure 5.5*).

Figure 5.5 Full-year Surface Current Rose Diagrams for Ana and Doina Locations



Source: Xodus (2018)

5.3 Sediment Quality

An environmental baseline survey was undertaken in 2016 (RPS 2017a, RPS 2017b), including sediments at the Ana and Doina sites that were analysed for:

- particle size;
- nutrients, carbon, redox potential and pH;
- hydrocarbons; and
- metals

The results of these analyses are summarised below.

5.3.1 Particle Size Analysis (PSA)

The seabed in the studied area was clearly dominated by fine particles. The average PSA from the Ana platform and Doina site are presented in *Table 5.1.*

Table 5.1 Particle Size Analysis

Parameter	Site	Average value
Size	Ana production platform	0.067 mm
	The area of the Doina subsea assembly	0.029 mm
Silts and Clays	Ana production platform	56.43 %
	The area of the Doina subsea assembly	75.38 %
Sand	Ana production platform	23.46 %
	The area of the Doina subsea assembly	16.23 %

Source: Auditecoges (2018)

5.3.2 Nutrients, Carbon, Redox Potential and pH

Concentrations of total inorganic nitrogen were generally low. Sediments at the stations in the area of the Ana platform were 0.95-5.23 mg kg^{-1} (average 2.04 mg kg^{-1}). In the Doina area, the nitrogen values varied between 1.52 and 5.44 mg kg^{-1} (average 2.21 mg kg^{-1}).

The sediments collected from the Ana platform location were homogeneous throughout the surface and had the lowest TOC content range: 1.36 - 1.75% (average 1.60%). Contributions to the total weight of the samples collected in the Doina area were in the range 2.19 - 2.81% (mean 2.48%).

The values of the Redox potential varied from -220 to +220 mV across the studied area. Negative redox potential (namely indicators of low, hypoxic or anoxic sediments) was recorded at half of the stations in the Doina area and the area of the Ana platform. The average values of the redox potential were also negative in each of the visited sites, with a maximum reading of -10.5 mV recorded at the Ana platform.

The studied area was predominantly alkaline, most samples producing values between pH 8.0 and pH 8.9. The only exceptions were some stations in the Doina area, where pH 7.9 was recorded.

5.3.3 Hydrocarbons

The Total Hydrocarbon (THC) concentrations at the Ana platform site were 9.75 ± 3.65 µg.g^{-1}; at the Doina site were 8.19 ± 3.99 µg.g^{-1}. These were all low and below the biological effect threshold of 50 µg.g^{-1} (United Kingdom Offshore Operators Association (UKOOA) threshold levels).

5.3.4 Metals

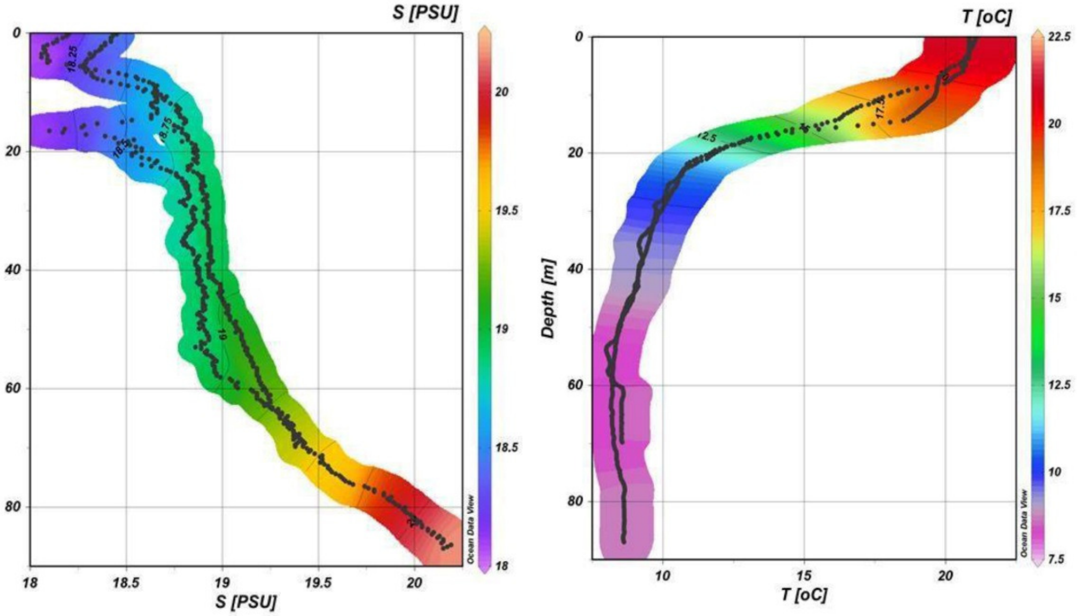
Metal concentration rates were positively correlated with the silt and clay content, which was expected as most metal contamination is associated with fine fraction of sediments. For all the metals analysed for, concentrations were higher in the Doina area than the Ana platform area due to the higher silts and clay content in the sediments.

Concentrations of barium ranged from 71 mg kg^{-1} (export route) to 7,250 mg kg^{-1} (Doina Field). Noticeably, the highest concentrations of barium across all sites were recorded in sediments within the Doina field, with values up to two orders of magnitude higher than other sites surveyed, but barium levels were also high in the Ana field. It is likely that the raised sediment barium levels noted are associated with previous drilling activities and the use of drilling fluids rich in barite (Xodus, 2018).

5.4 Water Parameters

The water column temperature and salinity data shows stratification. The highest temperatures of approximately 21°C are recorded in the surface layer (0 - 5 m), below which decline rapidly between 5 - 20 m water depth to approximately 12°C. Below 20 m, temperatures decrease at slower rate to a minimum of approximately 8°C at depths of 80 m and beyond. Salinity values show a more uniform change with water depth, fluctuating between 18 – 18.5 PSU in the upper layers under the influence of freshwater inputs from the Danube, and thereafter increasing with depth towards 20 PSU near the seabed at 70 – 80 m (Xodus, 2018).

Figure 5.6 Temperature and Salinity Profiles



Source: Xodus (2018).

