Kenya Waste Management Guidelines

(developed for petroleum sector)

FINAL DRAFT

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Developed by:	National Environment Management Authority (NEMA)		
Approved by:			

List of Acronyms

- EIA – Environmental Impact Assessment
- EMCA 199 - Environmental Management and Coordination Act 1999.
- EPA – Environmental Protection Agency
- EU – European Union
- IBP – International Best Practice
- KPC - Kenya Pipeline Company
- KPRL – Kenya Petroleum Refineries Limited
- NEMA – National Environment Management Authority
- PPP – Public private partnership
- RAP - Remedial Action Plan
- UK – United Kingdom
- US – United States of America
- WDR – Waste Disposition Report
- WMP – Waste Management Plan

CONTENTS:

1 Introduction

1.1 Purpose

These guidelines are developed to provide petroleum companies, i.e., those conducting operations in the up-, mid-, and downstream sectors, with guidance as to how to achieve or remain in compliance with existing Kenyan legislation on waste management, and to adopt best international practices. Although the guidelines apply to all petroleum sector waste (up, mid, down), waste from downstream operations is -to a greater extent already covered by existing regulations. Therefore, the focus of these guidelines is on the up and mid-stream sectors of petroleum industry.

Petroleum companies shall observe requirements of these guidelines in handling waste from petroleum operations. Requirements imposed by enacted, Kenyan law is mandatory for the responsible duty holder, as specified in legislation (section 4 of these guidelines). The term “must” indicates a requirement, while terms such as “recommends”, “expects”, “should” indicate recommendations based on international best practice, rather than on Kenyan law.

Some recommended practice that are based on international best practice might be in contradiction with current requirements imposed by Kenyan regulations. Such recommendations are referred to in these guidelines solely for the purpose of providing general guidance on widely accepted, industry practice. They are not intended to encourage petroleum companies to breach national legislation in any form or fashion.

NEMA along with other competent bodies of Kenya works on alignment of current Kenyan regulations with international best practice as it applies to petroleum sector and introduction of official amendments into corresponding regulations.

The National Environment Management Authority (NEMA) will initiate formal review of these guidelines five years following their publication, to ensure that they continue to reflect up-to-date scientific and technical knowledge. An earlier review may be initiated at NEMA’s discretion, or if petitioned by government, industry or the public.

1.2 Scope

These guidelines is based on Kenyan legislation on waste management. On one hand, it aims at providing petroleum operators with a thorough analysis of every statute, regulation, policy, or guideline containing requirements on the management of hazardous, and non-hazardous waste. On the other hand, it addresses regulatory gaps found in Kenyan legislation. These guidelines focus on obligations imposed on waste generators, but it excludes requirements applicable to other stakeholders involved in the waste management process, e.g., waste transporters, sewage exhausters, and final disposal facilities.

These guidelines are broken down into sections.

Section 2 aims at describing the types of waste typically produced by the petroleum sector (up-, mid- and downstream). The list does not include any waste other than the waste produced specifically by the petroleum sector, such as domestic and solid waste. The list includes the types of waste almost exclusively generated by petroleum activities, e.g., drilling muds, cuttings, waste oil.

Section 3 provides an overview of the current status of waste management processes in Kenya. It gives background on the population growth and national industrialization that has led to increased waste generation, challenges derived from these factors, and steps taken to address these challenges. Furthermore, this section describes issues arising specifically from petroleum sector waste generation, including factors such as the lack of infrastructure, capacity, and public awareness.

Section 4 provides a list of Kenya's laws and regulations that directly or indirectly make provisions related to waste management. For every regulation, this section provides a general description of its contents, and a list of specific requirements established therein, as well as the national authorities in charge of enforcing them.

Section 5 of the guidelines identifies gaps or matters that are not regulated by Kenyan law. The section identifies two main categories of gaps:

- Gaps arising from vagueness or incompleteness of existing regulation. This category includes instances where regulations fail to provide details on how to comply with an existing requirement, as well as gaps due to the lack of complementary regulations.
- Gaps arising from legislation's failure to regulate a specific issue altogether. This type of gap is caused by the fact that Kenya's environmental law is not tailored to regulate petroleum activities, hence it fails to capture issues specific to the industry.

Section 5 identifies instances where Kenyan law contradicts international best practice.

Section 6 is divided in several subsections pertaining to different phases of waste management, i.e., prevention, categorization, storage, transportation, treatment, disposal, and remediation. For each phase, the guidelines identify steps and actions that, according to international best practice, generators must take. This section is based on international best practice, even if they are not in line with national requirements.

2 Types of waste produced by petroleum operations

In addition to common waste produced by any industrial undertaking, e.g., sewage, sanitary and domestic waste, petroleum operations also generate solid and liquid waste that is specific to the sector. The most relevant include:

- **Cuttings**, i.e., the small pieces of formation rock and subsurface materials that break away because of the action of drill bit teeth as a well or direction borehole is being drilled.[1]
- **Drilling muds**, i.e., a suspension, usually in water but sometimes in oil (natural, synthetic and diesel), used in rotary drilling, consisting of various substances in a finely divided state (commonly bentonitic clays and chemical additives), introduced continuously down the drill pipe under pressure and through openings in the drill bit and transported back up in the annular space between the pipe and the walls of the hole to a surface pit or tank where it is conditioned and reintroduced into the wellbore. It is used to lubricate and cool the bit, carry the cuttings up from the bottom, and prevent blowouts and cave-ins.[2]
- **Drilling fluids**, i.e., the fluid portion of drilling wastes consisting to water, drilling muds, fine cuttings, and additives.[3]
- **Naturally occurring radioactive materials (NORM)**, i.e., materials typically found in certain types of barium or strontium scales that may be deposited in the wellbore or production tubulars.[4]
- **Produced water**, i.e., water - naturally present in a reservoir - that is produced along with hydrocarbons (oil, gas, and crude bitumen) from a well.[5]

[1] Alberta Energy Regulator, *Directive 050: Drilling Waste Management*, pg. 153 (2016).
[2] *Id.*
[3] *Id*.
[4] Schlumberger, *Oilfield Glossary*.
[5] Canada-Newfoundland and Labrador Offshore Petroleum Board, *Offshore Waste Treatment Guidelines*, pg. 8 (2010).

- **Used Oil**, i.e., any semi-solid or liquid product consisting totally or partially of mineral oil or synthesized hydrocarbons (synthetic oils) that has been used and as a result of such use is contaminated by impurities rendering it unsuitable for its original use and includes oily residues from tanks, oil-water mixtures, and emulsions.[6]
- **Sludge**, i.e., an accumulated free settling wet solid typically consisting of hydrocarbon, water, and inorganic sediments (i.e. sands, silts, etc.).[7]
- **Wastewater**, e.g., oily water, pipeline test water or waste fluids/solids generated from the cleaning of a pipeline (pipeline pigging water).[8]
- **Contaminated soil,** i.e., hydrocarbon-bearing soil that must be either remediated or removed.
- **Oily debris**, i.e., oil-contaminated soil, rags and other absorbent materials, such as filters.
- **Flowback water**, i.e., the fluids and entrained solids that emerge from a well during the flowback process. The flowback process allows fluids and entrained solids to flow from a well following a treatment, either in preparation for a subsequent phase of treatment or in preparation for cleanup and returning the well to production.[9]

3 Status of waste management in Kenya

3.1 General

Kenya has a growing human population, as well as rising industrialization of its economy. [10] Although there are laws in place governing waste management, lenient implementation of such laws has led communities to be overwhelmed by their own waste. [11] This situation impacts both the environment, and public health. [12] These impacts range from clogged drainage and sewers, waterborne diseases like typhoid, cholera and diarrhea, increased upper respiratory diseases from open burning of the garbage, to malaria.[13]

Waste management is mostly the responsibility of county governments.[14] However, such authorities have not prioritized this duty, and have not allocated sufficient resources to carry it out.[15] This has resulted in poor waste management which includes indiscriminate dumping, uncollected waste, and lack of waste segregation across the country. [16]

Waste transportation is not in line with international best practices. [17] It is conducted using open trucks, hand carts, donkey carts, among others. Such practices have resulted in littering, making waste visible in public spaces. Nevertheless, some county governments, in line with national legislation, have adopted appropriate transportation trucks, and/or privatized waste management through public private partnerships (PPP).

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[6] National Environment Management Authority, *Technical Guidelines on the Management of Used Oil and Oil Sludge in Kenya*, pg. 10 (2016).
[7] Alberta Energy Regulator, *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*, pg. 148 (2006).
[8] State of Louisiana Department of Natural Resources, *E&P Waste, Disposal Technique, and Facility Type Codes and Descriptions* (2011).
[9] 40 CFR 60.5430.
[10] National Environment Management Authority, *The National Solid Waste Management Strategy*, 2015.
[11] *Id*.
[12] *Id*.
[13] Ministry of Environment and Natural Resources, *National Appropriate Mitigation Action on a Circular Economy Solid Waste Management Approach for Urban Areas in Kenya,* 2016.
[14] National Environment Management Authority, *The National Solid Waste Management Strategy*, 2015.
[15] *Id*.
[16] *Id*.
[17] *Id*.

Due to absence of adequate disposal sites, waste disposal is also a challenge in Kenya. Cities that have designated sites, practice open dumping of mixed waste because they are not adequately equipped.[18] In response to this situation, the National Environment Management Authority (NEMA) has directed county governments to create waste disposal areas, and to undertake basic action to manage them, including fencing, manning, and weighing of the waste.[19]

In this context, Vision 2030 – Kenya's long-term development plan – acknowledges that efficient and sustainable waste management systems are necessary.[20] Consequently, the plan sets flagship projects for five cities namely; Mombasa, Kisumu, Eldoret, Nakuru and Thika are to have fully functional and compliant waste management systems, by developing strategies towards achieving sustainable waste management.[21] In line with Vision 2030, NEMA developed the National Solid Waste Management Strategy directed at assisting the public and institutions to engage in proper waste management by complying with national regulations on the matter.

3.2 O&G Specific

In addition to the problems described in the section above, management of waste produced by oil and gas operations also faces challenges, including, for example, human, technological, economic, as well as policies and legal factors.

Studies indicate that local communities are largely unaware of the impacts of petroleum waste on the environment and public health.[22] In Turkana, for example, some communities use petroleum waste – such as high-density polythene liners used to make silicate and mud waste pits - for the construction of housing structures known as "Manyattas."[23] Cases have also been identified of communities using used chemical containers to store water during droughts.

Furthermore, technology used to manage hazardous waste generated by petroleum operations is not adequate. Technologies adopted in other countries are not used in Kenya, and the current legal framework is inadequate for their implementation since it neither fosters nor requires their use. Examples include Thermal Desorption Units (TDUs) for the recovery of oil-based muds, and bioremediation, using biologically modified organisms. One of the factors hindering the use of state-of-the-art technology in Kenya is the limited human capacity locally to handle it, which – along with importation costs – makes it expensive to use. [24]

At this point, high temperature incineration is the only method to treat and dispose of hazardous waste approved by Kenyan law (see section 4.3.2.2 *infra*). This method, however, is costly and the country does not have the capacity to handle volumes generated by the petroleum sector. Incineration sites exist only in Nairobi. Petroleum waste is usually transported by operators licensed by NEMA, and cover approximately 850 kilometers (528 miles) to reach the disposal site located in Stony Athi, Machakos County, near Nairobi. This results in high transportation costs, which in turn increases the overall cost of hazardous waste management, and of petroleum activities.

The major sources of waste generation from the petroleum sector include:

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[18] *Id*.
[19] *Id*.
[20] Kenya's Vision 2030, http://vision2030.go.ke/social-pillar/#67
[21] National Environment Management Authority, *The National Solid Waste Management Strategy*, 2015.
[22] Ministry of Energy and Petroleum of Kenya, *Strategic Environmental and Social Assessment of the Petroleum Sector in Kenya*, 2016.
[23] *Id.* at 99.
[24] Ministry of Energy and Petroleum of Kenya, *Strategic Environmental and Social Assessment of the Petroleum Sector in Kenya*, 2016.

- Port of Mombasa (waste oil from the ships) (see section 4.4 *infra*),
- Petroleum retail facilities,
- Depots of the Kenya Pipeline Company (KPC),
- Kenya Petroleum Refineries Limited (KPRL) (Kenya's only refinery is currently being used only as a storage facility), and,
- Industries using fuel oil. [25]

4 Legal and institutional framework

This section aims at providing a list and a description of every piece of Kenyan legislation regulating waste management generated by petroleum operations. Furthermore, this section contains a detailed list of specific requirements imposed on companies generating hazardous, and non-hazardous waste. It also contains citations of legal requirements, and references to annexes to regulations, whose review and use is necessary to fully comply with Kenyan law. In addition to the aforementioned requirements, this section also specifies which documents, e.g., licenses and/or certificates operators are required to obtain, and the authorities entitled to issue them.

Current legislation and regulations

4.1 Environmental Management and Coordination Act 1999 (EMCA 1999)

4.1.1 Summary

EMCA 1999, as amended in 2015, is the main law governing environmental protection in Kenya. It provides the legal and institutional framework applicable to all local industries, including the petroleum sector. EMCA 1999 established the National Environment Management Authority (NEMA). The purpose of NEMA is to exercise general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of the government in the implementation of all policies relating to the environment.

EMCA 1999 contains a broad spectrum of provisions directed at environmental protection, including licensing and permitting; monitoring and enforcement; protection of water bodies; conservation of bio-diversity; environmental restoration; management of hazardous materials; air quality management; effluent discharges; and waste management.

EMCA 1999 is the parent act from which a number of subordinate regulations stem. Due in part to its broad scope, EMCA 1999 fails to provide specific information necessary to give effect to its mandates. Consequently, reaching compliance requires studying EMCA 1999 in concurrence with the relevant subordinate regulation, e.g., the Environmental Management and Coordination (Waste Management) Regulations 2006.

4.1.2 Relevant requirements and provisions

4.1.2.1 Effluents

- To deposit any substance in a lake, river or wetland or in, on or under its bed, if that substance would or is likely to have adverse environmental effects on the river, lake or wetland, requires a prior **environmental impact assessment approved by NEMA**. [Regulation 42(1)(e) EMCA].
- Operators must discharge any effluents or other pollutants only into existing sewage systems. Prior to such discharges, operators have to obtain a **license of discharge granted by a county government** (see section 4.2.2.2 *infra*) [Regulation 74(1) EMCA].
- Discharges into the environment require an **effluent discharge license granted by NEMA** (see section 4.2.2.1 *infra*) [Regulation 75(1) EMCA].

[25] *Id*.

- Obtaining the effluent discharge license mentioned above requires operators to install a plant for the treatment of such effluents before they are discharged into the environment. [Regulation 74(2) EMCA].

4.1.2.2 Solid Waste

- It is prohibited to dispose of any waste in such manner as to cause pollution or ill health to any person [Regulation 87(1) EMCA].
- Every person whose activities generate wastes shall employ measures essential to minimize wastes through treatment, reclamation and recycling. [Regulation 87(4) EMCA].
- Operators foreseeing to generate hazardous waste must obtain a **waste license granted by NEMA**. [Regulation 88(1) EMCA].

4.2 Environmental Management and Coordination (Water Quality) Regulations 2006

4.2.1 Summary

The Environmental Management and Coordination (Water Quality) Regulations 2006 provides more specific instructions on how to reach compliance with requirements imposed by EMCA 1999 on discharges of effluents into sewage systems, and into the environment (see section 4.1.2.1. *supra*).

Water Quality Regulations apply to water used for domestic, industrial, agricultural, and recreational purposes; water used for fisheries and wildlife purposes, and water used for any other purposes. Different standards apply to different modes of usage. These regulations provide for the protection of lakes, rivers, streams, springs, wells and other water sources. The objective of the regulations is to prohibit discharge of effluent into the environment contrary to the established standards. The regulations further provide guidelines and standards for the discharge of poisons, toxins, noxious, radioactive waste or other pollutants into the environment in line with the Third Schedule of the regulations.

The regulations have standards for discharge of effluent into the sewer and aquatic environment. While it is the responsibility of the sewerage service providers to regulate discharges into sewer lines based on the given specifications, NEMA regulates discharge of all effluent into the environment.

4.2.2 Relevant requirements and provisions

4.2.2.1 Effluents into the environment – Effluent Discharge License

- Operators intending to apply for an effluent discharge license granted by NEMA must use the application form (Form A) provided in the Seventh Schedule of the Water Quality Regulations, accompanied by a fee of K.Shs. 5,000 [Regulation 16(1), Seventh Schedule, and Eleventh Schedule of Water Quality Regulations].
    - Operators filing the aforementioned form are invited to follow the "Guidelines to Filling in Application Form for Effluent Discharge Licence" developed by NEMA, which is available on the agency's website.
    - If approved, an Effluent Discharge License will be issued following the template (Form B) provided in the Seventh Schedule of the Water Quality Regulations [Regulation 17(1), and Fran Template of Water Quality Regulations].
- Holders of effluent discharge licenses granted by NEMA must make sure that such discharges comply with standards set out in the Third Schedule of the Water Quality Regulations [Regulations 11, 12(1), and Third Schedule of Water Quality Regulations].
    - Such holders must carry out effluent discharge quality and quantity monitoring, and submit quarterly records of such monitoring to NEMA. [Regulation 14(1) of Water Quality Regulations].
        - Such monitoring must be made in accordance with methods and procedures prescribed by NEMA [Regulation 14(1) of Water Quality Regulations].

        - Such records must be kept using the form provided in the Sixth Schedule of the Water Quality Regulations. [Section 14(2), and Sixth Schedule of Water Quality Regulations]
    - In monitoring their discharges, such holders must follow the monitoring guide for discharge into the environment provided in the Fourth Schedule of the Water Quality Regulations [Regulation 12(2), and Fourth Schedule of Water Quality Regulations].
- For guidance on effluent sampling, operators are referred to:
    - Chapter 5 of US EPA's, NPDES Compliance Inspection Manual (2017), https://www.epa.gov/sites/production/files/2017-01/documents/npdesinspect.pdf
    - Part D of British Columbia's Field Sampling Manual (2013), https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual
    - Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)", http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf
- For guidance on methods to determine standards of effluent discharges, operators are referred to Annex 8.7 - Comparative Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Upstream Sector

4.2.2.2 Effluents into the sewage system – License of Discharge

- Holders of licenses to discharge effluents into the sewer line issued by a county government must make sure that such discharges comply with standards set out in the Fifth Schedule of the Water Quality Regulations [Regulation 13(1), and Fifth Schedule of Water Quality Regulations].

4.3 Environmental Management and Coordination (Waste Management) Regulations 2006

4.3.1 Summary

The Environmental Management and Coordination (Waste Management) Regulations 2006 (Waste Management Regulations) provide more specific instructions on how to reach compliance with requirements imposed by EMCA 1999 on waste management (see section 4.1.2.2. *supra*).

4.3.2 Relevant requirements and provisions

- Waste generators must **separate** hazardous, from non-hazardous waste [Regulation 6of Waste Management Regulations].
- Waste considered hazardous is
    a. any waste specified in the Fourth Schedule of the Waste Management Regulations, e.g., waste oils/water, hydrocarbons/water mixtures, or emulsions; or
    b. any waste having the characteristics defined in the Fifth Schedule of the Waste Management Regulations, e.g., explosive or flammable.

  Any waste not fitting said categories is considered non-hazardous [Regulation 16, Fourth, and Fifth schedules of Waste Management Regulations].

4.3.2.1 Provisions applicable to hazardous, and non-hazardous waste

- Any person whose activities generate waste must **collect, segregate and dispose** or cause to be disposed of such waste in the manner provided for under the Waste Management Regulations [Regulation 4(2) of Waste Management Regulations].
- Waste generators must **transfer** waste to persons licensed to transport and dispose of waste [Regulation 4(2), of Waste Management Regulations].

- Waste generators must install at its premises **anti-pollution technology for the treatment of waste** they produce. Such equipment must be based on best available technology [Regulation 14 (1), (2) of Waste Management Regulations].
    - Owners cannot dispose of industrial waste unless it has been treated following the methodology established by NEMA [Regulation 15 of Waste Management Regulations].

4.3.2.2 Provisions applicable to hazardous waste

- Operators foreseeing to generate hazardous waste must obtain an **Environmental Impact Assessment License** (EIA license) [Regulation 17 of Waste Management Regulations].
- Every generator of hazardous waste shall ensure that every container or package for storing such waste is secure and labelled in easily legible characters, written in English and Kiswahili. [Regulation 18 (1) of Waste Management Regulations]
- Storage – Labelling
    - The label of containers of hazardous waste must contain the following information:
        - The identity of hazardous waste,
        - The name, physical address, and telephone contact of the generators,
        - The waste composition and total weight of waste,
        - The normal storage stability and methods of storage,
        - The name and percentage of weight of active ingredients and names and percentages of weights of other ingredients or half-life of radioactive material,
        - Warning or caution statements, which may include any of the following as appropriate:
            - The words "WARNING" or "CAUTION";
            - The word "POISON" (marked indelibly in red on a contrasting background); and,
            - The words "DANGER! KEEP AWAY FROM UNAUTHORIZED PERSONS"; and,
            - A pictogram of a skull and crossbones.
        - A statement of first aid measures, including the antidote when inhaled, ingested, or dermal contact and a direction that a physician must be contacted immediately.

      [Regulation 18 (2) (of Waste Management Regulations]
- Storage – Packaging:
    - Hazardous waste generators must ensure that:
        - the collection of such waste is conducted in such a manner that will not cause scattering, escaping and/or flowing out of the waste; and,
        - the equipment for the storage of waste is in such a state that it shall not cause the scattering of, escaping of, or flowing out of the waste or emitting of noxious smells from the waste.

      [Regulation 8(1), (2)of Waste Management Regulations]
- Treatment: Generators of hazardous waste must either treat or cause such waste to be treated either in accordance to the terms of their hazardous waste generator license; or, in its absence, using the classes of incinerators prescribed in the Third Schedule of the Waste Management Regulations [Regulation 19 (1) (of Waste Management Regulations].
- Final disposal: After treatment, hazardous waste must be disposed of in accordance with the conditions laid down in the corresponding license [Regulation 19 (2) of Waste Management Regulations].

4.4 Environmental (Prevention of Pollution in Coastal Zone and other Segments of the Environment) Regulations 2003

4.4.1 Summary

The Environmental (Prevention of Pollution in Coastal Zone and other Segments of the Environment) Regulations 2003 (Coastal Pollution Regulation) applies to all ships, i.e., every description of vessel or craft or floating structure, located in the territorial waters of Kenya.

The Coastal Pollution Regulation requires ships to off-load oil or oily mixture and wastes to the certified Port Waste Reception Facility at the Port of Mombasa.

4.4.2 Relevant requirements and provisions

- Ships, including any floating structure, in Kenyan territorial waters must have a **Port Waste Disposal Certificate** granted by the certified Port Waste Reception Facility at the Port of Mombasa. The certificate is granted after off-loading oil or oily mixture and wastes to the aforementioned facility [Regulation 6(1), and Schedule of Coastal Pollution Regulation].
- Ships must also carry an Oil Record Book, which has to detail entries on machinery space operations, cargo and ballast operations [Regulation 5 of Coastal Pollution Regulation].

4.5 Environmental (Impact Assessment and Audit) Regulations, 2003

4.5.1 Summary

The Environmental (Impact Assessment and Audit) Regulations, 2003 (EIA Regulation) contains provisions specifying the process that certain operations, e.g., those generating hazards waste, must follow in order to obtain an Environmental Impact Assessment License (EIA license). The process includes drafting reports assessing the likely impact of a given project, as well as the measures to be implemented in order to mitigate such impact. The EIA Regulation also establishes the minimum content of said documents.

4.5.2 Relevant requirements and provisions

- Operators required to obtain an Environmental Impact Assessment License, e.g., those generating hazardous waste, have to submit a report to NEMA, before beginning of operations, specifying the waste to be generated by their activities, the methods of their disposal, and describing mitigation measures to be taken [Regulation Section 7(e)-(f), 16(c), 18(f)].

