PROJECT RISK ASSESSMENT

UXO research – Drangedalsvegen, Porsgrunn

20/09/2024

Client	SIVILARKITEKT MNAL
Contractor	ADEDE BV
Version	Version 1

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1. RELATED DOCUMENTS

[1] 23/10/1987 Geotechnical Report: H227B-1 Hovedvegnettet i Grenland – Kultangen-prosjektet – Orientering om grunnforhold

[2] 22/11/2021 Historical UXO Research, Porsgrunn (Norway)

[3] 15/11/2018 Historical UXO Research, Porsgrunn Herøya Industri Park (Norway)

2. INTRODUCTION

2.1 SCOPE OF WORKS

Sivilarkitekt MNAL (Norway) is planning to build a social complex with residential buildings and car parks on Dragedalsvegen in Porsgrunn (figure 1,2)

As the project area is close to Herøya peninsula, which was bombed in 1943, it is likely to be contaminated with unexploded ordnance (UXO). A historical study of wartime by ADEDE [2,3] concludes that the project area has a very high probability of containing unexploded 500 lbs aerial bombs, a high probability of being contaminated with 3-inch rockets and 8.8 - 10.5 cm artillery shells, and a low probability of containing 1000 & 2000 lbs sea mines on land. This UXO risk assessment provides valuable insight into the potential hazards posed by such ordnance during groundworks.

The scope of this Project Risk Assessment is to propose correct prevention and mitigation measures for any given activities that is susceptible to UXO risks. The measures are intended to eliminate and/or reduce these risks. The procedure for assessing the risks associated with the performance of projects tasks will be evaluated before and after the application of safety measures in order to provide a clear picture of the method used.

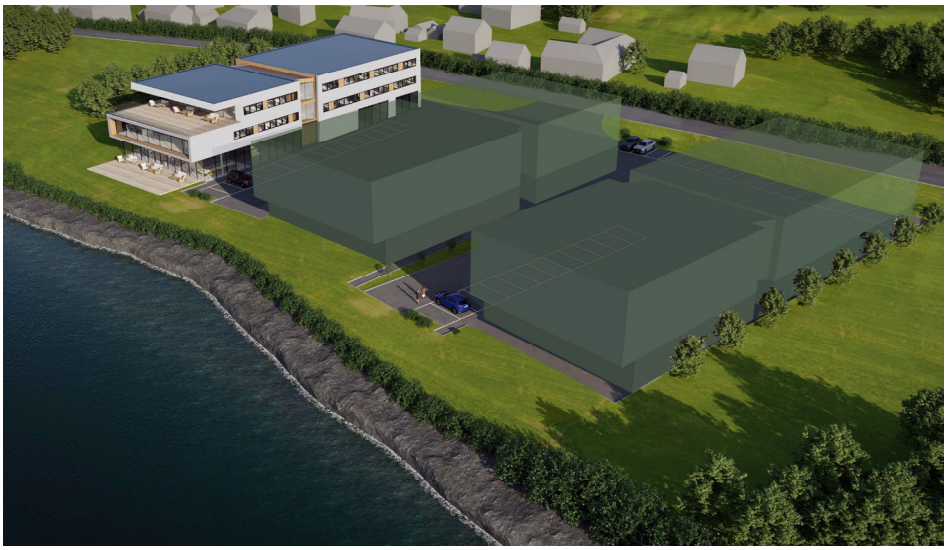

Fig 1. – Conceptual rendering of the project.

fig. 2 - Situation of the project area in Drangedalsvegen, Porsgrunn.

