Keuper Gas Storage Project

Preliminary Environmental Information Report – Major Accidents and Disasters

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institution
BGL	Below Ground Level
CA	Competent Authority
CDM	Construction Design and Management
COMAH	Control Of Major Accident Hazards
DCO	Development Consent Order
DEFRA	Department for the Environment, Food and Rural Affairs
EIA	Environmental Impact Assessment
EDP	Emergency Depressurisation
ERM	Environmental Resources Management
ESD	Emergency Shutdown
FEED	Front-End Engineering Design
FRA	Flood Risk Assessment
GPP	Gas Processing Plant
HAGI	Hydrogen Above Ground Installation
HAZAN	Hazard Analysis
HAZID	Hazard Identification
HAZOP	Hazard and Operability Analysis
HSA	Hazardous Substances Authority

Acronym	Description
HSC	Hazardous Substances Consent
HSE	Health and Safety Executive
HSWA	Health and Safety at Work Act
ISEP	Institute of Sustainability and Environmental Professionals
ISO	International Organization for Standardization
KGSL	Keuper Gas Storage Limited
KGSP	Keuper Gas Storage Project
LPA	Local Planning Authority
MAAD	Major Accidents and Disasters
MAAP	Major Accident Prevention Policy
MAH	Major Accident Hazards
MC	Material Change
PCSR	Pre-Construction Safety Report
POSR	Pre-Operation Safety Report
PEIR	Preliminary Environmental Information Report
SIMOPS	Simultaneous Operations
SRAM	Safety Report Assessment Manual
SSSV	Subsurface Safety Valve
UXO	Unexploded Ordnance

15. MAJOR ACCIDENTS AND DISASTERS

15.1 INTRODUCTION

15.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) addresses potential major accidents and disasters (MAADs) associated with the Proposed Development that could affect people or the environment.

15.1.1.2 The baseline situation is considered before the likely environmental effects of the Proposed Development are identified during its construction and operational phases. Mitigation measures to reduce any negative environmental effects are identified as appropriate, before the residual environmental effects are assessed.

15.2 LEGISLATION, POLICY AND GUIDANCE

15.2.1.1 The preparation of the Major Accidents and Disasters Chapter has been informed by the following policy, legislation, and guidance.

15.2.2 LEGISLATION

15.2.2.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017[1] (the EIA Regulations) requires a MAADs Assessment to identify potential significant adverse effects of the Proposed Development on safety and the environment.

15.2.2.2 The EIA Regulations require 'a description of the expected significant adverse effects of the development on the environment deriving from the vulnerability of the development to risks of major accidents and/or disasters.'

Control of Major Accident Hazards (COMAH) Regulations (2015)

15.2.2.3 The principal health and safety legislation covering onshore storage of hazardous gases underground is the COMAH Regulations 2015[2]. The COMAH Regulations provide a framework for the regulation of establishments where there is potential for a major accident to people or to the environment to occur. The COMAH Regulations requires operators to take all measures necessary to prevent major accidents and limit their consequences.

15.2.2.4 Underground gas storage facilities are within the scope of the COMAH Regulations if the quantity of flammable gas stored meets or exceeds the thresholds in Schedule 1, Part 2 of the Regulations. For hydrogen, this threshold is between 5 tonnes (lower-tier) and 50 tonnes (upper-tier). Based on the expected storage capacity, the

[1] HM Government (2017) *Infrastructure Planning (Environmental Impact Assessment) Regulations*. Available at: https://www.legislation.gov.uk/uksi/2017/572/contents/made
[2] HM Government (2015) *The Control of Major Accident Hazard Regulations*. Available at: https://www.legislation.gov.uk/uksi/2015/483/contents/made

Proposed Development is anticipated to be an upper-tier COMAH site.

15.2.2.5 The Proposed Development will comprise the COMAH establishment.

15.2.2.6 The COMAH Regulations require upper-tier sites to prepare and submit a safety report, which starts as a Pre-Construction Safety Report (PCSR) submitted to Competent Authority (CA) prior to the commencement of construction activities. This report demonstrates that all necessary measures have been identified and will be implemented to prevent major accidents and limit their consequences to people and the environment

15.2.2.7 The safety report is then updated, becoming a Pre-Operation Safety Report (POSR) required to be submitted to the CA in a reasonable time before commencing operation (e.g. 3 to 6 months). The report must address the criteria set out in the Safety Report Assessment Manual (SRAM)[3] for technical, predictive, descriptive, environmental and emergency response criteria.

15.2.2.8 The COMAH Regulations also requires upper-tier operators to prepare and test an on-site emergency plan, as well as supplying information to the local authorities and public to enable off-site emergency plans to be developed.

Land Use Planning and Hazardous Substances Consent

15.2.2.9 Hazardous Substances Consent (HSC) is required to be obtained from the Hazardous Substances Authority (HSA), typically the Local Planning Authority (LPA), who then must consult the Health and Safety Executive (HSE) on these applications to consider whether the presence of a significant quantity (referred to as the 'Controlled Quantity') of a hazardous substance is acceptable in a particular location.