4.6 Environmental Impact Assessment Guidelines and Administrative Procedures

4.6.1 Summary

The Environmental Impact Assessment Guidelines and Administrative Procedures (EIA Guidelines) provides details on the information NEMA expects to find in applications for EIA licenses, and how it will assess such applications. More specifically, the EIA Guidelines provide further instructions on the mitigation measures that operators are required to include in their applications under the EIA Regulation.

4.6.2 Relevant requirements and provisions

Under the EIA Guidelines, EIA license applications must:

> Identify fully the proposed measures that shall be implemented to address the identified adverse effects. Similarly, the effectiveness of these measures towards achieving desired objectives shall be assessed. A wide range of options will be proposed to prevent, reduce, remedy, or compensate for the various adverse effects [Regulation 2.6.4 of EIA Guidelines].

In reviewing the suitability of mitigation measures, the review panel will consider the following questions:

- What mitigation measures are proposed and what alternative designs or sites have been considered?
- What lessons from previous similar projects have been incorporated into this EIA?
- Are there any significant impacts whose mitigation or abatement cannot be prescribed?
- Have interested parties and affected communities been effectively involved?
- Is adequate consideration given to provision of compensation for loss of/or damage to property, or for resettlement? [Regulation 2.11 of EIA Guidelines].

4.7 The Petroleum (Exploration, Development and Production) Act, 2019)

4.7.1 Summary

The Petroleum (Exploration, Development and Production) Act, 2019 (Petroleum Act) is the main law governing upstream petroleum operations in Kenya. It provides the legal and institutional framework applicable to the sector and created the Upstream Petroleum Regulatory Authority (UPRA). The purpose of UPRA is to exercise general supervision and co-ordination over all matters relating to the upstream petroleum sector, and to be the principal instrument of the government in the implementation of all applicable policies.

The Petroleum Act contains a broad spectrum of provisions, including licensing and permitting; revenue sharing; contractual matters; decommissioning; monitoring and enforcement; as well as environment, health and safety-related issues, e.g., waste management, damage compensation, and emergency preparedness.

The Petroleum Act is a parent act that was passed in early 2019 will require a number of subordinate regulations to give full force to its provisions.

4.7.2 Relevant requirements and provisions

Under the Petroleum Act, upstream petroleum operators must:

> Ensure that the management of production, transportation, storage, treatment and disposal of waste arising out of upstream petroleum operations is carried out in accordance with all 'the applicable environmental, health, safety and maritime laws and best petroleum sector practices.

5 Gaps in Kenyan legislation

This section aims to identify issues relating to the management of waste produced from petroleum operations that are not regulated in Kenyan legislation. These issues can be divided in two categories: (1) those arising from vagueness or ambiguity in existing regulation; and (2) those arising from the absence of regulation on certain matters. These guidelines do not aim to bridge the aforementioned gaps. They are identified for illustrative purposes only. Gaps in Kenyan legislation will be addressed by national authorities, following the corresponding regulatory process.

Furthermore, this section also provides a table with identified instances in which Kenyan law and international best practices are in direct contradiction.

5.1 Gaps due to vagueness or ambiguity

This type of gap consists of requirements established in Kenyan legislation with which compliance is difficult to achieve due to either the regulations' incompleteness, or to inaction of public bodies responsible for complementing them. The following is a list of such gaps:

1) **Gaps on methods to monitor discharges to the environment.**

Under the Water Quality Regulations, holders of effluent discharge licenses are required to monitor their discharges in accordance with the methods and procedures of sampling and analysis prescribed

by NEMA (see section 4.2.2.1 *supra*). However, such methods and procedures have not yet been developed.

2) Gaps on equipment for treatment of non-hazardous waste.

Under the Waste Management Regulations, waste generators must install at their premises anti-pollution technology for the treatment of the non-hazardous waste that is produced. (see section 4.3.2.1 *supra*). The Waste Management Regulations states that such technology must be based on either best available technology not entailing excessive costs, or on measures prescribed by NEMA [Regulation 14(2) Waste Management Regulations].

However, there are neither prescribed measures on the matter nor recommendations on the use of existing national or international standards. These guidelines do not contain provisions on this matter because, as established below (see section 5.3 *infra*), the installation of treatment equipment for non-hazardous waste on site is not compatible with international best practices.

Kenya legislation does contain provisions on facilities to treat hazardous waste (see section 4.3.2.2 *supra*).

3) Gaps on methods of treatment of non-hazardous waste.

The Waste Management Regulations prohibits operators producing non-hazardous waste from discharging or disposing of waste unless it has been treated in a treatment facility and in a manner prescribed by NEMA.

However, there are no approved methods for treatment of non-hazardous waste. These guidelines contain provisions on treatment of the most common types of waste generated by petroleum operations (see section 6.4.2 *infra*).

At the same time methods for the treatment of hazardous waste are described in generators' licenses. In their absence, generators must treat hazardous waste using the classes of incinerators prescribed in the Third Schedule of the Waste Management Regulations (see section 4.3.2.2 *supra*).

4) Gaps on tracking of hazardous waste.

Under the Waste Management Regulations, operators transporting waste (either hazardous or non-hazardous) must possess at all times during transportation of such waste a duly filled tracking form as set out in Form III of the First Schedule of the Waste Management Regulations [Regulation 8(4), First Schedule of Waste Management Regulations]. The form must contain information such as the license number of the transporter, the description of the waste, and a certification that the waste has been transferred to a company duly licensed to conduct disposal activities.

Best international practice imposes the same requirement not only on transporters, but also on other parties managing hazardous waste, such as generators and facilities in charge of its final disposal. More information is provided in section 6.4 below.

5) Gaps on the Oil Dispersant Use Policy

Kenya's Oil Dispersant Use Policy [section 3(5)] requires the provision of information contained in Appendix VII of such document to be provided to the authority in charge of authorizing the use of oil dispersants, prior to making a decision on the matter. Reference to Appendix VII appears to be a typographical error. Reference should be made to Appendix VIII on Dispersant Use Decision Elements and Documentation Forms.

Kenya's Oil Dispersant Use Policy states that only substances listed in the Product Schedule of the Kenya National Marine Oil Spill Response Contingency Plan. However, the plan does not seem to have been adopted.

5.2 Gaps due to absence of regulation

Kenya's legislation on waste management applies to all industries in the country. Namely, Kenya does not have legislation specifically regulating waste generation from petroleum activities; hence, it fails to cover issues pertaining exclusively to the petroleum sector. This section addresses gaps arising from these omissions:

- Kenyan law has no provisions on underground disposal.
- Kenyan law fails to regulate produced sand, completion and well work-over fluids, and naturally occurring radioactive materials (NORM)
- Unlike other jurisdictions, Kenya's legislation requires installation of a treatment plant on-site for effluents to comply with maximum permissible pollutant limits.
- Water Quality Regulations do not provide sufficient requirements and methods for disposal of Liquid Effluents derived from the petroleum sector, except for discharge into water bodies and sewage system which may not necessarily provide for effective methods for various reasons, e.g. availability of sewage system for disposal of large volumes of effluents.
- Water Quality Regulations discusses discharges into sewers. However, there are no limitations placed on oil and gas waste, which might meet with opposition from the public, even if treated as required for all industrial facilities. Likewise, Water Quality Regulations does not recognize specific waste waters that are common in upstream, midstream and downstream petroleum operations. Therefore, application of Water Quality Regulations to petroleum sector may be problematic.
- Kenya has no regulatory requirements applicable to deck drainage systems for removing oil containing fluid from an offshore facility.
- Article 8 of the Coastal Pollution Regulation allows the Director General of NEMA to investigate when any visible traces of oil are noted near the ship or in its wake. No additional information is provided on how such investigations would occur or the authority given to NEMA to stop these vessels from leaving Kenyan waters.
- Drilling muds:
    - Current regulations make no provisions for the use of oil-based, synthetic-based, or water-based drilling muds and fluids. Most jurisdictions restrict or prohibit the use of synthetic or oil-based drilling muds for both on- and offshore operations.
    - NEMA or any other regulator does not have monitoring or reporting requirements for drilling fluids or muds.
    - There are no details on the disposal of drilling fluids and cuttings beyond "best petroleum industry practice."
- Most of Kenya's requirements on waste apply to hazardous – as opposed to non-hazardous – waste. Consequently, it fails to impose a number of requirements on non-hazardous waste that are in place in other jurisdictions. These requirements include, for example, waste management permits, and recording systems.
- Unlike other jurisdictions, Kenya's law requires operators to install anti-pollution equipment to treat waste produced at the facility.
- Kenya's legislation does not address management of sanitary waste, hence it fails to grant authorities the power to review and approve operator's proposed managing options of sanitary waste.
- Kenya's legislation only allows for the possibility of disposing of production waste by shipping it to a licensed facility. This restricts other alternatives, for example, underground injection.
- Current regulations encourage the modification of processes to produce less waste, but do not offer suggestions or incentives.
- There is no mention of soil contamination in Kenyan regulations.

- Kenya's legislation does not impose hazardous waste record-keeping, manifesting, and tracking requirement on generators.

5.3 Instances of Kenyan law being misaligned with international best practices

Citation	Provision	International Best Practice (IBP)	IHSM Recommendation
Regulation 15 of Waste Management Regulations	Hazardous waste must be incinerated either by the generator or a third party, or treated using any other appropriate technology approved by the authority.	IBP provides a wider range of options for disposal of hazardous waste such as: injection in disposal wells, in the annular space of wells, and biological or physical treatment, such as thermal desorption.[26]	Kenyan regulation should be amended to allow hazardous waste generators to treat such waste using innovative methodologies, and state of the art technology.
Regulation 74(2) of EMCA	Operators discharging wastewater into the environment must have a treatment plant on-site.	IBP does not require wastewater generators to have treatment plants on site. [27]	Kenya law should be re-drafted as to allow wastewater generators to outsource wastewater treatment, without compromising minimum standards.
Regulation 17 (1) (2), Waste Management Regulations	Waste generators must install at its premises anti-pollution technology for the treatment of waste they produce. Such equipment must be based on best available technology.	IBP allows treatment of waste to be conducted either on- or off-site. [28]	Kenyan regulation should be modified to allow waste generators to outsource waste treatment based on best available technology, and aimed at reaching acceptable environmental standards
Form III, First Schedule, Waste Management Regulations	Form provided by Kenyan law to track waste does not have box for information of waste generator.	IBP requires waste generators to track waste from "cradle to grave." Hence, tracking form requires information on generator.[29]	Form provided by Kenyan regulation to track waste should include box for information of waste generator.
Strategic Environmental and Social Assessment of the Petroleum Sector in Kenya, 99-100 (2016).	Kenyan law restricts the use of biologically modified organisms, necessary for treatment of hazardous waste by bioremediation.	IBP recommends treatment of drilling fluids bioremediation.[30] Adopted techniques must ensure the efficacy of the proposed bacteria for bioremediation.	Kenyan law should be amended to allow use of biologically modified organisms for treatment of hazardous waste.
Third Schedule, Water Quality Regulations.	Standard for effluents discharged into the environment differ from	Standard for effluents discharged into the environment differ from	Standards for effluents discharged into the environment set by Kenyan

[26] International Finance Corporation, *Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development*, pg. 9 (April 2007).
[27] *Id.* at 5-6.
[28] *Id.* at 9.
[29] Alberta Energy Regulator, *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*, Figure 8.1.
[30] International Finance Corporation, *Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development*, pg. 9 (April 2007).

	levels recommended by IBP. For example, limit for Chemical Oxygen Demand (COD) is 50 mg / L.	levels recommended by IBP. For example, limit for Chemical Oxygen Demand (COD) is 125 mg / L.[31]	law should be revised to match current IBP. See Annex 985.

[31] *Id.*, Table 1 (April 2007).

6 Recommended practices

This section aims at providing petroleum operators with environmentally sound methods to manage waste throughout its lifecycle, i.e., from prevention, to generation and final disposal. This section is built on the two prior sections. On one hand, it is based on the regulatory requirements listed in section four. However, due to the shortcomings mentioned in Section five of the guidelines, recommended practices proposed in this section draw from the international best practices, i.e., those established in guidelines issued in other jurisdictions such as the UK, the EU, the US, and Canada.

6.1 Waste categorization and classification

The waste generator must characterize each waste. They must then use waste characterization to assess the appropriate handling, treatment, and disposal of that waste. Waste characterization is the assessment of the physical, chemical, and toxicological characteristics of the waste.

The waste generator must first determine if the waste (e.g. drilling cuttings, domestic wastes, oil wastes, refining wastes etc.) requires classification. For the most part, nearly all forms of household, commercial or industrial wastes require classification, unless it is not a waste (e.g. it is a product) or if it is explicitly excluded from classification. If the material is waste, the generator should define the code or codes that would need to be applied to the waste, for the tracking of the waste throughout its life-cycle. In order to define such code, generators must first classify waste into one of two categories: hazardous or non-hazardous. Waste is considered hazardous if it is listed as such in the Fourth Schedule of Kenya's Waste Management Regulations, 2006; or if it has any of the properties listed in the Fifth Schedule of the same regulation. This information might be derived from:

- The manufacturers' safety data sheets;
- The waste is derived from a well-understood industrial process;
- Sampling and analysis of the waste using established sampling and analytical protocols.

If the waste is listed as hazardous in the Fourth Schedule of Kenya's Waste Management Regulations, 2006 (e.g. drilling fluid contaminated drill cuttings), the generator must then determine the chemical composition of the waste in order to define the hazardous properties. Reference must be made to Schedule 5 of the Waste Management Regulations 2006.

Schedule 5 of the Kenya Waste Management Regulations 2006, defines some 17 hazardous properties/waste types, in accordance with the UN Recommendations 1988, but doesn't provide any guidance documentation on the methodologies that must be followed in making the assessment of waste characteristics (e.g. chemical thresholds, physical characteristics, sampling and testing requirements etc.).

Best practice recommends three different approaches to determining if the waste displays hazardous properties. These are:

- calculation - referring to a concentration limit for a hazard statement code (s);
- testing to prove whether a particular hazardous property is present or not (typically used for the physical properties – explosive, oxidizing, and flammable); or
- the safety data sheet if the waste is a manufactured product whose composition has not changed, for that specific product.

In accordance with international best practice, generators should make the assessment in terms of factors such as ignitability, corrosiveness, reactivity and toxicity. In the case of each of these four factors a series of parameters should be used to carry out the assessment including, individual

standards, the prescribed methods to be used to carry out any analytical chemistry, and legal definitions. A chart detailing the aforementioned methodologies can be found in section 8.3. below.

Generators should implement the aforementioned process through an electronic "yes", "no" decision tree approach to facilitate the accurate, efficient and traceable classification of waste types.

Section 8.2 contains an illustrative generic categorization matrix, based on Kenya's Waste Management Regulations, for the types of waste that might arise during the development of onshore petroleum operations. Completing the matrix, would require:

- adding all the wastes identified in the operator's waste management plan; and,
- the analysis of the individual wastes in order to fully categorize the wastes and develop a waste management strategy similar to that presented in the table above.

Operators must properly document each waste stream generated by the facility, and keep that documentation for at least three years after the waste is no longer generated, stored, or recycled or until the site is closed. Documentation should support the classification and coding of a waste stream.

If process knowledge (e.g., when waste is derived from a well-understood industrial process) is used in classifying a waste, generators should document that knowledge and keep it on file for three years. Process knowledge should be in writing or stored in some electronic form. The process knowledge should support a generator's reasoning about why the waste has been given a particular classification. It should also support the generator's reasoning about why a particular test method was not performed.

The following are some examples of process knowledge that may assist in classifying waste:

- description of the waste;
- date of initial waste generation;
- a detailed description of the process generating the waste (that is, identification of chemicals or other materials in the process that generated the waste stream (including any potential breakdown products);
- manufacturer's literature such as Material Safety Data Sheets—MSDSs (although they were not created for the purpose of determining waste classification, and do not contain information on all constituents found in a product, MSDSs may be helpful);
- full description of activities that generated the waste stream;
- identification of potential contaminants; and
- other documentation generated in conjunction with the particular process.

If analytical data is used to classify a waste, the generators should use data supported by documentation of the sampling procedure and the analytical testing. The following lists specify information that should be maintained when analytical data is used for classification purposes.

<u>Sampling Procedure</u>

The following procedures should be documented:

- dates of sample collection;
- description of the site and/or unit from which the sample was taken, including sampling locations;
- the method and equipment used for sampling;

- a description of the sampling techniques, including collection, containerization, and preservation; and
- rationale—that is, supporting reasons—for the sampling plan (why the number, type, and location of samples taken accurately represent the waste stream being characterized).

Analytical testing

Documentation of analytical testing should include the following:

- Analytical results (including quality control data);
- Analytical methods (including any preparatory methods);
- The detection limits for each analysis;
- Name of laboratory performing the analysis;
- Chain of custody—documentation tracking the condition of the waste containers. For example, were the waste containers and their seal intact or broken upon arrival at the laboratory? Were the containers full, half-full, or empty? Did all the containers arrive at the laboratory or just a partial shipment?

6.2 Storage, collection, and handling procedures for hazardous and non-hazardous waste

Waste from oil and gas operations, whether hazardous or non-hazardous, are generally stored in one of three locations:

- in a storage area on an approved oil and gas facility;
- at a waste storage facility (stand-alone site) operated by an oil and gas company for collection of their own wastes; or
- at a waste transfer station operated by an independent company as a third-party waste receiver.

This section contains general criteria applicable to all types of locations mentioned above. Storage areas should meet the following requirements:

Environmental Protection and Safety Practices

The following environmental protection and safety practices should be considered:

- Selecting a storage site that minimizes the potential for environmental concerns;
- Implementing operating procedures, maintenance practices, and inspection programs to maintain the integrity of the primary containment device and any associated equipment such as valves, fittings, piping, or pumps;
- Implementing operating practices to prevent the buildup of static electricity during the transfer of flammable liquids;
- Storing the materials in a manner such that:
    - materials do not generate extreme heat or pressure or cause a fire or explosion,
    - materials do not produce uncontrolled fumes or gases that pose a risk of fire or explosion,
    - materials do not damage the structural integrity of a storage facility, and
    - incompatible materials are segregated to prevent contact even in the event of a possible release.

Release/Spill Prevention

One of the purposes of waste storage guidelines is to ensure that such waste is adequately contained to prevent soil, surface water, and groundwater contamination through effective primary containment, secondary containment, and leak detection. When these prevention systems are in place, the next most significant contributor to contamination is accumulated releases/spills.

While often small in nature, these releases/spills may occur for a variety of reasons, such as load line connection spills, tank overflows, truck overfilling, and flange, valve, and fitting leaks. The occurrence of these types of releases/spills are an indication of opportunities for improvements in operations.

Approval holders or licensees should include within their operating procedures proactive measures to prevent the occurrence of these releases, such as plans and policies to prevent releases, as well as documentation of their frequency and the cause of occurrence in order to determine the overall program effectiveness. These measures should include contracted services, as contractors are often responsible for the loading operations that may result in intermittent releases. Some of the measures that have proven to reduce release volumes and frequency include:

- company inspection and maintenance programs;
- company operations handbooks/environmental bulletins;
- operator and contractor training on company expectations and reporting:
- contractor pre-job orientations;
- detailed records (internal spill/incident reports); and
- a database of incidents to allow for analysis of spill cause and frequency.

Storage Space

Hazardous waste should be stored in a safe and secure manner. In general, hazardous waste should be stored according to the following points:

- Drainage is controlled to prevent spills or leaks from leaving the site and to prevent run-off from entering the site:
- Wastes are segregated by chemical compatibility to ensure safety of the public, workers and facility;
- Hazardous wastes are stored in a secure area with controlled access. Only persons authorized to enter and trained in waste handling procedures should have access to the storage site;
- Regular inspections of stored hazardous wastes are performed and recorded. Containers are placed so that each container can be inspected for signs of leaks or deterioration. Leaking or deteriorated containers should be immediately removed and their contents transferred to a sound container;
- A record of the type and amount of waste in storage should be maintained;
- Hazardous waste containers should not be allowed to fill up with water when stored outdoors. Drums frequently accumulate water from rainfall, if stored upright, outside, without proper sealing. Empty containers need to be stored on their side to prevent water from entering;
- A comprehensive groundwater monitoring program should also be implemented;
- Storage sites should have emergency response equipment and material appropriate for the hazardous waste stored on site;

- Hazardous waste storage sites should meet all local by-law and zoning requirements. It is recommended that the county governments be advised of the storage facility and its contents for emergency planning and response purposes.

Storage spaces should be located so that they meet the following criteria:

- Readily accessible for firefighting and other emergency procedures;
- Not located in a floodplain, unless appropriate alternative secondary containment measures are incorporated into the design and installation;
- Chosen so as to minimize the risk of environmental damage, including any threats to the integrity of the storage facility, the quality of soils, surface water, and groundwater, and the health of humans, animals, and plants during the construction, operation, and closure of the storage area/facility;
- Not located within 100 m of the normal high-water mark of a body of water, permanent stream, or water well used for domestic purposes.

A response plan, which shall be maintained on-site at all times, should describe appropriate measures to follow in the event of any emergency such as a fluid spill, tank fire or any other hazard. Employees should be trained in respect to normal and emergency situations.

Storage Containers

Generally, hazardous waste should be stored in containers as follows:

- In the original containers, where possible, or in containers manufactured for the purpose of storing hazardous waste. The containers should be sound, sealable and not damaged or leaking;
- Clearly labelled according to an internationally-recognized hazard information system, such as the UN Globally Harmonized System of Classification and Labelling of Chemicals, UN Recommendations on the Transport of Dangerous Goods, or Canada's Work Site Hazardous Materials Information System (WHMIS);
- The containers should be sealed or closed at all times, unless in use.

Materials shall not be stored indefinitely. Petroleum wastes and empty barrels should not be stored for longer than one year.

Permanent Storage

Permanent storage refers to the storage of materials produced, generated, or used by the petroleum sector in a device that is a permanent, fixed part of an operating facility. Such devices may include

- aboveground tanks;
- underground tanks;
- container storage areas;
- lined earthen excavations; and
- bulk pads.

Storage devices must comply with relevant standards issued by the Kenya Bureau of Standards, e.g. KS 1969:2013 on underground storage tanks, and KS 1938 2012 on storage of LPG. Such devices can also conform to internationally-recognized technical standards applicable to storage operations/facilities, such as those developed by the following organizations:

- Alberta Energy Regulator
- British Standards Institution (BSI)
- Comité Européen de Normalisation (CEN)
- Comité Européen de Normalisation Electrotechnique (CENELEC)
- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)
- Engineering Equipment and Materials Users Association (EEMUA)
- the American Society of Mechanical Engineers (ASME)
- the American Petroleum Institute (API); and
- UK Health and Safety Executive (HSE).

Temporary Storage

Temporary storage refers to the storage of materials produced, generated, or used in specific operations of the petroleum sector and should typically not exceed three months. Specific operations associated with temporary storage are plant turnarounds, construction operations, containment and cleanup of a spill, emergency conditions, and well drilling, completions, testing, and servicing operations (e.g., portable test tanks).

Temporary single-walled aboveground tanks used to store fluids in the above-cited operations do not require an impervious liner; they do require diking unless the operation qualifies for it to be optional. Diking is optional in situations where the site is manned for the duration that fluids are being produced into the tank, the tank is fitted with a high-level shutdown device to prevent fluids from overflowing, or the fluids are not being produced to the tank, but are simply being stored.

Licensees exercising the option to not dike a tank for well drilling, completions, testing, or servicing operations should empty the tank or remove it from the site within 72 hours of completing the operation. Approval holders or licensees should use reasonable judgement to ensure that environmentally sensitive areas are protected and as such, should not consider the option to not dike a tank when it is located close to a water body.

The temporary storage of sludges or solids (e.g., contaminated soil, spill debris, oily waste, drilling waste) from the above-listed operations in steel-fabricated, solids-storage bins (e.g., lugger bins, drilling rig tanks) does not require diking or secondary containment.

Even in temporary storage situations, contaminated materials or materials possessing the potential to leach should not be stored directly on the ground. At the end of the specific operation, the stored materials should be transferred to a permanent storage facility/area or be appropriately treated and/or disposed-of.