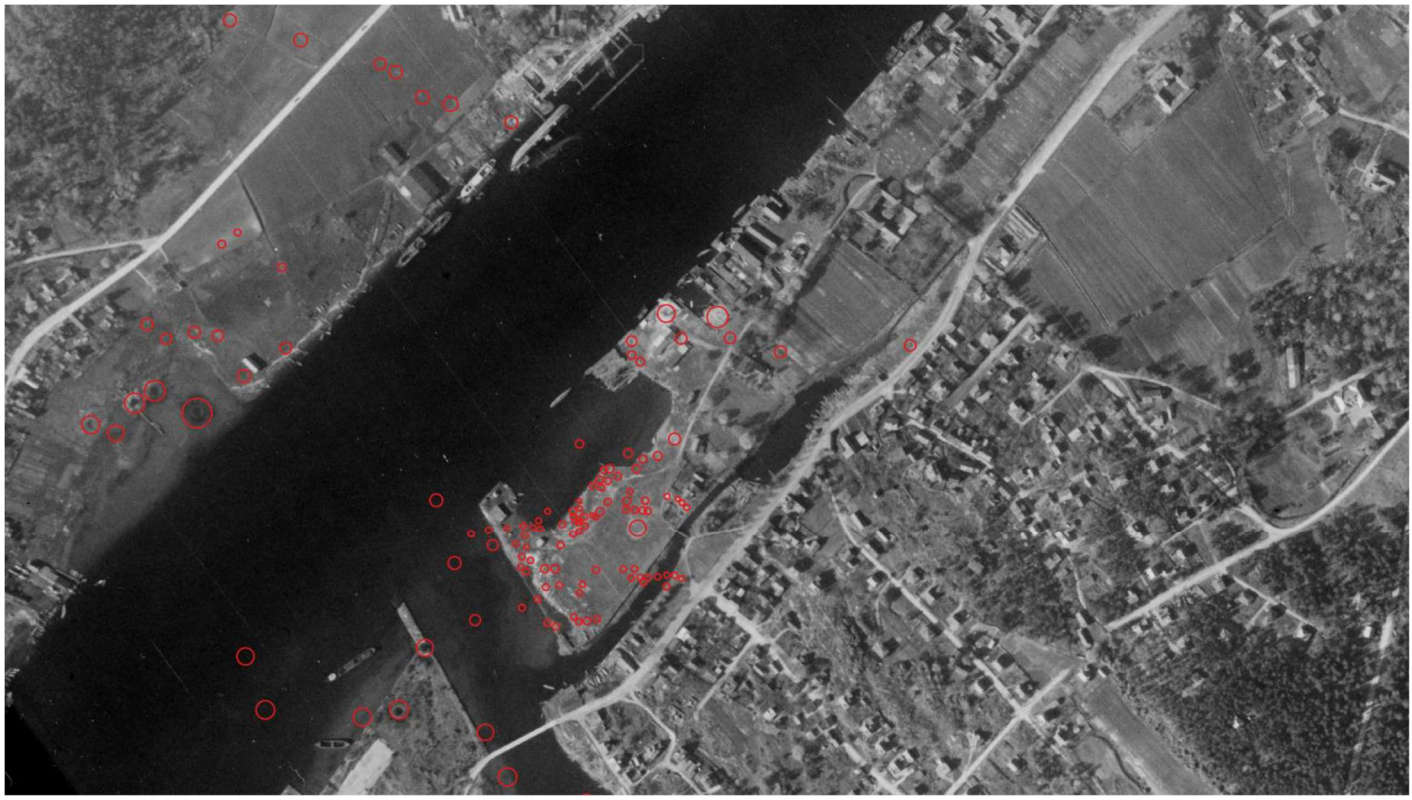

fig. 3 - Situation of the project area on a historical aerial photograph of 6 May 1945.[1]

[1] *National Collection of Aerial Photography, Sortie 106G/L/0104, Frame 3284.*

2.2 OBJECTIVES

Sivilarkitekt MNAL (Norway) asks ADEDE to prepare an UXO-related Project Risk Assessment (PRA) to cope with the UXO risks during groundworks. In this study, the risks of an accidental UXO explosion for every type of expected groundwork is analysed. Prevention and mitigation measures are advised to organise all groundwork as safely as possible.

The following aspects are covered in this UXO risk assessment:

- Scope of project and objectives
- Inventory of location-specific circumstances
- Inventory of planned construction work
- Project Risk Assessment
    - Introduction to risk assessment studies
    - Project risk calculations
        - Overview of unexploded ordinance (UXO) and potential occurrence in project area
        - Information on types of fuzes and status of ammunition.
        - Brief UXO-risk calculation (RA).
        - Impact & safety perimeters for each UXO
        - Identification of influencing factors and effects
    - Prevention and mitigation measures
- Advise concerning the risk mitigation strategy

2.3 SYNTHESIS OF PLANNED GROUNDWORK

Activities as listed below, increase the risk of an accidental UXO explosion. Therefore, those groundworks will be addressed in this Project Risk Assessment report.

- Drilling for geotechnical investigation.
- Excavations/removal of soft soils.
- Embankments in the area and other large mass movements.
- Deep excavation

3. LOCATION SPECIFIC CIRCUMSTANCES

The project area is partly rural (woods, meadows and farmland) and partly urban (residential areas). If an explosion were to occur near the residential areas, additional damage to infrastructure and residents would be expected (apart from the damage it may cause to the construction site itself).