15.2.2.10 The Application must detail the expected inventory of the identified hazardous substances to be processed, stored and/or transferred (received/offloading/shipped) and expected applicable measures, methods for use/storage/transfer, as prescribed in the HSC application form.

15.2.2.11 In assessing the application for consent, HSE will produce a map with three risk contours (or zones), representing defined levels of risk or harm which any individual would be subject to. Should the HSA grant consent, this map defines the consultation distances within which HSE must be consulted over any relevant future planning applications.

[3] Health and Safety Executive (2015) *Safety Report Assessment Manual (SRAM) – 2015*. Available online: https://www.hse.gov.uk/comah/sram/docs/comah-sram-2015.pdf

Borehole Safety

15.2.2.12 The Boreholes Safety and Operations Regulations 1995[4] and The Offshore Installations and Wells (design and construction etc.) Regulations 1996[5] apply to activities or operations in connection with the extraction of minerals by a borehole, including the construction of caverns in salt formations by solution mining.

15.2.2.13 The regulations include requirements for drilling operations, well maintenance, and other general operations. The regulations require operators to notify the HSE at least 21 days in advance of drilling activities.

15.2.3 OTHER RELEVANT LEGISLATION AND GUIDANCE

15.2.3.1 The following legislation and guidance will be considered and followed (where applicable):

- The ISEP 'Major Accidents and Disasters in EIA: A Primer'[6];
- The Health and Safety at Work etc. Act 1974 (HSWA)[7];
- The Construction Design and Management (CDM) Regulations 2015[8];
- Chemicals and Downstream Oil Industries Forum Guidelines, Environmental Risk Tolerability for COMAH Establishments[9];
- Guidelines for Environmental Risk Assessment and Management (DEFRA, 2011)[10];
- HAZOP and HAZAN: Identifying and Assessing Process Industry Hazards, 1992[11];
- Process Plants – a Handbook for Inherently Safer Design, 2006[12];
- ISO 31000:2018 Risk Management principles and guidelines (The International Standards Organization, 2018)[13];

[4] HM Government (1995) *Boreholes Safety and Operations Regulations*. Available online: https://www.legislation.gov.uk/uksi/1995/2038/contents/made

[5] 5 HM Government (1996) The offshore installations and wells (design and construction etc) regulations 1996. Available online: https://www.legislation.gov.uk/uksi/1996/913/contents

[6] The Institute of Environmental Management and Assessment (2020) *Major Accidents and Disasters in EIA: A Primer.* Available online: https://www.iema.net/resources/reading-room/2020/09/28/major-accidents-and-disasters-in-eia-an-iema-primer

[7] UK Legislation (1974) *Health and Safety at Work etc. Act*. Available online: https://www.legislation.gov.uk/ukpga/1974/37/contents

[8] UK Legislation (2015) The Construction (Design and Management) Regulations. Available online: https://www.legislation.gov.uk/uksi/2015/51/contents/made

[9] Chemical and Downstream Oil Industries Forum (2013) Guidelines Environmental Risk Tolerability for COMAH Establishments. Available online: https://www.sepa.org.uk/media/219154/cdoif_guideline__environmental_risk_assessment_v2.pdf

[10] Department for Environment, Food and Rural Affairs (2011) Guidelines for environmental risk assessment and management: Green leaves III. Available online: https://www.gov.uk/government/publications/guidelines-for-environmental-risk-assessment-and-management-green-leaves-iii

[11] Trevor A. Kletz (1992) Hazop and Hazan: Identifying and Assessing Process Industry Hazards

[12] Trevor A. Kletz, Paul Amyotte (2010) Process Plants: A Handbook for Inherently Safer Design, Second Edition

[13] ISO Standards (2018) Risk management — Principles and guidelines

- Reducing Risks, Protecting People: HSE's decision making process, (HSE, 2001)[14]; and
- British Standards (BS) EN 61511 (2017) - Functional safety[15].

15.3 CONSULTATION

15.3.1.1 This section provides a summary of the consultation undertaken to date regarding MAADs.

15.3.1.2 A Scoping Opinion was sought from the Planning Inspectorate to determine the content of the assessment, as well as the approach and methods to be used. A Scoping Opinion was received from the Planning Inspectorate on 5 June 2025 (**Appendix 1B)**.

15.3.1.3 **Table 15.1** summarises how this chapter of the PEIR addresses key points from the EIA Scoping Opinion relating to MAADs.

TABLE 15.1 – SCOPING RESPONSES

Consultee	Topic	Summary of Comment	How This is Addressed in the PEIR
The Planning Inspectorate	Seismic event	Based on no evidence of faults, the Inspectorate is content to agree that this matter can be scoped out of further assessment.	This matter has been scoped out of further assessment.
The Planning Inspectorate	Flooding	In the absence of information concerning the likely flood risk at this stage, the Inspectorate cannot agree to scope this matter from assessment. The ES should include an assessment of	The final ES will include an assessment of flooding in the context of MAADs, where likely significant effects could occur. If significant effects are not likely to occur then evidence of

[14] The Health and Safety Executive (2001) Reducing Risks: Protecting People; HSE's decision-making process
[15] British Standards (BS) EN 61511 (2017): Functional safety. Safety instrumented systems for the process industry sector - Framework, definitions, system, hardware and application programming requirements

