SAFE AND SUSTAINABLE DECOMMISSIONING OF OFFSHORE STRUCTURES TAKING INTO CONSIDERATION THE PECULIARITIES OF THE ASEAN & SOUTH ASIA REGIONS

TECHNICAL GUIDELINES

RECOMMENDATION OF GUIDELINES TO ENHANCE THE SAFETY OF DECOMMISSIONING PROCESS WITHIN THE SOUTHEAST ASIA REGION

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PREFACE

Southeast Asia is poised to become a significant player in the decommissioning of offshore oil and gas assets. In particular, Southeast Asia will face the challenge of decommissioning over 1,700 fixed offshore structures and more than 7,000 wells (Wood, 2018). By 2040, the decommissioning activity brings up the biggest challenge for operators, governments, and service providers (Gabriel and Eduardo, 2020, Na et al., 2017, Parente et al., 2006) with an estimated 2000 of structures likely to stop production by 2040 (Sommer et al., 2019). More than 1700 fixed offshore platforms and half of the offshore structures in Southeast Asia region, particularly in Malaysia, Thailand, Indonesia, Vietnam, and Brunei are more than 20 years old and will be decommissioned.

The decommissioning process in Southeast Asia faces several complications. There are no specific regional regulations; countries rely on general guidelines and technical standards, which are often inadequate. This lack of clear regulations and poor enforcement create significant obstacles. Additionally, the region has limited expertise in offshore decommissioning, with a developing industry and a shortage of experienced professionals. This gap necessitates bringing in knowledge and skills from experts in other regions. Moreover, there is insufficient research on the impacts of decommissioning on marine fauna and flora, leading to potential environmental risks. Decommissioning older structures, over 40 years old, poses safety and health risks for workers and sea users. Ensuring the safe removal of these installations is critical for protecting human health and the environment. Lastly, the region struggles with inadequate infrastructure for the storage and disposal of hazardous waste, further complicating effective decommissioning (Syed Ahmad, 2022).

The research project “Safe and Sustainable Decommissioning of Offshore Structures Taking into Consideration the Peculiarities of the ASEAN & South Asia Regions” (SEELOS1920\1\111) aims to address these challenges, with three Work Packages and specific objectives as follows:

Work Package	Objective
1	To develop methods and guidelines which will enhance the safety of decommissioning process within the specific environment of the region
2	To identify and help improvement of recycling facilities for decommissioning offshore structures in the region
3	To develop a long-term network for sharing information, best practices, facilities and capacity building in the region

Work Package 1 specifically focuses on:

Work Package	Activities
WP1A	To review the current decommissioning plans, practices, incidents, limitations, guidelines etc. for baseline data collection.
WP1B	To develop safe methods for the removal of structures during the decommissioning process in the region.
WP1C	To develop guidelines/ code of practices for safe & sustainable decommissioning or repurposing for structures in the region.

This project aims to address the unique challenges of offshore decommissioning in Southeast Asia, ensuring that decommissioning activities are conducted safely and sustainably.

This document is the research result of WP1. It was undertaken by WP1 members, including:

1. Universiti Teknologi Petronas (UTP) – WP1 Leader
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3. Liverpool John Moores University (LJMU).
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1. Introduction

1.1 Purpose of the Guidelines

The objective of these guidelines are to serve as a reference for service providers involved in the safe decommissioning of fixed offshore structures in the Southeast Asia Region. It includes recommendations for detailed procedures in pre-decommissioning, technical execution, and post-decommissioning activities, all to be performed in accordance with the applicable legal framework.

1.2 Scope and Applicability of the Guidelines

The guidelines focus on decommissioning activities concerning oil and gas fixed offshore structures in the Southeast Asia region. It is recommended in compliance with relevant international conventions, national regulations, and regional guidelines governing decommissioning activities.

Its focus is specifically on identifying risks and mitigating them during the removal process of fixed offshore structures in offshore decommissioning. The guidelines address three removal options for fixed offshore structures: Complete removal, partial removal, and leave in situ.

Total removal involves the complete dismantling and removal of the offshore structure from its location. This approach requires extensive planning and execution, including cutting and lifting the structure piece by piece. It often involves higher costs and environmental impact due to the complete removal of the structure. Partial removal, on the other hand, entails removing the topside and any other visible components while leaving the substructure in place on the seabed. This option is not as intense as total removing, but it still requires a lot of work and resources. The option is when the topside contains hazardous materials or when there are environmental concerns. Leave in-situ, typically as reefing, means keeping the entire structure or certain parts of it in its current location on the seabed. This approach can serve as a habitat for marine life, and this option is typically more cost-effective than complete removal. However, a thorough assessment of environmental impacts is required, and future use of the area must be considered. The evaluation of these removal options aims to identify key challenges, assess associated risks, and develop effective mitigation plans tailored to each approach. This comprehensive assessment ensures that the chosen decommissioning strategy aligns with safety, environmental, and economic objectives while complying with relevant regulations and guidelines.

2. Decommissioning Overview

2.1 Definition of Decommissioning

As stated by the ASEAN Council on Petroleum (ASCOPE) (2012), decommissioning is the final phase of oil and gas operations, requiring consideration throughout the facility's lifecycle. It emphasizes planning for cost-effective disposal at the facility's end of life. Additionally, decommissioning involves the removal, disposal, and dismantling of structures (Nåmdal 2011; Zainai 2022).

The decommissioning of offshore structures involves several phases, which are planning, preparation, dismantling, recycling or reusing or disposing, monitoring, and completion. After obtaining approval for decommissioning plans, the process begins with well plug and abandonment. The facilities and pipelines are subsequently cleaned and isolated permanently. After that, the topsides are removed and transported to onshore sites where they can either be recycled or disposed of properly. Substructures are removed, and the remaining structures on-site are identified to avoid hazards. Debris are cleared from the seabed, surveys are conducted, and post-condition monitoring takes place.

The guidelines propose a comprehensive decommissioning framework, starting with the pre-decommissioning stage. This phase involves planning and obtaining approval from the relevant authority, developing a decommissioning plan, and executing it. The final stage is post-decommissioning, which involves activities after the completion of decommissioning operations.

2.2 Review of Current Guidelines in Southeast Asia

In Southeast Asia, which includes Malaysia, Thailand, Indonesia, Vietnam, and Brunei, there are currently no specific regulations dedicated solely to governing the decommissioning of oil and gas structures. Instead, the region adheres to general principles outlined in international and national regulations, alongside the ASCOPE Decommissioning Guidelines (ADG) for Oil and Gas Facilities, which serve as a regional decommissioning guidelines. ASCOPE's establishment aims to provide reference guidelines on technical offshore decommissioning and disposal options for its ten member countries in the Southeast Asia region, which include Malaysia, Thailand, Indonesia, Vietnam, and Brunei, while also developing its technical guidelines. For example, Malaysia relies on PETRONAS Procedure and Guidelines for Upstream Activities (PPGUA) as its primary decommissioning guidelines. Indonesia follows the Code of Work (PTK) of the Oil and Gas Task Force, No.40/2018 Abandonment and Site Restoration. Thailand has a decommissioning legal framework through the amended Petroleum Act of 1971. Vietnam updated the 1994 Law on Petroleum in 2015 to align with the UNCLOS. In Brunei, Decommissioning and Restoration Guidelines for Onshore and Offshore Facilities were implemented in 2009. Table 1 identifies the countries in the region that have ratified relevant international conventions.

Table 1: Ratification of international convention by southeast Asian countries (ASEAN Council on Petroleum (ASCOPE) 2012)

ASCOPE Member Country	**Malaysia**	**Thailand**	**Indonesia**	**Vietnam**	**Brunei**
Geneva Convention 1958	X	X			
UNCLOS 1982	X	X	X	X	X
Basel Convention (1989)	X	X	X	X	X
Note: X: Ratification					

2.2.1 International Convention and Guidelines

For decades, international conventions have been developed with a focus on environmental protection, safety, and the sustainable management of marine resources. These conventions, which are relevant to offshore decommissioning, play a crucial role in establishing procedures for decommissioning offshore structures. Here are four key conventions that address aspects of offshore structure decommissioning. Countries must adhere to these international laws and regulations in the decommissioning process.

i. Geneva Convention, 1958 - The convention acknowledges the sovereign rights of states to explore natural resources (Article 2(1)). Coastal states are permitted to construct, maintain, or operate installations under the condition that abandoned or disused installations are entirely removed for safety purposes (Article 5(5)).

ii. United Nations Convention on the Law of the Sea, 1982 (UNCLOS) – The convention applies to installations within signatory states offshore waters. It requires the removal of abandoned or unused installations within the signatory states' Exclusive Economic Zone (EEZ) rather than dumping. Additionally, the convention requires the control of marine pollution. It permits the abandonment of installations, provided that the safety of navigation complies with acceptable international standards (Article 60(3)).

iii. Basel Convention, 1989 - The convention controls the global movement and disposal of hazardous wastes, regulating how they can be transported between countries. Both the exporting and importing countries must agree before any waste is exported, ensuring mutual consent. Countries are obligated to manage and dispose of hazardous wastes safely and responsibly, adhering to strict guidelines. Before exporting hazardous wastes, countries must inform and obtain consent from the receiving country. Hazardous wastes can only be moved if there is no danger to health or the environment, emphasizing the importance of safety and environmental protection.

iv. International Maritime Organization (IMO) Guidelines and Standard, 1989 – The convention is concerned with safety and navigation, emphasizing the importance of ensuring safe maritime passage. It mandates the removal of abandoned or disused offshore installations or structures except where non-removal is consistent with IMO guidelines. Coastal states may determine if an installation is permitted to be left whole or partially in place when it will serve a new use if permitted to remain and can be left without causing unjustifiable interference with other sea users.