A drop-off bomb of 500 lb can penetrate the subsurface of the valleys at this site up to 7 MBGL. However, it is unlikely that UXO will be found close to outcrops or in areas where outcrops are covered by a thin layer of sediment (< 1 MBGL). UXO tends to ignite or fragment on impact with outcrops. However, If UXO has penetrated the sedimentary subsurface close to an outcrop (rock), an accidental ignition during groundwork will cause a directional release of the explosive energy away from the outcrop (energy bounce on hard, solid outcrops.

3.1 OVERVIEW (TABLE)

GEOGRAPHY	INFRASTRUCTURE	VEGETATION	GEOLOGY
▪ Urban area in theeastern side ▪ Rural area in western area	▪ Some workshops and/or farms in rural area ▪ Residential buildings in the eastern side ▪ Roads and pavement	▪ Woodlands ▪ Cropland with some trees as vegetation in rural area	▪ Outcrops covered with thin layers of firm sediments ▪ Wet ground with some marches ▪ Possible quick clay (glaciomarine deposits) ▪ Loosely consolidated marine sediments (sand, silt, clay)

Table 1 – overview of location specific circumstances.

4. PLANNED GROUNDWORK

4.1 INTRODUCTION

Due to the historical background of the project area [2,3], the groundworks for this project have a high UXO risk (Chapter 5). This chapter provides an overview/inventory of planned groundworks in a UXO contaminated area. Mitigation measures are required to ensure the safety of the worksite and the often urban environment. These mitigation measureswill be discussed in the next chapter (PRA). Several types of groundworks have been added to the preliminary limited list provided by the Municipality of Porsgrunn to provide a broader assessment of the most common types of groundworks for such project.

Next activities are planned for the construction of the new project alongside Drangedalsvegen, preparatory work:

- Felling trees
- Demolition work
- Breaking up old roads/parking & pavement along the main road
- Installing drainage systems
- Vibrating in piles/poles
- Drilling for geotechnical investigations

- Excavation
    - Surficial excavation / removal of soils
    - Deep excavation
    - Excavation close to pipelines/underground sewers
- Heavy vibration
    - Driving/vibrating poles into the ground
- Mass movement/stabilization
    - Embankments and other large mass movements

4.2 INVENTORY OF PLANNED GROUNDWORK

Table 2 documents the panned groundworks and additional groundwork that often occur in such projects, in relation to the planned depth of the groundwork and a description of its UXO-risk.

Type of activity	Planned depth of groundwork	Description of UXO risk
Preparatory work		
Demolition work	Near to surface	Demolition work involves vibration and excavation, which could potentially tamper with nearby UXO. This applies to both underground and above-ground demolition works.
Breaking roads, parking, pavement	Near to surface	When breaking up the existing sidewalks and roads, there is a risk of manipulation of nearby ammunition.
Felling trees/vegetation	Depends on depth of roots Likely < 2 MBGL	Clearing plants and felling trees poses an increased risk of accidental explosions. UXO may be overgrown by the trees' root systems.
Drilling for geotechnical research	Up to 70 MBGL	Drilling on an UXO will lead to a calamity.
Excavation work		
Deep excavation (> 2 MBGL)	> 2 MBGL	Excavation work in the UXO-suspicious subsurface is highly risky. Ammunition can
Surficial excavation (< 2 MBGL)	< 2 MBGL	Be hit and manipulated unknowingly, causing detonation of the fuze.
Working close to pipelines and underground sewers	Depends on depth of underground sewer system and pipelines, likely > 2 MBGL	Sewer pipes a.o. can transport the energy over a long distance as a shock wave created by an explosion of UXO.

Heavy vibrating activities		
Vibrating piles/poles in subsurface	Likely > 2 MBGL	Vibrating piles/poles into the subsurface can trigger surrounding UXO to explode. Studies from the Netherland pointout that these heavy vibrations have an impact range of about 10 m around the pile driven into the subsurface.
Mass movement/stabilization		
Embankments and large mass movements	Uncertain	Mass movements of reused soils can contain undetected 8.8 and 10.5 cm artillery ammunition. During transport, loading or depositing the soils this ammunition is heavily manipulated which can trigger the UXO to explode. Larger UXO as the allied 500 lb bombs are not expected since they most probably will be detected by the working teams during loading of sediments. Only If the materials are brought in from other sites with no historical record of warfare, no UXO risk is expected.

Table 2 – Inventory of planned groundwork.