As mentioned above, most of Kenya's requirements on waste apply to hazardous waste – as opposed to non-hazardous waste. Therefore, gaps are present in the requirements specifically applicable to the latter. It is recommended to amend Waste Management Regulations to establish requirements for petroleum operators to obtain non-hazardous waste permits granted by NEMA. Such permits should be issued subject to operator's compliance with minimum:

- technical requirements such as design, construction, operation, maintenance, closure, and reclamation of surface pits, ponds, lagoons, or tanks, and
- financial assurance requirements associated with operation of such facilities administrative requirements such as record-keeping, monitoring and reporting

Reporting requirements for drilling fluids or muds

Petroleum Companies shall document the following information and retain it in the well file of the well that generated the drilling waste and make the information available NEMA upon request:

- The surface land location, unique well identifier (UWI), and well license number of the well that generated the drilling waste.
- The type of drilling mud system used, including: i) a list of all fluid additives and mud products used; ii) the volume of each fluid additive and mud product added; iii) luminescent bacteria toxicity documentation, if available, for all fluid additives and mud products used; and iv) metal content documentation, if available, for all of the fluid additives and mud products used and the cumulative metal content of the mud system. If different mud systems were used for different sections of the hole and were segregated and managed separately, the above information must be documented for each system.
- The method used to store the drilling waste, and a plot plan identifying the location of the storage system
- The volume of drilling waste generated and the management method used, including i) drilling waste assessment information, including analytical and field testing results, as well as a sketch of the sump or drilling waste storage system showing the locations and depths of the subsamples taken to obtain the representative composite drilling waste sample; ii) the name, location, and approval number of any waste management facility to which drilling waste was sent; iii) the following information for any land application/disposal method used: receiving soil assessment information; if applicable, post-disposal sampling information; a detailed map of the disposal area; proof of landowner/department/agency consent; and the drilling waste disposal rates and supporting calculations.
- If different drilling waste types (as a result of different mud systems being used) or phases (e.g., clear liquids, fluids, solids, cuttings, total waste, cement returns, drill-stem test fluids) were segregated, the information above must be documented for the management of each segregated type or phase.
- If biodegradation was used to manage the drilling waste, the information documenting the operation must also be provided.

Petroleum Companies shall retain the information listed above in the well file until the well site and any associated remote drilling waste storage or biodegradation site have successfully been reclaimed.

6.3 Liquid waste, hazardous and non-hazardous waste prevention, and control procedures

In accordance with best practices, there are two main approaches to pollution prevention and control of petroleum sector:

- A pollution prevention-based environmental management system;
- Pollution control plan.

Over the last 10 years, a significant shift in focus from pollution control (and waste management) to pollution prevention (and waste minimization) has occurred. The predominant factor causing this shift was the realization that pollution and waste cost money and do not result in any positive revenue stream for the industries that generate them. Today, pollution prevention, energy efficiency, and other environmental best management practices are considered to be quality programs as much as environmental programs.

For the petroleum sector, a pollution prevention-based environmental management system represents a best practice, providing a flexible framework for identifying and implementing pollution prevention alternatives and other process improvements. By developing a system specific to a company's culture and needs, creative problem-solving will be encouraged on a continuous basis. A pollution prevention-based environmental management system is integrated into core business practices. Petroleum operators should develop a pollution prevention-based environmental management system.

Systems Approach to Pollution Prevention

Developing a Pollution Prevention-Based Environmental Management System

The systems approach is an analytical framework that includes process analysis, problem solving and decision-making and results in a series of action plans for implementation.

These action plans will have a high likelihood of success both in terms of environmental and economic benefits. A well-designed pollution prevention-based environmental management system is action-oriented and provides for continuous improvement.

The individual tools within the systems approach are summarized below:

- Build a pollution prevention team;
- Create process maps. Draw diagrams and maps that indicate the processes that generate waste, use energy, and consume resources to identify areas for improved efficiency and productivity;
- Perform activity-based costing and Pareto analysis. Identify total costs for generating and managing wastes to aid in prioritizing areas that require improved efficiency and productivity;
- Perform root cause analysis. Identify the root cause for wastes or losses to determine the most effective avenues for improvement;
- Identify alternatives. Generate a complete list of alternatives using tools to ensure that all possible solutions are considered;
- Prioritize alternatives. Rank alternatives based on relevant factors (e.g., cost, technical feasibility, timetable to implement) to allow for consensus on preferred approaches;
- Develop an action plan. Incorporate the results of the previous steps into a cohesive plan to realize cost-effective pollution prevention, energy efficiency, and resource conservation.

Pollution Prevention Program Development

Traditionally, pollution prevention has been promoted through a hierarchy that addresses (in order from most to least cost-effective) the following:

- Source Reduction
- Recycling
- Treatment
- Disposal

Source Reduction

Source reduction involves the use of processes, practices, or products to reduce or eliminate the generation of pollutants and wastes. Source reduction includes, but is not limited to, material substitution, process substitution, and process elimination.

Material Substitution

Materials that will result in less toxic wastes should be substituted for materials that are currently being used. Examples include the following:

- The substitution of less toxic drilling fluid additives will result in less toxic drilling wastes;
- Shifting from solvent-based paints to water-based paints reduces the toxicity of paint wastes.

Process Substitution or Elimination Processes

Process Substitution or Elimination Processes that result in less waste and increased efficiency should be substituted for processes that are currently being used. Also, entire processes s be eliminated if pollution prevention is implemented. For example:

- Well designs and drilling methods that reduce the volume of cuttings generated;
- Improved transportation methods that reduce the risk of spills and leaks;
- Improved separation techniques at the well that eliminate the need for several gas processing steps; and
- Good Housekeeping and Equipment Maintenance.

Good housekeeping and equipment maintenance are two best management practices that are often low-cost/high-benefit approaches to pollution prevention. A common example of good housekeeping practices involves the use of drip pans to catch leaks or drips from equipment. Equipment maintenance is important for two distinctly different reasons:

- routine maintenance will reduce the occurrence of leaks and drips, and
- routine maintenance will extend the lifetime of the equipment.

Water Conservation

Water conservation is another best management practice which, if successful, will greatly reduce the waste volume from oil and gas operations. Examples include the following:

- Low solids, non-dispersed drilling fluid systems may replace dispersed systems that typically require large volumes of water
- Careful use of water during equipment clean-up and efficient operations of cooling towers may result in reduced water volumes
- Increased use of “smart” pigs or ultrasonic devices to test wall thickness or detect weak spots can enable better targeting of pipeline sections requiring pressure testing or replacement. More efficient pigging and precleaning of pipelines prior to hydrostatic pressure testing will result in greatly reduced volume and toxicity of waste hydrostatic test water

Pollution Prevention in Design and Planning

Designing or planning for a new process or operation is the best time to address pollution prevention considerations. With an existing process, implementing pollution prevention can require some possible down time due to either equipment reengineering or technician training. This will greatly add to the cost and, therefore, reduce the economic benefit of the particular pollution prevention approach. In the design and planning phase, there is no status quo and, therefore, no down time and associated costs.

Training and Awareness

Training and awareness programs are critical to ensuring that pollution prevention is realized to its fullest potential. The best ideas will come from persons who work with machines, use materials, and

generate waste. These persons should be aware that often there are alternatives and that they constantly need to be thinking about ways to improve operations, efficiency, etc. It is always more effective to provide pollution prevention training to persons with process knowledge (often, the implementers and stakeholders) than to provide "pollution prevention experts" with process knowledge to develop a pollution prevention plan.

Life-Cycle Analysis

Pollution prevention often utilizes a principle known as "lifecycle analysis" to address all associated costs and possible solutions associated with a particular process or waste. Life-cycle analysis, sometimes referred to as "cradle-to-grave" analysis, is often used to track a particular material from its inception to its ultimate demise. This tracking usually requires documentation from other companies (both vendors and customers) in the material chain. In material substitution, for example, a possible material alternative that would drastically reduce a particular waste stream may require a process change by the vendor first. Also, a positive pollution prevention approach implemented by a particular company could have negative impacts to its customers or contractors. For these reasons, it is helpful to include vendors, customers, and contractors as part of the pollution prevention team.

Inventory Control

Inventory control addresses the effective use of data and information to track the procurement, use, and management of materials throughout the operation. Inventory control practices include the following:

- "Just-in-Time" procurement. Only purchase what is needed in the amounts needed. This is extremely important for chemicals or materials that have relatively short shelf-lives and have to be disposed if not used in a timely manner.
- Affirmative Procurement. Only purchase materials that have been or can be recycled. Purchase non-hazardous chemicals and materials whenever possible.
- Barcoding. Use barcodes to track material usage throughout the facility. This is extremely helpful in limiting the amount of material purchased if it is known how much of that material may be already stored at the facility. Through a chemical or material exchange program, chemicals and materials can be obtained from operations within the facility instead of having to purchase the materials.

Recycling

Recycling is addressed in two different fashions whenever possible: 1) in-process recycling, and 2) end-of-pipe recycling.

- In-process recycling implies that a material is recycled before it becomes a waste. If the material is not being treated as a waste, then waste management regulatory requirements are not applicable to these processes (no treatment permit required, for example). Because the recycling is in-process, the development of the alternatives requires knowledge of the process itself.
- End-of-pipe recycling implies that the material being recycled has already become a waste. In many cases, waste management regulatory requirements are applicable to these recycling processes.

Treatment (including waste segregation)

Waste treatment is usually the third option after source reduction and recycling opportunities have been exhausted. Treatment includes techniques such as precipitation, neutralization, stabilization, and incineration. Waste segregation is also considered as a treatment alternative. In many cases, waste treatment is performed off-site by a contracting organization. The waste generating organization should maintain very careful records regarding the contents of the waste so the proper waste

management procedures can be carried out. In many cases, information regarding the process that generated the waste is maintained with the waste information. Waste segregation is an environmental best management practice designed to reduce costs through storing incompatible wastes separately, including separating hazardous from non-hazardous wastes, or regulated from non-regulated wastes. In many circumstances, mixing regulated with non-regulated wastes renders the entire waste contents regulated and unnecessarily increases waste management costs.

Disposal

If there are no other practical options, disposal needs to be carried out in an environmentally responsible manner. In the majority of cases, waste disposal will be provided by a contractor. It is critically important that proper documentation and records are maintained regarding waste disposal both by the parent company and the contractor. In many regulatory environments, liability for the disposal of waste, for example, is not totally eliminated after the waste is removed from the site.

Section 8.1 below, on Pollution Prevention Alternatives for Waste Generated in O&G Operations, provides a list of waste streams typical produced in the petroleum sector, and pollution prevention alternatives. Such alternatives are provided based on the aforementioned hierarchy, i.e., source reduction, recycling, treatment, and disposal.

Traditional and Discrete Recommended Best Management Practices[32]

These best management practices were taken from the New Mexico Oil Conservation Division OCD's guidelines for permitting certain types of facilities in the oil and gas sector. The OCD has put together a list of traditional best management practices that are normally imposed on a facility. The list is not conclusive and sometimes may vary with site specific conditions. The emphasis of this list is to provide the sector with best management practices that have normally satisfied most regulatory concerns for the protection of public health and the environment.

Any good pollution prevention plan should detail the methods or techniques the operator proposes to use which ensure the operator's activities will not cause state regulations or groundwater standards to be violated and provides protection to public health and the environment. These best management practices should be used as guidance in considering alternatives in the company's comprehensive pollution prevention and environmental management system.

The list is as follows:

1. Waste Disposal: All wastes must be disposed of at an OCD approved facility. Only oilfield exempt wastes may be disposed of down Class II injection wells. Non-exempt oilfield wastes that are non-hazardous may be disposed of at an OCD approved facility upon proper waste determination.
2. Drum and Saddle Tank Storage: All drums and saddle tanks containing materials other than fresh water or fluids that are gasses at atmospheric temperature and pressure must be stored on an impermeable pad with curbing. Chemicals in other containers such as sacks or buckets must be stored on an impermeable pad and curb type containment.
3. Facility General Areas: Any facility area which shows evidence that leaks and spills are reaching the ground surface must be either paved and curbed or have some type of spill collection.
4. Above Ground Tanks: All above ground tanks which contain fluids other than fresh water must be contained in an impermeable bermed enclosure to contain a volume of one-third more than the total volume of the largest tank or of all interconnected tanks.

[32] http://www.emnrd.state.nm.us/ POLLUTIONPREVENTIONBESTMANAGEMENTPRACTICES for the New Mexico Oil and Gas Industry Prepared for New Mexico Energy, Minerals, and Natural Resources Department Santa Fe, New Mexico 2000

5. Below Grade Tanks/Sumps: All below grade tanks, sumps, and pits must have secondary containment and leak detection.
6. Housekeeping: Proposed methods for preventing contaminants from reaching the ground surface must be stated in the BMP. Records of inspections must be made and retained.
7. Spill Reporting: All spills/releases will be reported and remediated regulatory requirements.
8. Surface Water Protection: Any water contaminants must be contained within the facility boundaries. A description of the methods used to achieve this goal must be included in the BMP

Oil and Gas Exploration and Production

Oil and gas exploration and production activities include drill site preparation and drilling rig and oil field production operations. Examples of oil and gas exploration production process maps are presented below. Following each process map is a description of typical waste streams and pollution prevention alternatives that would likely result from implementing the systems approach tools.

- **Drill Site Preparation**

Wastes	Pollution Prevention Alternatives
Debris	• Develop procedures to keep areas clear of debris and practice good housekeeping to prevent contamination with lubricating oil. • Store in labelled containers/dumpsters. • Do not mix with contaminated or potentially hazardous material. • Recycle paper, metal, cardboard, and aluminium cans. Lubricating oil contaminated soil from heavy equipment (e.g., bulldozers)
Lubricating oil contaminated soil from heavy equipment (e.g., bulldoze	• Develop procedures to prevent contamination of soils; include preventative maintenance on lubricating oil system and containment. • Contain lubricating-oil spill; pick up and store in labelled container or recycle (if free liquid).
Contaminated rainwater (storm water)	• Improve work processes, and maintain equipment and facilities to prevent leaks and spills. • Cover facilities to prevent contamination of rainwater

- **Drilling Rig Operation**

Wastes	Pollution Prevention Alternatives
Lubricating oil	• Test oil and extend its use based on wear versus accumulated operating hours. • Recycle in-process whenever possible.
Spilled fuel	• Contain spill as soon as possible. • Incorporate good housekeeping to prevent spills
Drilling cuttings	• Minimize drilling hole size when possible. • Design and monitor drilling mud activities to minimize caving. • Substitute organic additives, polymers, or biodegradable additives for oil-based mud to reduce costs associated with clean-up of oil-based drill cuttings
Mud and additives	• Use a closed-loop mud system. • Use the reserve pit management system. • Optimize solids control. • Use low solids, non-dispersed muds.

	• Use an inside diameter wiping tool for drill pipe. • Control inventory (accurately estimate amounts required and purchase only as needed), and plan ahead to avoid unused materials. • Use unused additives at other sites
Pipe dope	• Choose biodegradable, lead-free pipe dope. • Purchase only what is needed.
Spent drill stem	• Purchase highly durable drill bits
Surplus casing	• Purchase and use only what is needed • Use surplus at other sites
Cement/grout	• Purchase and use only what is needed • Use surplus cement for erosion prevention • Return unused dry cement to vendor
• Produced water	• Use a closed-loop drilling fluid system. • Drill horizontal wells to minimize water production • Optimize production rate to minimize the influx of water • Treat the producing formation with polymers that decrease the permeability of water, while maintaining the permeability of hydrocarbons • Hydrotest pipelines, equipment, and tanks with produced water
Drums and containers	• Reuse drums and containers, clean (triple rinse) first only if necessary
Spent and unused solvents	• Substitute non-hazardous biodegradable surfactants (soap) for hazardous solvents (mineral spirits) to clean equipment. • Use drip pans to collect solvent for reuse (use dirty solvent for initial cleaning and clean solvent for final cleaning, if necessary). • Use spent solvent for paraffin removal or as paint thinner. • Control inventory (accurately estimate amounts required and purchase only as needed) to minimize the storage of unnecessary solvent
Oily rags	• Maintain equipment and facilities so that clean-up with rags is minimized • Segregate from other waste, and wash for reuse
Surplus chemicals	• Control inventory by accurately estimating amounts required, or purchasing smaller quantities only as needed. • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal. • Use non-hazardous products. • Store and maintain chemicals properly to prevent spills or leaks.
Rigwash	• Use dry cleaning when feasible. • Use low-volume, high-pressure hose nozzles with automatic cut-offs. • Remove paint solids from water and reuse.
Paint and paint wastes	• Paint only when necessary. • Purchase only the required amount and use it all before it becomes unusable. • Size the paint batch according to the specific job • Purchase highly durable paints • Control and reduce overspray

Sandblast media	• Use paints that do not require sandblasting • Use as aggregate in road mix, if allowable.
Liter and debris	• Rent rollaway trash trailer at drill site. Dispose of trash as needed.

- **Well Completion**

Wastes	Pollution Prevention Alternatives
Paraffin	• Install magnetic fluid conditioner to prevent paraffin formation • Use paraffin inhibitor chemicals • Use hot-oil treatment to dissolve paraffin in well and flow lines
Lubricating oil	• Test oil and extend its use based on wear versus accumulated operating hours. • Recycle in-process whenever possible
Produced water	• Use a closed-loop drilling fluid system • Drill horizontal wells to minimize water production • Optimize production rate to minimize the influx of water • Treat the producing formation with polymers that decrease the permeability of water, while maintaining the permeability of hydrocarbons. • Hydrotest pipelines, equipment, and tanks with produced water
Treating chemicals	• Control inventory by accurately estimating amounts required, or purchasing smaller quantities only as required • Offer to give to or exchange unused chemicals with other facilities in lieu of recycling, treatment, or disposal • Use non-hazardous products • Store and maintain chemicals properly to prevent spills or leaks
Sand	• Optimize production rate to minimize sand production • Use uncontaminated sand as fill material
Paint	• Paint only when necessary • Purchase only the required amount and use it all before it becomes unusable • Size the paint batch according to the specific job • Purchase highly durable paints • Control and reduce overspray.
Slop oil	• Recycle back into production stream • Replace impeller-type pumps used for fluid transfer service with “canned” submersible pumps to eliminate leaks from impeller pump seals and gear boxes • Send slop oil that cannot be recycled into production to a state-permitted tank bottoms reclamation facility
Scale	• Use scale inhibitors • Avoid mixing incompatible produced waters, which results in scale formation
Lubricating oil filters	• Change filters only when necessary • Use reusable filters • When handling filters, take precautions to prevent oil spillage • Isolate all drained fluids in a resealable container for in-process recycling.

Pit Liner	• Remove waste and liner for proper disposal • Remove oil and salt-laden mud, fold in and close with liner in place.

- **Separation and Treatment of Well Fluids**

Wastes	Pollution Prevention Alternatives
Blowdown	• Recycle back into production stream • Operate cooling towers efficiently to minimize the generation of blowdown • Cascade water use
Produced sand and scale	• Optimize production rate to minimize sand production • Use uncontaminated sand as fill material • Use scale inhibitors • Avoid mixing incompatible produced waters, which results in scale
Produced water contaminated soils	• Follow procedures, including maintenance, to prevent soil contamination • Use impervious primary and secondary containment • Use cathodic protection or coated pipe to reduce leaks due to corrosion
Surplus chemicals	• Accurately estimate amounts required, or purchase smaller quantities only as required • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Use non-hazardous products • Store and maintain chemicals properly to prevent spills or leaks
Filters	• Change filters only when necessary • Use reusable filters • Use differential pressure as an indicator of needed change • When handling filters, take precautions to prevent oil spillage • Isolate all drained fluids in a resealable container for in-process recycling

- **Storage and Transportation**

Wastes	Pollution Prevention Alternatives
Paraffin	• Install magnetic fluid conditioner(s) to prevent paraffin formation • Use paraffin inhibitor chemicals • Use hot-oil treatment to dissolve paraffin in well and flow lines
Produced water	• Use a closed-loop drilling fluid system • Drill horizontal wells to minimize water production • Optimize production rate to minimize the influx of water • Treat the producing formation with polymers that decrease the permeability of water, while maintaining the permeability of hydrocarbons • Hydrotest pipelines, equipment, and tanks with produced water
Produced sand	• Optimize production rate to minimize sand production
Scale	• Use scale inhibitors

	• Avoid mixing incompatible produced waters which will result in scale • May contain naturally occurring radioactive materials (NORM).
BS&W\tank bottoms	• Identify and reduce the source of solids • Recycle back through treatment system • Use cone-bottomed stock tanks and frequently run bottoms through heater-treater
Oil contaminated soil	• Develop procedures to prevent contamination of soils; include preventative maintenance on flow lines and primary and secondary containment under tank battery load-line connections • Use summary or secondary containment under tanks • Contain crude-oil spill; pick up and store in labelled container or recycle
Treating chemicals	• Control inventory by accurately estimating amounts required or purchasing smaller quantities only as required • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Use nonhazardous products
Volatile air emissions	• Install a vapor recovery system

- **Measurement and Testing**

Wastes	Pollution Prevention Alternatives
Surplus chemicals	• Control inventory by accurately estimating amounts required, or purchasing smaller quantities only as required • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Use non-hazardous products • Store and maintain chemicals properly to prevent spills or leaks.
Produced sand	• Optimize production rate to minimize sand production
Produced water	• Use a closed-loop drilling fluid system • Drill horizontal wells to minimize water production • Optimize production rate to minimize water influx • Treat the producing formation with polymers that decrease the permeability of water, while maintaining the permeability of hydrocarbons • Hydrotest pipelines, equipment, and tanks with produced water.
Volatile air emissions	• Install a vapor recovery system.

- **Pipeline**

Wastes	Pollution Prevention Alternatives
Waste from leaks	Reduce amount of waste generated by the following methods: • Use leak detection technology (e.g., chemical sensing cables) • Inspect for leaks in natural gas pipelines with surface-sampling instruments by the flame-ionization principle • Inspect areas for pools of product or dead vegetation on the pipeline right of way (Leaks in liquid natural gas pipelines are not as

	easily detected, and the soil around the line must be tested for constituents like propane and butane • Detect leaks through investigating loss of working line pressure • Train dispatchers and employees to recognize situations that are likely to result in leaks and to intervene appropriately • Inspect for worn gaskets and valve stem packings, fractures and corrosion in the pipeline and perform preventative maintenance. Inspection may be done manually or using smart pigs. Prevent corrosion in pipelines that may cause leaks or structural problems by the following methods: Coat pipe and joints to insulate metal from soil. • Construct anodes or "ground beds" at strategic points along the pipeline. These ground beds provide cathodic protection by inducing a very small electrical charge into the soil, impeding the flow of electrons to the pipe • Add corrosion protection to tank bottoms • Monitor groundwater • Inspect seals, valves, and pumps and perform preventative maintenance to avoid leaks • Ensure that liquids have impermeable primary and secondary containment • Aboveground tanks should have secondary containment underneath tank bases and piping (or move piping above ground for daily visual inspection) to capture any releases before soil or groundwater is contaminated.
Filters	• Replace filters only as needed • Change filters only when necessary. Use differential pressure as an indicator of needed change • Use stainless steel, reusable filters • Evaluate applicability of filterless centrifugal oil cleaning. (Use "spinners" to replace or lengthen oil filter life. • Install lubricating oil purification equipment to reduce frequency of conventional filter replacement • Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle free liquids back into production stream.
Tank bottom sludges	• Keep turbulent flow in tank to prevent sedimentation • Add appropriate chemical agents to reduce tank bottom
Pigging wastes	• Use appropriate chemicals to reduce accumulation of paraffin

- **Liquid Hydrocarbon Separation**

Wastes	Pollution Prevention Alternatives
Surplus chemicals	• Control inventory by accurately estimating amounts required or purchasing smaller quantities only as needed • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Use non-hazardous products • Store and maintain chemicals properly to prevent spills or leaks. Use impervious primary and secondary containment.