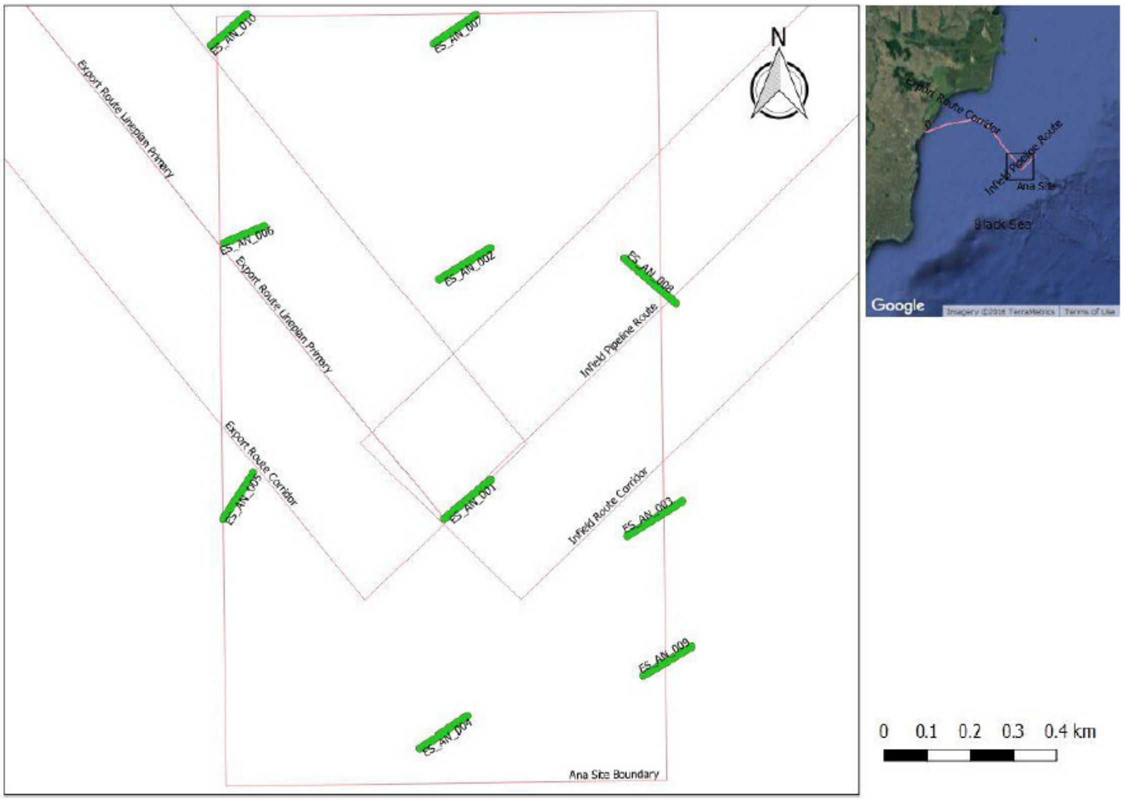
5.5 Plankton

Phytoplankton sampled in the Project area in 2015 comprised 55 species from six taxonomic groups. Among these, dinoflagellates dominated accounting for 49% of all recorded species followed by Bacillariophyta accounting for 24% out of the total number of phytoplankton species. It was reported that the upper side of the euphotic zone, in the 0-10 m layer, was the most important area for growth of phytoplankton (20-80% of total biomass). In terms of density, diatoms dominated including *Chaetoceros socialis*, *Pseudonitzschia delicatissima* and *Cerataulina pelagica*. Zooplankton was represented by 14 species belonging to 10 taxonomic groups, and mostly consisted of meroplankton with bivalve, gastropod, polychaete and decapod larvae (Xodus, 2018).

5.6 Benthos

The 2016 baseline survey of the Ana field (*Figure 5.7*) identified seabed habitat structured by the mussel *Modiolula phaseolina* throughout the surveyed area. This habitat is regarded as equivalent to the EUNIS habitat A5.379 “Pontic deep circalittoral muds with *Modiolula phaseolina*” (RPS 2017a).

Figure 5.7 Ana Field Drop Down Video and Digital Still Transects



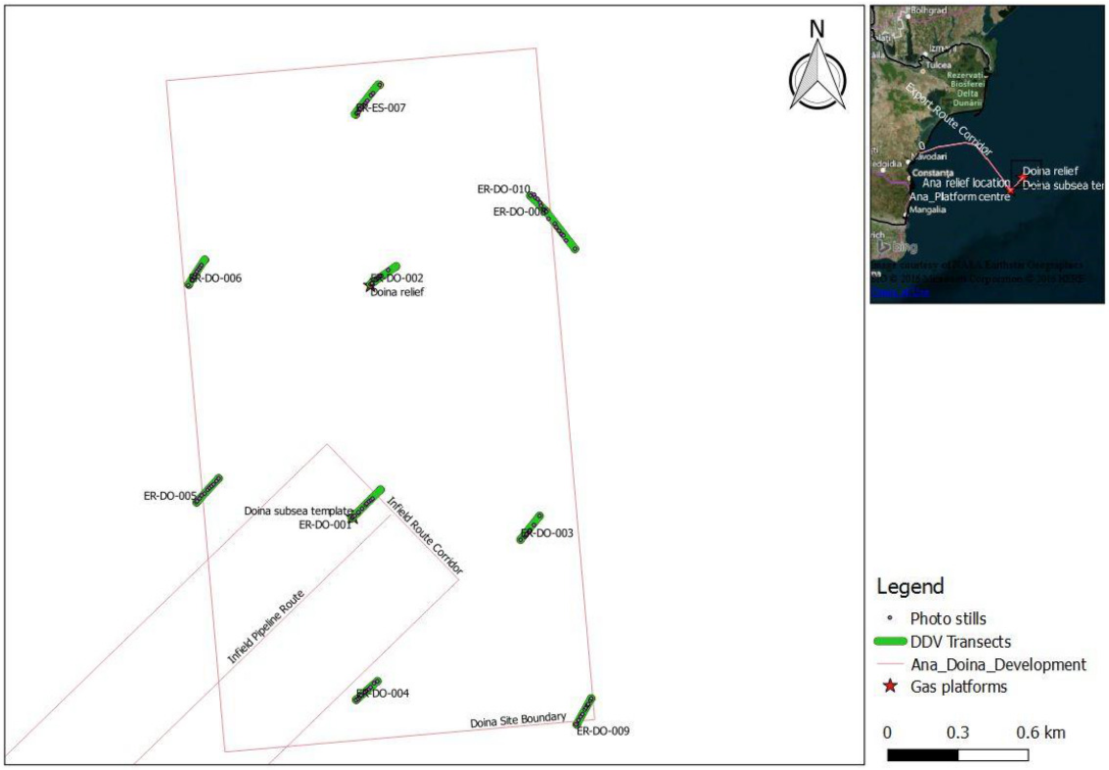
Source: RPS 2017a

Some of these shell beds hosted live *M. phaseolina*. The faunal assemblage associated with live *M. phaseolina* beds or shell gravel typically consisted of sessile epifauna, chiefly tunicates *Ciona intestinalis*, sponges *Suberites* sp. and *Sycon* sp. as well as foraging fish (juvenile *M. merlangus* and gobies *Pomatoschistus* spp. and *Gobius* sp.).

The 2016 baseline survey of the Doina field showed that the seabed site was dominated by fine substrata and mussel *M. phaseolina* shell characteristically covered by phytodetrital material. The biotic component was represented by three main biotopes that could be ascribed to the following EUNIS habitat types:

- Mussel *Modiolula phaseolina* beds equivalent to the EUNIS habitat A5.379 “Pontic deep circalittoral muds with *Modiolula phaseolina*”;
- Muddy communities dominated by the anemone *P. solitarius* similar to EUNIS habitat A5.37B “Pontic deep circalittoral muds with *Pachycerianthus solitarius*”; In addition, a mixture or transition habitat between A5.379 and A5.37B, where *P. solitarius* was common or frequent while *M. phaseolina* was not overly abundant; and
- A species-poor muddy seafloor with *M. phaseolina* shell habitat without a clear faunistic assemblage was assigned to EUNIS A5.37 “Deep circalittoral muds” (RSP 2017b).