5. PROJECT RISK ASSESSMENT (PRA)

5.1 INTRODUCTION – RISK PARAMETERS

A project UXO risk assessment evaluates, quantifies, and compares the risks of project related groundwork in an UXO- suspicious area when (1) no extra mitigation measures are taken and (2) advised safety measures for each activity is incorporated to eliminate or reduce the high risks to an acceptable level. A semi-quantitative interpretation of the risks is needed and can be obtained based on sets of pre-defined parameters using the Fine and Kinney method:

Risk = Probability x Exposure x Severity
R = P x E x S

The pre-defined parameters correspond with indicative values ranging from ‘exceptionally low’ to ‘exceedingly high’:

- Probability with values ranging from 0.1 = ‘unthinkable’ to 10 = ‘to be expected,
- Exposure with values ranging from 0.1 ‘very rarely’ to 10 = ‘continuously’,
- Severity with values ranging from 1 = ‘light wounds’ to 100 = ‘catastrophic

Symbol	Description	Values	
R_{PRA}	Estimated risk of an accidental explosion of UXO due to project specific activities	**R < 21**	**Slight risk; acceptable**
		21 ≤ R < 71	**Small risk: attention required**
		71 ≤ R < 201	**Moderate risk; apply simple measures**
		201 ≤ R < 401	**Substantial risk; apply large measures immediately**
		401 ≤ R	**Risk is too high; stop activities / operations**
P_{PRA}	Probability of triggering an UXO explosion during accidental manipulation when performing project specific tasks.	0,5	Highly unlikely, but conceivable
		1	Unlikely, but possible in the long term
		3	Unusual (but possible)
		6	Possible
		10	To be expected
E_{PRA}	Exposure of project specific tasks to the UXO dangers: depends on occurrence/depth of UXO and the type/magnitude of the projects specific task	0.5	Seldom exposed
		1	Rarely
		2	Sometimes
		3	Often
		6	Frequently
		10	Constantly exposed
S_{PRA}	Severity of injury and damage after an UXO explosion; depends on type/content of UXO and caused effects (impact range, heat, shock wave, …)	1	Slight effect; injury without absence
		3	Important; injury with absence
		7	Severe, lasting injury
		15	Very severe, lasting disability
		40	Disaster, a fatal casualty
		100	Major disaster, multiple fatal casualties

Table 3 – values of the pre-defined parameters.

It is important to underline that a Project Risk Assessment (PRA) differs from the UXO Risk Assessment (RA), as shown in the UXO Risk Assessment document or a general Task Risk Assessment (TRA). Table 4 explains the, sometimes subtle, differences between PRA, RA and TRA studies. Clear and unambiguous definitions with correct descriptions and examplesare essential for a correct interpretation of the risk assessments.

Symbol	Definition	Example of estimations
Ruxo	Estimated risks for the diverse types of UXO expected at the project area during project work	Ruxo = Puxo x Euxo x Suxo Example: How dangerous will the 500 lb bombs dropped during WW2 be for the project?

R_{PRA} (this study)	Estimated risk of UXO-related accidents due to unsafe project decisions, actions and/or situations	$R_p = P_p \times E_p \times S_p$ Example 'Incorrect planning of excavation work': How dangerous can excavation work be in a high UXO-risk area without taking mitigation measures?
R_t	Estimated work-related risks of all tasks, actions, decisions, and situations.	$R_t = P_t \times E_t \times S_t$ Example: How dangerous is it to work next to an excavator?

Table 4 – Definitions and examples of several types of risk assessments. This document inventories and evaluates R_P for project decisions, actions and/or situations.

5.2 UXO RISKS (RUXO)

The general UXO risk of the project site is listed below (table 5). The UXO risk assessment report describes this calculation for all types of UXO expected in site Drangedalsvegen near the Porsgrunn Selva river in detail. These evaluations are based on historical preliminary investigations [2,3], several geotechnical studies, and a thorough UXO knowledge.

Type of UXO	Probability	Exposure	Severity	Risk
Allied 500 lb drop-off bombs	10	6	100	6000
Allied 3-inch rockets (N-part)	6	6	100	3600
Allied 1000-2000 lb naval mines (river area)	10	0,5	100	500
German 8.8 & 10.5 cm AA grenades	6	3	40	720

Table 5 – R_{UXO} for the expected UXO in subsurface of work sites.

The risks are too high in the project area. Prevention and mitigation measures are necessary to decrease the risks to an acceptable level. In addition, this document will evaluate the planned groundwork in relation to the UXO risks. An important note when dealing with UXO: all ammunition is designed with a single goal, to create as much damage to people or infrastructure as possible. This explains the maximum scores of 100 for the Sp-parameter.