2.2.2 National Law and Regulation

Regulating offshore decommissioning requires a comprehensive understanding of national laws and regulations governing various aspects of the offshore sector. While Southeast Asian countries may not have specific laws dedicated solely to offshore decommissioning, they rely on existing national legislation to address decommissioning activities. The national laws and regulations of these countries cover a range of aspects of the oil and gas industry, encompassing environmental protection, safety standards, taxation, licensing, and authority over maritime resources.

Malaysia

i. Merchant Shipping Ordinance, 1952 – Governs shipping activities in transportation O&G,
ii. Continental Shelf Act, 1966 – Authority over exploration and exploitation within the maritime zone,
iii. Environmental Quality Act, 1974 (EQA) – Environmental protection and pollution control,
iv. Exclusive Economic Zone Act, 1984 (EEZ) – Malaysia's Exclusive Economic Zone (EEZ), extending authority over maritime resources,
v. Occupational Safety and Health Act, 1994 (OSHA) – ensure a safe and healthy working environment for employees in all industries,
vi. Atomic Energy Licencing Act, 1984 – Concerning the development and utilization of atomic energy safety regulations,
vii. Petroleum Development Act, 1974 – Manage the petroleum industry: - licensing and contract.
viii. Malaysian Maritime Enforcement Agency Act, 2004 – Safety and security of maritime activities.

ix. Fisheries Act, 1985 – Mitigate the impact on fisheries and marine ecosystem by O&G operation.

Thailand

i. Section 801/1 and 80/2 of Petroleum Act 1971 – Govern the exploration, production, and management of petroleum resources within the country,
ii. Petroleum Income Tax Act 1971 – Regulates the taxation of income derived from petroleum operations,
iii. Thailand – Malaysia Joint Authority Act B.E. 2533, 1990 – Act on Offences Relating to Offshore Petroleum Production Places, 1987,
iv. Department of Mineral Fuels (DMF) - Regulates and manages various aspects of the oil and gas industry.

Indonesia

i. Minister of Energy and Mineral Resources Regulation No. 15, 2018 – Postproduction activities in upstream oil and gas,
ii. Law of the Republic of Indonesia No. 32, 2009 – Environmental protection and management,
iii. Law of the Republic of Indonesia No. 18, 2008 – Domestic waste management,
iv. Government Regulation No. 22, 2021 – Management of waste and transboundary of waste,
v. Regulation of MoEF of the Republic of Indonesia No. 6, 2021 – Procedures and requirements for the management of hazardous waste,
vi. Regulation of MoT of the Republic of Indonesia No. 20, 2021 – Import regulation and policy,

vii. Regulation No. 45, 2023 – Safety of ionizing radiation and security of radioactive source,
viii. Regulation No. 53, 2022 – Safety and security of nuclear material mining,
ix. Regulation No. 5, 2021 – Risk-based licensing,
x. Regulation No.61, 2012 – Radioactive waste management,
xi. Minister of Finance Regulation No.140, 2020 – Management of state-owned goods originating from the implementation of cooperation contracts, Minister of Energy.

Vietnam

i. Ministry of Industry and Trade (MOIT) – Regulating the oil and gas industry,
ii. Ministry of Natural Resource and Environment (MONRE) – Oversees environmental protection and management,
iii. PetroVietnam – State-owned oil and gas company responsible for conducting oil and gas exploration, production, and development projects.

Brunei

i. Control of Major Accident Hazard (COMAH) Regulation – Ensure safety by identifying and managing major accident risks,
ii. The Petroleum Mining Act (Revised 1984) – Governs the exploration and production of petroleum resources,
iii. The Petroleum (Pipe- Lines) Act (Revised 1963) – Regulates the construction, operation, and maintenance of petroleum pipelines,
iv. The Territorial Waters of Brunei Act (Revised 2002) – Authority over its maritime territory and regulates activities within its territorial water,

v. The Land Code (Strata) Act (Revised 2000) – Land ownership, property rights.

2.2.3 Industry Standards, Policy, or Guidelines, Codes and Standards

The countries have established their own initiatives by developing guidelines and standards providing service providers, operators, stakeholders, and all involved parties with accessible references. These guidelines and standards are aligned with both international and national legal frameworks. For instance, Malaysia has PPGUA, which serves as the primary guidelines for decommissioning procedures, while Thailand has been preparing the Draft of the Thailand Decommissioning Guidelines for Upstream Installations since 2009. These initiatives demonstrate proactive efforts by these countries in establishing comprehensive frameworks for offshore decommissioning.

Malaysia

i. PETRONAS Procedures and Guidelines for Upstream Activities (PPGUA),
ii. PETRONAS HSSE Minimum Procedures and Requirement for Decommissioning of Upstream Installations,
iii. PETRONAS Basic Technical Requirements (PBTR) 2018 Decommissioning Guidelines,
iv. Sustainable Artificial Reefing Procedure,
v. PETRONAS Technical Guidelines (PTG); PTG18.33.05 on mercury management,
vi. PETRONAS Technical Standards (PTS); PTS 18.72.01 on waste management,
vii. Environmental Guidelines for Decommissioning of O&G Facilities in Malaysia 2019 (DOE),
viii. LEM/TEK/58 rev1 (2016) on code of practice on radiation protection relating to TENORM in oil and gas facilities,

ix. LEM/TEK/30 rev3 (2016) on guidelines on radiological monitoring for oil and gas facilities operators associated with TENORM.

Indonesia

i. Code of Work of Oil and Gas Task Force (SKK Migas) No. 40,
ii. Code of Conduct (PTK) No. 040.

Thailand

i. Draft Thailand Decommissioning Guidelines for Upstream Installations 2009,
ii. The Ministerial Regulation on the decommissioning plans, cost estimation, and financial security for the installation decommissioning in the petroleum business.

Vietnam

i. Decision No. 40/2007/QD-TTg on decommissioning of fixed petroleum installations, equipment, and facilities,
ii. Decision No. 41/1999/QD-TTg on safety management in oil and gas activities,
iii. Decision No. 04/2015/QD-TTg on safety management in oil and gas activities,
iv. Decision No. 37/2005/QD-BCN on the protection and abandonment of oil and gas wells,
v. Decision No. 10/VBHN-BCT on the protection and abandonment of oil and gas wells,
vi. Circular No. 17/2020/TT-BCT on the protection and abandonment of oil and gas wells.

Brunei

- Oil and Gas Exploration and Production Guidelines. Volume 9: Decommissioning.

There are several important steps involved in obtaining permits and approvals. Initially, operators and or service providers are responsible for preparing the necessary documents required by regulators. Subsequently, these documents must be submitted to the relevant regulatory authorities for review. The regulatory body conducts a thorough examination to ensure adherence to applicable regulations, safety standards, and environmental requirements. In certain instances, public consultation may be conducted to address any concerns raised. Upon approval, the operator/service providers receive the necessary permits to commence the decommissioning process. Throughout this process, operators/service providers must adhere to the conditions outlined in the permits and allow regulators to monitor compliance. Finally, upon completion of decommissioning, operators/service providers are required to furnish regulators with any requisite reports detailing the process.

The regulatory bodies responsible for permitting and approvals in the decommissioning process for Southeast Asian countries are listed below. However, within the ASEAN region, operators typically handle the permit applications.

- Malaysia – PETRONAS oversees offshore decommissioning activities. Operators must seek approval from PETRONAS before starting the decommissioning operations.
- Indonesia – Satuan Kerja Khusus Pelaksana Kegiatan Usaha Hulu Minyak dan Gas Bumi (SKKMIGAS) acts as the temporary regulatory authority for upstream oil and gas activities. Operators

must comply with SKKMIGAS regulations and obtain approval prior to decommissioning.

- Thailand - The Department of Mineral Fuels (DMF) is the primary regulatory authority overseeing oil and gas activities in Thailand. Operators require permits from DMF before conducting decommissioning operations.
- Vietnam – The government of Vietnam, through its relevant departments or ministries overseeing oil and gas activities, is responsible for permitting and approval. Operators must adhere to regulations set by the government and obtain approval before commencing decommissioning.
- Brunei - The government of Brunei, particularly its relevant regulatory agencies overseeing oil and gas activities, is responsible for permitting and approval. Operators must comply with regulations set by the government and obtain approval before conducting decommissioning.

2.2.4 Financial Requirements

Financial assurance is important, as documentation is required to address potential liabilities related to decommissioning activities. This might involve allocating funds or obtaining insurance to ensure enough resources for decommissioning expenses and site clearance. Financial requirements vary across Southeast Asia countries. In Malaysia, financial requirements for decommissioning are through a cessation fund designated for the Production Sharing Contract (PSC). This was established in 1998 and contributed by operators. Indonesia follows a similar approach with a post-operation fund, which operators also contribute. Thailand's financial security can be provided by individuals or a combination thereof. Vietnam has a financial guarantee fund that the operator sets up. In Brunei, the fiscal responsibility for decommissioning activities falls on Duty Holders, who are required to develop and present a detailed methodology for estimating costs related to Decommissioning and Remediation (D&R) activities.

2.3 Stakeholder Engagement

Engaging with stakeholders and the local community through transparent communication and consultation efforts is essential during public consultation in the decommissioning process. Meeting reporting requirements to regulatory authorities is also necessary, involving regular updates on decommissioning progress, environmental monitoring findings, and any incidents or accidents that occur during the decommissioning process.

Moreover, obtaining necessary permits and approvals from regulatory authorities is mandatory before starting decommissioning operations. This requires the submission of comprehensive decommissioning plans, risk assessments, and other relevant documents for thorough review and approval.

