12 SOIL AND GROUNDWATER

12.1 INTRODUCTION

During the construction and operation phases, different activities have the potential to generate wastewater, accidental spills, which could lead to impacts on the quality of groundwater due to leaching. In addition, groundwater use for the Project could impact the availability of groundwater for users in surrounding communities. In the Project Study Aarea, the groundwater aquifers are primarily Irrawadian and Peguan aquifers. Changes to in-situ groundwater levels, groundwater quality and any changes to soil structure and quality due to Project activities may lead to impacts to ecological receptors, as well as any future groundwater users. Therefore, understanding potential changes to the groundwater elevations, flow patterns, groundwater quality, and associated changes in soil quality, is considered essential in forming an overall understanding of Project impacts. In this regard, this Chapter presents an evaluation of the potential impacts on groundwater levels and quality and issues pertaining to quality of the in-situ soils. Impacts relating to topsoil loss due to surface water flows are discussed and assessed in-depth within the Surface Water Quality (***Chapter 9***). This is primarily due to the fact that management of surface water is related to ensuring that topsoil does not become mobilised as suspended solids.

This Chapter also develops management, mitigation and monitoring measures needed to ensure that any identified impacts can be reduced to as low as reasonably practical. Such measures are presented and will form part of the overall environmental and social management plan for the Project.

12.2 ASSUMPTIONS AND LIMITATIONS

The assessment of potential impacts related to groundwater and soils in this section is based on the environmental baseline data (presented within ***Chapter 5***), socio-economic baseline data (presented within ***Chapter 6*****)** and the information available from the Sponsor at the time of writing. Judgements and assessments have been made based on professional knowledge and previous experience of ERM. It is noted that no quantitative modelling has been undertaken with regards to any elements of the ground water impact assessment. Should there be significant changes in factors such as assumed input data or assessment criteria, then elements of this impact assessment and associated management, mitigation and monitoring measures may need to be amended to reflect these changes.

The environmental parameters sampled in the baseline survey, data from which have been used in the assessment, are commonly found contaminants and were selected based on extensive analysis suites provided by internationally recognized laboratories. Contaminants outside the analysis suite used under this ESIA were not assessed.

12.3 *SCOPE OF ASSESSMENT*

Based on the IFC Scoping Study and the Project Description (presented in ***Chapter 2***), the key potential impacts on soils and groundwater identified arise from the following activities.

Construction Phase

- Power Plant
  - Accidental events (spills, leaks and uncontrolled releases) associated with the storage, handling and disposal of hazardous materials, including fuels;
  - Soil disturbing activities and excavation during initial site preparation activities;
  - Wastewater Discharges and Run-off;
  - Storage and disposal of hazardous and non-hazardous waste;
  - Groundwater abstraction; and
  - Hydrotest discharges associated with Pre-commissioning & Testing.
- Gas Supply Pipeline
  - Accidental events (spills, uncontrolled releases) associated with the storage, handling and disposal of hazardous materials, including fuels;
  - Storage and disposal of hazardous and non-hazardous waste;
  - Soil disturbing activities and excavation associated with pipeline development; and
  - Pre-commissioning and testing liquids being directly discharged to the environment and eventually the groundwater aquifers.
- 230kV Overhead Transmission Line
  - Accidental events (spills, uncontrolled releases) associated with the storage, handling and disposal of hazardous materials, including fuels;
  - Storage and disposal of hazardous and non-hazardous waste; and
  - Soil disturbing activities and excavation associated with pole installation and development of access roads.
- Water Supply Pipeline and Wastewater Discharge Pipeline
  - Accidental events (spills, uncontrolled releases) associated with the storage, handling and disposal of hazardous materials, including fuels;
  - Storage and disposal of hazardous and non-hazardous waste; and
  - Soil disturbing activities and excavation associated with pipeline installation and associated access roads.

Operation Phase

- Power Plant
  - Accidental events (spills, uncontrolled releases) associated with the storage, handling and disposal of hazardous materials, including fuels; and
  - Storage and disposal of hazardous and non-hazardous waste.
- All linear infrastructure
  - Accidental events (leaks, uncontrolled releases).

12.4 LEGISLATION REQUIREMENTS

The groundwater impact assessment is based on international guidelines. The requirements of these international guidelines have been reviewed and discussed in detail in ***Chapter 3***.