5.3 EFFECTS OF AN UXO EXPLOSION

A single explosion of UXO can cause a variety of "impact" effects, with the magnitude of these effects depending on the type of UXO. The risk assessment must take the following effects into account if an accidental explosion occurs in this projectarea:

- Shock wave (air pressure, also sound pressure) with damaging effects on people and infrastructure
- Ground shock (in soil and water) with destructive effect on people and infrastructure
- Fragmentation/dispersion of fragments (fast-flying shards and splinters) both from the UXO itself as from nearbymaterials. Fragmentation under water is limited.

- Underwater bubble jet effect with destructive effects on nearby infrastructure
- Explosion heat
- Chemical aerosols (smoke and gas)

5.3.1 SHOCKWAVE (AIR PRESSURE)

A shock wave is created because the explosive converts into a large amount of gaseous reaction products in a very short time after detonation. The detonation of 1 gram of explosives releases approximately 1,000 litres of gas, which changes the air pressure, and propagates through the environment at high speed. If the expansion of the gas is restricted on one side, for example by a hard rock outcrop, the energy will bounce off and intensify in the other 'free' directions. The shock wave can have deadly effects on the human body, damage surrounding infrastructure and break distant windows. Depending on the depth of the explosive, the effect will create craters at ground level. If the explosive is too deep to form a crater, the air pressure will compress the surrounding soil material. This creates a so-called gas pocket (artificial cavity). The formation of an underground gas pocket changes the mechanical properties of the soil. Depending on the depth and groundwater level, the gas pocket will fill with groundwater and may collapse over time. This can cause overlying and nearby structures to collapse or damage.

5.3.2 GROUND SHOCK

A ground shock is a violent accelerated shock wave (supersonic) through surrounding matter (water and/or soil) that occursduring a detonation. The greater the density of this matter, the further the shock wave propagates. As a result, pipes, foundations, floating objects on water, etc. can be destroyed or damaged at a great distance.

5.3.3 FRAGMENTATION

Fragmentation occurs when UXO and surrounding material are fragmented during its detonation. The resulting shards are blown away at great speed by the shock wave. Shards can have a deadly effect on the human body and damage surrounding infrastructure.

5.3.4 UNDERWATER BUBBLE JET EFFECT

The air pressure caused by an underwater shock wave will compress the surrounding water creating a huge gas bubble. This gas bubble is at fast speed filled up with water which creates strong surrounding currents which can suck floating objects under water. When the gas bubble reaches the surface, it will create a sudden depression in the water surface which can sink floating objects in seconds.

5.3.5 EXPLOSION HEAT

An explosion of ammunition is an exothermic reaction that can reach enormous temperatures (thousands of degrees) in a short time. This heat creates major damage in the immediate vicinity of the explosion and can trigger fires in nearby buildings, infrastructure, cars, etc.

5.3.6 CHEMICAL AEROSOLS

During explosion chemical aerosols (smoke, fumes and gasses) are released into the air. These can cause harmful respiratory problems.

6. PREVENTION AND MITIGATION MEASURES - PRA

The UXO risk calculations (paragraph 5.2) point out that UXO risk mitigation measures must be implemented before any project specific groundwork can start. The project risk assessment for each type of groundwork is given in table 6. This table shows the specific activity and the sites where the activity will be performed. Then, a first risk calculation without UXOmitigation measures is given, followed by a list of prevention and mitigation measures. The last 4 columns re-evaluate therisk parameters (PPRA, EPRA, SPRA, RPRA) after implementing those mitigation measures.

The table is a practical instrument for contractors and subcontractors. A Quick screen of their activities gives them a clearinsight in several safety measurements needed to decrease the risks of UXO during their operations and throughout the project. These measurements are basically divided in 3 categories:

i. Preliminary security preparations and informing involved parties
ii. Preliminary geophysical UXO research and uncover
iii. Assistance by UXO-expert

TYPE OF ACTIVITIES	WORK SITE	PPRA	EPRA	SPRA	RPRA	ADVISED MITIGATION & PREVENTION MEASURES	PPRA	EPRA	SPRA	RPRA
PREPARATORY WORK										
DEMOLITION WORK	On areas where infrastructure needs to be removed	3	1	100	**300**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2). ▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ All surface layers that do not come into direct contact with CTE-suspected layers can be removed without the intervention of a certified CTE expert company. ▪ If foundations have not been disturbed since WWI & WWII, or if there is any doubt, demolition works should be carried out under the supervision of a CTE expert, especially if CTE has been found in the vicinity. ▪ Cease demolition work immediately if a high-risk object is spotted. ▪ In the event of discovering CTE, the CTE expert will implement the necessary safety measures. ▪ The CTE expert will approach, identify the target, and ensure the	1	1	15	15

						safety of the situation.				
BREAKING UP ROADS,PARKING, PAVEMENT.	On areas where roads, parkingor pavements need to be removed	3	1	100	**300**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2). ▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ All surface layers that do not come into direct contact with CTE-suspected layers can be removed without the intervention of a certified CTE expert company. ▪ If foundations have not been disturbed since WWII, or if there is any doubt, demolition works should be carried out under the supervision of a CTE expert, especially if CTE has been found in the vicinity. ▪ Cease demolition work immediately if a high-risk object is spotted. ▪ In the event of discovering CTE, the CTE expert will implement the necessary safety measures. ▪ The CTE expert will approach, identify the target, and ensure the safety of the situation	1	1	15	15