Consultee	Topic	Summary of Comment	How This is Addressed in the PEIR
		flooding in the context of MAADs, where likely significant effects could occur, or evidence of agreement with relevant consultation bodies that significant effects are not likely to occur and can be scoped out of the assessment. Appropriate cross-reference to the Hydrology and Flood Risk ES chapter and FRA should be included in the ES.	agreement with relevant consultation bodies will be provided. The final ES will cross-reference to the Hydrology and Flood Risk chapter where appropriate.
The Planning Inspectorate	Impacts of increased diffusivity, potential leakage permeability and emissions of hydrogen	Paragraph 2.2.1.4 of the Scoping Report refers to the Secretary of State's additional information requests to permeability and leakage is not included in Appendix K. The ES should consider impacts of increased diffusivity, potential leakage, permeability and	Impacts of increased diffusivity, potential leakage, permeability, and emissions of hydrogen, where likely significant effects could occur will be assessed in the final ES.

Consultee	Topic	Summary of Comment	How This is Addressed in the PEIR
		emissions of hydrogen, where likely significant effects could occur. Appropriate cross-references to accompanying safety reports should be included in the ES.	

15.3.2 OTHER CONSULTATION

15.3.2.1 At the time of writing, no other consultation relating to MAADs has been undertaken.

15.4 BASIS OF THE ASSESSMENT

15.4.1.1 MAADs is a new standalone chapter in the Material Change (MC) and therefore there is no direct comparison between the assessment of the Consented Development and the MC. Elements of MAADs were considered as part of the safety reports provided at that time. The basis for assessment uses the updated guidance for MAADs and considers the material changes of the Proposed Development.

15.4.1.2 The following key infrastructure will be included in the MAADs Assessment in the EIA:

- Underground hydrogen storage;
- Hydrogen Above Ground Installation (HAGI);
- Gas Processing Plant (GPP);
- Wellhead and associated facilities; and
- Venting / Flaring Technology.

15.4.2 SCOPE OF ASSESSMENT

15.4.2.1 The MAADs Assessment covers all aspects of the Proposed Development that could have potential significant adverse effects on people and the environment.

15.4.2.2 The MAADs Assessment covers both construction and operation phases of the Proposed Development. However, only significant adverse safety or environmental impacts have been considered. For example, typical safety hazards associated with construction have not been included in the assessment. The assessment has been carried out taking account of the ISEP guidance referenced in Section 15.2.5 and the definitions of 'major accidents' and 'disasters' contained therein. However, a precautionary approach has been adopted, applying these definitions for this assessment to reflect the design status and level of detail as the Proposed Development passes through pre-FEED.

15.4.2.3 Hazards arising during the decommissioning phase of the Proposed Development are considered comparable to those that will be experienced during the construction period. Appropriate best practice mitigation measures will be applied during any decommissioning works and documented in a Decommissioning Environmental Management Plan (DEMP) prepared in accordance with legislative requirements prevailing at the time.

15.4.2.4 A summary of the key elements of Proposed Development is provided in **Chapter 2, Proposed Development Description**.

15.4.3 ELEMENTS SCOPED OUT OF ASSESSMENT

15.4.3.1 The MAADs Assessment will cover the construction and operation phases of the Proposed Development. However, only significant adverse safety or environmental effects will be considered. For example, typical health and safety hazards associated with construction will not be included in the assessment (although those related to airborne dust and contaminated land will be addressed by other EIA topics). Hazards arising during the decommissioning phase of the Proposed Development will be considered comparable to those that will be experienced during the construction phase.

15.4.3.2 No significant risks associated with major accidents were identified in the following systems due to the inert process fluid:

- Instrument Air System;
- Nitrogen System;
- Cooling Water System;
- Surface water attenuation systems.

15.4.4 ADDRESSING UNCERTAINTY

15.4.4.1 There are no uncertainties that have been identified for the MAADs Assessment. The assessment has been undertaken on the assumption that the mitigation and monitoring measures outlined in the accompanying technical chapters of this PEIR will be implemented.

15.4.4.2 This assessment is carried out under the assumption that the Proposed Development is to be designed, constructed and operated in line with best practice and thereby resulting in a low vulnerability of the Proposed Development to the risks of major accidents and disasters.

15.5 ASSESSMENT METHODOLOGY

15.5.1 HAZID METHODOLOGIES

15.5.1.1 The MAADs Assessment will be carried out using a Hazard Identification (HAZID) study methodology which includes identification of sources / pathways / receptors, an assessment of the worst-case credible safety and environmental consequences and documenting of the planned measures to prevent or mitigate the undesirable events.

15.5.1.2 The following section describes the key steps in the HAZID study process.

Step 1: Select *Major Accident Hazard*

- Safety and Environmental hazards of the Proposed Development which have been identified via pre-FEED HAZID/ENVID studies were reviewed. Those with potential significant consequences to the environment or personnel safety were considered as MAAD events.