2.3.1 Responsibilities of Service Providers and Stakeholders

Service providers and stakeholders need to work together closely to make sure decommissioning activities are executed safely and in line with regulations. Effective communication, transparency, and meeting reporting duties are important for achieving successful decommissioning while reducing harm to the environment and communities nearby. Their duties cover various stages, from planning to carrying out activities and reporting.

Table 2: Responsibilities of service providers and stakeholders

Stages	**Responsibilities**
Preparation and Planning	**Service Providers:** Prepare comprehensive decommissioning plans, including risk assessments, environmental impact assessments, and financial assurance documentation. **Stakeholders:** Provide input on environmental concerns and community interests during the planning phase.

Stages	Responsibilities
Regulatory Compliance	**Service Providers:** Ensure all decommissioning activities comply with relevant national and international regulations and guidelines. **Stakeholders:** Monitor the decommissioning process for compliance and raise concerns with regulatory authorities if necessary.
Permitting and Approval	**Service Providers:** Obtain necessary permits and approvals from regulatory authorities before starting decommissioning operations. Submit required documents and comply with regulatory review processes. **Stakeholders:** Participate in public consultation processes initiated by regulatory authorities and provide feedback on decommissioning plans.
Execution of Decommissioning	**Service Providers:** Implement decommissioning activities according to approved plans and permit conditions, ensuring safety practices are followed and environmental risks are mitigated effectively. **Stakeholders:** Monitor the progress of decommissioning activities and report deviations or safety concerns to regulatory authorities.
Reporting Obligations	**Service Providers:** Prepare and submit regular progress reports to operators and regulatory authorities detailing the status of decommissioning activities, any incidents or accidents, and environmental monitoring results. **Stakeholders:** Provide input for post-decommissioning reports, particularly regarding environmental impacts and adherence to regulatory requirements.

3. Recommendation Technical Guidelines for Decommissioning

3.1 Pre-Decommissioning Stage Guidelines

The pre-decommissioning stage of offshore decommissioning represents a key stage in the lifecycle of oil and gas structures. As these structures reach the end of their productive lives, detailed planning that follows regulatory requirements is essential to ensure safe and environmentally responsible decommissioning. This phase involves identifying decommissioning options, evaluating environmental considerations, and engaging with regulatory bodies.

Planning for decommissioning should begin at least three years before activities, extending to five years for potential derogation cases. Within this period, preliminary meetings with government regulatory bodies occur at the three to five-year mark. By the three-year mark, decommissioning options are identified, and a comparative environmental assessment is completed, alongside the preparation of an initial draft decommissioning plan. Two years before decommissioning started, the first draft of the decommissioning program was submitted, followed by a feedback process from regulators at 21 months. At 18 months, the second draft is submitted with responses to feedback, followed by consultation with legal organizations and baseline surveys if necessary. At 16 months, the second round of feedback is received. By the 12-month, the final draft of the program is submitted, along with applications for relevant permits and consultations with environmental bodies for waste disposal licenses. Four to six months before decommissioning, written approval is granted by regulators, and permit applications for chemical usage or discharge are submitted at the four-month mark. Finally, six weeks before decommissioning, hydrographic offices are provided notice of the change in status of the pipeline or installation.

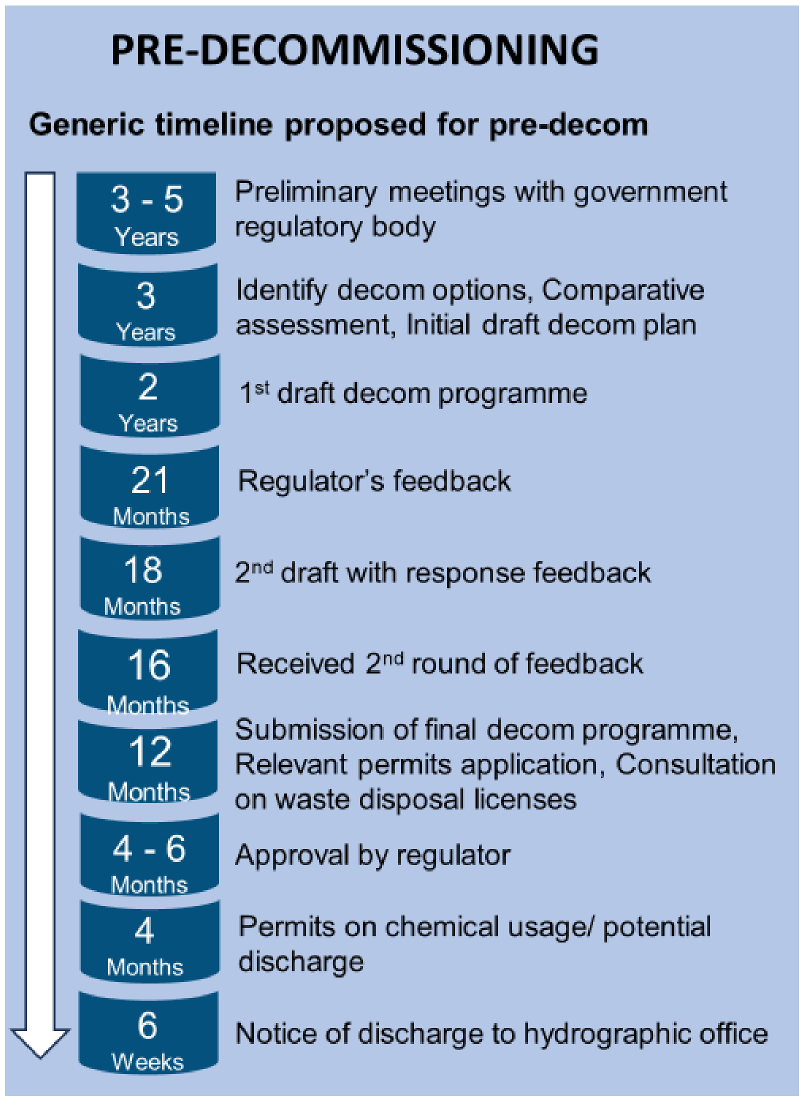

Figure 1: Generic timeline proposed for pre-decom

3.1.1 Risk Assessment and Planning

During the pre-decommissioning phase, it is critical to conduct thorough risk assessments to identify potential hazards and associated risks related to decommissioning activities. Additionally, a comprehensive environmental impact assessment should be undertaken to evaluate the potential effects on marine ecosystems, water quality, and marine life. Implementation of a robust Health, Safety, and Environmental (HSE) management system is essential to ensure the well-being of personnel and environmental integrity.

Comprehensive decommissioning plans containing detailed procedures and timelines are essential, along with a project management framework to oversee scheduling and coordinate stakeholders. A comprehensive waste management plan should be developed to handle and dispose of hazardous materials in compliance with regulations. Furthermore, establishing a detailed budget that considers all aspects of the decommissioning project ensures sufficient funding for safe and effective completion. Engaging with stakeholders, including regulatory authorities and local communities, is crucial to address concerns and ensure regulatory compliance throughout the pre-decommissioning phase.

3.1.2 Technical Requirement

In the pre-decommissioning stage, it is important to establish technical specifications and standards for equipment, materials, and methodologies to ensure the effectiveness and safety of decommissioning activities. This involves establishing specific needs for equipment like cutting tools and decontamination tools, as well as outlining materials for structural changes, containment, and waste management. Additionally, detailed procedures must be outlined, emphasizing safety procedures and quality control measures in compliance with industry standards and regulatory requirements. Decommissioning techniques and methodologies should be selected based on site-specific conditions, informed by thorough surveys and assessments to understand structural integrity, corrosion levels, and potential environmental contamination. Environmental impact must also be carefully considered when choosing the appropriate techniques and methods.

3.1.3 Environmental Impact Assessment/Best Practicable Environmental Option

In the pre-decommissioning stage, conducting an Environmental Impact Assessment (EIA) is essential to evaluate potential environmental risks and impacts. Determining the Best Practicable Environmental Option (BPEO) for decommissioning is also critical, emphasizing environmental sustainability and minimizing negative effects. This involves assessing various decommissioning alternatives and choosing the most environmentally responsible and socially acceptable option.

3.1.4 Risk Assessment Recommendation

The following outlines the recommended risk assessment approach for service providers undertaking the decommissioning removal process. This recommendation is confined to three removal methods, evaluated against three principal risk factors:

Removal methods:

1. Complete removal
2. Partial removal
3. Leave in-situ

Risk factors:

1. Occupational Safety
2. Environmental
3. Financial/Economic

When prioritization rules can be defined in advance of a project by the organization and included in organizational process assets, they can be customized to the individual project. For probability and impact, descriptive adjectives (such as exceedingly high, high, medium, low, and exceptionally low) or numeric numbers can be used. When numeric values are used, they can be multiplied to generate a probability-impact score for each risk, allowing the relative importance of hazards to be assessed within each priority level.

The probability scale for a risk naturally ranges from 0.0 (no probability) to 1.0 (high probability) (certainty). The severity of the risk's effect on the project's objective is reflected in the risk impact scale. The goal of both approaches is to assign a value to the impact on project objectives if the risk arises.

The figure below is a matrix of Probability-Impact (P-I). It illustrates how to evaluate if a risk is low, moderate, or high by multiplying the scale values provided by estimations of probability and impact. The risk score assists in categorizing the risk and guiding risk response actions.