Figure 5.8 Doina Field Drop Down Video and Digital Still Transects



Source: RPS 2017b

The A5.379 "Pontic deep circalittoral muds with *Modiolula phaseolina*" habitat is typical of the lower circalittoral belt west of the Crimean Peninsula, and is found in the Bulgarian and Romanian shelfs at depths ranging from 50 m to 180 m (Oguz, 2007; Wenzhofer et al., 2002). The same *M. phaseolina* biocenosis, consisting of *M. phaseolina*, *P. solitarius* and *A. stepanovi* was previously mapped and described for a nearby area (Luth, 2004). As regards to all other species recorded (e.g. tunicates, sponges, fish), none are regarded as endangered or threatened and have been previously reported in the wider Black Sea area by others (Çinar et al., 2014; Koukouras et al., 1995; Zaitsev and Alenxandrov, 1998; Zaitsev and Mamaev, 1997) (RPS 2017a).

None of the habitats recorded by the baseline surveys of the Ana or Doina field are considered to be Annex I habitats, or to be Priority or Critical habitats as defined by EBRD PR6 or IFC PS6 (for further information refer to Supplementary Lender Information Package Critical Habitat Assessment (ERM, 2019).

6. DRILL CUTTINGS DISPERSION ASSESSMENT

6.1 Methodology

To estimate the spread and thickness of discharged drill cuttings from the Ana and Doina wells modelling was undertake using the Cornell Mixing Zone Expert System (CORMIX) Version 11 (www.cormix.info). CORMIX is a steady state model which assumes the release is a continuous discharge. Since the simulation requires the results of a series of discrete discharges, the deposition can be approximated by converting the total mass to be discharged overboard into an equivalent flow rate over the course of one day at a computed concentration of solids. The accumulation at the seabed is examined after a day of loading the total amount.

The model examines the composite range of sediment accumulation over a distribution of particle sizes which each have specified constant settling velocities. Particle size distributions of typical drill cuttings and fluids were used to estimate the settling velocities for ten particle size classes (the maximum permitted by the model). Finer particle sizes with smaller densities will be transported over greater distances than larger or denser particles.

All particles are carried horizontally at the same velocity as the ocean currents. The model permits a single horizontal current speed applied throughout the water column; an average current speed was used from metocean data. The dominant surface current direction (flowing towards the southwest) was applied.

6.2 Scenarios Assessed

Two scenarios were examined: combined releases from the Ana wells (Ana-100 Vertical Well, Ana-101 Deviated Well, Ana-102 Deviated Well, Ana-103 Deviated Well), and the Doina-100 Vertical Well.

Releases from all five wells (except the top hole releases from Doina-100 which will be drilled riserless) are assumed to occur from the MODU’s cuttings discharge chute above the water surface. For the four Ana wells, the releases are at 23 m above mean sea level (MSL), the elevation required for drilling over the Ana Platform. For the Doina well releases after the 36” top hole, the releases are assumed to be at 12 m above MSL. Although increasing the release’s distance from the sea floor will typically increase the spread of particles away from the release location, releasing into the air will allow the particles to enter the water with a non-zero initial velocity due to the acceleration due to gravity from freefall through the air. The 36” top hole release for the Doina-100 well was run separately in CORMIX.

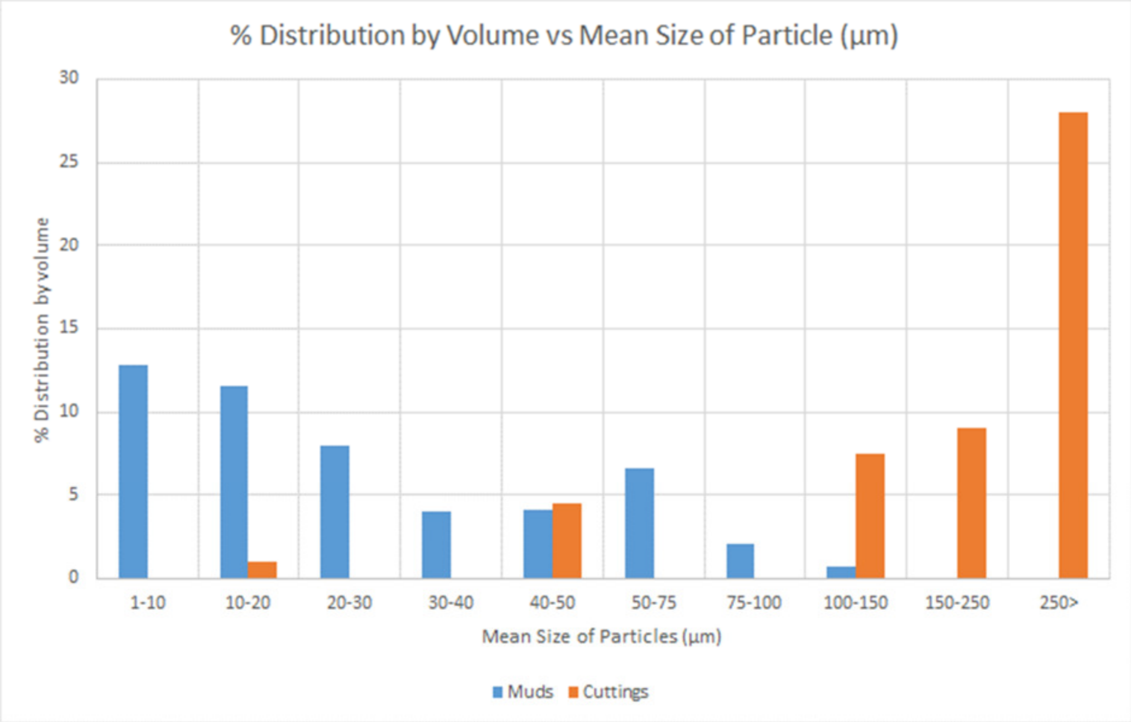
Particles size distributions were obtained from the literature (see Table 6.1 for the particle sizes and percent volume in each category). The particle size classes for cuttings and WBDF were blended together and divided into ten size categories (Figure 6.1). The volumes of WBDF and cuttings estimated for discharge from each well in the MGD Project ESIA are provided in Table 3.1.

Table 6.1 Particle Sizes for Cuttings and WBDF

Drill Cuttings		WBDF	
Mean size (µm)	**% Distribution (by volume)**	**Mean size (µm)**	**% Distribution (by volume)**
12.6	2.0	0-5	9.37
41.12	9.0	5-10	16.28
108	15.0	10-15	14.71
218	18.0	15-20	8.31
620.5	16.0	20-25	7.61
1056.7	15.0	25-30	8.39
3612.3	25.0	30-35	4.24
		35-40	3.82
		40-45	4.53
		45-50	3.75
		50-75	13.31
		75-100	4.19
		100-120	1.49

Source: Drilling Cuttings Distribution based on Brandsma and Smith, 1999; WBDF distribution is based on product specifications provided by Malvern Instruments, 2007

Figure 6.1 Blended Particle Size Distributions for Cuttings and Fluids



Values for water column salinity and temperature with depth were obtained from the MGD ESIA report (Xodus, 2018). Values at 40 m depth were used as input. At this depth, the water temperature is approximately 9.1 ºC, salinity is 18.9 psu and density is therefore approximately 1014.7 kg/m³. Information on currents was also taken from the MGD ESIA. Though surface currents may travel in any direction, the primary direction at both location is flowing towards the southwest. Current speeds in the area of the wells typically range from 0.5 m/s at the surface to 0.05 m/s at the bottom. An average current speed of 0.275 m/s was used in the model.