Step 2: *Identify Sources, Pathways and Receptors*

- For each major accident hazard, all potential sources (i.e., cause of the hazard) with potential to cause significant harm were identified. Pathways (i.e., the route by which the source can reach the receptor) and receptors (i.e. specific component of the environment that could be adversely affected) were assessed.
- At this stage, screening was carried out to assess whether the source and pathway could result in a hazard which was deemed significant and therefore whether it will be assessed further as part of the MAADs Assessment.
- The process of identifying MAADs hazards included a review of previous incidents and will be based on the experience of technical safety consultants with experience in each of the sectors relevant to the Proposed Development

Step 3: Develop Consequences

- The ‘worst case credible’ consequences of the undesirable event were then evaluated and recorded. The unmitigated consequences (without giving credit to mitigations) were documented.
- The assessment applied Rochdale Envelope principles, which involves assessment of the reasonable worst-case credible MAADs risks and consequences associated with the Proposed Development. This conservative methodology establishes the worst-case scenarios, the risk of which should be reduced to a level that is ‘As Low as Reasonably Practicable’ (ALARP) during

the detailed design, construction planning and operation of the Proposed Development.

Step 4: identify Mitigations

- Mitigations were documented for the identified sources and consequences. At the MAADs Assessment stage of the Proposed Development, safety and control systems have not been fully designed. However, good practice industry approaches to managing risk were considered. In addition, equipment such as process monitoring, safeguarding systems and embedded mitigation were considered as required.

Step 5: Determine the Tolerabilty and the significance of the Mitigated risk

- The determination was based on a review of the risk ranking from the pre-FEED HAZID/ENVIID studies, considering severity of the worst-case consequences and the likelihood of the event with mitigations in place.

15.5.2 METHODOLOGY FOR THE ASSESSMENT OF EFFECTS

15.5.2.1 Risks categorised as 'Broadly Acceptable' and 'Tolerable if ALARP' (with mitigation in place) are not considered to have significant environmental effects; a risk categorised as extreme (with mitigation in place) would have a significant environmental effect.

15.5.2.2 It is noted that the MAADs Assessment will not constitute a formal ALARP demonstration and any inferred alignment between the ALARP regions and the levels of risk claimed is purely indicative, due to the early stage of the design.

15.6 BASELINE

15.6.1.1 This section presents a description of the baseline environmental characteristics within the Study Area. The baseline relevant to this topic comprises:

- A description of potential natural hazards which may affect the Site, including meteorological hazards, geological hazards, and other types of hazards;
- Existing major accident hazard (MAH) sources that may affect the Site; and
- Sensitive environmental receptors within the Study Area at risk of MAADs hazards associated with the Proposed Development.

15.6.2 NATURAL HAZARDS

15.6.2.1 2013 seismic data was acquired to confirm the suitability of the surveyed area for the KGSP. The seismic data was analysed and it was confirmed there is no evidence of faults for the planned locations of the KGSP. Given the very low risk and likelihood of a major accident or disaster occurring from seismic activity, this potential hazard has been scoped out of the assessment.

15.6.2.2 The potential impacts of flooding will be considered in **Chapter 7, Hydrology and Flood Risk** of this PEIR, and the Flood Risk Assessment (FRA), which will accompany the final ES.

15.6.3 FUTURE BASELINE CONDITIONS

15.6.3.1 The baseline environment for the MAADs assessment is expected to change throughout the Proposed Development lifecycle. Climate change is expected to alter precipitation patterns and temperatures, bring about more frequent extreme weather events and result in a rise in sea levels. These factors will influence the MAADs future baseline. Impacts relating to climate change have been assessed in the following chapters of this PEIR:

- **Chapter 7, Hydrology and Flood Risk;**
- **Chapter 8: Air Quality; and**
- **Chapter 17: Climate Change and Greenhouse Gas Emissions.**

15.6.3.2 Throughout the lifecycle of the Proposed Development, it is probable that technology will progress. This could lead to increased safety and environmental protection, introduce new risks through the adoption of unknown technology, and/or require additional regulatory compliance measures. The introduction of any new technologies to the Proposed Development will incorporate the appropriate risk assessment.

15.7 MITIGATION

15.7.1.1 Mitigation against MAADs will be achieved through the application of best engineering design practices, adherence to relevant standards, and implementation of robust safety systems. These measures will be subject to independent assessment by the Competent Authority under the COMAH Regulations.

15.7.2 SITE LAYOUT

15.7.2.1 The site layout has been developed to minimise the risk of escalation in the event of a MAADs. Key features include:

- Application of safe separation distances between hazardous and non-hazardous areas;
- Segregation of utilities and process equipment;
- Minimisation of leak sources and orientation of equipment to reduce escalation potential from jet fires;
- Reduction of congestion and confinement to mitigate overpressure risks;
- Protection of vulnerable pipework through burial or physical barriers, particularly at road crossings;

- Design of access routes to support safe operations, maintenance, and emergency response; and
- Discharge of local vents and reliefs to safe locations.

15.7.2.2 **Figure 2.2** shows the site layout and can be found in **Chapter 2: Proposed Development Description**.