Blowdown	• Substitute brand of scale inhibitor for more effective brand • Recycle back into production stream • Operate cooling towers efficiently to minimize generation of blowdown • Cascade water use.

- **Dehydration**

Wastes	Pollution Prevention Alternatives
Glycol	• Test regularly to avoid potential problems (e.g., corrosion) • Optimize flow rates in the dehydration system • Maintain proper temperatures to avoid hydrocarbon contamination.
Filters	• Use filterless centrifugal oil cleaning to replace or lengthen oil filter life • Change filters only when necessary. Use differential pressure as an indicator of needed change • Use reusable filters. • When handling filters, take precautions to prevent oil spillage • Isolate all drained fluids in a resealable container for in-process recycling
Activated charcoal	• Send to recycling facility
Spent molecular sieve	• Install activated carbon upstream of the unit to remove corrosion inhibitors, amines, absorber oils, glycol, and other contaminants to extend the life of the sieve • Regenerate for reuse.

- **Recovery of Natural Gas Liquids**

Wastes	Pollution Prevention Alternatives
Iron sulphides	• Consider alternative methods of removing hydrogen sulfide from gas stream • Treat production streams with biocide or scale inhibitor to reduce iron sulphide formation.
Slop oil	• Recycle back into production stream • Replace impeller-type pumps used for fluid transfer service with “canned” submersible pumps to eliminate leaks from impeller pump seals and gear boxes • Send slop oil that cannot be recycled into production to a state-permitted tank bottoms reclamation facility
Paraffin	• Install magnetic fluid conditioner(s) to prevent paraffin formation • Use paraffin inhibitor chemicals. • Use hot oil treatment to dissolve paraffin in well and flow lines.
Lubricating oil	• Test oil and extend its use based on wear versus accumulated operating hours • Recycle in-process whenever possible.
Filters	• Use filterless centrifugal oil cleaning to replace or lengthen oil filter life

	• Change filters only when necessary. Use differential pressure as an indicator of needed change • Use reusable filters • When handling filters, take precautions to prevent oil spillage • Isolate all drained fluids in a resealable container for in-process recycling
Blowdown	• Substitute brand of scale inhibitor for more effective brand • Recycle back into production stream • Operate cooling towers efficiently to minimize the generation of blowdown • Cascade water use

- **Sulphur Compound Removal**

Gas and product treating includes the removal of sulphur compounds, primarily hydrogen sulphide (H2S) and carbon dioxide (CO2), from gas through a process called "sweetening."

Amine Absorption Alternatives

Wastes	Pollution Prevention Alternatives
Amines	• Use an amine reclaimer in the system to allow reuse of amine and minimize the volume of waste generated. • Use an amine filter to extend life of solution and maintain efficiency.
Filters (amine and charcoal)	• Change filters only when necessary. Use differential pressure as an indicator of needed change • Use reusable filters • When handling filters, take precautions to prevent oil spillage • Isolate all drained fluids in a resealable container for in-process recycling
Iron sponge and iron sulphide scale	• Consider alternative methods of removing hydrogen sulphide from gas stream • Treat production streams with biocide or scale inhibitor to reduce iron sulphide formation.

- **Dry Bed Absorption Alternatives**

Wastes	Pollution Prevention Alternatives
Air emissions (e.g., SO2)	• Operate equipment efficiently to minimize air emissions • Inspect, monitor, and maintain equipment regularly • Install and maintain catalytic converters • Reduce horsepower demands to reduce emissions.
Catalysts (e.g., activated natural bauxite, aluminium oxide)	• Substitute a less hazardous catalyst • Use catalyst completely before removing from the system • Regenerate spent catalyst
Blowdown	• Substitute brand of scale inhibitor for more effective brand • Recycle back into production stream • Operate cooling towers efficiently to minimize the generation of blowdown

- **Well Servicing and Workover**

Wastes	Pollution Prevention Alternatives
Hydraulic fluids	• Introduce into production stream at facility where generated.
Spent solvents	• Use biodegradable, water-based solvents or soap cleaners. • Substitute non-hazardous surfactants (soap) for hazardous solvents (mineral spirits) for equipment cleaning • Use up all solvent in containers; ensure that no residues remain • Minimize amount of solvent being lost during cleaning or maintenance (e.g., use drip pans to collect solvent for reuse) • Clean equipment with high-pressure water, steam, or nontoxic solvents • Keep solvent containers tightly covered to decrease loss due to vaporization • Use inventory control to minimize volume of unnecessary solvent stored • Use dirty solvent for initial cleaning and clean solvent for final cleaning.
Used oil	• Minimize the volume of lubricating oil by extending its use • Test oil and extend its use based on wear versus accumulated operating hours. • Install lubricating oil purification equipment on engines to eliminate the need for lubricating oil changes • Practice preventative maintenance to reduce leaks and drips • Contract with service company to purify and regenerate oil for reuse rather than replacing with new lubricating oil • Consider use of synthetic oil • Use oil additives that improve engine and oil performance. Used oil filters • Change filters only when necessary. Use differential pressure
Used oil filters	• Change filters only when necessary. Use differential pressure as an indicator of needed change. • Use stainless steel, reusable filters. • Evaluate applicability of filterless centrifugal oil cleaning. Use "spinners" to replace or lengthen oil filter life. • Install lubricating oil purification equipment to reduce frequency of conventional filter replacement. • Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle free liquids back into production stream.
Produced water	• • Drill wells to minimize water production (e.g., horizontal wells, if feasible) • Recycle water in hydrotesting of pipeline, equipment, and tanks.
Muds	• Use a closed-loop mud system whenever possible to reduce volumes of drilling fluid wastes. • Optimize solids control (e.g., hydrocyclones or centrifuges) to minimize need to dilute mud • Use low solids, non-dispersed muds whenever drilling conditions allow.

Acids	• Recycle by neutralizing excess caustics (see 40 CFR §264.1 (g)(6)).
Fracturing fluids	• Use "mix-on-the-fly" systems for fracturing fluids • Recycle unused fracturing oil back into production stream • Plan fracturing job carefully to avoid mixing unnecessary fluids.

- **Well Treatment**

Wastes	Pollution Prevention Alternatives
Drums and containers	• Switch to purchase of materials and chemicals in bulk containers, reducing the amount of drums requiring handling. Added benefit: less drum handling results in fewer spills and releases requiring clean-up (of contaminated soil) • Purchase materials in returnable/recyclable drums and containers
Unused or spent chemicals	• Control inventory by accurately estimating amounts required, or ordering small quantities only as needed • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Determine whether non-hazardous or less hazardous products are available by asking manufacturers' representatives and trade groups.
Produced water	• Recycle water in hydrotesting of pipeline, equipment, and tanks.
Fracturing fluids	• Use "mix-on-the-fly" systems for fracturing fluids • Recycle unused fracturing oil back into production stream • Plan fracturing job carefully to avoid mixing unnecessary fluids

- **Enhanced oil recovery operations**

Wastes	Pollution Prevention Alternatives
Unused or spent chemicals	• Control inventory by accurately estimating amounts required, or ordering smaller quantities only as needed • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Determine whether non-hazardous or less hazardous products are available by asking manufacturers' representatives and trade groups.
Fuel oil filters	• Change filters only when necessary. Use differential pressure as an indicator of needed change • Use stainless steel, reusable filters • Evaluate applicability of filterless centrifugal oil cleaning. Use "spinners" to replace or lengthen oil filter life • Install lubricating oil purification equipment to reduce frequency of conventional filter replacement • Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle free liquids back into production stream
Spilled oil	• Sump placed at fill line (sump equipped with pump and level switch).

- **Rig Maintenance**

Wastes	Pollution Prevention Alternatives
Unused or spent chemicals	• Control inventory by accurately estimating amounts required, or ordering smaller quantities only as needed • Offer (or exchange) unused chemicals to other facilities in lieu of recycling, treatment, or disposal • Determine whether nonhazardous or less hazardous products are available by asking manufacturers' representatives and trade groups
Fuel oil filters	• Change filters only when necessary. Use differential pressure as an indicator of needed change • Use stainless steel, reusable filters • Evaluate applicability of filterless centrifugal oil cleaning. Use "spinners" to replace or lengthen oil filter life • Install lubricating oil purification equipment to reduce frequency of conventional filter replacement • Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle free liquids back into production stream.

- **Truck Transportation**

Wastes	Pollution Prevention Alternatives
Rinse water	• Recycle wash and rinse water within a closed loop system (e.g., rinse water from the last rinse can be recycled as wash water for the cleaning step
Spilled chemicals	• Store and maintain chemicals properly to prevent spills or leaks • Only retain the smallest possible quantities.
Oil Filters	• Keep good records of truck maintenance and replace filters as infrequently as possible to ensure maintenance • Change filters only when necessary. Use differential pressure as an indicator of needed change • Use stainless steel, reusable filters • Evaluate applicability of filterless centrifugal oil cleaning. (Use "spinners" to replace or lengthen oil filter life.) • Install lubricating oil purification equipment to reduce frequency of conventional filter replacement • Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle free liquids, if possible

- **Accident avoidance**

Wastes	Pollution Prevention Alternatives
Spilled product	• Ongoing driver safety training • Safe driver incentive programs • Contingency plans and implementation training including: spill response, equipment use, waste management, reporting

Liquid Waste

Kenyan regulation does not recognise specific waste waters that are common in upstream, midstream and downstream petroleum operations. This classification can assist with establishing effluent standards and other relevant environmental requirements. The following wastewaters are typical for petroleum sector:

Upstream Onshore/Offshore/ Midstream

- Produced Water.
- Hydrostatic Testing Water
- Sewage
- Drainage and storm waters
- Tank bottom waters
- Firewater
- Wash waters
- General oily water
- Cooling Water
- Ballast and storage displacement water
- Deck drainage water

Downstream:

- Industrial Process Wastewater - Sour wastewater is generated from desalting, topping, vacuum distillation, pre-treating, light- and middle-distillate hydrodesulfurization, hydrocracking, catalytic cracking, coking, and breaking/thermal cracking.
- Hydrostatic Testing Water

Neither does local regulation provide guidance on methods and procedures of sampling and analysis of liquid effluents. Annex 8.6 contains a matrix on parameters and analytical procedures for substances frequently released by petroleum sector.

6.4 Waste transportation, treatment, and disposal procedures

6.4.1 Transportation

6.4.1.1 Manifesting

An integral component of proper waste management is the use of documents (manifests) to ensure wastes are safely transported and received at their intended point of treatment and/or disposal. Waste tracking is an equally important component of proper waste management. Waste tracking refers to a system by which the handling, movement, treatment, and disposal of wastes are monitored by the waste generator.

A manifest should be completed and accompany the waste shipment when transporting hazardous waste on public roads. Manifests are documents that include specific information about the waste, its source and its destination. These documents provide detailed information to first responders in the event of an accident, and serve as a tool for confirming that shipments of dangerous wastes are properly handled, transported, and disposed-of.

The shipping name identified on the manifest, which is used to describe the waste, should be determined in accordance with the classification system detailed in section 6.1 above. Shipments of mixed wastes comprised of several waste types should be manifested as the most dangerous waste contained if the individual quantities of each waste type are not known. Indicate the total volume of

the waste on the manifest. The waste generator should indicate on the manifest or attachment the waste types included in the mixed waste shipment.

Manifests are composed of one original and three copies of the same form containing the information detailed above. The generator and the transporter should fill in information in the original. After the generator hands over the waste to the transporter, the former retains the first copy, and the latter keeps the original, and the remaining copies. When the transporter delivers the waste to the receiver, the former retains the second copy of the manifest, and surrenders the remaining copies and the original to the receiver. After verifying that there are no discrepancies between the cargo and the manifest, the receiver should complete the original form, retain the third copy of the manifest, and give the original back to the generator. Manifest copies and supporting documentation should be retained by all parties (generator, transporter, and receiver) for a minimum of two years from the date of shipment.

If the receiver notes a serious discrepancy regarding the quantities or characteristics of the waste shipped relative to what was received, the receiver should notify the generator and the transporter within 24 hours of the time received. A serious discrepancy is one which may have resulted in an impact to the environment (i.e. spills, leakage, waste does not arrive at intended receiver) or one where the waste received differs significantly from the waste sent by the generator. In cases where a serious discrepancy is the result of an action by the transporter (i.e. accident, leak, etc.) the transporter should notify the generator within 24 hours of the occurrence. All other discrepancies should be notified as soon as possible, but no later than 60 days from the date of shipment.

Section 8.4 below provides a manifest form template.

Notwithstanding the recommendations mentioned above, where a single truck must make several trips to move the entire quantity of a specific oilfield waste, a single manifest may be used with attachments documenting each load. Where more than one truck is used to move a quantity of the specific oilfield waste, each truck must carry a manifest, with attachments for repeat trips if necessary. If the information requirements in any particular case exceed the limitations of the manifest, it is acceptable to use attachments provided their existence is indicated on the manifest.

A manifest is not required for the following:

- when the quantity of hazardous waste transported does not exceed 5 kg or 5 L;
- when the waste is a non- hazardous;
- when the oilfield wastes are treated/disposed on-site;
- when the waste is uncontaminated produced water (contaminants which would make the produced water hazardous, must not be present);
- when the hazardous waste is transported from the site of origin to another site, provided the licensee or approval holder of both sites are the same; and
    - the person in charge of the vehicle transporting the hazardous waste displays on the vehicle a placard that corresponds to the placards set out internationally-recognized hazard communication systems, such as the UN Recommendations on the Transport of Dangerous Goods, and
    - the shipment is accompanied by a shipping document that shows the hazard class, the emergency response contact, the total mass or volume of the hazardous waste to which the shipping document relates, and the number of packages where applicable.

6.4.1.2 Tracking

Waste generators are responsible for tracking their wastes from "cradle to grave". Generators should be aware of the quantities and types of waste they generate, how they are handled, and where and how they are ultimately disposed of. The generator is responsible for ensuring appropriate treatment and disposal of the waste occurs.

All waste generators are required to implement and maintain a waste tracking system. The development and type of system used is solely their choice and preference. All tracking systems should be effective and capable of displaying due diligence. The system should be capable of providing information required for the waste disposition report (see below).

Generators are encouraged to develop a waste disposition report (WDR). The WDR is a summary of the types and quantities of wastes, the point(s) of generation/consolidation and the specific disposal method(s) utilized. All hazardous and many non-hazardous wastes which are treated/disposed should be included. The waste generator should include in their report, any waste disposed by service companies which was generated in association with the generator's operations.

Tracking system data, and the WDR are to be maintained for a minimum of two years.

6.4.2 Treatment and Disposal

This section contains a summary of recommended treatment and final disposal methods for the most common types of waste associated with the petroleum sector.

6.4.2.1 Drilling Fluids and Drilled Cuttings

The primary functions of drilling fluids used in oil and gas field drilling operations include removal of drilled cuttings (rock chippings) from the wellbore and control of formation pressures. Other important functions include sealing permeable formations, maintaining wellbore stability, cooling and lubricating the drill bit, and transmitting hydraulic energy to the drilling tools and bit.

Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams generated during oil and gas drilling activities. Numerous drilling fluid systems are available, but they can generally be categorized into one of two fluid systems:

- Water-Based Drilling Fluids (WBDF): The continuous phase and suspending medium for solids (or liquid) is water or a water miscible fluid. There are many WBDF variations, including gel, salt-polymer, salt-glycol, and salt-silicate fluids;
- Non-Aqueous Drilling Fluids (NADF): The continuous phase and suspending medium for solids (or liquid) is a water immiscible fluid that is oil-based, enhanced mineral oil-based, or synthetic-oil based.

Diesel-based fluids are also available, but the use of systems that contain diesel as the principal component of the liquid phase is not considered current good practice.

Typically, the solid medium used in most drilling fluids is barite (barium sulfate) for weight, with bentonite clays as a thickener. Drilling fluids also contain a number of chemicals that are added depending on the downhole formation conditions.

US approach – disposal of drilling fluids:

Drilling fluids should be disposed of separately from other wastewater to prevent contamination of drinking water and soil. Drilling fluids and muds are typically not introduced into the general waste stream or sewerage systems.

For onshore operations, land-spraying, reinjection, or biodegradation are options. Injection wells may be preferable with specific well design and monitoring requirements necessary.

For offshore operations, reinjection or overboard discharges are options. Limitations on types of fluids and discharge rates should be implemented.

UK Approach – use and disposal of drilling muds

Synthetic and Oil Based Muds

- The use of oil- and synthetic-based drilling muds is discouraged with technical justifications to the regulator required for any use.
- Disposal of drill cuttings from oil-based and synthetic -based mud require an oil discharge permit and it must be shown to be the Best Practicable Environmental Option (BPEO)
- Are prohibited overboard, unless treated to be <1% oil-based fluid/mud contamination by dry weight
- Discharges of oil-based muds or oil-based fluids that may occur at well start-up should be included in the drilling operation application along with estimates of volumes and tonnage of the expected discharge.
- Components of oil-based mud systems must be listed individually on the application.
- Actual discharges must be reported later.

Water Based Muds

Disposal of water-based drilling muds is permitted

- onsite with an oil discharge permit
- offsite by reinjection without a permit
- overboard with details reported to BEIS
- there are no reporting or monitoring requirements for reinjection of water-based mud cuttings.

Nigeria Approach

EGSASPIN states that except otherwise specifically permitted by the Director of Petroleum Resources, whole drilling mud/fluids, spent drilling mud/fluids, brine, drill cuttings, well treatment wastes, deck drainage or residues thereof, from water and oil/synthetic based muds from drilling activities shall not be discharged directly or indirectly into:

- Any inland waters (fresh, brackish, (tidal or non-tidal) or (reservoir)
- Swamp, coastal or nearshore waters and shallow offshore
- Any pit on land/swamp other than approved temporary holding retention pit(s) and/or steel tanks so designed and utilized that there shall be no overflow, leakage or seepage. Such discharges shall be permitted in offshore (discharge zones) areas 12 nautical miles away from the shoreline and of depth not less than 200 feet provided the limitations as specified in are satisfied.

IFC provisions (drilling fluids/cuttings and completion and well work-over fluids)

Onshore

Drilling fluids are circulated downhole and routed to a solids control system at the surface facilities where fluids can be separated from the cuttings so that they may be recirculated downhole leaving the cuttings behind for disposal. These cuttings contain a proportion of residual drilling fluid. The drilling fluid is replaced when its rheological properties or density of the fluid can no longer be maintained or at the end of the drilling program. These spent fluids are then contained for reuse or disposal (NADFs are typically reused).

Feasible alternatives for the treatment and disposal of drilling fluids and drilled cuttings should be evaluated and included in the planning for the drilling program.

Alternative options may include one, or a combination of, the following:

- Injection of the fluid and cuttings mixture into a dedicated disposal well;
- Injection into the annular space of a well;
- Storage in dedicated storage tanks or lined pits prior to treatment, recycling, and / or final treatment and disposal;
- On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal using established methods such as thermal desorption in an internal thermal desorption unit to remove NADF for re-use, bioremediation, landfarming, or solidification with cement and/or concrete. Final disposal routes for the non-hazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill, including landfill cover and capping material where appropriate. In case of landfarming, it should be demonstrated that subsoil chemical, biological and physical properties are preserved, and water resources are protected;
- Recycling of spent fluids back to the vendors for treatment and re-use.

Consider minimizing volumes of drilling fluids and drilled cuttings requiring disposal by:

- Use of high efficiency solids control equipment to reduce the need for fluid change out and minimizing the amount of residual fluid on drilled cuttings;
- Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids and cuttings generated.

Pollution prevention and control measures for spent drilling fluids and drilled cuttings should include:

- Minimizing environmental hazards related to residual chemicals additives on discharged cuttings by careful selection of the fluid system;
- Careful selection of fluid additives taking into account technical requirements, chemical additive concentration, toxicity, bioavailability and bioaccumulation potential;
- Monitoring and minimizing the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock used in the fluid formulation.

The construction and management measures included in these guidelines for surface storage or disposal pits should also apply to cuttings and drilling fluid pits (see section on produced water below). For drilling pits, pit closure should be completed as soon as practical, but no longer than 12 months,

after the end of operations. If the drilling waste is to be buried in the pit following operations (the Mix-Bury-Cover disposal method), the following minimum conditions should be met:

- The pit contents should be dried out as far as possible;
- If necessary, the waste should be mixed with an appropriate quantity of subsoil (typically three parts of subsoil to one part of waste by volume);
- A minimum of one meter of clean subsoil should be placed over the mix;
- Topsoil should not be used but it should be placed over the subsoil to fully reinstate the area;
- The pit waste should be analyzed and the maximum lifetime loads should be calculated.

A risk based assessment may be necessary to demonstrate that internationally recognized thresholds for chemical exposure are not exceeded.

Treatment and disposal of drilling fluids and drilled cuttings offshore

Drilling Fluids and Cuttings – NADF

1) NADF: Reinject or ship-to-shore, no discharge to sea

2) Drilled cuttings: Reinject or ship-to-shore, no discharge to sea except:

- Facilities located beyond 3 miles (4.8 km) from shore;
- For new facilities: Organic Phase Drilling Fluid concentration lower than 1% by weight on dry cuttings;
- For existing facilities: Use of Group III non-aqueous base fluids and treatment in cutting dryers. Maximum residual Non-Aqueous Phase Drilling Fluid (NAF) 6.9% (C16 -C18 internal olefins) or 9.4% (C12-C14 ester or C8 esters) on wet cuttings;
- Hg: max 1 mg/kg dry weight in stock barite
- Cd: max 3 mg/kg dry weight in stock barite
- Discharge via a caisson (at least 15 m below surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)

Drilling Fluids and Cuttings – WBDF

1) WBDF: Reinject or ship-to-shore, no discharge to sea except:

- In compliance with 96 hr. LC-50 of Suspended Particulate Phase (SPP)-3% vol. toxicity test first for drilling fluids or alternatively testing based on standard toxicity assessment speciose (preferably site-specific species)

2) WBDF cuttings: Reinject or ship-to-shore, no discharge to sea except:

- Facilities located beyond 3 miles (4.8 km) from shore;
- Hg: 1 mg/kg dry weight in stock barite
- Cd: 3 mg/kg dry weight in stock barite
- Maximum chloride concentration must be less than four times the ambient concentration of fresh or brackish receiving water

Discharge via a caisson (at least 15 m below sea surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)

6.4.2.2 Produced Water

Oil and gas reservoirs contain water (formation water) that is produced when brought to the surface during hydrocarbon production. The produced water stream can be one of the largest waste products, by volume, managed and disposed of by the onshore oil and gas sector. Produced water contains a complex mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds, and in many cases, residual chemical additives (e.g. scale and corrosion inhibitors) that are added into the hydrocarbon production process.

Feasible alternatives for the management and disposal of produced water should be evaluated and integrated into production design. The main disposal alternatives for onshore operations may include injection into the reservoir to enhance oil recovery, and injection into a dedicated disposal well drilled to a suitable receiving subsurface geological formation. Other possible uses such as irrigation, dust control, or use by other sectors, may be appropriate to consider if the chemical nature of the produced water is compatible with these options. The main disposal alternatives for offshore operations may include injection along with seawater for reservoir pressure maintenance, injection into a suitable offshore disposal well, or export to shore with produced hydrocarbons for reuse or disposal after proper treatment. Where disposal to sea is the only feasible option, the Environmental and Social Impact Assessment (ESIA) should establish mitigation targets.

Produced water discharges to surface waters or to land should be the last option considered and only if there is no other option available. Discharged produced water should be treated to meet the following limits:

- Total hydrocarbon content: 10 mg/L
- pH: 6-9
- Biological Oxygen Demand (BOD): 25 mg/L
- Chemical Oxygen Demand (COD): 125 mg/L
- Total Suspended Solids (TSS): 35 mg/L
- Phenols: 0.5 mg/L
- Sulfides: 1 mg/L
- Heavy metals (total): 5 mg/L
- Chlorides: 600 mg/l (average), 1200 mg/L (maximum).[33]

Produced water treatment technologies will depend on the final disposal alternative selected and particular field conditions. Technologies to consider may include combinations of gravity and / or mechanical separation and chemical treatment, and may require a multistage system containing a number of technologies in series to meet injection or discharge requirements. Sufficient treatment system backup capability should be in place to ensure continual operation and/or an alternative disposal method should be available.