6.3 Assessment Results

Drill cuttings and WBDF discharges will create a footprint of deposited sediment on the seabed. This deposition of cuttings and WBDF has the potential to impact benthic communities over a defined area of the seabed due to direct burial of benthic organisms and potentially due to changes in sediment quality (IOGP 2016b).

While there are no national guidelines regarding depositional impacts, there are biological criteria reported. For the purposes of estimating potential impacts, a thickness threshold value of 5 cm is assumed. This value derives from publications by Ellis and Heim (1985) and MarLIN (2011), which indicate exposure to gradual increase in sediment deposition of 5 cm over the course of a month, typical of exposure from drilling discharges, has the potential to result in mortality among biota in benthic communities. This 5 cm value also closely corresponds to 5.4 cm determined by Smit (2008) to be the 50% hazardous level for burial impacts to benthic fauna based on chronic exposure tests with effects mainly measured based on the probability of test organisms to escape burial. This same research determined the 5% hazardous level was 0.65 cm, which was recently cited in IOGP (2016b) as the lowest value where potential for mortality among the most sensitive benthic biota was likely to begin. However, this criterion from IOGP (2016b) refers to impacts from instantaneous burial, not the gradual accumulation examined in this study.

Model results are presented in Figure 6.2 to Figure 6.3 as depictions of the total thickness of deposited cuttings and WBDF on the seafloor. The cumulative deposition from all four Ana wells are provided in a single figure (Figure 6.2). Table 6.2 provides the maximum thickness of the deposits in each scenario, the furthest distance the deposits travel from the release location, and areas (hectares) of deposition of 1 – 5 cm, and >5 cm.

In each of the cases, the cuttings discharge plume deposits the material slightly over 200 m along the centerline from the discharge location. The total releases from the Ana wells reached 208 m from the center. The releases from the Doina well first reached 12 m from the top hole release, and subsequently 210 m from the remaining releases above the water surface. It should be noted that the maximum thickness of cuttings deposits (116 cm) associated with the drilling of the Doina-100 well are the result of the riserless drilling of the 36" top hole and these deposits are located within a few metres of the well location (see Figure 6.3). The combined deposition from the Ana wells, and the deposits from the Doina-100 well, have parts of the sediment footprint which exceed the 5 cm threshold limit for impacts to benthic communities.

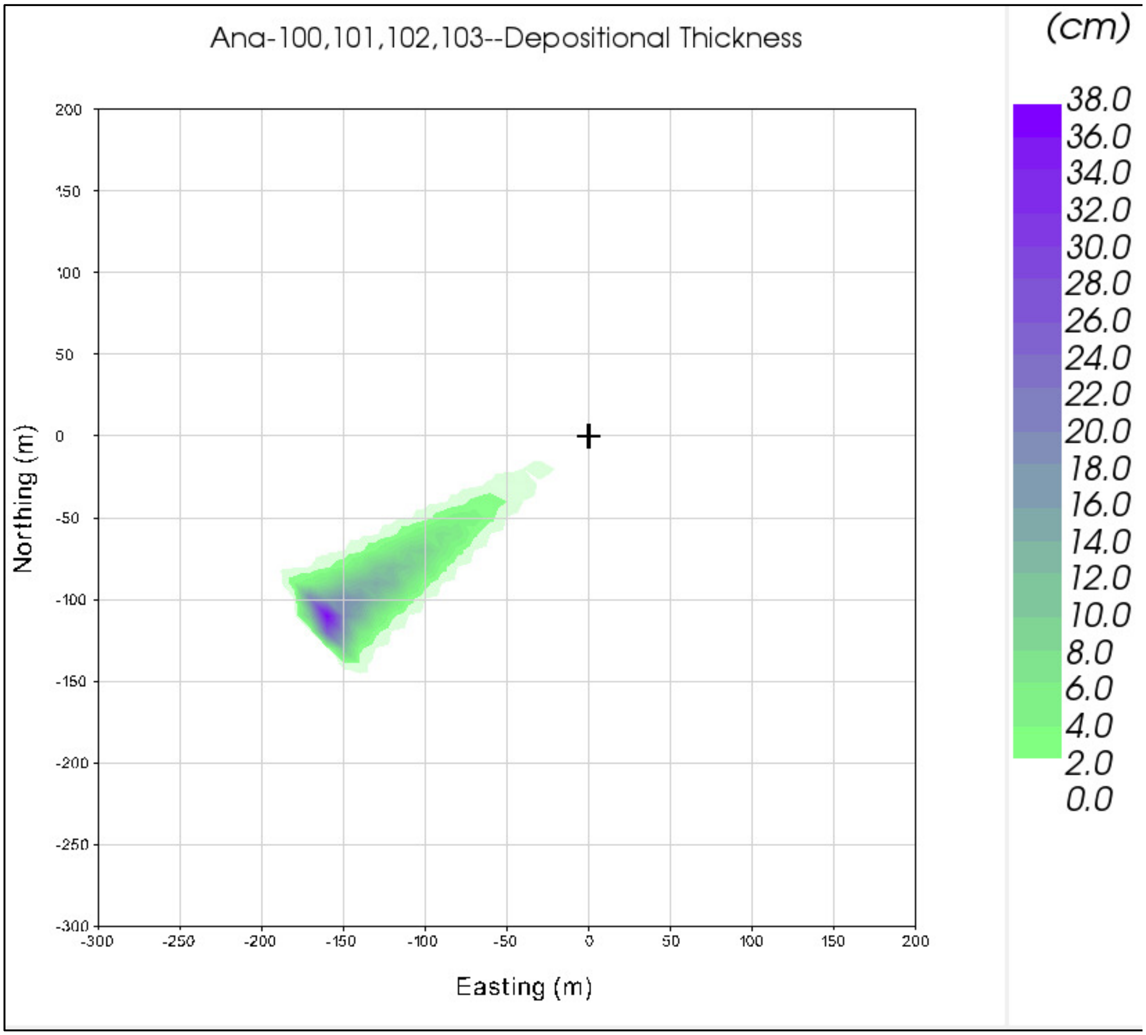
Table 6.2 Summary of Model Results

Scenario	Maximum Thickness (cm)	Distance of Deposition (m)	Area of Deposition 1-5 cm (ha)	Area of Deposition >5 cm (ha)
Ana	38	208	0.24	0.54
Doina	116	210	0.57	0.01

The volumes of WBDF and cuttings estimated for discharge from each well provided in Table 3.1 are conservative estimates based on the same volume of WBDF and cuttings being discharged. The actual WBDF attached to cuttings and the final discharge of the used WBDF at the end of each well will be lower than this estimate due to the use of the drill cuttings cleaning technology. The overall footprints of drill cuttings and WBDF over the threshold of 5 cm are therefore likely to be smaller than those modelled.