15.7.3 RELIEF /VENT SYSTEMS

15.7.3.1 Relief valves and vent discharges are routed to safe locations, and flame arrestors are installed where appropriate. The vent system is continuously purged with nitrogen to prevent the ingress of air and the formation of flammable mixtures. Facilities are included to verify oxygen levels remain low, and procedures are in place to manage purge system failures. Maintenance protocols ensure that relief lines remain clean and free from obstructions, particularly following construction or recommissioning activities. These systems are designed in accordance with industry standards, including EPSHEG8, and American Petroleum Institution (API) guidance, and are subject to regular inspection and testing.

15.7.4 CONTROL OF IGNITION SOURCES

15.7.4.1 Ignition control measures are implemented across the proposed development to reduce the likelihood of fire or explosion. These include hazardous area classification, control of portable ignition sources such as lighters and mobile phones, and the use of anti-static PPE. Hot work is strictly controlled through a permit-to-work system, and hot surfaces are identified and managed through insulation or cooling where practicable. Equipment is designed to meet ATEX temperature classifications, and a regular maintenance programme ensures continued compliance.

15.7.5 SAFETY RELATED CONTROL SYSTEMS

15.7.5.1 The Proposed Development includes a basic process control system which ensures that the process variables remain within defined safe operating limits via monitoring of conditions using suitable sensors and process instrumentation. Where the detailed design hazard and risk assessment identifies the need for additional instrumented safeguards, these will be defined as safety related control systems. These will be independent from basis control and will be specified in compliance with BS EN 61511 (2017) to meet the required safety integrity. Emergency Shutdown (ESD) and Emergency Depressurisation (EDP) systems will be installed to isolate and depressurise equipment in the event of a hazardous event.

15.7.5.2 Safety related control systems will be subject to inspection, testing, management of change and audit throughout the facility lifetime.

15.7.6 SUBSURFACE SAFETY VALVE

15.7.6.1 A surface-controlled Subsurface Safety Valve (SSSV) will be installed within the production tubing at a depth of at least 30 m below ground level (BGL). This valve is designed to automatically isolate the cavern from the surface in the event of an emergency, such as a rupture of the wellhead. The SSSV acts as a fail-safe device, closing immediately upon detection of abnormal conditions to prevent uncontrolled gas flow to the surface. This provides a critical barrier, allowing well control to be regained until permanent remedial actions, for example a well workover can be implemented.

15.7.6.2 The SSSV is part of a broader well completion strategy that includes a packer/tubing arrangement designed to protect the cemented annulus from pressure fluctuations during cavern operations. In the event of tubing failure, gas will migrate to the annulus between the tubing and casing, where it will be safely collected and detected via pressure monitoring at the wellhead. This configuration allows for remedial work, including tubing replacement, without the need to decommission or flood the cavern.

15.7.6.3 All well completion components in contact with hydrogen—including the SSSV—are specified to be hydrogen-resistant, addressing the risk of hydrogen embrittlement. Materials are selected and qualified to ensure long-term integrity under hydrogen service conditions, in line with industry guidance and best practice.

15.7.7 SECONDARY CONTAINMENT

15.7.7.1 The Proposed Development utilises secondary containment systems to prevent the spread of hazardous liquids in the event of a loss of primary containment. These systems include bunds and kerbing around tanks, vessels, and pipework, particularly for hazardous liquids such as oil and closed drain vessels. A closed drain system collects liquids from various process separators and routes them to a degassing vessel. Gases evolved from the contaminated water are vented through an odour removal system, and the remaining water is transferred to a drum for offsite disposal via road tanker. The containment strategy is designed to intercept spills and prevent environmental contamination, supporting safe and compliant operations.

15.7.8 CONSTRUCTION

15.7.8.1 During construction and commissioning, specific measures are in place to manage risks associated with major accident hazards. An emergency plan will be developed to address potential on-site consequences, particularly during simultaneous operations (SIMOPs). The plan will include procedures for managing ignition sources, hazardous activities, and emergency response. Personnel will be trained in emergency procedures, and regular exercises will be conducted to ensure preparedness. The Safety Management

System will govern all construction-phase activities, including permit-to-work systems, monitoring of well integrity, and verification of containment systems.

15.8 ASSESSMENT OF EFFECTS

15.8.1.1 Following the ISEP guidance (2020), potential hazards that meet the below criteria have been scoped out of the PEIR:

- The Proposed Development is not vulnerable to the hazard or does not have the potential to cause the hazard;
- The hazard is not likely to result in effects that lead to fatality, multiple fatalities, permanent injury, widespread/irreversible harm or damage i.e. the hazard will not result in a major accident and/or disaster;
- There is no potential pathway or receptor in terms of EIA regulations;
- It is a workplace hazard that will only impact the workers directly involved i.e. fall from height or misuse of tools. These are considered to be an occupational health and safety incident that is not included within an EIA and instead managed through compliance of the Management of Health and Safety at Work Regulations; or
- The hazard has been assessed within another chapter within this PEIR.
- In accordance with the EIA Regulations and ISEP guidance, cumulative effects have been assessed separately within **Chapter 18: Cumulative Impact Assessment** of this PEIR.

15.8.2 SUMMARY OF CONSTRUCTION EFFECTS

15.8.2.1 During the construction phase of the Proposed Development, the primary risk identified relates to the phased construction of the caverns, GPP, and interconnecting pipework. This introduces the potential for simultaneous operations (SIMOPs), where construction activities occur in proximity to operational infrastructure. Such scenarios increase the number of personnel on site and the likelihood of interactions with live systems.