FELLING TREES	Where trees/vegetation need to befelled	3	1	40	**120**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2). ▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ Trees and shrubs should be cut down to a maximum of 5 cm above ground level. 1. A ferromagnetic surface detection should be conducted over the green zones. 2. Analyze collected data and create a target list of suspicious locations and depths of possible CTE objects. ▪ The CTE expert will approach, identify the target, and ensure the safety of the situation	1	1	15	15
GEOTECHNICAL DRILLING	Soundings and sampling near the Porsgrunn Selva	10	2	100	**2000**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ Site specific emergency plan on site ▪ Non-intrusive Ferromagnetic UXO detection - Surface detection at locations on river Porsgrunn Selva (drop-off bomb loses kinetic energy when plunging through water column making penetrator depth in subsoil of river max. 2 m deep).	1	1	15	15

	up to the bedrock					▪ Geophysical analysis of data, UXO target mapping ▪ No drilling allowed in a range of 5 m around UXO-targets ▪ Drilling assisted by an UXO-expert with a real-time bore hole magnetometer Detection to safeguard the drill operation – detection followed by drilling deeper followed by detecting. ▪ If during the real time detection a significant signal occurs, drilling must stop atthat location and the area of 5 m around this borehole.				
EXCAVATION WORK										
DEEP EXCAVATION > 2 MBGL	All areas	6	6	100	**1800**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2). ▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ Ferromagnetic surface detection (accurate to 2 m-mv) over the strips to be excavated. ▪ Analysis of the measured data and preparation of a target list of suspected locations and depths of possible CTE objects. ▪ Approach, identification and securing of targets by a team of CTE experts + DOV support.	3	2	15	90

SURFICIAL EXCAVATION	Removal of soils	6	6	100	**3600**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2). ▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ Ferromagnetic surface detection (accurate to 2 m-mv) over the strips to be excavated. ▪ Analysis of the measured data and preparation of a target list of suspected locations and depths of possible CTE objects. Approach, identification and securing of targets by a team of CTE experts + DOV support.	3	1	45	45
WORKING IN PROXIMITY OF	In areas where groundwork is	6	1	100	**600**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2). ▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ Intrusive detection to 7 m-mv at locations of planned column foundations. Work in progress by CTE specialist company.	3	1	15	45

PIPELINES OR SEWERSYSTEMS	performed nearsewer systems					▪ Analysis of the survey data, establishment of a target list, retaining anomalies similar to those of the expected munitions. ▪ Approach, identification of targets and securing of situation by CTE experts, followed by removal of rig by DOV.				
HEAVY VIBRATING ACTIVITIES										
VIBRATING PILES inSOILS	Sites characterised with ahigh-water table	10	2	100	**2000**	▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ Site specific emergency plan on site <u>Piles/sheet piles on land</u> ▪ Intrusive magnetic detection until the desired depths in a grid covering the locationswhere piles/sheet piles are planned. Analysis of data. ▪ Uncovering of analysed UXO-targets by a team of UXO-experts ▪ Alternatively: change location of piles/sheet piles	3	1	15	45
MASS MOVEMENTS										
						▪ Safety briefing of contractors/personnel about working in an area with a high UXO risk ▪ CTE safety briefing for personnel by a CTE expert with clear communication guidelines. ▪ Emergency plan 'CTE Unexpected Discovery' must be known and available on-site (ADDENDUM 2).				