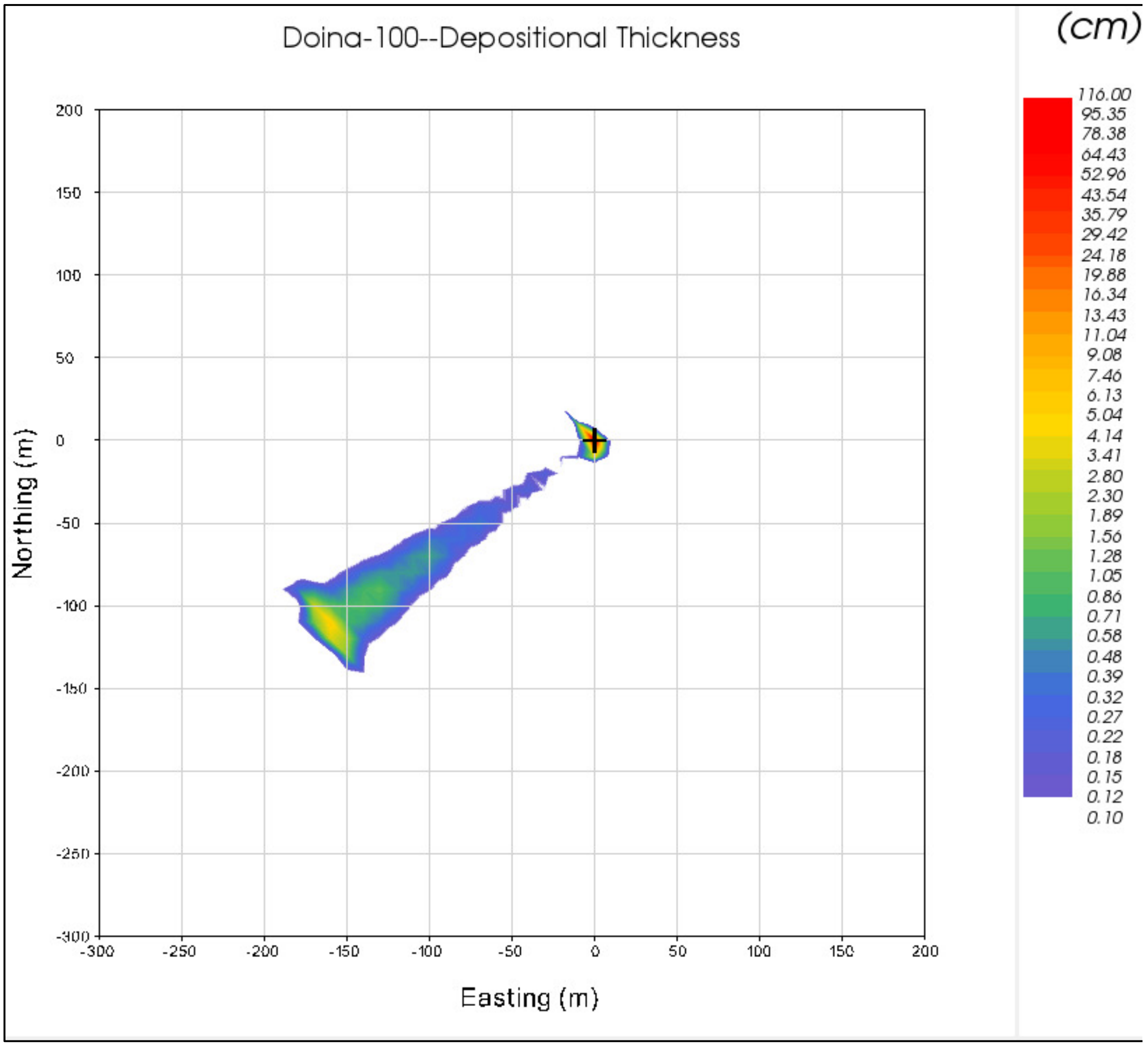
To determine if there would be any advantage in discharging cuttings below the sea surface, the difference in seabed footprint from discharge scenarios at 15 m below mean sea level via a caisson and from the MODU drill deck 22 m above the sea surface (ie direct discharge from the cuttings chute) were assessed. Due to the settling velocities of the difference particles modelled and the influence of the current on the lighter particles at these water depths, the overall distribution pattern was similar with the maximum height of the cuttings pile being greater with the sub-sea discharge. As the overall seabed footprint was similar it was concluded that there would be no advantage in installing a sub-sea discharge with respect to the overall area of impact.

Figure 6.2 Deposition Thickness from the Ana Wells



Note colour scheme in CORMIX is a relative scale for each model run so colours cannot be compared between outputs.

Figure 6.3 Deposition Thickness from Doina-100



Note colour scheme in CORMIX is a relative scale for each model run so colours cannot be compared between outputs.

7. ASSESSMENT OF DISPOSAL OPTIONS

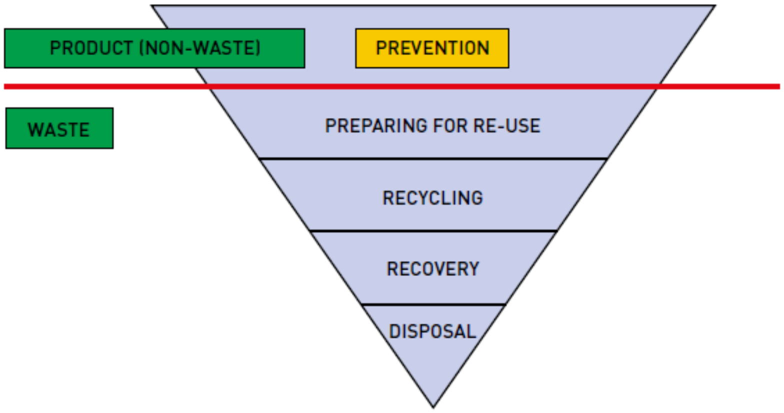
7.1 Objectives of Drilling Waste Management

The management of drilling wastes has two primary objectives:

- Compliance with regulatory requirements; and
- Ensuring that drilling operations are not unreasonably delayed (IOGP, 2016a).

Additionally, drilling wastes should be managed in a manner consistent with the waste hierarchy (Figure 7.1).

Figure 7.1 Waste Hierarchy (European Union)



Source: IOGP, 2016a

Different approaches to treatment and disposal of drill cuttings are applied in different countries. All options have different advantages and disadvantages with respect to the natural environmental, energy use, emissions, health and safety, and costs.

The sections below examines the options with reference to the MGD, taking into account the type of fluid to be used, well locations, the receiving environment and the availability of facilities. The regulatory acceptability / requirements of each option are summarised as a coarse screen; if the option was not allowable under prevailing regulations it would not be considered further. Each option is then discussed in relation to the four decision criteria selected for this BPEO, namely technical, environmental, cost and health & safety considerations.