15.8.2.2 Enhanced Mitigation measures will include the development of a SIMOPs risk assessment, a tie-in strategy for live plant connections, and a debrining philosophy supported by appropriate permitting and human factors integration. Site layout and traffic management plans will be developed to minimise the risk of vehicle-related incidents, and lifting strategies will be implemented for the safe handling of heavy components.

15.8.2.3 Potential construction effects, collated from the pre-FEED HAZID and Pre-Construction Safety report are summarised in **Table 15.2** and demonstrate that with the mitigation committed to by the Proposed Development in place, there are no residual risks in the 'Intolerable' category. All potential construction hazards can be judged to be 'Tolerable if ALARP' or 'Broadly Acceptable' and is therefore deemed Not Significant in EIA terms.

15.8.2.4 Potential effects associated with flooding during construction will be assessed in detail within **Chapter 7: Hydrology and Flood Risk**.

15.8.3 SUMMARY OF OPERATIONAL AND MAINTENANCE EFFECTS

15.8.3.1 The Proposed Development will operate as a COMAH site. As such, all relevant responsibilities under the COMAH Regulation will be fulfilled, including the implementation of a Safety Management System, and the preparation of a Major Accident Prevention Policy (MAPP). These will be developed in coordination with the Competent Authority.

15.8.3.2 During the operation and maintenance phase of the Proposed Development, the primary risks relate to the storage, transfer, and processing of hydrogen under high pressure. The most significant hazard is the potential for loss of containment, which could result in ignition and escalation to jet fire or explosion. These risks are particularly relevant to buried pipework, high-pressure interfaces, and areas where hydrogen may accumulate in confined spaces.

15.8.3.3 Mitigation measures embedded in the design include the use of hydrogen-compatible materials, cathodic protection for underground pipework, and the application of fire and gas detection systems linked to ESD and EDP systems. The site layout has been developed to minimise escalation potential, with separation distances and buried infrastructure reducing the likelihood of domino effects. Hydrogen embrittlement and elastomer swelling have been addressed through material selection and specification.

15.8.3.4 The Proposed Development will be operated under a Safety Management System that includes inspection, testing, and maintenance regimes, as well as emergency response planning. These measures are designed to ensure that operational risks remain within acceptable limits and are reduced to a level that is ALARP.

15.8.3.5 Potential operation and maintenance effects, collated from the pre-FEED HAZID, pre-FEED ENVID and Pre-Construction Safety report are summarised in **Table 15.3** and demonstrates that with the mitigation measures committed to by the Proposed Development in place there are no residual risks within the 'Intolerable' category. All potential operational and maintenance hazards can be assessed as 'Tolerable if ALARP' or 'Broadly Acceptable' and is therefore deemed 'Not Significant' in EIA terms.

15.8.4 CONSTRUCTION EFFECTS – DETAILED ASSESSMENT

TABLE 15.2 – POTENTIAL CONSTRUCTION EFFECTS

Receptor	Source and/or Pathways	Reasonable Worst Consequence if Event did Occur	Mitigation	Acceptability/ Tolerability and Significance
Human receptors: Environment	Simultaneous operations near live systems	Injury or exposure to hazardous conditions	• SIMOPs risk assessment • Permit-to-work system • Emergency planning	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Proposed Development Infrastructure	Increased vehicle movements during construction and commissioning	Damage to assets or risk of collision	• Traffic management plan • Designated routes • Access control	Tolerable if ALARP – Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	Loss of containment of hydrogen gas during commissioning and/or de-brining.	Potential for release/accumulation of uncombusted hydrogen (indirect greenhouse gas release, refer to **Chapter 17, Climate Change and Greenhouse Gas Emissions)** AND/OR Ignition causing a jet fire and/or explosion leading to major safety consequences for the site.	• First fill with gas and debrining of caverns is not a new operation to the Applicant. Debrining philosophy to be reviewed and updated. • Overpressure trip on the debrining pipework at each wellhead will stop debrining process. • Develop a Human Factor Integration Plan to include the debrining operation. • Develop a commissioning plan for the whole facility.	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	Presence of Unexploded Ordnance (UXO)	Sub-surface construction activities such as drilling, buried pipeline installation.	• Initial UXO survey conducted – site classified as low risk, noting that former RAF Craneage airfield was identified as a potential target during World War II. • Investigation surveys will be conducted where required before construction activities commence.	Acceptable Not Significant
Human receptors; Environment; Proposed Development Infrastructure	Presence of natural gas within sub-surface layers due to migration from neighbouring facilities.	Potential for a release of natural gas due to drilling activities, which could result in major safety consequences if ignited.	• Minimal probability of occurring due to the characteristics of salt caverns. • Cavern spacing has been designed to ensure adequate separation distances to all underground salt caverns in the area. • Neighbouring facilities (Stublach Gas Storage and Holford Gas Storage) are experienced in operating their caverns safely and perform regular cavern integrity surveys to ensure no loss of containment.	Tolerable if ALARP Not Significant (with mitigation)