12.5 SUMMARY OF BASELINE CONDITIONS

Chapter 5 provides the details of the baseline conditions for soil and groundwater in the Project Area of Influence. The Project area is underlain by the Irrawadian and Peguan aquifers, with the regional data supplemented by soil and groundwater sampling.

The key findings were:

- The soils on and around the Project site were generally sandy clays with a silty clay subsoil. Analysis was undertaken for a range of heavy metals and hydrocarbons with all sampled species well below the relevant WBG/IFC/WHO guidelines.
- Whilst no specific hydrogeological assessment was undertaken, the area was noted to overlay two aquifers. The first of which is the Irrawadian aquifer which is generally suitable for domestic use and irrigation purposes, with the Peguan aquifer generally suitable only for irrigation purposes. Given the nature of the soils, these aquifers are prone to leaching during monsoon seasons which can lead to rising groundwater levels, saturation of soils and very high pore-water pressure in slopes in sedimentary deposits.
- Groundwater in the region is very dependent upon natural recharge, particularly from the Ayeyarwady River and its upper watershed. Declining groundwater levels and quality in the region have been noted, particularly due to environmental degradation of water sources and uncontrolled excessive pumping of wells. The groundwater depth within the immediate vicinity of the project is approximately 39 to 41m, based on the sampling conducted
- Sampling of groundwater from wells of various depths in the area showed high sulphate and COD levels across most of the wells, with two of those sampled showing Total Coliform Bacteria levels of 16,000 to 17,000 MPN/100/ml.

12.6 ASSESSMENT METHODOLOGY

Potential impacts on groundwater associated with the construction and operation of the Project have been reviewed in ***Chapter 4***. Based on this review, potential sources of groundwater impact that may arise during the construction and operation phases of the Project have been identified and are presented in the following sections. All the identified sources of potential impacts are then evaluated and their impact significance is determined considering the factors of the nature and magnitude of impacts and sensitivity of the groundwater and soils.

There are a number of intrusive activities that occur throughout the lifecycle of the Project which, if not managed effectively, may cause impacts to the soils and groundwater in the vicinity of the Project. The temporal and spatial spread of activities will mean that actual impacts will be dependent on the specific activities. Accordingly, to enable clearer identification of impacts and development of management and mitigation measures specific to each activity, the potential surface water impacts are described on an activity basis. During the scoping for impacts, potential construction and operation related groundwater impacts were identified.

12.7 RECEPTOR IDENTIFICATION AND SENSITIVITY

Within the area, groundwater is not generally relied upon as a source of irrigation water for the widespread cereal crops, with flood irrigation from surface water sources the preferred method. However, it was noted within ***Chapter 6*** – Description of Socio-Economic Baseline that the people of the villages are nearly wholly reliant upon groundwater as their source of domestic and drinking water. Presently, there are no other technically or economically feasible options for sourcing this domestic water and based upon this and the high potential that the quality and quantity of this groundwater source can easily be modified (as noted by the high levels of COD, sulphate and Total Coliforms in some of the sampled wells) means that the sensitivity of the groundwater as a receptor is considered to be **high**.

12.8 ASSESSMENT OF IMPACTS

12.9 CONSTRUCTION PHASE

Construction of the Power Plant will be carried out by the construction contractor appointed by the Sponsor. The construction phase for the Project will comprise of primarily two distinct phases: (a) civil construction work that would require a minimum of one year for completion; and (b) mechanical and electrical work for Plant commissioning. The entire construction phase is expected to continue for approximately 22.5 months. The approximate number of workers for both civil and mechanical works is expected to be around 600 - 900. The workers will be sourced both locally as well as externally. Impacts during the construction phase are noted as being similar across all aspects of the Project (i.e. Power Plant and all linear infrastructures) and are thus assessed collectively. Based upon this, during the construction phase the following impacts are identified as potentially occurring:

- Loss of soil structure, quantity and quality due to improper management during site clearance activities;
- Changes to groundwater levels during development due to abstraction/dewatering (if necessary);
- Soil and groundwater contamination due to potential leaks, spills and contaminated fill materials during all phases of Project construction;
- Soil and groundwater contamination due to improper construction waste storage and disposal; and
- Soil and groundwater contamination due to improper discharge of waste water discharges and runoff.