To reduce the volume of produced water for disposal the following should be considered:

- Adequate well management during well completion activities to minimize water production;
- Recompletion of high water producing wells to minimize water production;
- Use of downhole fluid separation techniques, where possible, and water shutoff techniques, when technically and economically feasible;

[33] International Finance Corporation, *Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development*, Table 1 (April 2007).

- Shutting in high water producing wells.

To minimize environmental hazards related to residual chemical additives in the produced water stream where surface disposal methods are used, production chemicals should be selected carefully by taking into account their volume, toxicity, bioavailability, and bioaccumulation potential.

Disposal into evaporation ponds may be an option for produced waters. The construction and management measures below should also apply to produced water ponds. Surface Storage and Disposal Pits

If surface pits or ponds are used for wastewater storage or for interim disposal during operations the pits should be constructed outside environmentally sensitive locations. Wastewater pit construction and management measures should include:

- Installation of a liner so that the bottom and sides of the pit have a coefficient of permeability of no greater than 1 x 10-7centimeters per second (cm/sec). Liners should be compatible with the material to be contained and of sufficient strength and thickness to maintain the integrity of the pit. Typical liners may include synthetic materials, cement/clay type or natural clays, although the hydraulic conductivity of natural liners should be tested to ensure integrity;
- Construction to a depth of typically 5 m above the seasonal high-water table;
- Installation of measures (e.g. careful siting, berms) to prevent natural surface drainage from entering the pit or breaching during heavy storms;
- Installation of a perimeter fence around the pit or installation of a screen to prevent access by people, livestock and wildlife (including birds);
- Regular removal and recovery of free hydrocarbons from the pit contents surface;
- Removal of pit contents upon completion of operations and disposal in accordance with the waste management plan;
- Reinstatement of the pit area following completion of operations.

Hydrostatic Testing Water

The disposal alternatives for test waters following hydrotesting include:

- injection into a disposal well if one is available or
- discharge to surface waters or land surface
- discharge to sea
- send offshore pipeline hydrotest water to onshore facilities for treatment and disposal, where practical

If the discharge of hydrotest waters to the sea is the only feasible alternative for disposal, a hydrotest water disposal plan should be prepared that considers points of discharge, rate of discharge, chemical use and dispersion,9 environmental risk, and monitoring. Hydrotest water disposal into shallow coastal waters and sensitive ecosystems should be avoided.

Cooling Water

Antifoulant chemical dosing to prevent marine fouling of offshore facility cooling water systems should be carefully considered. Available alternatives should be evaluated and, where practical, the seawater intake depth should be optimized to reduce the need for use of chemicals. An assessment of alternatives should be adequately documented. Appropriate screens should be fitted to the seawater intake, if safe and practical, to avoid entrainment and impingement of marine flora and fauna.

The cooling water discharge depth should be selected to maximize mixing and cooling of the thermal plume to ensure that the temperature is within 3 degrees Celsius of ambient seawater temperature at the edge of the defined mixing zone, or if the mixing zone is not defined, within 100 meters of the discharge point. Operators should consider mixing desalination brine from the potable water system with cooling water or other effluent streams. If mixing with other discharge streams is not feasible, the discharge location should be carefully selected with respect to potential environmental impacts. In particular, in the case of coastal and/or brackish water, the reverse osmosis process should be designed to allow reduction of the salinity of the rejected effluent.

Other Waste Waters

Other waste waters routinely generated at offshore facilities are listed below, along with appropriate treatment measures:

- Sewage: Gray and black water from showers, toilets, and kitchen facilities should be treated in an appropriate on-site marine sanitary treatment unit in compliance with International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 requirements.
- Food waste: Organic (food) waste from the kitchen should, at a minimum, be macerated to acceptable levels and discharged to sea, in compliance with MARPOL 73/78 requirements.
- Ballast and storage displacement water:10 Water pumped into and out of storage during loading and off-loading operations should be contained and treated before discharge to meet the guidelines.
- Bilge waters: Bilge waters from machinery spaces in offshore facilities and support vessels should be routed to the facility's closed drainage system or contained and treated before discharge to meet the guidelines provided in Table 1 of Section 2. If treatment to this standard is not possible, these waters should be contained and shipped to shore for disposal.
- Deck drainage water: Drainage water generated from precipitation, sea spray, or routine operations, such as deck and equipment cleaning and fire drills, should be routed to separate
- Drainage systems in offshore facilities. This includes drainage water from process areas that could be contaminated with oil (closed drains) and drainage water from non-process areas (open drains). All process areas should be bunded to ensure that drainage water flows into the closed drainage system. Drip trays should be used to collect runoff from equipment that is not contained within a bunded area and the contents routed to the closed drainage system. Contaminated drainage waters should be treated before discharge to meet the guidelines.

Note: Disposal of other types of wastewater can be consulted in IFC Onshore Oil and Gas Development and IFC Offshore Oil and Gas Development as provided in the references below.

6.4.2.3 Produced Sand

Produced sand originating from the reservoir is separated from the formation fluids during hydrocarbon processing. The produced sand can be contaminated with hydrocarbons, but the oil content can vary substantially depending on location, depth, and reservoir characteristics. Well completion should aim to reduce the production of sand at source using effective downhole sand control measures

Produced sand should be treated as an oily waste, and may be treated and disposed of along with other oil contaminated solid materials (e.g. with cuttings generated when NADFs are used or with tank bottom sludges).

If water is used to remove oil from produced sand, it should be recovered and routed to an appropriate treatment and disposal system (e.g. the produced water treatment system when available).

6.4.2.4 Completion and well work-over fluids

Completion and well work-over fluids (including intervention and service fluids) can typically include weighted brines, acids, methanol and glycols, and other chemical systems. These fluids are used to clean the wellbore and stimulate the flow of hydrocarbons, or simply used to maintain downhole pressure.

Once used these fluids may contain contaminants including solid material, oil, and chemical additives. Chemical systems should be selected with consideration of their volume, toxicity, bioavailability, and bioaccumulation potential.

Feasible disposal options should be evaluated for these fluids. Alternative disposal options may include one, or a combination of, the following:

- Collection of the fluids if handled in closed systems and shipping to the original vendors for recycling;
- Injection to a dedicated disposal well, where available;
- Inclusion as part of the produced water waste stream for treatment and disposal. Spent acids should be neutralized before treatment and disposal;
- On-site or off-site biological or physical treatment at an approved facility in accordance with the waste management plan.
- Collect the fluids where handled in closed systems and ship them to shore to the original vendors for recycling, if applicable.
- Ship onshore for treatment and disposal, if applicable.

6.4.2.5 Naturally occurring radioactive materials (NORM)

Low Specific Activity (LSA) or Naturally Occurring Radio-active Material (NORM) shall be monitored in production tubing, vessels, pumps, valves, Sulphate and Carbonate Scales, Sands and Sludges.

Depending on the field reservoir characteristics, naturally occurring radioactive material (NORM) may precipitate as scale or sludges in process piping and production vessels. Where NORM is present, a NORM management program should be developed so that appropriate handling procedures are followed.

If the presence of NORM/LSA is indicated at levels of 50micro rems/hr above background concentrations or 30pci/gm:

(i) A survey of its extent shall be made by the identification of the radionuclides and the determination of specific/surface activities.

(ii) A radiological risk assessment shall be made.

(ii) Appropriate precautions shall be defined and taken to minimize potential exposure to individuals.

(iii) Attention should be paid to cleaning and disposal methods.

Radiation protection against NORM/LSA shall be aimed at the minimization of external irradiation and the prevention of internal contamination.

The limit for specific activity shall be 1 Bq/gm or 27pci/gm. (1 Bq (becquerel) = 1 nuclear disintegration per second).
The dose limit on the exposure to NORM/LSA radiation shall not exceed 50 mSv/a (milli – Sievert per annum).

If removal of NORM is required for occupational health reasons, disposal options may include: canister disposal during well abandonment; deep well or salt cavern injection; injection into the annular space of a well or disposal to landfill in sealed containers.

Sludge, scale, or NORM-impacted equipment should be treated, processed, or isolated so that potential future human exposures to the treated waste would be within internationally accepted risk-based limits. Recognized industrial practices should be used for disposal. If waste is sent to an external facility for disposal, the facility must be licensed to receive such waste.

6.4.2.6 Treatment Methods of Non-Hazardous Waste

Although it is established in Kenyan law, treatment of non-hazardous waste is not a required under best international practices. Treatment involves changing a waste's physical, chemical, or biological character or composition through designed techniques or processes. If required, there are three primary categories of treatment—physical, chemical, and biological

Examples of physical treatment

- Immobilization: Encapsulation Thermoplastic binding
- Carbon absorption: Granular activated carbon (GAC), Powdered activated carbon (PAC)
- Distillation: Batch distillation, Fractionation, Thin film extraction, Steam stripping, Thermal drying
- Filtration
- Evaporation/volatilization
- Grinding
- Shredding
- Compacting
- Solidification/addition of absorbent material

Examples of chemical treatment:

- Neutralization
- Oxidation
- Reduction
- Precipitation
- Acid leaching
- Ion exchange
- Incineration
- Thermal desorption
- Stabilization
- Vitrification
- Extraction: Solvent extraction, Critical extraction
- High temperature metal recovery (HTMR)

Examples of biological treatment:

- Aerobic: Activated sludge, aerated lagoon, trickling filter, rotating biological contactor (RBC)
- Anaerobic digestion

6.5 *Procedure for remediation and rehabilitation of hazardous waste contaminated land and waters*

6.5.1 Land

When an operation comes to an end, the site needs to be prepared for subsequent use. Usually, remediation plans are part of the permitting of the site from the planning stage onwards and should, therefore, have undergone regular updating, depending on changes in the operation and in negotiations with the regulator and other stakeholders. In some cases, the aim is to leave as little a footprint as possible, whereas in other cases, a complete change of landscape may be aimed for. In any case, negative environmental impacts need to be kept to a minimum.

Some sites can be handed over to the subsequent user after a relatively simple reclamation, e.g. after reshaping, covering and re-vegetation. In other cases, after-care will need to be undertaken for long periods of time, sometimes even in perpetuity.

It is impossible to restore a site to its original condition. However, the operator, the authorities and the stakeholders involved should agree on the successive use. It will usually be the operator's responsibility to prepare the site for this. To receive a permit for the closure, the characteristics of the impounded material should be well determined (e.g. amounts, quality/ consistency, possible impacts).

Site remediation, before closure of a facility can be sub-divided into a number of steps.

Step 1: Initial Assessment

During this step, the qualified person conducts a site assessment to collect necessary technical information. Soil and groundwater effects should be assessed as well as potential effects on the surrounding population. A critical factor in a site assessment is completely defining and delineating the extent of the contamination in both soil and groundwater, even if it has crossed the source property boundary.

An Environmental Site Assessment (ESA) should identify the nature and extent of contaminants. A well-planned, comprehensive assessment will allow site managers to make informed decisions about potential remediation. There are three stages of phased investigation, depending on the size and complexity of the contaminated site, ranging from the general to the specific. The three phases of investigation are described below.

<u>Phase I: Site Information Assessment</u>

The purpose of the Phase I ESA is to identify actual and potential site contamination. In Phase I, the objective is to assemble all available historical and current information to help develop a field-testing program, should one be required. The work will begin by reviewing all data gathered for legal, transactional or environmental reasons (e.g., site classification, if already conducted) and supplementing this information as required.

The work frequently encompasses three broad aspects:

- Facility Characteristics: A current and historical description of the site and its facilities is developed, particularly as it relates to the areas of concern like contaminant sources and discharge points. Visual inspections, facility records reviews and discussions with informed personnel are employed. In addition, above and below ground structures are reviewed (using

blueprints, if available) as possible sources of contaminant migration. Prior site uses and surrounding land uses are also considered;

- Contaminant Characteristics: Contaminants that may be present at the site are identified. Their quantities and concentrations are estimated by visual inspections, reviews of documentation and discussions with informed staff;
- Physical Site Characteristics: The geology, hydrology and hydrogeology are examined using available data. The overall aim is to provide a more comprehensive description and understanding of the local site characteristics and to develop a current and historical description of the area.

The sources of information can include:

- aerial photographs;
- geology and groundwater reports;
- topographical, geological and other maps;
- hazardous Materials Spill Database; and
- previous site investigation reports.

The review will also include a site inspection and discussions with personnel and residents informed about the site and its history and conditions. The site inspection will examine vegetation stress, key ecological receptors, leachate breakout and signs of contamination discharge. Surrounding land uses will also be considered. Drinking water sources and wells will be noted using published well records correlated to site observations. Proximity of the site to surface water bodies or sensitive habitats (e.g., wetlands) should also be identified.

Phase II: Reconnaissance Testing Program

The objective of the Phase II ESA is to confirm the presence and characterize the substances of concern at the site. Characterization of the contamination (i.e., degree, nature, estimated extent and media affected) and site conditions (i.e., geological, ecological, hydrogeological and hydrological) are necessary to develop a remedial action plan or to identify the need for more specific Phase III investigations. It also may be decided that no further action is required or that immediate action is needed. Further study may be necessary to determine risks to public health, safety or the environment. This may take the form of human health and ecological risk assessments using Phase II investigation data.

The Phase II sampling program should include the adoption of sampling procedures, quality assurance/quality control procedures and laboratory analytical protocols. In addition, preliminary environmental quality remediation criteria should be selected.

Phase III: Detailed Testing Program

The results of the Phase II investigation will determine the need for a Phase III ESA. If sufficient data have been obtained at Phase II to characterize the site and/or the risk to human health and the environment, then the process may move directly to a remedial action plan (if it is required).

Alternatively, a Phase III detailed investigation may be necessary if the Phase II results indicate that significant contamination exists that will require remediation. This investigation will specifically address outstanding issues with a view to obtaining enough information to formulate a remedial action plan. The objectives of Phase III investigation are:

- to target and delineate the boundaries of identified contamination;

- to define, in greater detail, site conditions to identify all contaminant pathways, particularly with respect to possible risk assessment;
- to provide contaminant and other information necessary to finalize environmental quality remediation criteria or risk assessment; and
- to provide all other information required to develop a remedial action plan and input to specifications and tender documents.

Remediation

The remediation criteria are presented in the context of four types of land use: agricultural, residential/parkland, commercial and industrial. The criteria are considered generally protective of human and environmental health for specified uses of soil at contaminated sites. It is important to note that it is the intended future land use that governs the decision on the level of remediation performed at a site. Identifying the type of land use will help assess the extent of human and ecological exposure to contaminants in the soil, and is essential for planning practical remediation programs. The type of land found adjacent to the contaminated site may affect the remediation criteria levels to follow.

There are three basic approaches that may be utilized for the development of Site-Specific Remediation Objectives:

- Tier 1 Direct adoption of remediation criteria (Criteria-based Approach);
- Tier 2 Adoption of remediation criteria, with limited modifications (Modified Criteria Approach); and
- Tier 3 The use of risk assessment (Risk-based Approach).

The criteria-based approach is designed to require fewer resources while providing a scientifically defensible basis for protection that is sufficiently flexible to account for certain site-specific factors. This approach is believed to provide an effective alternative to detailed risk assessment methods. The risk-based approach can be more complex and costlier, and is generally utilized when a criteria-based approach is not suitable for a site (e.g., large, complex industrial site).

Tier 1 - Criteria-Based Approach

Under this approach, the remediation criteria selected for a site are adopted as the remediation objectives. In general, this method is most applicable where site conditions, receptors, and exposure pathways are similar with those assumed in the development of the criteria. Other factors that may bear weight on the decision to directly adopt criteria include cost, time, simplicity and technical considerations.

Where a Tier 1 approach determines that applicable criteria are exceeded for the land use, specific remedial actions will be required unless a Tier 2 approach justifies the application of site-specific objectives and/or on-going site management.

Tier 2 - Modified-Criteria Approach

In certain circumstances, remediation criteria may be modified, within specified limits, and adopted for use as the remediation objective for the site. The acceptability of a Tier 2 approach for evaluation of off-site impacts may be subject to review by the regulator and the acceptance of other affected parties.

In general, the method may be utilized in situations where site conditions, land use, receptors or exposure pathways differ only slightly from those assumed in the development of the "generic" criteria.

Tier 3 - Risk-Based Approach

In certain circumstances, the criteria-based approach may not be suitable for a site (e.g., pathways of exposure, target chemicals, receptors or other site characteristics differ from those used to develop the criteria-based approaches) and risk assessment procedures may be required in the development of Site-Specific Remediation Objectives. Site-specific objectives are developed from the results of the risk assessment to establish a concentration corresponding to an acceptable risk to human or ecological receptors. Site-Specific Remediation Objectives for soil should be developed using risk assessment when there are:

- significant ecological concerns (e.g., critical or sensitive habitats for wildlife; rare, threatened or endangered species; parkland or ecological reserves; hunting or trapping resources);
- unacceptable data gaps. Examples include:
    - exposure conditions are particularly unpredictable or uncertain;
    - there is a lack of information about receptors;
    - there is a high degree of uncertainty about hazard levels;
- special site characteristics. For example:
    - the site is so large, or the estimated cost of remediation is so high, that a risk assessment is needed to provide a framework for site investigation and to set remediation priorities;
    - site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivation of criteria.

If site conditions exceed the applicable remediation criteria, the responsible party should submit the evaluation report to the authorities and advise affected parties.

Step 2: Preparation of a Remedial Action Plan

At this point the responsible party and qualified person will review the results of the site assessment and determine whether to remediate the site to the generic criteria or complete further work to develop site-specific remedial criteria using risk assessment approach.

Once the remediation criteria have been determined for the site, the qualified person should prepare a Remedial Action Plan (RAP) detailing the methodology for achieving these criteria as well as the proposed remedial action.

The RAP should:

- include contact information, including names of key personnel, consultants, contractors, telephone, mail, fax, and email contacts, physical addresses;
- summarize all data on contaminants identified during the site investigation(s);
- identify contaminants of concern and the media affected;
- identify the proposed clean up criteria and method(s) by which they have been derived;
- identify, quantify and characterize the materials to be treated/removed;
- summarize remedial options evaluated and the method used to select the preferred remedial strategy;
- describe the selected clean up method and its technical feasibility;

- detail an implementation plan, including a schedule;
- discuss control measures to minimize fugitive air emissions, surface water control, worker health and safety;
- identify the fate of residual contaminants; and
- identify remedial verification and long-term monitoring plans.

The final action in this step is to submit the RAP to regulator for approval.

Step 3: Remedial Action Plan Implementation

The responsible party and the qualified person shall proceed with the approved RAP and submit monitoring reports to regulator on the pre-determined schedule. The responsible party should advise the regulator if activities deviate from the approved RAP. Regulator will assess the significance of any deviations and respond accordingly. In situations where predictions included in the RAP fail to be achieved, the responsible party may be required to re-evaluate Step 2 and enhance the RAP.

Step 4: Site Closure

When the responsible party and qualified person are satisfied that all the requirements of the RAP have been met, a closure report will be forwarded to regulator. Upon receipt and acceptance of the closure report, the regulator will conclude the management process by issuing a letter advising that no further remedial action is required.

6.5.2 Water

A review of the literature reveals that the use of oil dispersants is one of the most recommended oil spill cleanup methods. Consequently, operators should refer to the Oil Dispersant Use Policy for Kenya. Operators are also encouraged to use any equipment they consider necessary to contain spills. For example: sorbents, booms, skimmers, and tracking devices.

6.6 Preparation of waste management plan for all categories of waste

Applications for licenses/permits to conduct hydrocarbon operation should be accompanied by a waste management plan (WMP).

The WMP should be drafted in clear and certain terms. It should provide information sufficient to allow NEMA to evaluate the applicant's ability to comply with Kenya law. It should also list the measures that will be taken to prevent, or reduce as far as possible, the waste generated, and any adverse effects on the environment and human health caused by the applicant's operations. The scope of the WMP should be discussed with NEMA prior to the beginning of drafting.

Issuance of an operating/environmental license implies approval of the applicant's WMP, and the latter becomes part of the former. Consequently, deviation from the WMP during the course of activities is not allowed, unless the applicant obtains prior approval from NEMA.

To be approved, the WMP should provide full details of, at least, the following:

1. A description of the operation generating such waste;
2. Information on the condition of the land where operations are to be conducted;
3. How applicant will prevent or reduce the waste generated, and the harmfulness of any waste generated, and the potential damage to water, air, and/or soil;
4. If applicant requires operation of a high-risk facility, the WMP should include a major-accident prevention policy, a safety management system for implementing it, and an internal emergency plan:

a. A high-risk facility consists of a facility:
    i. whose failure or incorrect operation could give rise to a serious danger to human health and/or the environment, whether immediately or over time, on-site or off-site; or
    ii. contains waste classified as hazardous above a certain threshold defined by NEMA.

5. If applicant requires operation of a low-risk facility, i.e., any facility other than a high-risk one, the WMP should include an explanation of why the facility should be considered low-risk, as well as an identification of possible accident hazards;
6. Waste characterization and classification in accordance with section 6.1 above, and a statement of the estimated total quantities of extractive waste to be produced during the operational phase.
7. A description of how the environment and human health may be adversely affected by the deposit of such waste and the preventive measures to be taken in order to minimize environmental impact during operation and after closure, including the location, construction, management, and eventual rehabilitation of the waste facility.
8. Proposed pollution prevention plan, in line with section 6.3 above.
9. Proposed waste handling and storage procedures in line with section 6.2 above.
10. Proposed monitoring and control procedures for movement of waste, in line with section 6.4.1 above.
11. Measures to manage waste gases, e.g., produced by waste incineration.
12. Measures to encourage recovery of waste by recycling, re-use or reclamation.
13. Treatment and final disposal of waste in line with section 6.4.2 above. This shall include the design of any facility used for such purpose.
14. Proposed plan for closure, including rehabilitation, after-closure procedures, and monitoring, in line with section 6.5 above.