7.2 Sea Disposal – Option 1

The discharge of WBDF and WBDF cuttings to sea is acceptable under Romanian regulations. Previous wells drilled in the Ana and Doina fields have been drilled with a WBDF with all cuttings and fluids discharged to sea.

The MGD Project are applying IFC guidance as GIIP. The IFC Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (IFC, 2015) requirements with respect to sea disposal include the following.

- *Feasible alternatives for the disposal of spent WBDF and drilled cuttings from well sections drilled with either WBDF or NADF should be evaluated. Options include injection into a dedicated disposal well offshore, injection into the annular space of a well, and containment and transfer to shore for treatment and disposal. When no alternative options are available, residual WBDF might be discharged to sea at the end of a drilling program, provided that the overall ESIA conducted for the site has considered this scenario, demonstrating the environmental acceptability of this practice.*

- *When discharge to sea is the only alternative, a drilled cuttings and fluid disposal plan should be prepared, taking into account cuttings and fluid dispersion, chemical use, environmental risk, and necessary monitoring. Discharge of cuttings to sea from wells drilled with NADF should be avoided. If discharge is necessary, cuttings should be treated before discharge to meet the guidelines provided in Table 1 of section 2.*
- *Drilling fluids to be discharged to sea (including as residual material on drilled cuttings) are subject to tests for toxicity, barite contamination, and oil content provided in Table 1 of Section 2. Barite contamination by mercury (Hg) and cadmium (Cd) must be checked to ensure compliance with the discharge limits provided in Table 1. Suppliers should be asked to guarantee that barite quality meets this standard with pre-treatment, if necessary.*
- *WBDF and treated drilled cuttings discharge should be made via a caisson submerged at an appropriate depth to ensure suitable dispersion of the effluent (i.e., a dispersion study demonstrates that the relevant impact is acceptable).*

Table 7.1 Extract from IFC, 2015 Table 1 – Effluent Levels from Offshore Oil and Gas Development

Parameter	Guideline
Drilling Fluids and Cuttings - WBDF	1) WBDF: Reinject or ship-to-shore, no discharge to sea except: In compliance with 96 hr. LC-50 of Suspended Particulate Phase (SPP)-3% vol. toxicity test first for drilling fluids or alternatively testing based on standard toxicity assessment species (preferably site-specific species) 2) WBDF cuttings: Reinject or ship-to-shore, no discharge to sea except: - Facilities located beyond 3 miles (4.8 km) from shore; - Hg: 1 mg/kg dry weight in stock barite - Cd: 3 mg/kg dry weight in stock barite - Maximum chloride concentration must be less than four times the ambient concentration of fresh or brackish receiving water - Discharge via a caisson (at least 15 m below sea surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)

Source: IFC, 2015

7.2.1 Technical Considerations

The MODU (GSP Uranus) is currently configured to allow for the discharge of WBDF cuttings to the sea following solids control (comprising shale shakers, hydrocyclones and a mud cleaner). This type solids control equipment is proven technology, providing a low risk of reliability issues to the drilling operations. Following the completion of drilling of each well, the WBDF is circulated out of the well and replaced with brine as part of the well completion process. This volume of WBDF will be discharged overboard to the sea. Power requirements for this option are considered to be low. No additional modifications to the MODU are required for this disposal operation.

7.2.2 Environmental Considerations

For the Ana and Doina wells, calcium carbonate is planned to be used as the weighting agent rather than barite. Most of the organic additives in WBDF cuttings adsorb tightly to inorganic particles in the cuttings and disperse through the water column. Some portion of the insoluble drill cuttings may accumulate within relatively short distances of the discharge point, depending on metocean conditions (IOGP, 2016b). Marine water column organisms are at a low risk of harm from drill cuttings discharges because of rapid dilution and dispersal of drill cuttings. Decreased light penetration from the turbidity of the cuttings plume may temporarily decrease primary production of phytoplankton. Particles may clog the gills or digestive tract of zooplankton in the immediate area surrounding the discharge site. Mobile species, such as fish and larger crustaceans, usually avoid or move away from plumes of suspended drill cuttings, thereby minimising the risk of harm (IOGP, 2016b). The MGD WBDF chemicals have been selected in order to minimise impacts to the marine environment being either PLONOR, OCNS Group E or HQ Band Gold or Silver (see Table 3.2). Taking into account the use of low toxicity chemicals in the WBDF and the dispersion of cuttings, it is unlikely that there will be any significant impacts to marine water column organisms from the sea disposal of the WBDF cuttings.

The accumulation area and thickness of drill cuttings on the seabed is a function of cuttings and drill fluid types, particle size and metocean conditions. WBDF cuttings accumulations on the seafloor will alter the physical and chemical composition of the sediments; these include changes to appearance and topography, sediment grain size and mineralogy, and increase in concentration of one or more metals, such as barium (barium sulphate is widely used as a weighting agent in drilling fluids). The effects of cuttings deposits on benthic communities result from burial, changes in sediment size, and low sediment oxygen concentrations that result from microbial degradation of organic matter.

Where discharged drill cuttings form a distinct layer on the seabed, the benthic animals living in this area will be smothered. Effects of WBDF cuttings accumulation in sediments are usually minor and biological recovery is often well underway within a year of completion of discharge (IOGP, 2016b). The ability of benthic macrofauna to survive burial depends largely on their mobility and the frequency and the rate and depth of cuttings deposition. Burial, therefore, is likely to result in a change to the benthic community composition. Burrowing animals are more tolerant than surface living filter feeders; attached or sessile animals with very limited ability to move, such as mussels, are the most susceptible and are most likely to perish due to smothering. Additionally, in a review of data on the sensitivity of marine fauna to elevated turbidity caused by clays and weighting agents, sessile megafauna, including filter feeding molluscs, were the most sensitive (IOGP, 2016b).

The drill cuttings dispersion analysis for the MGD has illustrated that the bottom deposition of WBDF and cuttings is expected to occur within approximately 200 m of the discharge locations. At the Ana well sites, the assessment indicates that the deposition of cuttings may occur up to a maximum depth of 38 cm with the total area affected by the deposition of cuttings is approximately 0.78 ha (0.24 ha with 1 – 5 cm of deposition; 0.54 ha with >5 cm deposition). At the Doina-100 well location the maximum thickness of cuttings deposits, 116 cm, are associated with riserless drilling of the 36” top hole; these deposits are located within approximately 10 – 15 m of the well location. Cuttings from the remainder of the Doina well sections (drilled with a riser and discharged from the MODU) will be deposited in a similar pattern to the Ana wells, however to a lesser thickness with a maximum depth of approximately 5 cm predicted; the total area affected by the deposition of cuttings is approximately 0.58 ha (0.01 ha with 1 – 5 cm of deposition; 0.57 ha with >5 cm deposition). It is noted that the any drilling mounds from the riserless section at Doina would need to be levelled (by jetting with seawater using drill pipe run from the MODU or a suction pump fitted to an ROV) as the seabed around the hole needs to be relatively level for the installation of the subsea wellhead system and subsea Christmas tree.