Table 3: Probability-impact matrix table

	Impact				
Probability	**0.05**	**0.10**	**0.20**	**0.40**	**0.80**
0.90	0.05	0.09	0.18	0.36	0.72
0.70	0.04	0.07	0.14	0.28	0.56
0.50	0.03	0.05	0.10	0.20	0.40
0.30	0.02	0.03	0.06	0.12	0.24
0.10	0.01	0.01	0.02	0.04	0.08

Low
Medium
High

There are three factors to be considered during the risk assessment:

a. Occupational safety factor
b. Environmental factor
c. Financial/Economic factor

3.1.5 Occupational Safety Factor

The considerable health and safety challenges confronted by personnel engaged in offshore decommissioning operations result from a confluence of factors. These include the intricate organization of decommissioning activities, the deteriorating condition of aging infrastructure, the extensive scale of decommissioning projects, the intricate interplay between vessels, aircraft, and structures, and the diverse workforce required for each phase of the decommissioning process. The offshore environment, marked by unpredictable variations in wind, waves, air temperature, and currents, exposes offshore personnel to a broader array of health and safety risks, encompassing environmental exposure, marine evacuations, and personnel transfers between aircraft, vessels, and structures. The logistical intricacies inherent in offshore operations may lead to delays, necessitating personnel to spend extended periods completing tasks compared to their onshore counterparts, thereby prolonging their exposure to occupational health and safety hazards.

The segment below compiles the best practices to mitigate common risks involved with occupational safety factors across three removal processes:

a. Complete removal.
b. Partial removal.
c. Leave in-situ.

These recommendations can be utilized for risk assessments conducted during the planning phase of decommissioning activities.

3.1.5.1 Best Practices (Complete Removal)

	Risk	Mitigation Plans
1	Explosive cutting has not been historically used in offshore decommissioning in SEA (Southeast Asia). Still, it is now considered to be an option worth assessing in reducing the time involved in cutting offshore structures within ASEAN. The limitations on the use (and associated inefficient downtime) of mechanical/hydraulic cutters may be overcome, leading contractors to consider explosive cutting methods requiring diving support and leading to increased risk of occupational safety.	1. Do not utilize explosive cutting. 2. Utilize ROV. 3. Limit the volume of explosives. 4. Utilize subsea cutting tools and abrasive cutting. 5. Proper handling of the explosive. 6. Mock-up trial of explosive cutting. 7. Strict patrolling. 8. Minimize blast wave. 9. Conduct gas free. 10. Monitor the bottom time limits of divers. 11. Radio communication with the divers. 12. Work from the downstream of the flow of the sea current.
2	Cutting operations, whether they involve the use of cold-cutting-based cutting tools or hot-cutting-based tools, involve extensive and complex layouts at the JACKET. Based on the current inventory of decommissioning equipment and methods available in ASEAN, offshore personnel have been exposed to risks originating from jacket-cutting methods	1. Proper planning of cutting operations. 2. Conventional divers for external cutting. 3. Preparation work prior to cutting. 4. Cold-cutting based tools. 5. Mock-up trial of cutting. 6. Review the requirement for the depth to cut. 7. Minimize underwater work. 8. Employ an experienced contractor. 9. Do not utilize the excavation method if not needed.
3	Undercutting the sediment during excavation within the pile cluster could cause a collapse of overlying sediments and partial burial of divers.	1. More than one diver should be working underwater. 2. Increase excavation diameter from the pile. 3. Employ an experienced contractor. 4. Minimize underwater work. 5. Perform debris survey.
4	Severe weather impacts lifting, backloading, and transportation operations, leading to increased risks to personnel during such operations.	1. Postpone risky operations. 2. Avoid the jobs during monsoon. 3. Equip the platform with weather forecast systems.

	Risk	Mitigation Plans
5	Lifting pad eyes used during the installation of the platform are sometimes considered to be reused during the decommissioning of the facility to avoid time and costs associated with fabricating, installing, and welding new pad eye points on the structure before the structure. If such integrity-uncertain pad eyes are utilized for lifting during offshore decommissioning, the HSE impacts on multiple stakeholders are to be considered	1. Re-inspect lifting pad eyes. 2. Use new pad eyes. 3. Periodic rectification using NDT. 4. Verification of lifting gears and pad eyes. 5. Perform engineering check. 6. Estimate load capacities of the pad eye.
6	Failure of any part of the rigging sets or lifted objects/structures could impact the lifting operation, causing the jacket section to be lifted and dropped onto the deck of the crane barge/vessel, causing damage and occupational safety impact.	1. Guidance on storage practices. 2. Lifting gear inspection by a certified third-party company. 3. Conduct a site survey. 4. Secure loose items or remove them. 5. Early safety handling. 6. Designated tow route plan. 7. Proper emergency response plan. 8. Check on the weather forecast. 9. Proper rigging design and selection. 10. Cut verification. 11. Follow lifting procedures. 12. Provide a lifting certificate. 13. Conduct a Feasibility study. 14. Utilize ROV. 15. Inspection of marine vessels. 16. Alternative lifting method.
7	Marine vessels and platform collision accidents have been recorded in the past during offshore operations. In Offshore Decommissioning projects, such incidents may lead to Work stoppage caused by platform damage and unsafe working conditions. Subsequently, a revaluation of removal strategies needs to be done.	1. Marine fleet inspection. 2. Correct vessel selection and screening of marine crew. 3. The area is properly monitored, and there is clear communication with other vessel operators. 4. Repairing report with third-party approval.
8	Before the removal of the platform structure, process pipelines, risers,	1. Provide inventory checklists. 2. Conduct preparation work such as

	Risk	Mitigation Plans
	and process equipment will need to be depressurized, flushed, and cleaned. The process of cleaning and flushing pipelines, risers, and process equipment may pose some safety hazards to personnel.	flushing and pressure release. 3. Ensure personnel protective equipment is provided. 4. Follow the NORM safety procedure. 5. Ensure the NORM specialist is onboard. 6. Conduct a debris survey. 7. Provide guidance on safe handling and storage practices. 8. Conduct asset integrity program and V&V. 9. Ensure contaminates are at acceptable levels.
9	Removal of equipment from topside on occasion may contain the presence of heavy metals such as mercury and the presence of Normally Occurring Radioactive Materials (NORM) being exposed to topside personnel and associated stakeholders.	1. Provide inventory checklists. 2. Conduct preparation work such as flushing and pressure release. 3. Ensure personnel protective equipment is provided. 4. Follow the NORM safety procedure. 5. Ensure the NORM specialist is onboard. 6. Conduct a debris survey. 7. Provide guidance on safe handling and storage practices. 8. Conduct asset integrity program and V&V. 9. Ensure contaminates are at an acceptable level.

3.1.5.2 Best Practices (Partial Removal)

	Risk	Mitigation Plans
1	Explosive cutting has not been historically used in offshore decommissioning in SEA. Still, it is now considered to be an option worth assessing in reducing the time involved in cutting offshore structures within ASEAN. The limitations on the use (and associated inefficient downtime) of mechanical/hydraulic cutters may be overcome, leading contractors to consider explosive cutting methods requiring diving support and leading to increased risk of occupational safety.	1. Utilize ROV. 2. Limit the volume of explosives. 3. Utilize a subsea cutting tool. 4. Proper handling of the explosive. 5. Hire a competent blasting contractor. 6. Provide information towards public stakeholders affected. 7. Strict patrolling throughout the decom process. 8. Minimize blast wave after explosion. 9. Conduct a gas-free check. 10. Monitor the bottom time limits of divers. 11. Good radio communication with the divers. 12. Work from the downstream of the flow of the sea current.
3	Undercutting the sediment during excavation within the pile cluster could cause a collapse of overlying sediments and partial burial of divers.	1. Proper planning of cutting operations. 2. Utilize conventional divers for external cutting. 3. Conduct preparation work prior to cutting. 4. Utilize cold-cutting-based tools. 5. Mock-up trial of cutting. 6. Review the requirement for the depth for cutting. 7. Minimize underwater work. 8. Employ an experienced contractor. 9. Do not utilize the excavation method if not needed.
4	There are mounds of drilling cutting polluted with oil-based or synthetic drilling fluids under most of the old platforms. Before lifting the structure, these mounds should be cut into smaller pieces and removed. The problem is that these mounds have the buried part of installations that	1. Utilize ROV. 2. Employ an experienced contractor. 3. Minimize underwater work. 4. Minimize drill cutting use. 5. Leave drill cutting in place.

	Risk	Mitigation Plans
	should be removed first before lifting the structure. Removal of these polluted mounds releases toxic materials, posing an occupational safety hazard.	
5	Falling and failing containment vessels/equipment during lifting operations may cause hydrocarbon releases connected to process/riser/pipeline accidents, which may pose an HSE impact to multiple stakeholders. This is primarily rooted in the deteriorated integrity of such containment vessels/equipment.	1. Provide inventory checklists. 2. Conduct preparation work such as flushing and pressure release. 3. Ensure personnel protective equipment is provided. 4. Follow NORM safety procedure. 5. Ensure the NORM specialist is onboard. 6. Conduct a debris survey. 7. Provide guidance on safe handling and storage practices. 8. Conduct asset integrity program and V&V. 9. Ensure contaminates are at an acceptable level.
6	Severe weather impacts lifting, backloading, and transportation operations, leading to increased risks to personnel during such operations.	1. Early safety handling. 2. Avoid the jobs during monsoon. 3. Stop all work during severe weather periods. 4. Equip the platform with weather forecast systems.
7	Occupational risk exposure includes working at heights, basket transfers between vessels, trips, and falls, as well as lifting, cutting, and material handling. Since full removal takes longer than partial removal, the occupational risks to operating personnel increase in proportion.	1. Pre-check basket transfers prior to lifting. 2. Follow Working at Height rules. 3. Assign a watcher/buddy. 4. Conduct tool inspections. 5. Proper rigging design and selection. 6. Ensure having material and sling certification. 7. Ensure proper maintenance and NDT (Non-Destructive Testing) of rigging. 8. Use of gangway systems for transfer of personnel.
8	The deteriorated condition of an offshore platform may lead to reduced safety and fitness of the	1. Reassessment of the design of platforms. 2. Conduct a thorough inspection prior