For offshore operations, in addition to information mentioned above, a WMP should contain measures directed at segregating waste into hazardous and nonhazardous, and shipping it to shore for reuse, recycling, or disposal. The WMP should also contain a mechanism to track waste from the generation point to its final destination onshore. [34]

[34] International Finance Corporation, *Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development*, (June 2015), https://www.ifc.org/wps/wcm/connect/f3a7f38048cb251ea609b76bcf395ce1/FINAL_Jun+2015_Offshore+Oil+and+Gas_EHS+Guideline.pdf?MOD=AJPERES

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8 Annexes

8.1 Pollution Prevention Alternatives for Waste Generated in O&G Operations

*Where: **S** = Source reduction; **R** = Recycling; **T** = Treatment; **D** = Disposal.*

Waste	Alternatives
Absorbent materials	S: Prevent spills and leaks by practicing preventive maintenance and good housekeeping. R: Recover and contain used absorbent pads for recycling. R: Return used absorbent pads to vendor for recycling. T: D: Send to an approved, approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific material.
Acid, spent	S: Micro-meter solutions to minimize unused acid (continuous mix versus batch mix). R: Use to neutralize excess caustics T: D: Send to an approved, approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific acid.
Acid, unused	S: Purchase only quantity needed. R: Return unused portion to vendor. R: Register unused portion with a chemical exchange program. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific acid.
Activated charcoal filter media	R: Send to recycling facility. T: D: Send to an approved, approved surface waste management facility.
Aerosol can	S: Use non-aerosol containers whenever possible. Use all contents; do not dispose of until empty. R: Recycle metal cans at appropriate recycling facility. T: D: Send empty containers to state-permitted municipal solid waste landfill. **Special considerations:** Do not puncture.
Air emissions Includes: Nitrogen oxides (NOx), sulphur oxides (SOx), hydrocarbons, BTEX, carbon monoxide, particulates, halons, mercury, chlorofluorocarbons, refrigerants, VOCs,	S: Design and operate to minimize air emissions. Use regular preventative maintenance and monitoring procedures. S: Install and maintain catalytic converters. S: Use low NOx burners. S: Convert engines to lean-burn. Maintain and run all engines to be the most fuel efficient. S: Install pre-combustion chambers on engines. S: Install electronic ignition systems on engines. S: Use natural gas engines instead of engines fueled by diesel or other fuels. S: Tighten connections and replace packing to minimize leaks and fugitive emissions.

and fugitive emissions	S: Reduce emissions of unburned hydrocarbons in new facility design (e.g., route emissions to flare, route dehydrator still emissions to first stage compression, use electric drivers for compressors, use shorter piping runs with fewer flanges, use welded rather than screwed or bolted fittings). S: Reduce horsepower demands to reduce emissions. S: Maintain tank thief hatch seals. S: Route dehydrator still emissions to reboiler, firebox, first stage compression, or flare. S: Lower glycol circulation rate - avoid over dehydrating (vapor recovery). S: Eliminate use of sparge or stripping gas in dehydrators. S: Buy solvents and liquid chemical in bulk and keep containers covered. S: Buy less volatile solvents and liquid chemicals. S: Use dust control techniques at facilities. S: Eliminate the use of halon fire extinguishing materials. S: Revise test procedures so halon is not released. R: Use waste heat recovery opportunities where possible. R: Use vented or flared gas as fuel. R: Collect vented or flared gas, compress, and sell as product. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Amines, used	S: Use an amine reclaimer in the system to allow reuse of amine and minimization of the volume of waste amine generated. S: Use an amine filter to extend life of solution and maintain efficiency. S: Operate and maintain at proper temperatures to avoid hydrocarbon contamination. S: Maintain a testing program to avoid problems (e.g., corrosion). R: Return to vendor. R: Send to recycler. D: Send to an approved, approved surface waste management facility. **Special considerations**: Rich amine contains hydrogen sulfide, avoid skin contact, use PPE and consult MSDS for guidance.
Amine sludge, precipitated	S: Maintain appropriate pH to reduce the contribution of heavy metals to the sludge as a result of corrosion. S: Substitute potassium hydroxide for sodium hydroxide for pH control to reduce sodium content of sludge. D: Send to an approved, approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific material.
Ammonium hydroxide, spent (copy machine use)	S: Convert to copiers that do not require ammonium hydroxide. T: D: Nonhazardous: Obtain approval and send to an approved surface waste facility or send to a state permitted municipal landfill. **Special considerations:** Avoid eye and skin contact. Consult MSDS for additional guidance.
Antifreeze	S: Use a less toxic substitute for ethylene glycol (e.g., propylene glycol). R: Regenerate on site by filtration (if not thermally degraded). R: Send to a recycler. T:

	D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance
Asbestos, asbestos-containing material	S: Purchase asbestos-free products and equipment. S: Maintain asbestos-containing materials to keep friable (brittle) asbestos from becoming exposed (e.g., encapsulation). Mark materials that contain asbestos according to state special waste regulations. D: Asbestos must be removed by licensed operators and disposed of in state-permitted landfill approved for asbestos disposal. **Special considerations**: Asbestos must be handled by licensed operators
Batteries, lead acid	S: Use other sources of electrical current whenever possible. R: Return to vendor. When batteries are permanently taken out of service, send for recycling as soon as possible. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical. Temporarily store used batteries in a leak-proof container in a dry area.
Batteries Includes nickel-cadmium, lithium alkali, and lead-acid	S: Use other sources of electrical current whenever possible. S: Purchase long-life batteries to decrease the number needed. S: Use rechargeable batteries. R: Return to vendor or manufacturer. R: When batteries are permanently taken out of service, send to recycler as soon as possible. T: Remove electrolyte. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Send to a state-permitted municipal waste landfill. **Special consideration:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical. Temporarily store used batteries in a leak-proof container in a dry area.
Biocides, herbicides, insecticides, and all other pesticides (used for site or facility maintenance)	S: Use a licensed commercial pesticide application service. S: Properly store and label containers to prevent degradation and contamination. S: Use all contents/material and then triple rinse the container. Use rinsate as originally intended for the material. S: Practice good inventory control. Use excess at another facility. R: Return unused chemicals to vendor for recycling. R: Send unusable chemicals to a recycler. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use all pesticides in accordance with label instructions. Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.

Blasting sand/media	S: Use coatings that do not require sandblasting. S: Use alternative methods to reduce unnecessary sandblasting (e.g., use a paint that does not require sandblast preparation, cathodic protection from corrosion rather than paint, use tanks constructed of materials that do not need to be painted). S: Brush-blast and paint instead of blasting to base metal. S: Reduce blasting/painting frequency. S: Substitute suitable wastes (e.g., copper slag) for virgin blast media. S: Use dry ice pellets or recyclable media for some applications. S: Use lead-free paint or paints with lower levels of other metals. S: Buy in bulk hoppers to minimize sacks and pallets. S: Insure that purchased sandblast grit does not contain metal or other contaminants. S: Do not allow contractors to conduct unnecessary sandblasting and painting of their equipment on site. R: If permissible, send to a cement kiln as a substitute for feedstock. R: Separate from blasted paint waste and reuse blast media. R: Use as aggregate in road mix, if permissible. R: If uncontaminated and permissible, use on site as a substitute for virgin fill material. D: Hazardous: send to an approved hazardous waste treatment and disposal facility. D: Nonhazardous: send to a state-permitted municipal waste landfill. **Special considerations:** Test sandblast medium for TCLP heavy metals. Use appropriate PPE. Avoid eye and skin contact.
Blowdown, cooling tower	S: Operate cooling towers efficiently to minimize the generation of blowdown. S: Cascade water use. S: Substitute more acceptable biocides such as isothiazoline and amines for biocides such as pentachlorophenols and formaldehyde releasing compounds. S: Substitute corrosion inhibitors such as sulfite and organic phosphates for inhibitors that contain chromates. R: Recycle free liquids back into production stream. D: For material that cannot be recycled, send to an approved, approved surface waste management facility. **Special considerations**: May contain hydrogen sulfide and/or other harmful chemicals. Use appropriate PPE. Consult MSDS for additional guidance for specific chemicals.
Blow-out preventer test fluids	S: Collect leakage to avoid soil contamination. R: Return test fluids to system if uncontaminated. D: Send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Consult MSDS for additional guidance for specific chemicals.
Catalyst, spent (e.g., sulfur recovery process)	S: Substitute a less hazardous catalyst. S: Use catalyst completely before removing from system. S: Operate the system to prevent contamination. R: Regenerate spent catalyst. R: Certain types of catalysts can be sent to pulp and paper mills for reuse. R: Send to recycler for metals recovery. R: If permissible, send to cement kiln as a substitute feedstock.

	R: If uncontaminated and permissible, use on site as fill material. D: Send to an approved, authorized surface waste management facility.
Caustics, used (e.g., gas treatment or drilling fluids)	S: For gas treatment, consider alternate recyclable products. S: Plan drilling operation to minimize volume of fluid, thereby reducing caustic requirements. S: Use inventory control; e.g., a surplus chemicals exchange network that offers unused chemicals to other company facilities in lieu of disposal. R: Return unused caustic to vendor. R: Reuse to neutralize excess acids. T: Hazardous: Treat to meet standards. D: Send to an approved surface waste management facility. **Special considerations**: May be reactive or corrosive. Use appropriate PPE. Consult MSDS for additional guidance for specific material.
Cement returns	S: Calculate cement needs carefully to excess cement mixture. S: Use cement in other projects, such as erosion prevention. S: Require vendors to use nonhazardous cement additives. R: Return unused dry cement to vendor. R: Solid cement may be reclaimed if not contaminated. D: Send to state-permitted landfill (Class A, B, or C) for disposal. **Special considerations:** Use appropriate PPE. Avoid skin contact and inhalation of dust. Consult MSDS for additional guidance.
Chemicals, surplus or unusable	S: Use inventory control; e.g., a surplus chemicals exchange network that offers unused chemicals to other company facilities in lieu of recycling, treatment or disposal. S: Label and store chemicals properly (e.g., protect containers from weather and keep covered). S: Purchase chemicals in bulk with supplier retaining ownership of containers. S: Calculate chemical needs carefully to avoid surplus. S: Use the entire product. Transfer for use at other sites or find alternate uses. S: Use nonhazardous products whenever possible. S: Minimize the use and variety of similar-use chemicals when one chemical is suitable. R: Return surplus to vendor. R: Donate surplus laboratory chemicals to a high school or college. R: Send to a recycler. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. D: Nonhazardous: Obtain approval and send to an approved surface waste facility or send to a permitted municipal landfill. **Special considerations**: Consult MSDS for guidance for specific chemical. Keep labels on all containers. Do not dispose of chemicals in mud or workover pits.
Cleaning wastes	S: Minimize drips, leaks and spills by practicing good housekeeping. S: Wipe with recyclable rags rather than washing with cleanser or chemical. R: Regenerate cleansers or cleaning solvents for reuse. R: Send to a recycler. T: Hazardous: Treat to meet standards

	D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Compressor oil, filters, and blowdown waste	S: Use stainless steel, reusable filters. S: Isolate all drained fluids in a resealable container. (See Oil, Lube.) S: When handling filters, take precautions to prevent oil spilling. S: Change oil and filters only when necessary. Lab testing of oil and differential pressure gauge will indicate the need for filter replacement. (Note: Many lubricating oil vendors provide a testing service at no charge.) S: Evaluate applicability of filterless centrifugal oil cleaning. R: Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle back into production stream. R: Send used oil to a recycling facility. R: Introduce used oil into production stream. D: Send to an approved, OCD-approved landfarming facility. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Completion, workover, and well treatment fluids	S: Plan the job carefully to reduce excess fluids. S: Use less toxic substitutes for chemicals and products. S: Use improved acidizing technology and inhibition technology to decrease the frequency of well workovers and formation treatments. S: Use leftover, excess fluids on other jobs. R: Return all unused treatment fluids to the supplier. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Consult MSDS for additional guidance for specific chemicals.
Condensate	S: Prevent releases by complete regular inspection and maintenance of all surface lines and facilities. S: Treat as a product. R: Condensate should be recycled back into production stream. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Highly flammable. Use appropriate PPE. Respiratory protection may be required. Consult MSDS for additional guidance.
Construction/ demolition debris Includes: Spoil, vegetation, wood, scrap metal	S: Plan site to minimize size. S: Minimize demolition requirements. S: Consider portable pads or skid-mounted equipment. S: Use high-density polyethylene liners rather than concrete. R: Crush uncontaminated concrete for use as aggregate. R: Compost vegetation and use as soil supplement. Chip uncontaminated wood to use as mulch. R: Sell or offer for reuse.

	R: Send scrap metals to a recycler. D: Hazardous: Send debris contaminated with hazardous material to an approved hazardous waste treatment and disposal facility. Nonhazardous: Send to a permitted municipal landfill.
Copier toner, developer, solutions and cartridges	S: Buy recycled cartridges. S: Buy what you need and use what you buy R: Return empty containers and used components to the supplier or manufacturer. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste facility or send to a permitted municipal landfill.
Debris and soil, contaminated by used chemicals	S: Use proper containers, keep lids on containers and store properly to prevent overflow or spillage. S: Install containment to allow for better recovery of spills. D: Hazardous: Treat to meet standards. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: send to a permitted municipal waste landfill. **Special considerations:** Consult MSDS for guidance for each known chemical.
Debris, crude oil Soaked (if contaminated within production system, i.e., before point of sale)	S: Develop operational procedures that prevent contamination with crude oil by keeping areas clear of debris. S: Use leak-proof storage containers. T: Segregate oily wastes to allow them to weather before putting them in a trash bin. D: Send to an approved surface waste management facility. D: Send to state-permitted municipal landfill for disposal. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Handle as crude oil; consider a fire hazard.
Debris, lube oil contaminated	S: Develop operational procedures that prevent contamination with lube oil by keeping areas clear of debris. S: Store all lube-oil contaminated debris in a properly labeled, sealed container. R: Contractors are available to pick up & clean used rags for reuse. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact.
Debris, uncontaminated	S: Store in labeled containers/dumpsters. S: Do not mix with material that is contaminated or may be hazardous. R: Recycle paper, metal, cardboard, aluminum cans whenever possible. D: Send to an approved, state-permitted municipal landfill.
Domestic refuse, uncontaminated Includes: Food waste, packaging material, paper, plastic,	S: Reduce packaging; buy in bulk. S: Purchase and prepare only what is needed; avoid surplus. S: Purchase higher quality materials with longer use cycles. S: Use washable mugs, cups, plates, and utensils. S: Prepare fewer fried foods. S: Copy on both sides of the paper (duplex copying).

styrofoam, cooking oils and greases, and other trash.	S: Purchase recycled/recyclable materials. S: Use microbes and enzymes to control grease in traps. R: Obtain agreements to send packaging waste back to the vendor for reuse or recycling. R: Set up recycle bins for wood, paper, newspapers, plastic, glass, cardboard, aluminum, and other metals (i.e., food cans). R: Reuse waste paper or styrofoam as packaging materials and fillers. R: Send used cooking oils, grease and fat to a rendering or reclamation facility for reuse. R: Compost food and other biodegradable waste to use as soil additive. D: Send to an approved, state-permitted municipal solid waste landfill for disposal.
Domestic and sanitary wastewater	S: Use low flow and low water use toilets, showers and faucets. S: Repair or replace leaking equipment. R: Use treated water as facility wash-down water or to water grasses, plants, etc. R: Use digested sewage sludge for agricultural purpose, if permissible. T: Send to an approved wastewater treatment facility. D: Discharge under permit **Special considerations:** Use appropriate PPE. Avoid eye and skin contact.
Drilling fluids and additives, used	S: Use a closed-loop mud system whenever possible to reduce volumes of drilling fluid wastes. S: Use solids control technology (e.g., chemically enhanced centrifuge) to recover water from drilling mud and reserve pit. S: Optimize solids control (e.g., hydrocyclones or centrifuges) to minimize need to dilute mud. S: Use low solids, non-dispersed muds whenever drilling conditions allow it. S: Use an inside-diameter wiping tool for drill pipe to minimize loss of drilling fluid (can save approximately 0.4 barrels of drilling fluid per 1,000 feet of drill pipe). S: Use inventory control and careful planning to avoid unused materials. S: Use the entire product whenever possible. S: Transfer unused additives for use at other sites. S: Use products low in toxicity whenever possible. S: Carefully screen barite weighting agents for naturally occurring concentrations of heavy metals, particularly mercury and cadmium. S: Substitute organic additives, polymers, or biodegradable additives for oil-based mud to reduce toxicity. S: Use lubricants such as lubra beads and gilsonite-based additives for spotting fluids, rather than diesel oil. R: Have a drilling mud recycler pick up waste drilling mud for reconditioning and reuse. R: Reuse waste drilling mud for upcoming well spudding or plugging operations. R: Return surplus additives to vendor. R: Return oil-based mud to vendor for recycling. R: Reuse water-based mud whenever possible. T/R: Condition mud for reuse in drilling your next well. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill.

	Special considerations: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific material.
Drilling cuttings/solids	S: Minimize hole size (if feasible) when drilling. S: Drill horizontal holes if feasible to reduce number of wells required. S: Carefully design and monitor drilling mud programs to minimize caving, etc. S: Substitute organic additives, polymers, or biodegradable additives for oil-based mud to reduce costs associated with cleanup of oil-based drill cuttings. T: D: Dispose of oil-based drill cuttings at an approved disposal facility.
Drums/containers, containing unused chemicals or lube oil	S: Use the remaining chemical or lube oil for its intended propose whenever possible before disposing of drum. S: Switch to purchase of chemicals in bulk containers, reducing the amount of drums requiring handling. Added benefit: less drum handling reduces the chance of spills and releases requiring cleanup of contaminated soil or debris. R: Return unused chemical, in original drum/container (properly sealed and labeled), to vendor. R: If drum can be properly emptied: triple rinse, and recycle drum (add the rinse water to the chemical stream). R: Recycle empty drums/containers whenever possible. D: Hazardous: send to an approved hazardous waste treatment and disposal facility. D: Nonhazardous: Send to an approved landfarming facility. D: Nonhazardous: Send to a permitted municipal waste landfill. **Special considerations**: Consult MSDS for guidance for a specific chemical. Use appropriate PPE. Do not mix remaining contents with different chemicals. Do not dispose of chemicals in mud or workover pits. Keep labels on all containers.
Drums/containers, empty	S: Switch to purchase of materials and chemicals in bulk containers, reducing the number of drums requiring handling. Added benefit: less drum handling reduces the chance of spills and releases requiring cleanup (of contaminated soil). S: Purchase materials in returnable/recyclable drums and containers. R: Return undamaged drums/containers to vendor or send to a drum reconditioner/recycler. R: Reuse uncontaminated drums for other purposes (e.g., storage and transfer of nonhazardous waste. R: Send damaged, uncontaminated drums to a metal recycler. T: Acutely hazardous work: Triple rinse. D: Crush uncontaminated drums/containers and send to an approved, state-permitted municipal waste landfill. **Special considerations**: Drums/containers are empty if they contain the lesser: 1 inch of solid or liquid material or 3% by weight. Empty drums/containers may be explosive or flammable. Collection and proper disposal of rinsate may be regulated.
Electrical equipment, oil-filled (less than 50 parts per million polychlorinated	S: If putting back into service, do not refill or service with oils containing more than 50 ppm PCBs. R: Refurbish and reuse or sell for reuse. R: Recycle oils into production stream.

biphenyl content) and out of service Includes: Capacitors, transformers, switches, heat transfer fluids	R: Send scrap equipment to a metal recycler. R: Burn oil for energy recovery if permissible (PCB content may prohibit this option; check appropriate regulations). D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Filters, lube oil	S: When handling filters, take precautions to prevent oil spillage and the contamination of soil, etc. S: Change filters only when necessary. Use differential pressure as an indicator of needed change. S: Use stainless steel, reusable filters. S: Evaluate applicability of filterless centrifugal oil cleaning. (Use "spinners" to replace or lengthen oil filter life.) S: Install lubricating oil purification equipment to reduce frequency of conventional filter replacement. R: Isolate all drained fluids in a resealable container for recycling. (See Oil, Lube.) R: Before recycling spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle back into production stream. R: Send to a recycling facility. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. When handling filters, take precautions to prevent oil spills. Store all drained fluids in a reusable container. Oil filters are no longer accepted at state-permitted municipal landfills. Lube oil filters are considered a hazardous waste and must be managed as such.
Filters, process	S: Use or retrofit with stainless steel, reusable filters to reduce the volume of filters requiring recycling or disposal. S: Change filters only when necessary. Use differential pressure as an indicator of needed change. S: Evaluate applicability of filterless centrifugal oil cleaning. (Use "spinners" to replace or lengthen oil filter life.) R: Before disposing of spent filters, drain all free liquids from the cartridge or filter media into a container. Recycle back through production stream, on the lease from which the filters are generated. D: Send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific material.
Firefighting agents	S: Convert to less toxic alternatives. S: Eliminate the use of halon extinguishers. S: Avoid the use of dry agents when water will suffice. R: Contract with vendor to maintain firefighting equipment and take back all unused firefighting agents. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility.

	Nonhazardous: Obtain approval and send to an approved surface waste facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Fracturing fluids, unused	S: Use "mix-on-the-fly" systems for frac fluids. S: Recycle unused frac oil back into production stream. S: Plan frac job carefully to avoid mixing unnecessary fluids. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Glycol	S: Maintain a testing program to avoid problems (e.g., corrosion). S: Optimize flow rates in the dehydration system. S: Operate and maintain at proper temperatures to avoid hydrocarbon contamination. R: Regenerate for reuse. R: Send to a recycling facility. T: D: Hazardous: Send to an approved hazardous waste disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Consult MSDS for guidance for specific material. Use appropriate PPE. Ethylene glycol or triethylene glycol may contain high levels of hydrocarbon, making it regulated. Before transporting, analytical testing must be conducted to determine the flashpoint.
Hydrocarbon liquids	R: Reclaim and manage as product. R: Blend with product. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Hydrates	S: Inject methanol or glycol to inhibit hydrate formation. S: Melt in place. R: Return to water treating system to recover any contained hydrocarbons. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Hydraulic fluids	S: Introduce into production stream at facility where generated. S: Practice preventive maintenance to reduce leaks and drips. R: Recycle whenever possible. T: Hazardous: Treat to meet standards

	D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Hydrotest water from gathering lines (in primary field operations)	S: Conduct tests only when necessary. Use of "smart pigs" or ultrasonic devices to test wall thickness or holidays may enable better targeting of pipeline sections requiring pressure testing or replacement. S: Efficiently pig and pre-clean pipelines prior to hydrotesting to reduce the toxicity of the hydrotest water. S: Use produced water for hydrotesting rather than fresh water (reduction in use of water). R: Reuse hydrotest water in other tests. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Iron sponge and Iron sulfide scale, spent	S: Consider alternative methods of removing hydrogen sulfide from gas stream. S: Treat production streams with biocide or scale inhibitor to reduce iron sulfide formation. D: Send to approved, state-permitted disposal facility **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical. Dry iron sulfide and iron sponge will auto ignite; in confined space with adequate oxygen, it may explode. Contact with acid will release hydrogen sulfide. Always keep it wet. Spread iron sponge out on bare ground in an open, fenced area. Allow a minimum of 1 week for material to oxidize and cool to air temperature before transporting off site. Do not mix with acid or acidic water.
Laboratory samples	S: Collect only the amount necessary for analysis. S: Minimize testing; sample and analyze no more often than required. S: Use test methods/procedures which generate no or less waste (e.g., colorimetric testing). S: Use process knowledge instead of testing. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility.
Laboratory waste	S: Segregate waste chemicals (i.e., keep hazardous and nonhazardous waste chemicals separate) to reduce the amount of hazardous waste for management. S: Buy only the amount and size necessary. S: Use test methods that generate less or no waste. R: Sell or exchange excess unused chemicals. R: Send laboratory wastes to a recycler. R: Provide excess laboratory chemicals to schools for their use. T: Hazardous: Treat to meet standards

	D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations:** Consult MSDS for guidance for specific material.
Lubricating oil	S: Minimize the volume of lube oil by extending its use. S: Test oil and extend its use based on wear vs. accumulated operating hours. (Note: Many lubricating oil suppliers offer testing service at no charge.) S: Install lubricating oil purification equipment on engines to eliminate the need for lubricating oil changes. S: Practice preventative maintenance to reduce leaks and drips. Label containers appropriately. S: Contract with service company to purify and regenerate oil for reuse rather than replacing with new lubricating oil. S: Consider use of synthetic oil. S: Use oil additives that improve engine and oil performance. R: Recycle back into production stream on facility where generated. (Note: Ensure that no conflict arises with purchaser or refiner.) R: Send to an approved state-permitted recycling facility. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Used oil for disposal is assumed hazardous unless analytical testing determines it to be nonhazardous. Use appropriate PPE. Avoid eye and skin contact.
Mercury, free	S: Replace mercury manometers, level switches, flow meters and gas meters with electronic (digital) instruments. S: Do not use mercury in operations. R: Send to mercury recycler. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. **Special considerations:** Highly toxic. Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance.
Metal, scrap	S: If clean, re-use for structural steel. R: Sell to salvage/scrap dealer (metal recycler). D: Send to an approved, state-permitted disposal facility. **Special considerations**: Check for naturally occurring radioactive material (NORM) before disposal.
Methanol, used	S: Use all of the product whenever possible. R: Send to an approved, state permitted recycling facility. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Highly flammable. Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for guidance.