EMBANKMENTS &LARGE MASS MOVEMENTS	Embankments	6	6	100	**3600**	▪ Minimize personnel exposure: ensure only the minimum necessary personnel are involved (i.e., the least number of exposed individuals). ▪ Trees and shrubs should be cut down to a maximum of 5 cm above ground level. 3. A ferromagnetic surface detection should be conducted over the green zones. 4. Analyze collected data and create a target list of suspicious locations and depths of possible CTE objects. ▪ The CTE expert will approach, identify the target, and ensure the safety of the situation	3	1	15	45

MASS MOVEMENTS & STABILISATION

Risk - RPRA		Probability - PPRA		Exposure – EPRA		Severity – SPRA	
R < 21	Slight risk - acceptable	0.5	Highly unlikely	0.5	seldom exposed	1	Slight effect; injury without absence
21 ≤ R ≤ 71	Small risk – attention required	1	Unlikely but possible	1	Rarely	3	Important effects with absence (sick leave)
71 ≤ R ≤ 201	Moderate risk, apply simple measures	3	Possible	2	Sometimes	7	Severe: hospitalisation, lasting injuries
201 ≤ R ≤ 401	High risk – safety measure required	6	Likely	3	Often	15	Very severe: lasting disability
401 ≤ R	Unacceptable risk – Stop activities	10	To be expected	6	Frequently	40	Disaster; 1 fatal casualty
				10	Continue exposed	100	Disaster, multiple fatal casualties

7. ADVISE

As stated above and in the Project Risk Assessment table, we advise to adopt as many safety measures as possible stated in the PRA table. We strongly recommend the cooperation of an UXO-contractor for several reasons:

i. Informing employees of contractors and subcontractors with in-depth knowledge

ii. Correct and immediate safety decisions when UXO is found

iii. Carrying out UXO-surveys and uncover according to strict protocols (ISO 45001 certified and at least an EOD-specific certificate)

iv. Creating a safe environment which allows a straight-forward continuation of the effective project tasks.

To prevent and or mitigate accidental explosions of UXO, we advise following measures:

i. Preliminary security preparations and informing involved parties

- Preparing site specific emergency and intervention plans for employees at work and for inhabitants living closeto the project work. All emergency services should be contacted and a list of contacts in case of emergency isnecessary. The local commander of the fire brigade can, for example, be the coordinator for such emergency and evacuation plans. In all times, a clear and known entrance point to the site must be established which allowemergency services to reach all locations on this site. The emergency/ evacuation plans need a list of vulnerable inhabitants living or working near the sites (schools, hospitals, persons with disabilities, elderly people, …).
- Dissemination of information by an UXO-expert. All employees working on the site need to be informed correctly about possible UXO risks and need to understand the first basic safety rules when UXO is accidentally uncovered during groundwork. Attention needs to be made to give insights in how best to 'spot' UXO while working.
- The contact number of an UXO-expert gives a direct helpline in case of uncertainty. The UXO-expert's vision can give addition information when setting up the emergency and evacuation plan.
- When work is carried out near a residential area, or to protect infrastructure and employees on the worksite, bomb blankets can be used as an additional safety measure against the fragmentation effect of an accidental explosion of UXO. It will give effective protection at activities as sieving, dredging etc….

ii. Preliminary geophysical UXO research and uncover

- Ferromagnetic surface detection and uncover of analysed UXO-targets up to 2 MBGL. The ferromagnetic UXOsurvey can cover areas both on land and on the Porsgrunn Selva river. A drone with ferromagnetic detectors can cover large areas in a single day. The results of the survey need to be analysed to search magnetic anomalies which correspond to the expected UXO. After listing this up in a target list, the client can choose tochange positions of constructions to avoid hitting those targets or choose to remove the targets by a team of UXO-experts. This process is very delicate and needs to be carried out according to proven safety procedures.
- Intrusive ferromagnetic UXO survey can detect UXO until the desired depth. The borehole magnetometer records real-time information and records detailed data. If an area needs to be scanned, multiple boreholes arerequired to cover the area (every borehole can be placed 1.5 to 2 m from each

other in a grid covering the area). If only a single point for e.g. pile foundation is necessary, the client can then consider moving the locationof the pile if UXO is detected.

- GPR surface detection will detect objects in a ferrous contaminated area. This method can, in perfect site conditions reach up to 4 m depth for a 500 lb bomb, based on the GPR radar and the characteristics of a soil.This method works in sandy to silty areas, in areas with high water levels but it cannot work when the water or soil is contaminated with salt. Areas with clays give difficult to interpret data.

iii. Assistance by UXO-expert

- Prior to any excavation work, detection and identification must be completed to locate any potential UXO. Only after detection and identification can appropriate measures be taken, including engaging UXO experts for advice or intervention if needed. Do not proceed with any work until detection has been thoroughly conducted.
- A procedure called layer-wise excavation is advised if the area is less accessible for carrying out UXO-surveys,or at areas where the ferromagnetic survey gives saturated data. The UXO-expert will scan an area with his metal detector after which the operator can excavate the scanned layer of soil (40 cm). If UXO is detected, theUXO-expert can intervene immediately and safeguard the area. This process is continued until the desired depths, or until no more ferrous pollution is detected. If this latter is true, a new ferromagnetic surface detectioncan be opted.
- Demolition work, felling of trees and removing roots or work at sieving installations need to be assisted by UXO-expert so immediate security actions can be undertaken if UXO is spotted.