	Risk	Mitigation Plans
	structure to be boarded by decommissioning personnel. These include missing gratings, corroded stairways, and even, in some cases, partially collapsed structural elements that need to be made good before decommissioning can begin.	to decommissioning. 3. Perform End of Field Life maintenance. 4. Reduce the amount of offshore personnel boarding the platform. 5. Increase Potential Loss of Life (PLL) above 0.04.
9	Lifting pad eyes used during the installation of the platform are sometimes considered to be reused during the decommissioning of the facility to avoid time and costs associated with fabricating, installing, and welding new pad eye points on the structure before the structure. If such integrity-uncertain pad eyes are utilized for lifting during offshore decommissioning, the HSE impacts on multiple stakeholders are to be considered.	1. Use new pad eyes. 2. Periodic recertification using NDT. 3. Check the quality and suitability of the reused lifting pad eyes. 4. Estimate load capacities of pad eyes.
10	Failure of any part of the rigging sets or lifted objects/structures could impact the lifting operation, causing the jacket section to be lifted and dropped onto the deck of the crane barge/vessel, causing damage and occupational safety impact.	1. Provide guidance on storage practices. 2. Lifting gear inspection by a certified third-party company. 3. Conduct a site survey. 4. Secure loose items or remove them. 5. Early safety handling. 6. Designated tow route plan. 7. Proper emergency response plan. 8. Check on the weather forecast. 9. Proper rigging design and selection. 10. Utilize proper cutting tools. 11. Follow Lifting Procedures, which include verification/assurance. 12. Provide a lifting certificate. 13. Utilize ROV. 14. Inspection of marine vessels prior to mobilization. 15. Ensure having material and sling certification. 16. Alternative lifting method.

	Risk	Mitigation Plans
11	Marine vessels and platform collision accidents have been recorded in the past during offshore operations. In Offshore Decommissioning projects, such incidents may lead to Work stoppage caused by platform damage and unsafe working conditions. Subsequently, a revaluation of removal strategies needs to be done.	1. Ensure marine fleet inspection prior to mobilization. 2. Proper vessel selection and screening of marine crew. 3. Ensure the area is properly monitored. 4. Ensure clear communication with other vessel operators.
12	Before the removal of the platform structure, process pipelines, risers and process equipment will need to be depressurized, flushed, and cleaned. The process of cleaning and flushing pipelines, risers, and process equipment may pose some safety hazards to personnel.	1. Provide inventory checklists. 2. Conduct preparation work such as flushing and pressure release. 3. Ensure personnel protective equipment is provided. 4. Follow the NORM safety procedure. 5. Ensure the NORM specialist is onboard. 6. Conduct a debris survey. 7. Provide guidance on safe handling and storage practices. 8. Conduct asset integrity program and V&V. 9. Ensure contaminates are at acceptable levels.
13	Removal of equipment from topside on occasion may contain the presence of heavy metals such as mercury and the presence of Normally Occurring Radioactive Materials (NORM) being exposed to topside personnel and associated stakeholders.	1. Provide inventory checklists. 2. Conduct preparation work such as flushing and pressure release. 3. Ensure personnel protective equipment is provided. 4. Follow the NORM safety procedure. 5. Ensure the NORM specialist is onboard. 6. Conduct a debris survey. 7. Provide guidance on safe handling and storage practices. 8. Conduct asset integrity program and V&V. 9. Ensure contaminates are at an acceptable level.

3.1.5.3 Best Practices (Leave in Situ)

	Risk	Mitigation Plans
1	Explosive cutting has not been historically used in offshore decommissioning in SEA. Still, it is now considered an option worth assessing in reducing the time involved in cutting offshore structures within ASEAN. The limitations on the use (and associated inefficient downtime) of mechanical/hydraulic cutters may be overcome, leading contractors to consider explosive cutting methods requiring diving support and leading to increased risk of occupational safety.	1. Do not utilize explosive cutting. 2. Utilize ROV. 3. Limit the volume of explosives. 4. Subsea cutting tool. 5. Ensure proper handling of the explosive. 6. Hire a competent blasting contractor. 7. Mock-up trial of explosive cutting. 8. Provide information towards public stakeholders. 9. Strict patrolling throughout the decom activity. 10. Minimize blast wave. 11. Minimize underwater work. 12. Conduct a gas-free check. 13. Monitor closely the bottom time limits of divers. 14. Radio communication with the divers.
2	Severe weather impacts lifting, backloading, and transportation operations, leading to increased risks to personnel during such operations.	1. Perform critical operations out of monsoon/during a clear weather window. 2. Equip the platform with good weather forecast systems.
3	Occupational risk exposure includes working at heights, basket transfers between vessels, trips, and falls, as well as lifting, cutting, and material handling. Since full removal takes longer than leave-in-situ, the occupational risks to operating personnel increase in proportion	1. Conduct an engineering study of the lifting plan. 2. Competency of personnel to perform work at height. 3. Pre-check basket transfers. 4. Follow Working at Height Rules. 5. Assign a watcher/buddy. 6. Execution is done by trained personnel, and equipment is utilised in good condition. 7. Tool inspections prior to commencement of work. 8. Proper rigging design and selection. 9. Consider the use of gangway systems for the transfer of personnel from vessels to platforms.

	Risk	Mitigation Plans
4	Before the removal of the platform structure, process pipelines, risers and process equipment will need to be depressurized, flushed, and cleaned. The process of cleaning and flushing pipelines, risers, and process equipment may pose some safety hazards to personnel.	1. Follow best industry practice. 2. Provide an inventory checklist. 3. Ensure taking measurements of NORM. 4. Ensure the NORM specialist is onboard. 5. Study toxic materials. 6. Temporary pigging launchers/receivers can be used. 7. Cleaning of topside equipment to be done offshore. 8. Conduct a debris survey. 9. Provide guidance on safe handling and storage practices. 10. Ensure contaminates are at an acceptable level. 11. Flush pipeline prior to removal.

3.1.6 Environmental Safety Factor

A breakdown in the decommissioning process carries inherent risks for the nearby community and the surrounding environment. It is advisable for decommissioning activities to exert minimal influence on marine organisms in the vicinity, ensuring no release of contaminants into the environment. The potential environmental consequences stemming from the decommissioning process can exhibit both positive and negative aspects. Variations in scale, scope, duration, timing, and permanence characterize these impacts. Their effectiveness in being averted through preventive measures or alleviated by remedial actions also varies, contingent on the structure's specific characteristics and location.

Typically, the use of an Environmental Impact Assessment (EIA) is advocated to alleviate severe impacts on the environment and ecosystems during decommissioning activities. Successful execution of the EIA process demands a comprehensive understanding of the proposed decommissioning activities and their potential environmental repercussions.

Systematically identifying issues that may affect the environment and other users of the area is pivotal to the EIA process, akin to HAZID procedures. Once identified, these issues must be addressed to assess the potential magnitude of environmental impact, facilitating the implementation of mitigation measures, if necessary, to prevent or minimize adverse effects. Various sources of contaminants from offshore petroleum activities, such as by-products during oil and gas withdrawal, accidental discharges from vessels, mud drillings, and surface sediments or drill cuttings, can have detrimental effects. Examples are illustrated in the figure below:

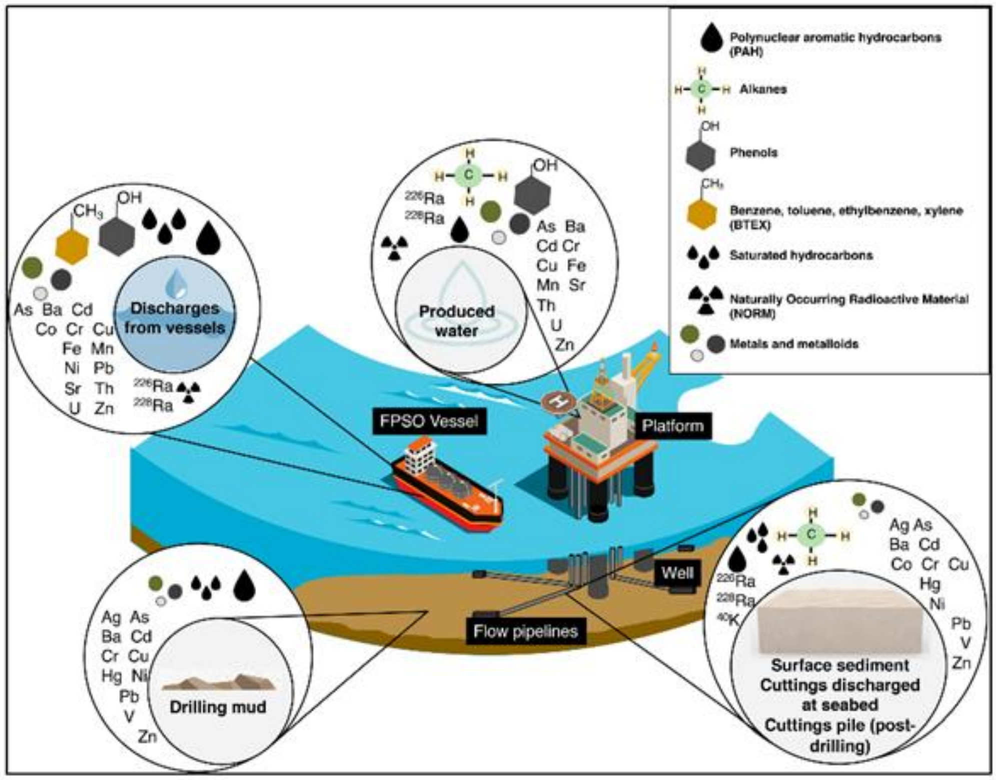

Figure 2: Sources of contaminants from offshore petroleum activities (Shams et al., 2023)

The segment below compiles the best practices to mitigate common risks involved with environmental factors across three removal processes:

a. Complete removal.
b. Partial removal.
c. Leave in-situ.