Receptor	Source and/or Pathways	Reasonable Worst Consequence if Event did Occur	Mitigation	Acceptability/ Tolerability and Significance
			• Ensure an appropriate communication plan is in place with neighbouring facilities ahead of construction activities. • Drilling and underground gas storage hazards are well known to the Applicant, as well as the appropriate regulations to comply with (BSOR) and risk assessment guidance to consider (HSE RR605). • SIMOPs risk assessment.	
Human receptors; Proposed Development Infrastructure	Heavy lifting operations	Dropped object injuries or equipment damage	• Lifting plans • Exclusion zones • Trained operators	Acceptable Not Significant
Human receptors; Environment	Hot works during construction (e.g. welding, cutting)	Fire or explosion risk due to ignition of flammable materials	• Hot work permit system. • Fire watch. • Gas testing. • Exclusion zones.	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Proposed Development Infrastructure	Loss of containment of nitrogen during leaching operations.	Potential for nitrogen release due to blowout at wellheads during leaching and/or specific 'string' pulling operations – leading to personnel safety consequences due to overpressure and/or asphyxiation.	• Overpressure protection philosophy has been prepared to mitigate against overpressure to pipework. • Standard operating procedure to safely depressurise well before 'string' pulling operations.	Tolerable if ALARP Not Significant (with mitigation)

15.8.5 OPERATION AND MAINTENANCE EFFECTS – DETAILED ASSESSMENT

TABLE 15.3 – POTENTIAL OPERATION AND MAINTENANCE EFFECTS

Receptor	Source and/or Pathways	Potential Effects	Mitigation	Acceptability/ Tolerability and Significance
Human receptors; Environment	Loss of Containment of Hydrogen	Potential for release/accumulation of uncombusted hydrogen (indirect greenhouse gas release, refer to **Chapter 17, Climate Change and Greenhouse Gas Emissions**) AND/OR	• Automatic emergency shutdown and depressurisation systems. • Minimise leak paths and ignition risk by reducing flanges (fully welded runs) and burying pipework where possible.	Tolerable if ALARP Not Significant (with mitigation)

Receptor	Source and/or Pathways	Potential Effects	Mitigation	Acceptability/ Tolerability and Significance
		Ignition causing a jet fire and/or explosion leading to major safety consequences for the site.	• Ventilation within buildings Use of hydrogen-compatible materials • Cathodic protection • Fire and gas detection systems • Routine inspection and maintenance	
Human receptors; Environment	Depressurisation of GPP due to emergency or process upset	Controlled release of hydrogen to flare, generating NOx emissions and potential air quality impacts.	• Flaring system designed to safely handle emergency releases • Emissions monitored and minimised through design and operational controls	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	Jet fire impinging on adjacent equipment / sites	Fire escalation to nearby equipment or adjacent sites (AGIs, HAGI, Stublach Gas Storage, Holford Gas Storage), increasing risk of further release or explosion	• Automatic emergency shutdown and depressurisation systems. • Minimise leak paths and ignition risk by reducing flanges (fully welded runs) and burying pipework where possible. • Emergency response plan to be developed as design progresses. • Communication with other facilities to ensure emergency response plans align. • Safety studies will be undertaken during detailed design to ensure appropriate separation distances between equipment to reduce escalation impacts.	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	Leak from buried pipework	Hydrogen release at surface, potentially igniting and causing localised fire or explosion	• Material selection • Porous ground overlay • Inspection and maintenance	Tolerable if ALARP Not Significant (with mitigation)

Receptor	Source and/or Pathways	Potential Effects	Mitigation	Acceptability/ Tolerability and Significance
Human receptors; Environment; Proposed Development Infrastructure	Hydrogen embrittlement	Gradual weakening of metal components, leading to potential leaks or failures	• Use of hydrogen-compatible materials • Corrosion allowances • Inspection regime	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	HP / LP interfaces (most notably max cavern pressure of 130 barg is above the GPP dehydration design pressure)	Potential for release/accumulation of uncombusted hydrogen (indirect greenhouse gas release, refer to **Chapter 17, Climate Change and Greenhouse Gas Emissions**) AND/OR Ignition causing a jet fire and/or explosion leading to major safety consequences for the site.	• Automatic emergency shutdown and depressurisation systems. • Equipment designed to required pressure ratings. • Detailed safety assessments will continue to be conducted throughout the design process (HAZOP, QRA).	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	Cavern integrity – shape & stability	Poor stability potentially leading to a well bore leak path and loss of containment of hydrogen, potential ignition causing a jet fire and/or explosion leading to major safety consequences for the site.	• The Applicant has significant experience with the design, construction and operation of salt caverns in the Northwich Halite formation, most recently the 20 caverns at Stublach Gas Storage Plant. • The Keuper salt caverns will be designed, constructed and operated in the same manner as the Stublach caverns. They will be stable and gas tight, designed with the same bell-shaped dome roofs as Stublach caverns, which are geo-mechanically very stable.	Tolerable if ALARP Not Significant (with mitigation)
Human receptors; Environment; Proposed Development Infrastructure	Cavern integrity – well equipment failure (casing cement, wellhead equipment)	Potential for release/accumulation of uncombusted hydrogen (indirect greenhouse gas release, refer to **Chapter 17, Climate Change and Greenhouse Gas Emissions**) AND/OR	• The Applicant has significant experience with the design, construction and operation of salt caverns in the Northwich Halite formation, most recently the 20 caverns at Stublach Gas Storage Plant.	Tolerable if ALARP Not Significant (with mitigation)