It is noted that soil and groundwater contamination due to improper construction waste storage and disposal would be the result of contaminated surface water run-off being discharged from waste storage and disposal areas. The production and discharge of this contaminated surface water is assessed extensively within ***Chapter 9***. It is considered that this impact has therefore already been covered and will not be re-assessed within the context of impacts to soil and groundwater. This is also the case with the impacts due to improper discharge of waste water and runoff which if direct to either a surface water, groundwater or soil receptor would all be subject to similar impacts and thus mitigation, management and monitoring measures.

Loss of Soil due to Improper Management during Site Clearance Activities

Soil works, including vegetation clearance, potential grading and levelling, compaction, construction of various structures must be carried out at the Power Plant site, access roads, and for the laying of the right of way for the gas pipeline and transmission line. Changes to soil structure may be caused by mechanical disturbance to the soil from these activities. Exposure of soil to rain and wind may in turn cause erosion and loss of top soil. The anticipated volume of spoil to be removed due to excavation activities is 20,000m^3, while the volume of material to be used for levelling is 30,000m^3. The material for levelling will be a combination of excavated soil on site, as well as additional soil brought in from an adjacent site. This phase of the Project is generally the most intensive in terms of potential for topsoil loss. Poor topsoil management can lead to a loss of topsoil through either the air (as dust) or as sediment entrained within surface water flows. Soil erosion can also result from poor management of stockpiled soils, excavated areas and general construction areas.

Additionally, soil will be compacted at the Power Plant site and access roads, permanent operator housing and the lay down area to ensure soil stability. Movement of heavy vehicles in the construction area will also result in soil compaction and damage to the soil structure. This compaction of the soil may potentially result in changed hydrological characteristics, such as reduced permeability and water infiltration to the soil, which could create additional surface run-off (and increase the flow velocity of this run-off), as well as reducing infiltration into subsurface aquifers.

Soils near the Project are mostly degraded, and are therefore prone to erosion. If compaction and erosion are not managed, associated potential impacts could include excessive sedimentation of local waterways, loss of topsoil and reduction in soil fertility, and detrimental changes to site hydrology. However, soil compaction erosion due to construction activities will only be limited to the vicinity of the transmission line, gas pipeline route, and the Project. Additionally, soil erosion is mostly a concern during periods of high rainfall, and the Project area is located in the Dry Zone, which experiences relatively low annual rainfall quantities.

Loss of topsoil, if not controlled, can result in a waste of valuable topsoil resource which can be used in rehabilitation activities and or/agriculture. Presently there are no mitigation, management and monitoring measures directly associated with topsoil management. The impacts are assessed in ***Table 12.1*** below.

Table 12.1 Assessment of Topsoil Loss during Construction

Impact	Loss of topsoil resources during construction				
Nature	**Negative**	Positive	Neutral		
	Potential impacts to groundwater would be considered to be adverse (negative).				
Type	**Direct**	Indirect	Induced	Cumulative	
	Impact on topsoil is direct				
Duration	Temporary	Short-term	**Long-term**	Permanent	
	Impacts are considered long term as a loss of topsoil may occur over a period longer than the construction phase				
Extent	**Local**	Regional	International		
	Impact is expected to be limited to the project footprint only, and therefore the extent is considered local.				
Scale	The scale of this impact is expected to be small given that it will occur over a relatively small area compared to the rest of the landscape. It will also only occur in valuable agricultural land in areas where the linear infrastructure goes directly through these areas. Based on current plans, it is proposed that these follow existing disturbed corridors as much as possible.				
Frequency	This impact will occur throughout the construction phase, with the most intensive time being during the clearance of the power plant site.				
Magnitude	Positive	Negligible	**Small**	Medium	Large
	Potential impacts associated with topsoil loss are anticipated to be small based upon the limited extent and scale.				
Receptor/ Resource Sensitivity	Low	**Medium**	High		
	The resource sensitivity (being the topsoil) is considered to be medium as it a valuable asset which can be easily lost due to inappropriate management practices.				
Significance	Negligible	**Minor**	Moderate	Major	
	The combination of a Medium Resource Sensitivity and Small Impact Magnitude will result in an overall Minor Impact.				