These recommendations can be utilized for risk assessments conducted during the planning phase of decommissioning activities.

3.1.6.1 Best Practices (Complete Removal)

	Risk	Mitigation Plans
1	Explosive cutting has not been historically used in offshore decommissioning in SEA. However, it is now considered an option worth assessing in reducing the time involved in cutting offshore structures within ASEAN. The limitations on the use (and associated inefficient downtime) of mechanical/hydraulic cutters may be overcome, leading contractors to consider explosive cutting methods that potentially leave behind residual toxic materials and create underwater noise pollution that affects marine life.	1. Utilise the most feasible type of explosive materials. 2. Environmental monitoring surveys. 3. Reduce shock waves or noise. 4. Utilize ROVs for cutting. 5. Closely monitor to ensure compliance towards SOP. 6. Use alternative methods, e.g., cold cutting.
2	Falling and failing containment vessels/equipment during lifting operations may cause hydrocarbon releases connected to process/riser/pipeline accidents, which may devastate the surrounding marine and benthic environment. This is primarily rooted in the deteriorated integrity of such containment vessels/equipment.	1. Ensure leakage/spill can be contained. 2. Conduct plugging/cleaning. 3. Inspect containment vessels/equipment. 4. Pass the treatment process before discharge. 5. Refer to marine operation procedure. 6. Monitor the contractors to ensure compliance towards Standard Operating Procedure (SOP).

3.1.6.2 Best Practices (Partial Removal)

	Risk	Mitigation Plans
1	Explosive cutting has not been historically used in offshore decommissioning in SEA. Still, it is now considered to be an option worth assessing in reducing the time involved in cutting offshore structures within ASEAN. The limitations on the use (and associated inefficient downtime) of mechanical/hydraulic cutters may be overcome, leading contractors to consider explosive cutting methods that potentially leave behind residual toxic materials and create underwater noise pollution that affects marine life.	1. Limit the usage of explosives 2. Environmental monitoring surveys before decommissioning 3. Reduce shock waves or noise 4. Utilize cutting using ROV 5. Ensure execution is regulated by international standards 6. Alternative media, e.g., cold cutting
2	Falling and failing containment vessels/equipment during lifting operations may cause hydrocarbon releases connected to process/riser/pipeline accidents, which may devastate the surrounding marine and benthic environment. This is primarily rooted in the deteriorated integrity of such containment vessels/equipment.	1. Ensuring the number of vessels kept to a minimum. 2. Ensure equipment is well-maintained. 3. Offshore vessels to avoid concentrations of marine mammals. 4. Minimum operational altitude will be set for helicopter transits and approaches. 5. Utilize proper vessels during operations. 6. Conduct a logistic study. 7. Optimise vessel time in the field. 8. Minimize fuel consumption. 9. Use ultra-low Sulphur fuel for vessels.
3	Before the removal of the platform structure, process pipelines, risers, and process equipment will need to be depressurized, flushed, and cleaned. The release of chemicals during cleaning and flushing of pipelines and removal of topside and jacket should be strictly controlled through Offshore Chemical Regulations.	1. Utilize environmentally friendly chemicals. 2. Cut the structure into pieces onshore. 3. Monitor the quality of offshore discharges. 4. Ensure equipment is in good condition. 5. Ensure approved chemicals are utilized.

	Risk	Mitigation Plans
		6. A slope barge should be available to transfer the liquid waste.
4	There are mounds of drilling cutting polluted with oil-based or synthetic drilling fluids under most of the old platforms. Before lifting the structure, these mounds should be cut into smaller pieces and removed. The problem is that these mounds have the buried part of installations that should be removed first before lifting the structure. Removal of these polluted mounds releases toxic materials and can affect the marine environment.	1. Study toxic materials. 2. Ensure strict compliance with NORMS. 3. Inspection to be done prior to execution. 4. Minimize the usage of chemicals offshore. 5. Monitor the quality of offshore discharges. 6. Ensure equipment is in good condition.

3.1.6.3 Best Practices (Leave in Situ)

	Risk	Mitigation Plans
1	Explosive cutting has not been historically used in offshore decommissioning in SEA. However, it is now considered an option worth assessing in reducing the time involved in cutting offshore structures within ASEAN. The limitations on the use (and associated inefficient downtime) of mechanical/hydraulic cutters may be overcome, leading contractors to consider explosive cutting methods that potentially leave behind residual toxic materials and create underwater noise pollution that affects marine life.	1. Utilize the most feasible type of explosive materials. 2. Limit the usage of explosives. 3. Ensure the area is clear of sea-based fauna. 4. Environmental monitoring surveys before decommissioning. 5. Reduce shock waves or noise. 6. Utilize cutting using ROV. 7. Ensure no marine animals are present. 8. Ensure execution is regulated by international standards. 9. Alternative media, e.g., cold cutting.
2	Falling and failing containment vessels/equipment during lifting operations may cause hydrocarbon releases connected to process/riser/pipeline accidents, which may devastate the surrounding marine and benthic environment. This is primarily rooted in the deteriorated integrity of such containment vessels/equipment.	1. Conduct plugging/cleaning before lifting operations. 2. Inspect containment vessels/equipment. 3. Spill recovery to be in place. 4. Study waste management. 5. Pass the treatment process before discharge.
3	Before the removal of the platform structure, process pipelines, risers, and process equipment will need to be depressurized, flushed, and cleaned. The release of chemicals during cleaning and flushing of pipelines and removal of topside and jacket should be strictly controlled through Offshore Chemical Regulations.	1. To cut the structure into pieces onshore. 2. Minimize the usage of chemicals offshore. 3. Ensure environmental audit is conducted. 4. Monitor the quality of offshore discharges. 5. Ensure proper planning and equipment are in good condition. 6. Ensure approved chemicals are utilized during the procedure. 7. A slope barge should be available to transfer the liquid waste.
4	There are mounds of drilling cutting polluted with oil-based or synthetic	1. Leave the mound in place. 2. Leave cutting in place.

	Risk	Mitigation Plans
	drilling fluids under most of the old platforms. Before lifting the structure, these mounds should be cut into smaller pieces and removed. The problem is that these mounds have the buried part of installations that should be removed first before lifting the structure. Removal of these polluted mounds releases toxic materials and can affect the marine environment.	3. Study toxic materials. 4. Ensure strict compliance with NORMS.

3.1.7 Financial/Economic Factor

The main emphasis regarding decommissioning risks frequently centres on potential complications in offshore dismantling operations and the consequential cost overruns. Nevertheless, the obligations concerning decommissioned assets persist beyond the completion of offshore structure removal from the seabed. Recent prominent cases have highlighted that these enduring responsibilities can result in substantial financial liabilities and damage to the operator's reputation.

The segment below compiles the best practices to mitigate common risks involved with financial/economic factors across three removal processes:

a. Complete removal.
b. Partial removal.
c. Leave in-situ.

These recommendations can be utilized for risk assessments conducted during the planning phase of decommissioning activities.

3.1.7.1 Best Practices (Complete Removal)

	Risk	Mitigation Plans
1	Explosives have not been historically used in offshore decommissioning in SEA. Still, they are now considered to be an option worth assessing in order to reduce the time involved in cutting offshore structures. The limitations on the use of mechanical/hydraulic cutters may lead contractors to resort to explosive methods requiring diver intervention, leading to increased risk of occupational safety and potentially leaving behind residual toxic materials and creating underwater noise pollution that affects marine life. This method of jacket leg cutting may have economic implications for multiple stakeholders economically due to the low experience of such methods in the region as well as the potential associated catastrophic economic risks resulting from an explosive cutting incident.	1. Control the release of toxic materials and emission of noise. 2. Developing requirements of the country's regulation. 3. Ensure the validity of certification/competency of technicians.
2	Loss of key personnel due to personal emergencies, requiring either replacement personnel or rescheduling.	1. Resource loading and planning in place. 2. Proper handover during crew/personnel change. 3. Place a "No Poaching Policy" for project staff.
3	Ship/vessel collisions involving one or more vessels in the marine fleet required for jacket removal are known to occur, leading to vessel damage, potential injuries, and aborted operations. Recovery costs from such incidents could be severe.	1. Have a proper emergency response plan. 2. Inspections on marine spreads. 3. Oil Spill Control plan. 4. Proper logistical planning. 5. Vessel's Dynamic Positioning Systems are in tip-top condition. 6. Vessel and Barge masters familiar with the location. 7. Backup personnel to avoid operation fatigue. 8. Impose marine warranties and insurance policies.

	Risk	Mitigation Plans
4	Marine vessel and platform collision accidents have been recorded in the past during offshore operations. In Offshore Decommissioning projects, such incidents may lead to Work stoppage caused by platform damage and unsafe working conditions. Subsequently, a revaluation of removal strategies needs to be done.	1. Have a proper emergency response plan. 2. Inspections on marine spreads. 3. Oil Spill Control plan. 4. Proper logistical planning. 5. Vessel's Dynamic Positioning Systems are in tip-top condition. 6. Vessel and Barge masters familiar with the location. 7. Backup personnel to avoid operation fatigue. 8. Impose marine warranties and insurance policies.
5	In European countries (particularly those that operate oil and gas fields in the North Sea oil and gas blocks), their governments or O&G Authorities heavily include 3rd party organizations and public stakeholders in the decision-making process when it comes to oil and gas activities. Blockage of offshore works has been known to occur due to objections from environmental organizations and public stakeholders, resulting in an economic impact on the at-risk stakeholders.	1. Conduct town hall meeting engagements/roadshows to identify risks and map out stakeholders and mitigation plans/strategies. 2. Prepare a proper removal and lifting procedure and execution plan.