Receptor	Source and/or Pathways	Potential Effects	Mitigation	Acceptability/ Tolerability and Significance
		Ignition causing a jet fire and/or explosion leading to major safety consequences for the site.	• A dual-barrier system will be applied for hydrogen storage, with the general principle that the first barrier is in contact with the storage medium and pressure, while the second barrier serves as a fallback and guarantees safety in case the first barrier fails (barriers include the salt formation, production casing cementation, packers, annulus-A, various valves including the SSSV and Master Valve). • Hydrogen compatible equipment, to which the Applicant has experience in completing some of the latest testing as part of the HyPSTER project. • Monitoring and testing of the systems via proven methods (wireline logging, sonar, mechanical integrity testing), ensuring compliance with the appropriate regulations (Borehole Regulations (BSOR 1995) and COMAH Regulations (2015)).	
Human receptors; Environment; Proposed Development Infrastructure	Simultaneous operations near live systems (wellhead interventions / workovers, GPP maintenance etc.)	Injury or exposure to hazardous conditions. Potential for release/accumulation of uncombusted hydrogen (indirect greenhouse gas release, refer to **Chapter 17, Climate Change and Greenhouse Gas Emissions**) AND/OR	• Suitable separation distances and laydown areas to be provided to ensure maintenance can be conducted safely. • Caverns drilled conventionally i.e. the wellheads are far away from each other making it safer to conduct well interventions. • SIMOPs risk assessment • Permit-to-work system	Tolerable if ALARP Not Significant (with mitigation)

Receptor	Source and/or Pathways	Potential Effects	Mitigation	Acceptability/ Tolerability and Significance
		Ignition causing a jet fire and/or explosion leading to major safety consequences for the site.	• Emergency planning	
Human receptors; Environment;	Potential production of hydrogen sulphide within storage caverns from sulphate reducing bacteria	Increase in hydrogen sulphide concentration within hydrogen removed from storage caverns. Potential risk to health and corrosion of equipment materials.	• Initial investigations indicate a low risk of hydrogen sulphide generation in the KGSP caverns. • Suitable materials of construction to be selected. • Suitable H2S removal technology has been allowed for in the GPP pre-FEED design (metal oxide beds), noting requirement for potential H2S monitoring, appropriate PPE and personnel monitoring around the vessels. • During FEED, consider potential options available to prevent formation such as UV treatment.	Tolerable if ALARP Not Significant (with mitigation)
Environment	Rainwater runoff / condensate	Contamination of surface water from oil or chemicals	• Oil/silt interceptors • Controlled discharge systems	Acceptable Not Significant
Environment	Routine venting or purging operations	Minor hydrogen release, potential odour or air quality impact	• Nitrogen purging • Oxygen monitoring • Vent routing to safe locations	Acceptable Not Significant
Environment	Mercaptans in off gas	Odour nuisance and potential air quality impact	• Oxidation/absorption systems are well established for this duty. • Confirm with network operator if hydrogen gas will be odourised.	Tolerable if ALARP Not Significant
Environment	Flooding	Loss of power and/or damage to equipment leading to a loss of containment of hydrogen – potential for ignition with major	• The plant design will consider the flood risk assessment and design accordingly to mitigate impact.	Tolerable if ALARP Not Significant

Receptor	Source and/or Pathways	Potential Effects	Mitigation	Acceptability/ Tolerability and Significance
		on and offsite safety consequences.	• Critical equipment will be designed to withstand/avoid/minimise flood risk impact and/or to shut down safely.	

15.9 SUMMARY OF CUMULATIVE EFFECTS

15.9.1.1 The cumulative effects of impacts from the Proposed Development together with impacts from other planned projects or developments on the same resources and/or receptors are assessed in **Chapter 18: Cumulative Impact Assessment**.

15.9.1.2 Cumulative effects relating to MAADs are equivalent to domino effects. The domino effects have been included in the MAADs Assessment at a high level and will be assessed further in the dispersion and domino effect modelling at a future phase to ensure risk levels are acceptable and ALARP.

15.10 SUMMARY AND CONCLUSIONS

15.10.1.1 This assessment is a review based on information available at this stage and has adopted a worst-case approach. As is normal practice, further hazard and risk analysis will be undertaken throughout the lifecycle of the Proposed Development in accordance with the requirements of applicable legislation and industry good practice guidance. This will ensure risks are managed to a level that is considered ALARP during the design, construction, and operation and maintenance phases of the Proposed Development.

15.10.1.2 As shown in **Table 15.2** and **Table 15.3**, with embedded mitigation there are no 'Intolerable' residual risks for effects relating to the construction and operation and maintenance phases of the Proposed Development. All potential MAADs, therefore, can be assessed as 'Tolerable if ALARP' or 'Broadly Acceptable'.

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