The deposition of cuttings will result in the smothering of sessile species in the vicinity of the Ana and Doina wells. The species with the most limited mobility are, such as *M phaseolina* mussels, and *C intestinales* tunicates are likely to perish in these areas. Burrowing species, such as polychaetes and amphipods are likely to have a higher rate of survival. Species with the highest mobility, such as brittlestars and fish are likely to have the highest rate of survival as they can relocate to adjacent habitat.

The maximum extent of cuttings deposition has been predicted to be 0.78 ha at the Ana location and 0.58 ha at the Doina location. The deep circalitoral mud habitats which will be affected by the deposition, including those with *M phaseolina* and *P. solitaries,* were widely recorded across the Ana and Doina field baseline surveys, and along the export pipeline.

The rate of recovery of seabed benthic populations will depend on the extent, thickness and persistence of the drill cuttings layer, water temperature, and the sensitivity of the populations present (OGP 2003). The recovery of benthic communities from these effects generally occurs by the recruitment of new colonising organisms and the subsequent migration from adjacent undisturbed sediments. There is typically a succession of benthic community composition and diversity during recovery. For habitats characterised by the presence of *M. phaseolina* mussels, recovery will depend on the fall of spat from nearby mussel beds. Full recovery may be delayed until sediment physical and chemical properties return to pre-discharge conditions; this depends upon natural deposition and transport of sediments (or substrate in the form of dead mussel shells) to and from the affected area combined with the biodegradation of sediment organic matter that results in reoxygenation of surface sediment layers (IOGP, 2016b). Recolonization rates for this mussel species are not known, but could be in the medium term (eg. 5-10 years).

As noted in *Section 5.6* above, the habitat in the areas which will be subject to drill cutting burial (A5.379 “Pontic deep circalittoral muds with *Modiolula phaseolina*”) are typical of the lower circalittoral belt west of the Crimean Peninsula, and is found in the Bulgarian and Romanian shelfs at depths ranging from 50 m to 180 m. It should also be noted that the area which will be impacted by the cuttings has evidence of previous disturbance from fishing and exploration drilling activities, as visible from side scan sonar imagery (*Figure 5.2* and *Figure 5.4*). Whilst mortality of the sessile *M. phaseolina* mussels species can be expected within these areas, and recovery may take 5-10 years, this is not considered to be a significant impact to the biodiversity of the area due to small footprint compared to the abundance of similar habitat in the wider area. As noted above none of the habitats recorded by the baseline surveys of the Ana or Doina field are considered to be Annex I habitats, or to be Priority or Critical habitats as defined by EBRD PR6 or IFC PS6.

The physical and chemical persistence of cuttings depends on the energy of the seafloor currents and the biodegradability of the drilling fluids chemicals. Most minerals in cuttings are stable and persistent in seawater and most organic chemicals in WBDF are biodegradable (IOGP, 2016b).

The low power requirements of this option, and lack of transport requirements, mean that emissions to air of pollutants and GHG from the combustion of fuels is the lowest of the disposal options.

7.2.3 Cost Considerations

The disposal of cuttings to the sea is a low cost option; the MODU does not require any additional CAPEX to facilitate disposal to sea. As the treatment technology involved provides a high level of reliability, cost impacts from the slow down or cessation of drilling due drilling waste management problems are also considered to be low risk.

7.2.4 Health & Safety Considerations

The disposal of cuttings to the sea has the lowest safety concerns; the MODU does not require any additional equipment (which may introduce hazards) to facilitate disposal to sea. The disposal to sea does not require any lifting operations as the treated cuttings are discharged from the solids control equipment and overboard via a discharge chute.

7.3 Land Disposal – Option 2

Land disposal of cuttings is acceptable under Romanian regulations; cuttings would need to be analysed and disposed of at a landfill site licenced to receive material as characterised by key analytes.

7.3.1 Technical Considerations

Technically, the collection of WBDF and cuttings in bins is feasible onboard the GSP Uranus MODU, however, deck space is constrained. To facilitate the use of cuttings bins in past drilling campaigns using NADF, a dedicated steel platform has been designed and fabricated. This platform is hung on the outboard side of the MODU hull underneath the cuttings discharge chute; cuttings bins are placed under the chute to collect the cuttings and replaced as required.

For the MGD drilling programme it has been estimated that approximately 500 to 550 cuttings boxes would need to be filled to transport all the cuttings back to land. This is based upon the estimated volume of WBDF and cuttings and the use of 2.6m^3 cuttings bins[2], noting that these are not filled to the maximum stated capacity. Larger bins cannot be used due to the load limitations of the temporary platform needed to facilitate a skip and ship operation. A dedicated PSV would also need to be used as an offshore floating storage area for the cuttings bins due to the lack of storage space on the MODU for full bins.

Deck space is not available on the MODU to allow for the installation of equipment required for the storage and bulk transfer of WBDF and cuttings (eg pneumatic transfer to storage tanks).

Once onshore, the available disposal options for cuttings are currently limited to either incineration or landfill. Incineration of NADF cuttings has been carried out on previous similar projects performed by other operators at the Lafarge Cement Plant in Medgidia, around 50 km from Midia Port. This option, however, would require oil to be added to the WDBF cuttings which the MGD will generate to enable them to be incinerated and as such is considered impracticable and undesirable, so is not addressed further. The remaining disposal option is the licensed landfill site located in Pitesti, approximately 375 km by road (one way) from Midia port.

7.3.2 Environmental Considerations

The PSV would make the 105-120 km journey to port and back to the rig around twice a week (a 1 day return trip) to discharge full bins and stock up with empty ones. Historical fuel consumption of marine diesel by the PSVs used by BSOG in 2018 for the exploration drilling campaign was on average 6 tonnes of fuel per day when in the field standing by at the rig location and 11 tonnes per day when in transit to and from the port.

Using an estimated 128 days drilling duration for all five wells, and the historic average fuel consumption figures, the PSV required for cuttings bins storage in the field will consume approximately 948 tonnes of fuel (see Table 7.2) and in the process emit approximately 3,080 tonnes CO_2e[3].

Table 7.2 Basis for PSV Fuel Consumption

PSV Operating Mode	Days	Fuel Consumption (tonnes/day)	Fuel Consumption (tonnes)
Transit	36 (2 days transit per week; 18 week (128 days) programme)	11	396
Standby	92 (128 day programme – 36 days transit)	6	552

Onward distribution of the cuttings to the point of disposal (landfill located in Pitesti, approximately 375 km from the port) would require road transport. It is assumed that the cuttings bins would be emptied at the port and the WBDF and cuttings transported via a tipper truck of 15 to 20 tonne capacity. For a total of 1,098 tonnes of WBDF and cuttings, this may involve 50 to 75 truck movements from the port to the point of disposal / reuse and back. Vehicle emissions generated from the combustion of diesel fuel for these HGV movements would emit approximately 61 to 62 tonnes CO_2e[4]. Other pollutants such as nitrogen oxides, sulphur oxides and particulate matter would also be emitted.

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[2] Cuttings bins used offshore need to be certified according to an international standard DNV 2.7-1 / EN12079. Cuttings bins are available in sizes ranging from 2.6m^3 to 6.4m^3.