- Drilling activities need to be assisted by an UXO-expert/ geoscientist with the aid of a real-time magnetometer/metal detecting probe. The procedure is needed to avoid direct and dangerous contact of the drill with any UXO in the subsurface. Measurements are followed by drilling deeper or stopping if a signal is recorded. The drill bits need to be uncovered before every next (deeper) measurement can take place. Alternatively, a special hollow drill bit can be used to directly assist the drilling (drill bits do not need to be uncovered before every measurement).

ADDENDUM I - SAFETY PERIMETERS

When discovering an UXO, it is of utmost importance to avoid any (further) manipulation of the explosive. Taking immediatedistance from the UXO is the first preventive measure. Further emergency coordination and actions can then be organizedfrom a safe distance. There are three types of safety perimeters when encountering explosives. The indicative values for UXO expected in these areas are given in chapters 4.2.1 to 4.2.4. of the previous report ‘UXO Risk Assessment’.

Note that in-field UXO knowledge is necessary during groundwork in this area, so a correct evacuation and shelter perimeter can be calculated by the national demining service. The evacuation and shelter perimeters given here are purelyindicative. Values given here do not consider extern factors (wind speed and direction, presence of local barriers which candirect explosion energy towards a certain area, …). It is the task of the national Norwegian demining service to calculate these perimeters.

- The reflex perimeter indicates the area that needs an immediate evacuation if UXO is found, to avoid triggering theUXO to explode. All persons must leave this area as quickly as possible, and incoming traffic must be stopped. Equipment within this perimeter must be left behind. The local authorities and national emergency or demining service are informed. An UXO-expert or the national demining service will identify

the UXO and take further precaution measures (installing evacuation and shelter perimeter, installing bomb sheets, …).

- The evacuation perimeter indicates the area that could be impacted by an explosion and the associated shock wave. All residents or persons present who are not part of the operational emergency or security services must leave this area as quickly as possible and incoming traffic must be stopped. The national Norwegian demining service decides the effective perimeter.

- The shelter perimeter indicates the area on top of an evacuation perimeter within which shrapnel could fall after anexplosion. Traffic within this perimeter (water, air and land) should therefore be shut down and all residents will beasked to stay indoors, away from doors and windows until after the UXO has been neutralized. The national Norwegian demining service decides the effective perimeter.

SAFETY PERIMETERS – 500 LBS DROP-OFF BOMBS

Safety perimeters	Reflex perimeter	100 m
	Evacuation perimeter	540 m
	Shelter perimeter	1430 m

SAFETY PERIMETERS – RP-3 ROCKETS

Safety perimeters	Reflex perimeter	50 m
	Evacuation perimeter	160 m
	Shelter perimeter	845 m

SAFETY PERIMETERS – 1000 & 2000 LBS NAVAL MINES

Safety perimeters	Reflex perimeter	100 m	150 m
	Evacuation perimeter	440 m	590 m
	Shelter perimeter	1410 m	1905 m

SAFETY PERIMETERS – 8.8 AND 10.5 CM GRENADES

Safety	Reflex perimeter	50

	Evacuation perimeter	110
	Shelter perimeter	700

ADDENDUM II – PROCEDURE “ACCIDENTAL UXO ENCOUNTER”

When UXO is accidentally discovered and no UXO-expert is at the project site, following steps are required to avoid accidents:

i. Preliminary measures

- Project plan & safety plan of contractor/subcontractor needs to cover the risks of UXO
- All employees need to be informed about the risks and this procedure
- During a kick-of meeting, all employees are reminder of the UXO-risks and this procedure, even when apreliminary survey and uncover of UXO has been performed.

ii. Discovery of UXO during groundwork

- STOP all work immediately and create a safety perimeter of 20 m
- NEVER manipulate or tough the UXO, do NOT reach or inspect the UXO
- Make sure you and other employees remain at a safe distance
- Contact the UXO-expert, the local police, (Police will contact the national demining service). Even if only 1explosive is found. Strictly follow up their advice.
- An UXO-expert at the project area can take immediate action to increase safety and safely remove the UXO to asafe place until the national demining service arrives. NEVER ever take these actions in your own hands!
- If no UXO-expert is at the site, always leave the UXO at the location where it is found. The police or national.
- Work at other places on the work site can resume ONLY after approval of the local authorities or the nationaldemining service.