Molecular sieve, spent	S: Install activated carbon upstream of the unit to remove corrosion inhibitors, amines, absorber oils, glycol, and other contaminants to extend the life of the molecular sieve. S: Regenerate molecular sieves for reuse. R: Before disposing of spent filters, drain all free liquids from the sieve media into a container. Recycle back through production stream, on the lease from which the sieves are generated. D: Send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific material.
Naturally Occurring Radioactive Materials (NORM), NORM-containing materials	S: Periodic monitoring for accumulations of NORM may minimize potential risks and liabilities. S: Use scale inhibitors where NORM scale accumulates. Circulate inhibitor in well or inject inhibitor into producing formation. S: Avoid mixing incompatible produced waters that will result in scale formation. S: Design facility to reduce locations prone to scale formation (e.g., large pressure drops and unnecessary pipe elbows). S: Do not mix NORM with other materials. S: Dually complete oil zone and water zone to allow water to be produced simultaneously but separately from oil and to allow control of water coning. (Research indicates that water production may be reduced by as much as half, thereby reducing exposure to NORM of production equipment carrying the oil stream.) S: Use polymer injection to reduce permeability to water in the production zone, thereby reducing the volume of radionuclide-containing water produced. S: Use rock plugging with gel slugs to block off water production in completions where there is a discernible separation of the oil and water zones. S: Carefully design gravel packs and other well screening procedures to reduce the volume of NORM-contaminated formation sand (coated by NORM scale) that is produced. S: Coat material surfaces with chemicals at critical points in the production system to reduce the availability of nucleation points for NORM-containing scale formation. S: Reinject NORM-containing produced water (containing scale inhibitors) for enhanced recovery, (preferably into the same zone from which it was produced), as soon as possible after initial production to increase the amount of NORM returned to the subsurface and decreasing the potential for the precipitation of NORM-containing scale in surface equipment. S: Store NORM-contaminated waste in either tanks or lined pits which will accommodate the eventual recovery and proper disposal of the NORM-contaminated waste. The contamination of soils with NORM may be averted by not storing NORM containing produced water or other waste in earthen pits, thereby decreasing the volume of NORM-contaminated waste. S: Provide NORM management procedures training for employees involved with the operation and maintenance of affected production facilities. R: Clean NORM-contaminated scale from pipe and equipment to minimize the volume of NORM- contaminated waste requiring disposal and allow the

	recycling of the pipe and equipment. However, restrictions on the level of radioactivity of the NORM-contaminated waste may be imposed. R: Use of NORM-contaminated waste (metals) as feedstock at smelters may be a potential method of recycling. However, restrictions on the level of radioactivity of the NORM-contaminated waste may be imposed. D: Send to licensed radioactive waste land disposal facility. Special considerations: Use appropriate PPE. Consult MSDS for additional guidance.
Oil, slop	S: Recycle back into production stream. S: Install a mechanical stirrer inside slop oil tank to keep sediment in suspension. S: Implement the use of canned submersible pumps to replace conventional impeller type pumps used for fluid transfer service. S: Eliminates leaks from impeller pump seals and gear boxes. R: Send slop oil that cannot be recycled into production stream to a state-permitted tank bottoms reclamation facility. T: D: Obtain approval and send to an approved surface waste management facility or send to a state permitted municipal landfill. **Special considerations:** May contain hydrogen sulfide and/or NORM. Use appropriate PPE. Avoid eye and skin contact. Handle as crude oil; consider fire hazard.
Oil, weathered	S: Pick up spilled liquids or solids as soon as possible after the spill is contained. Recycle back into production stream. S: Prevent spills or waste whenever possible. D: Send to an approved, state-permitted disposal facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Handle as crude oil.
Paint and paint wastes	S: Paint less frequently; only when necessary. S: Buy in bulk and only the volume needed. Use all of the product before it becomes unusable. S: Size paint batches systematically to specific jobs. S: Eliminate the use of lead paint; use water-based, lead-free paint or high-solids coatings. S: Purchase less toxic, less volatile paints and solvents. Purchase paints with greater durability. S: Paint contractor should be responsible for the proper management of unused paint, solvents, and empty containers. S: Reduce and control overspray. Use a brush for small jobs rather than spraying. S: Keep containers closed to reduce evaporation. S: Ensure paint containers are completely emptied and dried. S: Use separate solvents and/or containers for each paint color. When solvent is spent use it as a thinner for that particular color. R: Regenerate solvents for reuse. R: Send to a recycler. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility or send to a state-permitted municipal landfill.
Pallets	S: Buy materials in skid-mounted bulk hoppers or containers.

	S: Purchase recycled plastic pallets which have a longer life than wooden pallets. R: Reuse pallets. R: Return pallets to the vendor. R: Send wooden pallets to a pallet or wood recycler. R: Chip uncontaminated wooden pallets and use as mulch. D: Dispose in state-permitted municipal solid waste landfill.
Paraffin	S: Collect solidified paraffin in tanks, mix with paraffin solvent, and recycle back into production stream. S: Investigate the feasibility of installing magnetic fluid conditioner(s) to prevent paraffin formation. S: Use paraffin inhibitor chemicals. S: Use hot-oil treatment to dissolve paraffin in well and flow lines; send to production. R: Send mechanically removed paraffin to a recycler. D: Send to an approved, OCD-approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact.
PCB, oil	S: Replace any electrical equipment that is determined to be PCB containing with non-PCB containing, electrical equipment. D: Hazardous: Send to an approved hazardous treatment and waste disposal facility. **Special Handling**: Contact your Health and Safety Coordinator immediately!
Pesticides	S: Use rinse water in original application whenever possible. S: Use inventory control; e.g., a surplus chemicals exchange network that offers unused pesticides to other company facilities in lieu of disposal. S: Use a licensed commercial pesticide application service. S: Properly store and label containers to prevent degradation and contamination. S: Use all contents/material and then triple rinse the container. Use rinsate as originally intended for the material. S: Practice good inventory control. Use excess at another facility. R: Return unused chemicals to vendor for recycling. R: Send unusable chemicals to a recycler. T: D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Highly regulated substances. Use licensed applicators/contractors. Avoid eye and skin contact. Read warning labels; consult MSDS for additional guidance. Triple rinse drums/containers before disposal. Manage rinse water as hazardous unless reused.
Pigging wastes from gathering lines	S: Minimize paraffin accumulation (see paraffin). Add appropriate chemical agents to reduce accumulation of paraffin. S: Reduce accumulation of hydrates (see hydrates). S: Reduce accumulation of scale (see scale). R: If possible, reuse pigs. R: Recycle paraffin whenever possible. (See Paraffin.) D: Send to an approved surface waste management facility. **Special considerations**: May contain hydrogen sulfide; use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance.

Pigging wastes from transportation pipelines	S: Minimize paraffin accumulation (see paraffin). Add appropriate chemical agents to reduce accumulation of paraffin. S: Reduce accumulation of hydrates (see hydrates). S: Reduce accumulation of scale (see scale). R: If possible, reuse pigs. R: Recycle paraffin whenever possible. (See Paraffin.) D: Hazardous: Send to an approved hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Pipe dope, used	S: Choose biodegradable, lead-free pipe dope. S: Use all of the product whenever possible. S: Minimize waste, conserve compound for use at the next job. S: All drilling, well servicing, pipeline, and other contractors should be responsible for unused and waste pipe dope and containers. D: Send empty containers to an approved disposal facility. Send excess pipe dope waste to approved surface waste management facility. **Special considerations**: Pipe dope must be TCLP tested for lead to determine if it is a hazardous waste and therefore subject to regulatory requirements.
Pit wastes Includes: waste in reserve pits and emergency pits	S: Use rig wash judiciously. Install high-pressure, low-volume spray nozzles with automatic cutoffs. S: Segregate fresh water, salt water, and oil-based fluids and solids. Use the "reserve pit management system." S: Remove oil as soon as possible to minimize contamination of pit. S: Locate and eliminate all sources of water leaks. S: Grade site and use diversion structures to prevent or minimize storm water run-on volume. S: Use a closed-loop drilling fluid system if feasible. S: Design pit and pit system to minimize waste. For example, use the "V" shaped pit or the "reserve pit management system." S: Size and construct pits to accommodate only the necessary volumes anticipated plus an adequate freeboard. S: Use tanks/vacuum trucks rather than earthen pits for workovers. R: Stabilized, uncontaminated solids may be suitable for use as daily cover at landfills. R: Recover and reuse weighting materials and drilling fluids. Waste drilling mud can be reused at other locations for spudding or plugging and abandoning operations. R: Contract a drilling mud recycler to take waste drilling mud. D: Hazardous: send to an approved, state-permitted RCRA hazardous waste disposal facility. D: Nonhazardous: send to a state-permitted municipal solid waste landfill.
Plastic liners	S: Use reusable steel pits or portable tanks whenever possible. S: Purchase liners constructed of recycled plastic. R: Send to a plastic recycler. D: Hazardous: send to an approved hazardous waste treatment and disposal facility.

	D: Nonhazardous: Send to an approved landfarming facility. D: Nonhazardous: send to a state-permitted municipal solid waste landfill.
Produced sand	S: Improved gravel pack design. S: Optimize production rate to minimize sand production. S: Design perforations in completion to minimize sand production. R: Use as fill material, if uncontaminated R: Send to cement kiln as a substitute for feedstock, if permissible. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Produced water	S: Assess the feasibility of treating the producing formation with polymers that decrease the permeability of the formation for water, while the permeability of hydrocarbons remains unchanged. S: Use rock plugging with gel slugs to block off water production in completions where there is a discernible separation of the oil and water zones. S: Dually complete oil zone and water zone to allow water to be produced simultaneously but separately from oil and to allow control of water coning. (Research indicates that water production may be reduced by as much as half.) S: Investigate feasibility of dually completing gas/water producing zone and injection disposal zone (water phase separates and is not produced at surface). S: Carefully planned well completions. S: Reperforate well to reduce water production. S: Drill wells to minimize water production (e.g., horizontal wells when feasible). S: Optimize production rate to minimize the influx of water (e.g., coning). R: Create a system that distributes produced water to various waterfloods in area. Results: reduction in volume of produced water requiring disposal and reduction of the amount of make-up water purchased. Also, the need for water storage tanks for suction at water injection stations is eliminated by pumping directly from the water separation tanks to provide pressured water to the high-pressure injection pumps. This reduces cost associated with operating charge pumps at the water station. R: Use produced water for hydrotesting of pipelines, equipment and tanks. R: Desalinate for use in other E&P operations if water supply is scarce and the process is cost effective. D: Send to an approved, state-permitted disposal facility. **Special considerations**: May contain flammable or combustible compounds and hydrogen sulfide.
Rags, oily	S: Maintain equipment and facilities to prevent drips, leaks, and spills which would require cleanup. S: Use drip pans or other containment devices to collect leaks, drips or accidental spills. Empty containment devices properly. R: Keep separate from other wastes and wash for reuse. R: Send to recycler. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill.

	Special considerations: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Rigwash	S: Prudent use of water in rig maintenance. S: Use high-pressure, low-volume hose nozzles with automatic cutoffs. S: Set up a regular maintenance program for water systems to reduce leaks and drips. S: Remove paint solids from water arrestor holding tanks with a centrifuge or cyclone system. S: Reduce rigwash use by sweeping or other dry cleaning when feasible. S: Collect rigwash in tanks rather than earthen pits. R: Collect and reuse rigwash for subsequent rig wash-downs or for first stage washing of equipment. R: Use as make-up water in drilling and completion operations. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Sandblast media – see Blasting sand, media	
Scale, pipe and equipment	S: Use scale inhibitors. Circulate inhibitor in well or inject inhibitor into producing formation. S: Avoid mixing incompatible produced waters which will result in scale formation. S: Design facility to reduce locations prone to scale formation (e.g., large pressure drops and unnecessary pipe elbows). S: Dually complete oil zone and water zone to allow water to be produced simultaneously but separately from oil and to allow control of water coning. (Research indicates that water production may be reduced by as much as half, thereby reducing scale formation in production equipment carrying the oil stream.) S: Use polymer injection to reduce permeability to water in the production zone, thereby reducing the volume of water produced which is the source of scale. S: Use rock plugging with gel slugs to block off water production in completions where there is a discernible separation of the oil and water zones. S: Coat material surfaces with chemicals at critical points in the production system to reduce the availability of nucleation points for scale formation. R: Clean scale from pipe and equipment and recycle the pipe and equipment. D: Obtain approval and send to an -approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Scrubber wastes	S: Convert to natural gas as a fuel to avoid generating SO2 and fly ash. R: Remove solids through gravity separation, filtration, etc., and send liquids to water softening for steam generation or direct injection for enhanced recovery. R: Use as an oxygen scavenger.

	D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Silver-containing waste (e.g., film developing process)	S: Minimize the number of film reproductions. S: Install on-line equipment to remove silver from process liquids. R: Recover silver from the film/developing solution before disposal and recycle. R: Send waste liquids to a recycler. R: Send waste solids and film to a recycler. T: Hazardous: Treat to meet standards D: Dispose of silver-containing liquids in state-permitted wastewater treatment facility allowed to accept trace metals. D: Hazardous: Send to an approved hazardous waste treatment and disposal facility.
Soils, unused-chemical contaminated	S: Develop operational procedures that prevent contamination of soils. For example, use containment devices in chemical storage areas to prevent contamination of soils. S: Install fencing around chemical storage to discourage losses due to vandalism. R: Recover free liquids and recycle. T: Hazardous: Treat to meet standards. D: Hazardous: send to an approved, hazardous waste treatment and disposal facility. Nonhazardous: Send to an approved landfarming facility or send to a permitted-municipal landfill. **Special considerations:** Chemical spills on soils may produce a hazardous waste. Consult MSDS for guidance for each chemical.
Soils, crude oil contaminated (in primary field operations)	S: Pick up free liquid or solids spilled as soon as possible after the spill is contained. Recycle back into production stream. S: Develop operational procedures that prevent contamination of soils. For example, preventative maintenance on flowlines and containment under tank battery load-line connections. S: Use impervious secondary containment. Use pit liner material around and under production facilities. S: Consider use of magnetic ion coating technology for stuffing box packing rubbers, valve stems and other friction and wear points that may provide a source of leakage. S: Prepare and implement Spill Prevention, Control and Countermeasures (SPCC) Plans for each facility. S: Use cathodic protection or coated pipe to reduce leaks caused by corrosion. S: Consolidate produced fluid separation and well testing facilities. S: Use "canned submersible pumps" to replace conventional impeller type pumps use for fluid transfer service. R: Recover free crude oil and return to production stream. D: Send to an approved surface waste management facility. **Special considerations**: Handle as crude oil. Use appropriate PPE. Avoid eye and skin contact.
Soils, lube oil contaminated	S: Pick up spilled liquid or solids as soon as possible after the spill is contained and recycle.

	S: Develop operational procedures that prevent contamination of soils. For example, preventative maintenance on lubricating oil system and containment under system. S: Use impervious secondary containment. Use pit liner material around and under lubricating oil systems. R: Recover free lubricating oil and recycle. T: Hazardous: Treat to meet standards. D: Hazardous: Send to an approved, hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an -approved surface waste management facility or send to an approved, landfarming facility. **Special considerations**: Test for heavy metals (TCLP) to determine if hazardous. Use appropriate PPE. Avoid eye and skin contact. Lube-oil contaminated soil is assumed to be RCRA hazardous waste, unless analytical testing indicates it is nonhazardous.
Soil, produced water-contaminated	S: Develop operational procedures that prevent contamination of soils. For example, preventative maintenance on flowlines and containment under tank battery load-line connections. S: Use impervious secondary containment. Use pit liner material around and under production facilities. S: Consider use of magnetic ion coating technology for stuffing box packing rubbers, valve stems and other friction and wear points that may provide a source of leakage. S: Use cathodic protection or coated pipe to reduce leaks caused by corrosion. S: Consolidate produced fluid separation and well testing facilities. S: Use "canned submersible pumps" to replace conventional impeller type pumps use for fluid transfer service. S: Pick up spilled liquid as soon as possible after the spill is contained. S: Use smaller injection pumps at each injection well for secondary recovery projects and supply water by gravity drainage (low pressure lines) from a central water storage tank. S: Prepare and implement Spill Prevention, Control and Countermeasures (SPCC) Plans for each facility. D: Obtain approval and send to an -approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Solvents (organic solvents used in cleaning and degreasing equipment)	S: Use water-based solvents or soap cleaners that are biodegradable whenever possible. S: Substitute nonhazardous surfactants (soap) for hazardous solvents (mineral spirits) for equipment cleaning. S: Use up all solvent in container, ensuring no residue remains. S: Minimize amount of solvent being lost during cleaning or maintenance; for example, use drip pans to collect solvent for reuse. S: Use high-pressure water, steam or other non-toxic solvents to clean equipment. S: Keep solvent containers tightly covered when not in use to decrease loss due to vaporization. S: Use inventory control to minimize volume of unnecessary solvent stored. S: Use dirty solvent for initial cleaning and clean solvent for final cleaning.

	R: Send to a recycler. R: Filter/clean or regenerate solvents and reuse. R: Use spent solvent for paraffin removal. T: Hazardous: Treat to meet standards. D: Hazardous: Send to an approved, hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: May be highly flammable. Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for guidance for a specific solvent. Can be tested to determine hazard status.
Storm water	S: Improve work process and properly maintain equipment and facilities to reduce leaks, spills, etc. S: Cover facilities to eliminate contamination of storm water. S: Segregate storm water drainage from liquid storage, loading/unloading facilities and, operations areas from unimpacted areas. S: Clean up spills and leaks promptly to minimize storm water contamination. R: Use storm water as make-up water in the process. For example, use contaminated storm water for first stage washing of equipment, use storm water as make-up water in drilling/completion operations, and use storm water for process water and agricultural purposes. D: Discharge under permit
Sulfur recovery unit wastes, including sulfur-contaminated	S: Substitute a less hazardous catalyst in the Scot Tailgas process of a sulfur recovery plant. Nonhazardous spent catalyst waste can result, thereby resulting in disposal cost savings. D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.
Tank bottoms (basic sediment and water)	S: Recycle back through treatment system, with no additional requirements. S: Keep turbulent flow in tank to prevent sedimentation whenever possible. The use of mechanical stirring devices in oil storage tanks will eliminate build-up of tank bottom sediments and reduce chemical storage. S: Add appropriate chemical agents to reduce tank bottom accumulation. S: Treat light oil tank bottoms with high temperature in heavy oil dehydration facilities. S: Recover product by recycling light oil tank bottoms through heavy oil dehydration facilities. Results: added revenue and substantial cost savings through reduction of waste disposal. S: Use cone bottom stock tanks and run bottoms through heater-treater more frequently than normal. S: Reduce the number of tanks by consolidating produced fluid storage facilities. S: Keep a gas blanket on tanks to reduce oxygen and formation of iron oxides. A gas blanket can also reduce risk of explosion and subsequent leakage due to lightning strikes. S: Identify and minimize the source of solids. R: Send tank bottoms to crude oil reclamation plants. R: Send to a refinery coker.

	R: Use a centrifuge or filter press to recover oil and water from tank bottoms. D: Send to an approved, state-permitted disposal facility. **Special considerations**: May contain hydrogen sulfide. Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance.
Thread protectors	S: Avoid using excess pipe dope. S: Return to vendor. R: Reuse in operations or sell for re-use. R: Send to a reclamation facility that removes pipe dope and markets the thread protectors for reuse. R: Send to a scrap metal or plastic recycler. D: Hazardous: Send to an approved, hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility or send to an approved, landfarming facility. Send cleaned, crushed, nonhazardous thread protectors to municipal solid waste landfill. **Special considerations:** Considered hazardous waste if pipe dope is present and intended for disposal. Use gloves.
Tires	S: Rotate tires and align regularly. S: Maintain proper inflation pressure. S: Purchase tires with greater road-wear abilities. R: Send to a tire recycler. R: Purchase retreaded tires if feasible. D: Send to an approved, state-permitted municipal solid waste landfill.
Vacuum truck rinsate	S: Use chemicals and products that are less hazardous or toxic. S: Avoid mixing nonhazardous and hazardous wastes in vacuum truck. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved, hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical. Dangerous fumes may collect inside the tank. Use appropriate PPE. Avoid eye and skin contact.
Well completion, treatment, and stimulation fluids, unused	S: Recycle unused frac oil back into production stream. S: Use all of the product whenever possible; e.g., use excess frac oil, acid, stimulation fluids, and xylene in other wells. S: Use inventory control; e.g., a surplus chemicals exchange network that offers unused chemicals to other company facilities in lieu of disposal. S: Return unused portion to vendor. T: Hazardous: Treat to meet standards D: Hazardous: Send to an approved, hazardous waste treatment and disposal facility. Nonhazardous: Obtain approval and send to an approved surface waste management facility. **Special considerations**: Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for guidance for specific material. Can be tested to determine hazard status.

Workover wastes, used	S: Place into production stream whenever possible. R: Recycle free liquids back into production stream. T: D: Obtain approval and send to an approved surface waste management facility or send to a permitted municipal landfill. **Special considerations:** Use appropriate PPE. Avoid eye and skin contact. Consult MSDS for additional guidance for specific chemical.

The above section is based on the Pollution Prevention Best Management Practices for the New Mexico Oil and Gas Industry Guidance, issued by the Oil Conservation Division of the State of New Mexico.

8.2 Waste Categorization Matrix

		Hazardous Characteristics																
Waste Name	Waste Code	Explosives	Inflammable Liquids	Inflammable Solids	Substances or wastes liable to spontaneous combustion	Substances liable to combust on contact with water	Oxidizing	Toxic or Poisonous	Infectious substances to hazardous health	Corrosive	Substance liable to generate toxic gases on contact with air or water	Toxic	Ecotoxic	Capable of yielding another substance on disposal	Radioactive	Persistent wastes	Carcinogenic wastes
General waste																	
Acetylene																	
Aerosol Cans (Empty)																	
Aerosol Cans (Containing flammable products)																	
Aerosol Cans (Containing Non-flammable material)																	
Batteries (Dry)																	
Batteries (Lead Acid)																	
Concrete																	
Cooking oil																	
Crankcase Oil, Used																	
Diesel Fuel																	
Domestic Wastewater																	
Drilling Fluids (HDD)																	
Drums (Empty)																	
Filters																	

Fluorescent Light Bulbs																	
Food Waste																	
Glycols & Related Materials																	
Hydraulic Oil																	
MEK (Methyl Ethyl Ketone)																	
Nitrogen (Compressed)																	
Nitrogen (Cryogenic Liquid)																	
Oil Spill Related Wastes																	
Oily Rags																	
Paint																	
Paint Thinner																	
Paint Brushes and Cans																	
Pigs																	
Pipe Dope																	
Sandblast Materials (Residue)																	
Scrap Metals (NORM Free)																	
Tires, Used																	

8.3 Test Methods for Hazardous Characteristics

This section provides a listing of the indicative test methods for the analysis of water, soil, sludges, hydrocarbons and waste for characterization purposes. Test methods not listed in this section may also be considered, providing they can be validated through collaborative studies, comparison to SRM (Standard Reference Materials), and statistical analyses (precision, standard deviation data).

The Guidelines for Collaborative Study Procedure to Validate Characteristics of a Method of Analysis, in the appendix of AOAC. (1990), or Method Development and Evaluation, Method 1040 in APHA (1992), outlines steps that must be considered when preparing a collaborative study.