3.1.7.2 Best Practices (Partial Removal)

	Risk	Mitigation Plans
1	Explosives have not been historically used in offshore decommissioning in SEA. Still, they are now considered to be an option worth assessing in order to reduce the time involved in cutting offshore structures. The limitations on the use of mechanical/hydraulic cutters may lead contractors to resort to explosive methods requiring diver intervention, leading to increased risk of occupational safety and potentially leaving behind residual toxic materials and creating underwater noise pollution that affects marine life. This method of jacket leg cutting may have economic implications for multiple stakeholders economically due to the low experience of such methods in the region as well as the potential associated catastrophic economic risks resulting from an explosive cutting incident.	1. Control the release of toxic materials. 2. Developing requirements of the country's regulation. 3. Validity of certification/competency of technicians.
2	Cutting operations, whether they involve the use of cold-cutting-based cutting tools or hot-cutting-based tools, involve the use of heavy and complex machinery. Even with experienced riggers, technicians, and competent personnel, accidents from parts failure or misuse of complex machinery are likely to occur, which may have economic implications for certain stakeholders.	1. Validity of certification/competency.
3	During the lifting or transporting of assets, damages to equipment must be expected. However, damage to specialized equipment typically unavailable amongst local suppliers and vendors can lead to increased costs and potentially long lead times, leading to operational delays and longer marine standby time.	1. Project schedule execution with ETAs of long lead time to be accounted for. 2. Proper lifting/rigging design. 3. Fasten all equipment and steel. 4. Steelworks loaded must be accompanied by a manifest. 5. Rent standby equipment/spare equipment temporarily.

	Risk	Mitigation Plans
4	Service providers failing to complete contracted work or going out of business. New providers would need to be vetted, contracts signed, and schedules revised. This can incur costs for stakeholders involved in the decommissioning project.	1. Quality Assurance Program. 2. Risk management team. 3. Opening to contractors on clarification session discussion. 4. Conduct a contracting strategy workshop to include lessons learned from previous projects. 5. Develop a robust contracting strategy moving away from a lump sum contracting strategy. 6. Developing standardized structures, therefore, standardized decom methods.
5	Falling objects during lifting operations cause hydrocarbon releases connected to process/riser/pipeline accidents, which may devastate the surrounding marine and benthic environment. Aside from potential injury and loss of personnel, recovery costs from such incidents could be severe.	1. Ensure competency of contractor/worker. 2. Prepare a proper removal and lifting procedure and execution plan. 3. Oil Spill Control Mitigation and Contingency Plan. 4. All equipment has been checked and inspected. 5. Designated material landing/cargo docking area of the platform.

3.1.7.3 Best Practices (Leave in Situ)

	Risk	Mitigation Plans
1	Explosives have not been historically used in offshore decommissioning in SEA. Still, they are now considered to be an option worth assessing in order to reduce the time involved in cutting offshore structures. The limitations on the use of mechanical/hydraulic cutters may lead contractors to resort to explosive methods requiring diver intervention, leading to increased risk of occupational safety and potentially leaving behind residual toxic materials and creating underwater noise pollution that affects marine life. This method of jacket leg cutting may have economic implications for multiple stakeholders economically due to the low experience of such methods in the region as well as the potential associated catastrophic economic risks resulting from an explosive cutting incident.	1. Avoid the use of explosives. 2. Control the release of toxic materials and emission of noise. 3. Understanding the requirements of the country's regulation. 4. Develop an extensive program for the contractor/vendor evaluation process. 5. To ensure the validity of certification/competency of technicians.
2	Cutting operations, whether they involve the use of cold-cutting-based cutting tools or hot-cutting-based tools, involve the use of heavy and complex machinery. Even with experienced riggers, technicians, and competent personnel, accidents from parts failure or misuse of complex machinery are likely to occur, which may have economic implications for certain stakeholders.	1. Perform a full evaluation of the technical specifications for the removal/cutting works of the topside and jacket. 2. Ensures contractors/vendors are experienced. 3. Strict enforcement and compliance with related regulations. 4. Control emission of sound/vibrations.
3	A manual diver-operated dredge system would be required to dredge under the pile cluster below the mudline. This is furthermore compounded by the requirement by certain operators within the region to impose a five-meter below-the-mudline requirement for the removal of soil to facilitate pile removal. Such requirements add significantly to	1. Deploy ROV and study the seabed condition. 2. Regulatory bodies/governments shall consider the requirements of dredging under pile clusters.

	Risk	Mitigation Plans
	the economic overheads of projects through the addition of dredging equipment, diver man-hours, and standby or marine vessels.	
4	During the lifting or transporting of assets, damages to equipment must be expected. However, damage to specialized equipment, which is typically not available amongst local suppliers and vendors, can lead to an increase in cost and potentially long lead times, leading to operational delays and longer marine standby time	1. Align project schedule execution with ETAs of long lead time materials. 2. Provisioning adequate spares. 3. Implement proper lifting/rigging design. 4. Materials loaded on the supply vessels must be accompanied by a manifest and are accounted for.
5	Service providers failing to complete contracted work or going out of business. New providers would need to be vetted, contracts signed, and schedules revised. This can incur costs for stakeholders involved in the decommissioning project.	1. Implement a Quality Assurance Program. 2. Operators should consider opening to contractors clarification session discussions on contracting-related issues. 3. Conduct a contracting strategy workshop. 4. Make references from past lessons learned. 5. Develop a robust contracting strategy.
6	Ship/vessel collisions involving one or more vessels in the marine fleet required for jacket removal are known to occur, leading to vessel damage, potential injuries, and aborted operations. Recovery costs from such incidents could be severe.	1. Inspections should be conducted on marine spreads. 2. An Oil Spill Control plan should be put in place. 3. Place proper logistical planning. 4. Ensure the vessel's Dynamic Positioning Systems are in good condition. 5. Vessel and Barge masters must familiarize themselves with the location, local weather conditions, and the surrounding facilities. 6. Vessel Masters should have backup personnel.
7	Marine vessel and platform collision accidents have been recorded in the past during offshore operations. In	1. Inspections should be conducted on marine spreads. 2. An Oil Spill Control plan should be

	Risk	Mitigation Plans
	Offshore Decommissioning projects, such incidents may lead to Work stoppage caused by platform damage and unsafe working conditions. Subsequently, a revaluation of removal strategies needs to be done.	put in place. 3. Place proper logistical planning. 4. Ensure the vessel's Dynamic Positioning Systems are in good condition. 5. Vessel and Barge masters must familiarize themselves with the location, local weather conditions, and the surrounding facilities. 6. Vessel Masters should have backup personnel.
8	Falling objects during lifting operations cause hydrocarbon releases connected to process/riser/pipeline accidents, which may devastate the surrounding marine and benthic environment. Aside from potential injury and loss of personnel, recovery costs from such incidents could be severe.	1. Develop a proper lifting plan. 2. Hire/appoint a competent crane operator. 3. Remove or secure all loose times prior to heavy lifts. 4. Retrieval plan of dropped objects. 5. Cost of damage or recovery to be borne by the contractor. 6. Oil Spill Control Mitigation. 7. Perform proper flushing and cleaning of process equipment, pipelines, and risers. 8. Conduct a seabed survey ERP. 9. Obtain access to the previous seabed and debris report. 10. Allow natural degradation.
9	In European countries (particularly those that operate oil and gas fields in the North Sea oil and gas blocks), their governments or O&G Authorities heavily include third-party organizations and public stakeholders in the decision-making process when it comes to oil and gas activities. Blockage of offshore works has been known to occur due to objections from environmental organizations and public stakeholders, resulting in an economic impact on the at-risk stakeholders.	1. Conduct town hall meeting engagements with all stakeholders involved. 2. Take into consideration all environmental regulations before proceeding with a decommissioning plan.

3.2 Decommissioning Execution Stage Guidelines

This section delves into the recommendations for selecting the most appropriate removal process for decommissioning projects, focusing exclusively on fixed offshore structures. The scope of the recommendation excludes conductor and pipeline removal, concentrating instead on the execution process for topside removal and disposal, as well as substructure removal and disposal. These processes are vital components of decommissioning projects, demanding meticulous planning and execution to ensure safety, environmental protection, and cost-effectiveness.

3.2.1 Decommissioning Execution Process

The decommissioning execution process entails several critical phases, each necessitating detailed planning and execution to ensure the safe and efficient removal of decommissioned structures:

1. Topsides Removal and Disposal
    - Activities:
        i. Detailed engineering assessments and planning.
        ii. Implementation of safety protocols to protect workers.
        iii. Environmental safeguards to prevent contamination.
        iv. Cost-effective removal techniques.
2. Substructure Removal and Disposal
    - Activities:
        i. Structural assessments to determine dismantling strategy.
        ii. Implementation of safety measures for divers and workers.
        iii. Environmental safeguards to mitigate the impact on marine life.
        iv. Consideration of economic factors for cost-effective removal.

3.2.2 Decommissioning Removal Method Recommendation

In the context of offshore decommissioning activities, selecting the most suitable removal option for offshore structures involves careful consideration of numerous factors, including occupational safety, environmental impact, and financial implications. Among the available options, complete removal, partial removal, and leaving in situ stand out as primary choices. Each option presents distinct advantages and challenges, necessitating a comprehensive evaluation to determine the optimal approach for decommissioning projects.

The least preferred removal option across all risk factors would be complete removal. The most preferred options fall between partial removal and leaving in situ. In terms of occupational safety, partial removal emerges as the best option, followed by leaving in situ. Among the hazards associated with leaving in situ, explosive cutting stands out as a significant concern. This method requires more explosives to cut the platform into smaller pieces, potentially contributing to the preference for partial removal.