[3] Estimated using emission factor of 3,249.28 kg CO_2e / tonne of marine gas oil (Department for Business, Energy & Industrial Strategy, 2018. UK Government GHG Conversion Factors for Company Reporting).

[4] Estimated using emission factor of 1.09934 kg CO_2e / km for a 100% laden >17 tonne rigid HGV (Department for Business, Energy & Industrial Strategy, 2018. UK Government GHG Conversion Factors for Company Reporting).

7.3.3 Cost Considerations

The cost for the skip and ship option has been estimated to be approximately US$ 4.75 to US$ 4.95 million. This estimate includes US$ 0.75 million to US$ 0.95 million for the additional equipment, manpower and the onshore disposal costs at the processing facility or landfill site. It also includes an estimated US $4 million for the PSVs and onshore trucks required to transport the cuttings bins to the disposal facility.

The skip and ship operation is also dependent on the availability of empty cuttings bin and storage space for both full and empty bins. Should logistical reasons, PSV delay, constrain the supply of bins or storage space, there could be considerable cost impacts from the slow down or cessation of drilling.

7.3.4 Health & Safety Considerations

Skip and ship operations introduce safety hazards into the drilling operation, primarily through the large amount of lifting operations required. The cuttings boxes have to be lifted onto a PSV, transported to the MODU and lifted onto it for storage before being lifted to the filling station for use. Once filled with cuttings, the box is lifted from the filling station, transferred to a temporary storage area before being lifted down onto the PSV to be transported back to port where it is lifted onto the dock. Therefore there may be six or more crane lifts per box. With an estimated 500 to 550 boxes required for the drilling programme, this amounts to 3,000 to 3,300 individual crane lifts. This represents a significant increased safety risk to workers at the MODU and PSV and at the port. In addition, as the temporary platform where the cuttings boxes are filled is outboard of the drilling rigs hull, the handling of the skips involves over side work to be undertaken by personnel over open water.

As discussed above (Section 7.3.2) the onward transport of the cuttings to the point of reuse or disposal would require road transport which in turn can increase the risk of road traffic accidents from additional HGV traffic (an estimated 50 to 70 return journeys over the 18 week programme). These additional HGV journeys would also contribute to local air quality deterioration along the transportation route.

7.4 Reinjection – Option 3

Reinjection of cuttings is acceptable under Romanian regulations.

7.4.1 Technical Considerations

None of the MGD wells have been identified as being suitable well for cuttings reinjection. The well design for each of the casing strings to be run on both the Ana and Doina wells, requires that the casing strings are fully cemented to just below the sea bed to maintain both structural and pressure containing integrity of the well. There is therefore no annulus available that is open to a formation that would be suitable for cuttings reinjection. There is no available deck space on the selected MODU for the additional equipment which would be required to facilitate cuttings reinjection and no available alternative MODU in the Black Sea that has the required deck space. For the Ana wells, cuttings reinjection could only be achieved by drilling a dedicated injection well.

7.4.2 Environmental Considerations

Drilling of a dedicated disposal well would result in the emissions to air of pollutants and GHG associated with the fuel required to power the MODU and PSV for the period required to drill an additional disposal well (assume an additional 28 days based on similar length of time required for the MGD production wells). Energy would also be required to slurrify and pump cuttings down the well.

7.4.3 Cost Considerations

Drilling of a dedicated disposal well would require the wellhead platform to be redesigned to accommodate addition well slots. The cost of an additional well is estimated at approximately US$14.0 million.

In addition, the reliability of surface equipment and the potential for downhole issues associated with cuttings reinjection are potentially time-consuming and costly to resolve. Unavailability of reinjection could lead to cessation of drilling and a costly extension to the drilling programme.

7.4.4 Health & Safety Considerations

The use of additional equipment on the MODU to facilitate the reinjection of cuttings (if a suitable disposal well were available), may introduce some additional hazards onboard the MODU, as high pressure injection equipment would be required.

8. OPTIONS ANALYSIS AND JUSTIFICATION OF THE BPEO

The options analysis requires the performance of each option to be assessed against each decision criteria and the performance of each option is ranked against each other option. Given the number of options being assessed, a comparative ranking of *Low, Medium, High*, has been applied. *Table 8.1* summarises the relative performance of each potential disposal option with a high level summary of the issues discussed in *Section 7*. .

Based on the results of the options analysis, the sea disposal of WBDF and WBDF based cuttings has been identified as the BPEO. Whilst this option will have impacts to the aquatic environment (namely to sessile benthic fauna), as noted in *Section 7.2.2*, these impacts are not considered to be significant to biodiversity. Taking into account the other considerations, sea disposal considered to be the most preferable of the disposal options having the lowest GHG footprint; being the best (most reliable) technically; having the lowest cost; and presenting the lowest health & safety hazard profile.

8.1 Recommended Mitigation

A drill cuttings management plan will be developed and implemented. The objective of this plan will be to:

- Document the controls required for WBDF selection, use and discharge.
- Provide evidence of compliance with GIIP, in particular the requirements of the IFC EHS Guidelines of Offshore Oil and Gas Development, 2015.
- Provide details of required monitoring of biodiversity.

Given the comparison of discharge height exercise could not demonstrate a clear significant reduction in the overall area of seabed affected by cuttings deposition, the modification of the MODU to include caisson discharge below the mean sea level is not considered to be necessary.

Table 8.1 Options Assessment

Option	Environmental Considerations		Cost Considerations	Health & Safety Considerations	Technical Considerations
	Aquatic Environmental Impacts	GHG and Emissions Impacts			
1. Sea Disposal	Impacts to benthic organisms will occur from burial; area small in context of regional habitat distribution. Recovery expected in medium term. Impacts to water quality will be mitigated via WBDF chemical selection (PLONOR, Grade E or HQ Band Gold or Silver).	Lowest GHG footprint of the disposal options.	Commercially proven. Lowest cost option.	Standard equipment on MODU; procedures covering and crew familiar with use.	Industry standard option for WBDF cuttings disposal. High degree of MODU equipment reliability.
2. Land disposal	Use of PSVs to transport cuttings ashore will involve emissions to sea eg treated blackwater, cooling water.	Highest additional GHG emissions associated with marine and land transport.	Additional costs in order of US$ 4.75 to US$ 4.95 for equipment, offshore and land transport, labour and fuel. Potential costs due to lost drilling time from lack of storage space on MODU.	Additional hazards associated with large number of lifting operations; road transport from port to disposal location.	Limited availability of onshore disposal / re-use infrastructure: One licenced landfill.
3. Reinjection	Receiving strata should be isolated from aquatic environment.	Additional GHG emissions associated with drilling a injection well (if required), slurrification equipment and reinjection pumps.	Disposal well costs of approximately US$14.0 million. Potential costs due to lost drilling time due to surface or downhole problems.	Introduces additional equipment and associated hazards onto MODU.	No suitable well is available for disposal. Drilling of a dedicated disposal well discounted due to cost and environmental impacts.

Key

Lowest impact, cost, level of safety risk or best / most reliable technically performing option	Medium performing option	Highest impact, cost, level of safety risk or least reliable technically performing or unfeasible option

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