Analytical Methods; Reference Code Descriptions

1. AOAC, "Official Method of Analysis, of the Association of Official Analytical Chemists", current edition.
2. APHA-A WW A-WEF, "Standard Methods for the Examination of Water and Wastewater", current edition.
3. ASTM, "American Society for Testing and Materials", current edition.
4. Alberta Environmental Protection, "Methods Manual for Chemical Analysis of Water and Wastes", Alberta Environmental Centre, Vegreville, Alberta; October 1987, AECV87-M1, or latest edition.
5. Alberta Environmental Protection, "Methods Manual for Chemical Analysis of Pesticides and PCB Residues in Water and Wastes", Pollution Control Laboratory, Edmonton, Alberta, 1979.
6. Carter, M. R, "Soil Sampling and Methods of Analysis", Canadian Society of Soil Science, 1993.
7. Dionex Corporation Methods Manual.
8. ENVIRODAT, Dictionary of Codes, Environment Canada.
9. EPA, see US EPA.
10. FSPA, "Method Manual for Forest Soil and Plant Analysis", Kalra, Y. P. and Maynard, D.G., IRNOR-X-319, Forestry Canada.
11. McGill and Rowell, "Extraction of Oil from Soils", The Reclamation of Agricultural Soils after Oil Spills, Department of Soil Science, University of Alberta.
12. McKeague, J. A., "Manual on Soil Sampling and Methods of Analysis", Canadian Society of Soil Science, 1978.
13. NAQUADAT, Dictionary of Codes, Water Quality Branch, Environment Canada.
14. SM (Standard Methods), see APHA.
15. Syncrude, "Syncrude Analytical Methods for Oil Sand and Bitumen Processing", Syncrude Canada Ltd., Edmonton, Alberta, 1979.
16. TCLP, "Toxicity Characteristic Leaching Procedure".
17. TDGR, "Transportation of Dangerous Goods Regulation".
18. US EPA, "Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW -846", 1986 or latest edition.
19. US EPA, "Environmental Protection Agency Regulations on Test Procedures for the Analysis of Pollutants".
20. Test for Pyrophoric Substances or Test for Self-Heating Substances - Interim Compilation of Test Methods Under TDOR
21. Test for Solid Oxidizing Substances -Interim Compilation of Test Methods Under TDOR
22. By review of specified references or previous knowledge

Waste Characterization	
Analytical Parameter/Test	**Method**
Liquids/Solids	US EPA method 9095 Paint Filter Liquids
Dispersible Form	US EPA method 9095 Paint Filter Liquids
Flammable Liquids	ASTM 056-79, or ASTM 093-80, or ASTM 03828-81, or ASTM 03278-82
Flammable	ASTM093-80 USEPAMETHOO 1010
Flammable Solids	Readily Combustible Bum Test or Burning Rate Test -Interim Compilation of Test Methods Under TDGR
Flammable Solids	Test for Pyrophoric Substances or Test for Self-Heating Substances - Interim Compilation of Test Methods Under TDOR
Oxidizing Substances	Test for Solid Oxidizing Substances -Interim Compilation of Test Methods Under TDOR
Poisonous Solids or Liquids	By review of specified references or previous knowledge
Toxic Gases	By review of specified references or previous knowledge
Corrosive Solids or Liquids	Method 9040, 9041, 9045 SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods- US EPA
Polychlorinated Biphenyls or, Article containing PCB	US EPA Method 8080A or ASTM D 3304 or A Method for the Analysis of Polychlorinated Dibenzo-para-dioxins (PCDDs), and Polychlorinated Biphenyls (PCBs), etc. 1/RM/3, May 1990 Environment Canada
Toxic Leachate Waste	Method 1311 Toxicity Characteristic Leaching Procedure (TCLP) US EPA Reg 40CFR261 App II
Toxic Leachate Waste- containing Dioxin or Furan	A Method for the Analysis of Polychlorinated Dibenzo-para-dioxins (PCDDs), and Polychlorinated Biphenyls (PCBs), etc. 1/RM/3, May 1990 Environment Canada or Reference Method for the Analysis of Polychlorinated Dibenzo-para-dioxins (PCDDs), and Polychlorinated Dibenzo fruans (PCDFs) in Pulp and Paper Mill Effluents EPS 1/RM/19 Feb 1992 Environment Canada
Waste type 200 Spent Filters produced in the fabric cleaning industry where an organic solvent is used as the cleaning agent	Determine if the filters have been steam stripped in a steam cabinet with sparger for a period of 8 hours or more.
Waste Type 201 Spent Lubricating Oil and Undrained Lube Oil Filters Removed from Internal Combustion Engines	Calculated DE for filters
Landfillable halogenated solids	TCLP, General: - extract the sample in n-hexane using EPA 3550: Landfillable - run the extract as per EPA 9076; or - ethyl acetate or n-hexane extraction followed by combustion 8Ild microcolonnetric titration - Specific compounds- EPA 8240 and 8270 (SW-846)

Landfillable halogenated liquids	TCLP Petroleum Liquids: EPA 9076 for total halogenated organics, Alberta Environmental Protection Ml 06.0 for PCBs Water: EPA 9020 for total halogenated organics, Alberta Environmental Protection Al06.0 for PCBs PCB: analytical method involves the use of a gas chormatograph with an electron capture detector. The use of US EPA Method 8080A or AS1M D 3304 are recommended.
Landfillable nonhalogenated organic compounds	TCLP for cresols and cresylic acid: EPA 8270 following the acid extractables portions only, use compounds EPA 3510 or 3550 for sample extraction as appropriate. For remainder of parameters (liquids and solids): EPA 8240 purge and trap GC/MS (3 additional purge parameters) or GC/FID.
Landfillable spontaneously combustible hazardous waste	Test for Pyrophoric Substances or Test for Self-Heating Substances- Interim Compilation of Test Methods Under TDGR
Landfillable liquid hazardous waste containing metals	arsenic SM• 3114B, beryllium SM• 3120B, cadmium Naquadat No. 48011, chromium hexavalent SM• 3500-CrD, lead Naquadat No. 8201, mercury SM* 3500 HgB, nickel Naquadat No. 28011, selenium SM* 3114B, silver SM*3500-~gC, thallium SM* 3500-TIC, uranium Dionex Method 48 Note SM*=Standard Method
Landfillable solid hazardous waste containing metals	Method 1311 Toxicity Characteristic Leaching Procedure (TCLP) US EPA Reg 4CFR261. App ll (for hazardous waste buried with garbage) or (modified for hazardous waste buried alone, monofills)
Landfillable liquid hazardous waste containing cyanide	Naquadat No. 06608L with auto colorimetric instrumentation
Landfillable hazardous corrosive wastes	Method 9040,9041,9045 SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods

Water	
Analytical Parameter/Test	**Method**
PH	APHA 4500 W (B); AOAC 973.41; EPA 9040
Specific Conductance	APHA2510 (B), AOAC 973.40; EPA 9050
Major Ions	
Calcium	APHA 3500 Ca (C); APHA 3120 (B); EPA 6010 APHA3500Ca(B); EPA 7140 APHA 3500 Ca (D)
Magnesium	APHA 3500 Mg (C); APHA 3120 (B); EPA 6010 APHA 3500 Mg (B); EPA 7450; AOAC 974.27
Potassium	APHA 3500 K (C); APHA 3120 (B); EPA 6010 APHA 3500 K (B); EPA 7610; AOAC 973.53 APHA 3500 K (D)
Sodium	APHA 3500 Na (C); APHA 3120 (B); EPA 6010 APHA 3500 Na (B); EPA 7770; AOAC 973.54 APHA 3500 Na (D)
Chloride	APHA 4500 C1 (E); EPA 9250, 9251; APHA 4500 Cl (F); APHA 4110 (B) APHA 4500 Cl (B)
Nitrate (Nitrate +Nitrite - N) (Dissolved)	APHA 4500 N03 (E, F) APHA 4500 N03 (C); APHA 4110 (8) APHA 4500 N03 (H)
Sulfate (Dissolved)	APHA 4500 S04 (8); APHA 4110 (8) APHA 4500 S04 (F); EPA 9036
Metals, Total	APHA 3500 (C); APHA 3120 (8); EPA 6010 APHA 3500 (8); APHA 3111 (8, C, D)
Mercury	APHA 3500 Hg (8); APHA 3112 (8); EPA 7470·
Free Cyanides (CN)	APHA 4500 CN (E)
Oil and Grease	APHA 5520 (C) APHA 5520 (B)
Total Petroleum Hydrocarbon (Mineral Oil and Grease)	APHA 5520 (C) APHA 5520 (B)
Total Organic Carbon (TOC)	APHA 5310 (B); AOAC 973.47
Phenols	APHA 5530 (D) EPA 420.2
Total Dissolved Solids (TDS)	APHA 2540 (C) APHA 1030 (F)
Chemical Oxygen Demand (COD)	APHA 5220 (D) APHA 5220 (C);

Soil and Sludges	
Analytical Parameter/Test	**Method**
Saturated Paste and Paste Extract	McKeague 3.21
Water Saturation (%)	McKeague 3.21; McKeague 2.411; Carter 18.2.2
Texture	McKeague 4.8
Hydraulic Conductivity	McKeague 2.51; Carter 55.2; EPA 9100 Carter 55.3
Ph	McKeague 3.11, Carter 16.3; EPA 9045; McKeague 3.14, Carter 16.2.
Electrical Conductivity	APHA 2510 (B); EPA 9050; Carter 18.3.1; McKeague 4.1
Major Ions	
Calcium	APHA 3500 Ca (C); APHA 3120 (B); EPA 6010 APHA3500Ca(B); EPA 7140 APHA 3500 Ca (D)
Magnesium	APHA 3500 Mg (C); APHA 3120 (B); EPA 6010 APHA 3500 Mg (B); EPA 7450; AOAC 974.27
Potassium	APHA 3500 K (C); APHA 3120 (B); EPA 6010 APHA 3500 K (B); EPA 7610; AOAC 973.53 APHA 3500 K (D)
Sodium	APHA 3500 Na (C); APHA 3120 (B); EPA 6010 APHA 3500 Na (B); EPA 7770; AOAC 973.54 APHA 3500 Na (D)
Chloride	APHA 4500 Cl (E); EPA 9250, 9251; APHA 4500 Cl (F); APHA 4110 (B) APHA 4500 Cl (B)
Nitrate (Nitrate +Nitrite - N) (Dissolved)	APHA 4500 N03 (E, F) APHA 4500 N03 (C); APHA 4110 (8) APHA 4500 N03 (H)
Sulfate (Dissolved)	APHA 4500 S04 (8); APHA 4110 (8) APHA 4500 S04 (F); EPA 9036
Water Solids and Content	McKeague 2.411; Carter 5 1.2.
Available Nutrients	
Ammonia Nitrogen	APHA 4500 NH3 (D, H); Carter 4.4 APHA 4500 NH3 (F, G)
Nitrate Nitrogen	APHA 4500 N03 (E, F), McKeague 4.311; Carter 4.3 APHA 4500 N03 (C)
Phosphorous, extractable (Orthophosphate)	APHA 4500 P (F)~ AOAC 973.55, 973.56 McKeague 4.43, McKeague 4.44, FSPA 13.1
Nitrogen, Total (sum of ammonia, nitrate and nitrite nitrogen)	APHA 4500 NH3 (D, H) Carter 22.2 APHA 4500 (F, G)
Phosphorous, Total	APHA 4500 P (F) AOAC 973.55, 973.56
Cation Exchange Capacity (CEC)	McKeague 3.321; Carter 19.4 McKeague 3.34
Sodium Adsorption Ration (SAR)	McKeague 3.26 Carter 18.4.3
Metals, Total	APHA 3500 (C); APHA 3120 (B); EPA 6010 APHA 3500 (B); APHA 3111 (B, C, D)
Boron (B)	APHA 4500 B (D) APHA 3120 (B) EPA

	6010; Carter 12.2.4 McKeague 4.61; Carter 12.2.2 APHA 4500 B (B); McKeague 4.62
Mercury (Hg)	APHA 3500 Hg (B); APHA 3112 (B); EPA 7471
Arsenic (As)	APHA 3500 As (B); APHA 3114 (C), EPA 7061 APHA 3500 As (B); APHA 3113 (B); EPA 7060 APHA 3500 As (D); APHA 3120 (B); EPA 6010
Selenium (Se)	APHA 3500 Se (C); APHA 3114 (C), EPA 7741 APHA3500 Se(H); APHA3113 (B); EPA 7740 APHA 3500 Se (I); APHA 3120; EPA 6010
Oil and Grease	APHA 5520 (C) APHA 5520 (B)
Total Petroleum Hydrocarbon	APHA 5520 (C) APHA 5520 (B)
% Oil	EPA 3540; McGill and Rowell
Total Organic Carbon / Organic Matter	McKeague 3.613; Carter 21.2 McKeague 4.22
Phenols	APHA 5530 (D) EPA420.2
Bulk Density	McKeague 2.2

8.4 Recommended Manifest Form

<table>
<tr><td colspan="4">Generator</td><td colspan="4">Transporter</td></tr>
<tr><td colspan="2">Company Name:</td><td colspan="2">Operator Id.:</td><td colspan="2">Company Name:</td><td>City:</td><td>County:</td></tr>
<tr><td colspan="4">Address:</td><td colspan="2">Address:</td><td colspan="2">Postal Code:</td></tr>
<tr><td>City:</td><td>County:</td><td colspan="2">Postal Code:</td><td>Date:</td><td>Unit No.:</td><td>Phone:</td><td>Fax:</td></tr>
<tr><td colspan="4">Source Site Location:</td><td colspan="4" rowspan="2">Certification – I declare that I received wastes as offered by the Generator for delivery to the intended Receiver and that the information contained below is correct and complete.
NAME (Print): Signature:</td></tr>
<tr><td colspan="4">License Type & Number:</td></tr>
<tr><td colspan="4" rowspan="2">Intended Receiver:</td><td colspan="4">Receiver</td></tr>
<tr><td colspan="2">Company Name:</td><td>City:</td><td>County:</td></tr>
<tr><td>City:</td><td colspan="3">County.:</td><td colspan="2">Address:</td><td colspan="2">Postal Code:</td></tr>
<tr><td colspan="4">Receiving Site Location:</td><td colspan="2">Receiving Site Location:</td><td colspan="2">Operator Id.:</td></tr>
<tr><td colspan="4">NAME (Print): Signature:</td><td colspan="4">NAME (Print): Signature:</td></tr>
<tr><td rowspan="2">Waste Description</td><td colspan="3">Containers</td><td rowspan="2">Total Quantity</td><td rowspan="2">Unit No.</td><td colspan="2" rowspan="2">Waste Code</td></tr>
<tr><td>No.</td><td colspan="2">Type</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="8">Comments:</td></tr>
<tr><td rowspan="2">Discrepancies</td><td colspan="7"></td></tr>
<tr><td colspan="2">NAME (Print):</td><td colspan="2">Date:</td><td colspan="3">Signature:</td></tr>
</table>

8.5 Liquid Effluents Limits for Discharge

Table 1. Onshore liquid effluents limits for discharge to surface waters or to land

Parameter	Limits	Type of effluent
Total hydrocarbon content	10 mg/L	Produced water, Hydrotest water, Completion and well workover fluids, Stormwater drainage, Sewage
pH	6 - 9	Produced water, Hydrotest water, Completion and well workover fluids, Sewage
BOD	25 mg/L	Produced water, Hydrotest water, Sewage
COD	125 mg/L	Produced water, Hydrotest water, Sewage
TSS	35 mg/L	Produced water, Hydrotest water, Sewage
Phenols	0.5 mg/L	Produced water, Hydrotest water, Sewage
Sulfides	1 mg/L	Produced water, Hydrotest water, Sewage
Heavy metals (total) (incl. Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc)	5 mg/L	Produced water, Hydrotest water, Sewage
Chlorides:	600 mg/l (average) 1200 mg/L (max)	Produced water, Hydrotest water, Sewage

Table 2. Offshore liquid effluent limits for offshore discharge

Parameter	Limits	Type of effluent
Oil and grease	does not exceed 42 mg/l daily maximum; 29 mg/L monthly average	Produced water, Flow-Back Water
pH	5 and more	Completion and Well Work-Over Fluids (In compliance with 96 hr. LC-50 of SPP-3% vol. toxicity test first for drilling fluids or alternatively testing based on standard toxicity assessment species (preferably site-specific species))
other parameters	Compliance with MARPOL 73/78[h]	Sewage, Food Waste, Storage Displacement Water, Bilge water, Deck Drainage (non-hazardous and hazardous drains)

Table 3. Liquid Effluents Levels for Petroleum Refining Facilities

Pollutant	Unit	Guideline Value
pH	S.U.	6-9
BOD5	mg/L	30 b
COD	mg/L	125 c
Total Suspended Solids (TSS)	mg/L	30
Oil and Grease	mg/L	10
Chromium (total)	mg/L	0.5
Chromium (hexavalent)	mg/L	0.05
Copper	mg/L	0.5
Iron	mg/L	3
Cyanide	mg/L	

Total Free		1 0.1
Lead	mg/L	0.1
Nickel	mg/L	0.5
Mercury	mg/L	0.003d
Arsenic	mg/L	0.1
Vanadium	mg/L	1
Phenol	mg/L	0.2
Benzene	mg/L	0.5e
Benzo(a)pyrene	mg/L	0.5
Sulphides	mg/L	0.2
Total Nitrogen	mg/L	10f
Total Phosphorus	mg/L	2
Temperature increase	C^o	<3g

8.6 Matrix on Parameters and Analytical Procedures for Substances Frequently Released by Petroleum Sector

Parameter	Measurement Protocol
Biochemical Oxygen Demand, BOD	• ISO 5815: 2003(en) Water quality — Determination of biochemical oxygen demand after n days (BODn)
Chemical Oxygen Demand, COD	• ISO 6060: Water Quality – Determination of the chemical oxygen demand. • ISO 15705: Water Quality – Determination of the chemical oxygen demand index (ST-COD) – Small-scale sealed-tube method.
Total Suspended Solids, TSS	• ISO 11923:1997 Water quality -- Determination of suspended solids by filtration through glass-fibre filters
pH	• ISO 10523:2008(en) Water quality — Determination of pH
Oil & Grease	• ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Total hydrocarbon content	• ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Temperature	• US EPA, SESDPROC-102-R3, Field Temperature Measurement.
Chloride	• ISO 15682: Water Quality – Determination of chloride by flow analysis (CFA and FIA) and photometric or potentiometric detection
Colour/Dye/Pigment	• ISO 787-3:2000 General methods of test for pigments and extenders -- Part 3: Determination of matter soluble in water -- Hot extraction method • ISO 787-8:2000 General methods of test for pigments and extenders -- Part 8: Determination of matter soluble in water -- Cold extraction method
Heavy Metals (Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc)	• APHA 3113: Metals by electrothermal atomic absorption spectrometry. • EN ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP – OES) • EN ISO 12846: Water Quality – Determination of mercury. Method using atomic absorption spectrometry (AAS) with and without enrichment • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • EN ISO 15586: Water Quality - Determination of trace elements using atomic absorption spectrometry with graphite furnace • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements
Phenols	• ISO 6439: Water Quality – Determination of phenol index – 4-aminoantipyrine spectrometric methods after distillation • ISO 8165-2: Water Quality – Determination of selected monovalent phenols – Part 2: Method by derivatization and gas chromatography
Total Chromium	• ISO 9174: Water Quality – Determination of chromium – Atomic absorption spectrometric methods

Chromium VI *(refining only)*	• ISO 11083: Water Quality – Determination of chromium (VI) – Spectrometric method using 1,5-diphenylcarbazide. • ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES).
Ammonia (as N) *(refining only)*	• EN ISO 11732: Water Quality – Determination of ammonium nitrogen – Method by flow analysis (CFA and FIA) and spectrometric detection
Sulphide *(refining only)*	• ISO 10530: Water Quality – Determination of dissolved sulphide – Photometric method using methylene blue
pH	• Laboratory Procedures for Analysis of Exploration and Production Waste, Louisiana Department of Natural Resources
Electrical conductivity	• *id*[35].
sodium adsorption ratio SAR	• Id.
Total extractable hydrocarbons	• *Id.*
Benzene	• *Id.*
Toluene	• *CCME,* Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 4 Analytical methods
Ethyl benzene	• *Id.*
Xylene	• *Id.*
Ethylene glycol (EG)	• *Id.*
Polychlorinated biphenyl (PCB)	• *Id.*
Barium	• *Id.*
Cadmium	• *Id.*
Chromium	• *Id.*
Copper	• *Id.*
Lead	• *Id.*
Mercury	• *Id.*
Nickel	• *Id.*
Vanadium	• *Id.*
Zinc	• *Id.*

[35] Id. means in the same source

8.7 Comparative Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Upstream Sector

Parameter	Permissible Limits under Kenyan Law[36]	Permissible Limits Best Practices (onshore)[37]	Monitoring (frequency)[38]	Measurement Protocol[39]
Water Quality (Effluents)				
Biochemical Oxygen Demand, BOD	1.0 mg/L	25 mg/L	Quarterly	• ISO 5815: 2003(en) Water quality — Determination of biochemical oxygen demand after n days (BODn)
Chemical Oxygen Demand, COD	50 mg/L *(refining only)*	125 mg/L	Quarterly	• ISO 6060: Water Quality – Determination of the chemical oxygen demand. • ISO 15705: Water Quality – Determination of the chemical oxygen demand index (ST-COD) – Small-scale sealed-tube method.
Total Suspended Solids, TSS	30 mg/L	35 mg/L	Quarterly	ISO 11923:1997 Water quality -- Determination of suspended solids by filtration through glass-fiber filters
pH	6-9	6-9	Quarterly	ISO 10523:2008(en) Water quality — Determination of pH
Oil & Grease	Nil	10mg/L	Quarterly	ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Total hydrocarbon content	×	10 mg/L	Quarterly	ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Temperature	± 3 (in degrees Celsius) based on ambient temperature	×	Quarterly	US EPA, SESDPROC-102-R3, Field Temperature Measurement.
Chloride	×	600 mg/l (average), 1200 mg/L (maximum)	Quarterly	ISO 15682: Water Quality – Determination of chloride by flow analysis (CFA and FIA) and photometric or potentiometric detection
Color/Dye/Pigment	15 Hazen units (H.U.)	×	Quarterly	• ISO 787-3:2000 General methods of test for pigments and extenders -- Part 3: Determination of matter soluble in water -- Hot extraction method • ISO 787-8:2000 General methods of test for pigments and extenders -- Part 8: Determination of matter soluble in water -- Cold extraction method
Heavy Metals[40]	×	5 mg/L	Quarterly	• APHA 3113: Metals by electrothermal atomic absorption spectrometry. • EN ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP – OES) • EN ISO 12846: Water Quality – Determination of mercury. Method using atomic absorption spectrometry (AAS) with and without enrichment • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • EN ISO 15586: Water Quality - Determination of trace elements using atomic absorption spectrometry with graphite furnace

[36] Water Quality Regulations, Third and Fourth Schedule; Air Quality Regulations, Arts. 5-7, First Schedule.

[37] https://www.ifc.org/wps/wcm/connect/4504dd0048855253ab44fb6a6515bb18/Final%2B-%2BOnshore%2BOil%2Band%2BGas%2BDevelopment.pdf?MOD=AJPERES&id=1323153172270 ; https://www.ecfr.gov/cgi-bin/text-idx?SID=6b51273d47e8dc451e0aac10f60cdfee&mc=true&node=pt40.31.419&rgn=div5#se40.31.419_150 ; NAAQS Table, https://www.epa.gov/criteria-air-pollutants/naaqs-table

[38] Water Quality Regulations § 14; Air Quality Regulations, § 19, 68, Fourteenth Schedule.

[39] https://www.concawe.eu/wp-content/uploads/2017/01/report-no.-4_13.pdf ; Air Quality Regulations, Eleventh Schedule.

40 Heavy metals include: Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc.

				• ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements
Phenols	0.001 mg/L *(refining only)*	0.5 mg/L	Quarterly	• ISO 6439: Water Quality – Determination of phenol index – 4-aminoantipyrine spectrometric methods after distillation • ISO 8165-2: Water Quality – Determination of selected monovalent phenols – Part 2: Method by derivatization and gas chromatography
Total Chromium	2 mg/L *(refining only)*	5 mg/L	Quarterly	ISO 9174: Water Quality – Determination of chromium – Atomic absorption spectrometric methods
Chromium VI *(refining only)*	0.05 mg/L	32 mg/L	Quarterly	• ISO 11083: Water Quality – Determination of chromium(VI) – Spectrometric method using 1,5-diphenylcarbazide. • ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES).
Ammonia (as N) *(refining only)*	100 (mg/L)	10.6 kg/m3	Quarterly	EN ISO 11732: Water Quality – Determination of ammonium nitrogen – Method by flow analysis (CFA and FIA) and spectrometric detection
Sulphide *(refining only)*	0.1 mg/L	158 mg/L	Quarterly	ISO 10530: Water Quality – Determination of dissolved sulfide – Photometric method using methylene blue

9. Revision Matrix:

Revision	Date	Purpose	Prepared by	Reviewed/Approved
Draft	19/02/2019	Issued for review	IHS Markit/ESAL	NEMA
Final Draft	26/04/2019	Issued for approval	IHS Markit/ESAL	NEMA
Revised Final Draft	16/01/2020	Aligned with approved review report	IHS Markit/ESAL	NEMA