Regarding environmental impact, partial removal is favoured as the most preferred option, with leaving in situ as the next favourable choice. Similarly, explosive cutting is identified as the primary hazard associated with leaving in situ, mirroring concerns observed in the realm of occupational safety.

From a financial perspective, leaving in situ is prioritized as the most favourable option, followed by partial removal. Notably, one of the main hazards associated with partial removal is the risk of ship or vessel collisions, highlighting the multifaceted considerations involved in the decision-making process for offshore decommissioning activities.

Overall, the findings suggest that partial removal and leaving in situ are the preferred options across various risk factors, with the specific choice depending on factors such as safety, environmental impact, and financial considerations.

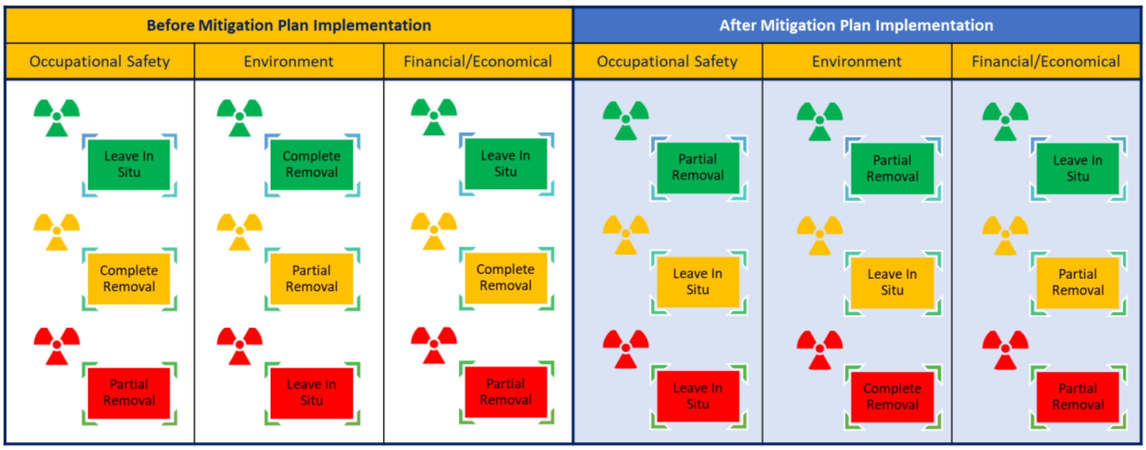

Figure 3: Suggested removal processes based on identified risk factors

3.3 Post-Decommissioning Phase Guidelines

The post-decommissioning phase is the final phase of decommissioning activities, which requires close monitoring. It is important to transition smoothly into this phase once the offshore structures have been decommissioned. This transition is essential for maintaining compliance, reducing risk, and gaining valuable insights for future undertakings. This phase focuses on evaluating the effectiveness of the decommissioning process, addressing any issues that arise, and planning for the next steps.

3.3.1 Monitoring and Compliance

1. Implement long-term monitoring programs to evaluate the environmental effects of decommissioning.
2. Implement regular environmental monitoring to track changes in water quality, marine ecosystem, and other relevant parameters.
3. Monitor the structural integrity through regular inspections, assessments, and the use of monitoring systems.
4. Conduct structural inspections to ensure the integrity of any remaining infrastructure and address any potential hazards.
5. Comply with regulatory requirements and reporting obligations by submitting monitoring data and compliance reports as required.
6. Effectively manage the disposal of decommissioned materials, equipment, and waste according to regulations and best practices.
7. Maintain engagement with stakeholders to address any concerns.

3.3.2 Environmental Monitoring Program

An environmental monitoring program aims to assess the long-term impacts of decommissioning activities and the commonly implemented during the post-decommissioning phase:

Table 4: Environmental monitoring program

Environmental Monitoring Program	Description
Water Quality Monitoring	Regular assessments of parameters like pH, dissolved oxygen, turbidity, and nutrient levels in the surrounding water are conducted to ensure compliance with regulations and to identify any contamination.
Marine Life Population Surveys	Tracking the abundance and diversity of marine organisms helps evaluate the health of the ecosystem and detect any changes after decommissioning.
Sediment Sampling and Analysis	Collect and analyze sediment samples from the seabed to evaluate quality, identify contaminants, and assess sedimentation rates.
Contamination Monitoring	Gathering and analysing sediment samples from the seabed is performed to assess their quality, identify contaminants, and evaluate sedimentation rates.
Remote Sensing	Using remote sensing methods like satellite imagery helps in monitoring changes in coastal and marine environments, such as shoreline erosion and habitat loss.

Post-decommissioning monitoring programs are essential for understanding the lasting impacts of decommissioning activities on the marine environment. These programs involve various components:

1. Baseline monitoring establishes pre-decommissioning conditions for comparison.

2. Habitat recovery monitoring assesses benthic habitat and coral reef regeneration.
3. Contaminant fate and transport modelling predict the long-term dispersion of pollutants.
4. Monitoring of marine protected areas evaluates biodiversity and habitat quality.
5. Seabed stability monitoring tracks erosion and sedimentation.
6. Ecological succession monitoring observes species changes over time.
7. Hydrocarbon monitoring assesses the effects of spill response efforts.
8. Public health surveillance ensures seafood safety and beach water quality, protecting local communities' well-being after decommissioning.

3.3.3 Closure and Handover Procedures

The closure and handover procedures mark the conclusion of the decommissioning project and transfer responsibility for the site to the appropriate parties. This final stage involves appropriate planning, thorough documentation, and effective communication with stakeholders and other involved parties to conclude the project. The following procedures outline the steps involved in closing out the decommissioning project:

i. Collect and document all relevant data and records related to the decommissioning process and ensure all documents are complete and organized for handover.
ii. Conduct an inspection of the decommissioned site and structure to verify that all activities have been completed.
iii. Prepare assets and equipment inventory by documenting their condition, status, issues, and requirements for disposal.
iv. Review project financials to reconcile budgets, expenditures, and any outstanding payments.
v. Evaluate site safety and security measures to confirm that all hazards are mitigated, access points are secured, and emergency response procedures are established.
vi. Notify relevant stakeholders, including regulatory agencies, communities, and project team members, of the decommissioning project's completion and status.
vii. Implement post-closure monitoring programs to track site conditions, environmental impacts, and regulatory compliance over time.

3.3.3.1 Data collection and record keeping

Data collection and record-keeping play crucial roles in ensuring safety, environmental compliance, and effective management of decommissioned assets. The process involves several key steps, which are establishing clear objectives for data collection and focusing on aspects such as environmental impact monitoring, structural integrity assessment, and regulatory compliance verification. Identifying sources of data includes documentation from the decommissioning process, including engineering reports, inspection records, environmental assessments, and regulatory permits. Additionally, ongoing monitoring programs may involve data from sensors, remote monitoring systems, and periodic site visits. Methods for data collection may include remote sensing technologies, underwater inspections, drone surveys, and sampling of sediments and marine life around the decommissioned structure. Data collection methods may involve conducting trial runs to evaluate the feasibility and effectiveness of selected approaches, considering factors such as accessibility, data quality, and safety.

In terms of record-keeping, establishing a comprehensive system for storing and managing data is critical. This may involve digital databases, cloud-based platforms, or specialized software designed for offshore asset management. Records should be organized, indexed, and archived to facilitate easy retrieval and analysis. Ensuring data security and confidentiality is essential, particularly when dealing with sensitive information such as environmental monitoring data or proprietary engineering designs. Access to data should be restricted to authorized personnel only. Regular data backups are essential to prevent loss due to technical failures or unexpected events. Version control mechanisms should be implemented to track changes made to records over time, ensuring the integrity and traceability of data. Documentation of the data collection and record-keeping process is crucial for transparency, accountability, and regulatory compliance. This may involve maintaining detailed records of data collection activities, including dates, locations, methodologies, and findings.

The procedures for collecting, documenting, and maintaining records of decommissioning activities ensure accuracy, consistency, and regulatory compliance. Below are detailed procedures for each aspect:

i. Data Collection:
   - Define the types of data to be collected during decommissioning activities - environmental monitoring data, operational records, inspection reports, and any other relevant information.
   - Specify the methods and instruments to be used for data collection, ensuring they are accurate, reliable, and aligned with regulatory requirements.
   - Determine the frequency and timing of data collection to capture relevant information at key stages of the decommissioning process.

ii. Documentation Procedures:
   - Establish standardized formats and templates for documenting decommissioning activities.
   - Clearly outline the details to be documented, including dates, locations, personnel involved, activities performed, observations made, and any incidents that occur.

- Assign data collection and documentation responsibilities to designated personnel, specifying their roles and obligations in maintaining accurate records.

iii. Recording Methodologies:

- Implement efficient recording methodologies to facilitate data entry, storage, and retrieval.
- Ensure that recorded data are labelled, organized, and indexed for easy reference and analysis.
- Implement version control measures to track changes and updates to records over time.

4. Conclusion

4.1 Future Considerations

Looking ahead, it is imperative to regularly reassess and refine these guidelines considering shifting regulatory landscapes, technological progressions, and insights gained from decommissioning endeavours. As time progresses, it becomes increasingly vital to adapt, ensuring alignment with evolving industry standards and best practices.

Anticipated future enhancements encompass integrating innovative technologies to streamline monitoring and data acquisition processes, refining stakeholder engagement tactics for optimal inclusivity, augmentation of training initiatives to bolster expertise, and cultivating collaborative platforms to facilitate knowledge exchange among industry peers.

Recognizing the dynamic nature of decommissioning practices, these guidelines are designed to evolve iteratively, subject to continual evaluation and adaptation. As such, ongoing revisions are paramount, ensuring their relevance and effectiveness in the ever-evolving landscape of decommissioning endeavours.

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