Mitigation and/or Management Measures

During soil disturbing activities, the mitigation measures developed with regards to surface water quality (***Chapter 9***) will serve to prevent soil loss through limiting TSS loading in surface water bodies. Additionally, mitigation measures developed within ***Chapter 7*** (Air Quality), particularly those aimed at dust prevention, will also minimise soil losses. Other mitigation measures to be implemented include:

- Delineation of clearance boundaries to limit the areas to be cleared;
- Scheduling clearance activities (if possible) to avoid extreme weather events such as heavy rainfall, extreme dry and high winds;
- Revegetation areas with temporary land use, conducting progressive rehabilitation;
- Demarcate routes for movement of heavy vehicles to minimise disturbance of exposed soils and compaction of sub-surface layers;
- Reuse topsoil as much as possible within rehabilitation activities;
- Control erosion through diversion drains, sediment fences, and sediment retention basins; and
- Where topsoil is to be stored for later use in rehabilitation activities, the following basic principles are to be applied:
  - Stockpiles to be separated into topsoil and sub-soil and be located at least 50m from any surface water source or groundwater well;
  - To the extent possible, stockpiles are to be located in areas surrounded by natural wind barriers to minimise the potential for wind erosion;

- o Stockpile storage areas are to be prepared in advance of the removal of topsoil as much as possible; and
- o Topsoil heights are to be restricted in height to 2m above ground level to minimise wind erosion, and they are only to be partially compacted on the upper layer in order to promote aeration, maintain soil vertical structures, reduce runoff and encourage infiltration.

Residual Impacts

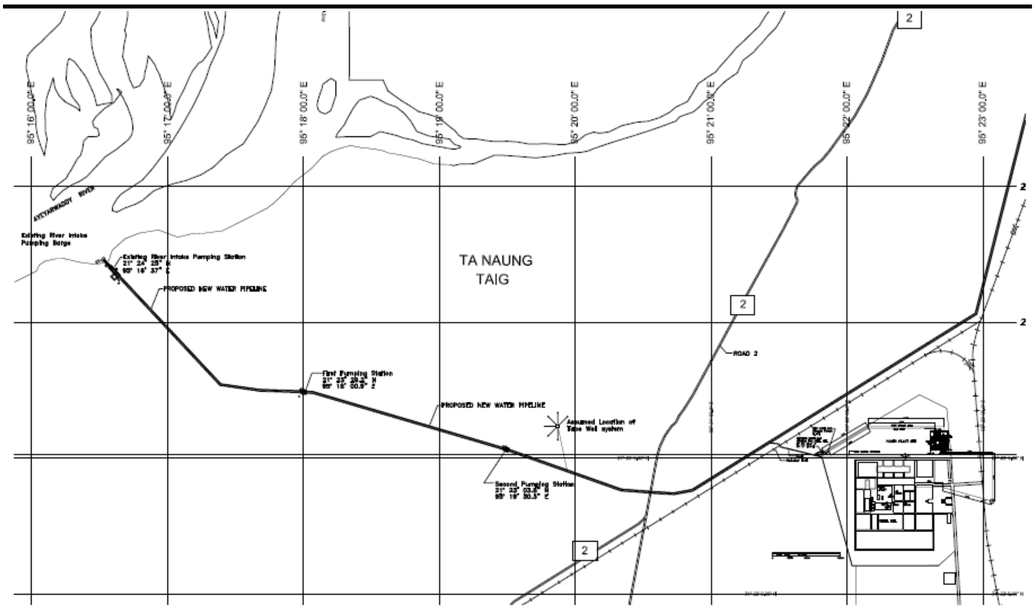
Based upon the implementation of the above management and mitigation measures, the residual impact level can be reduced to **negligible**. This is due to the fact that all topsoil would be retained and/or reused, thus reducing the scale even further and the magnitude to negligible.

Changes to Groundwater Levels during Construction as a result of Abstraction and Dewatering Activities

Some groundwater abstraction will be undertaken via a tube well during the construction phase, until the water pipeline from the Ayeyarwady River is operational. Groundwater abstraction activities during the construction phase may lead to temporary lowering of the groundwater table, adversely impacting groundwater availability.

The planned location of the tubewell for groundwater abstraction is shown in ***Figure 12.1***. The Sponsor estimates that an average of 700m^3/month will be required, with a total consumption of 15,000m^3 during the construction phase. The quantity of groundwater abstracted and associated draw down will be monitored.

Figure 12.1 Location of Tube Well during Construction



The significance of potential impacts to groundwater due to groundwater abstraction during the construction phase is assessed in the following table, and mitigation measures are presented.

Table 12.2 Impacts to Groundwater due to Groundwater Abstraction during Construction Phase

Impact	Draw-down from extraction of onsite groundwater wells could potentially impact groundwater levels.				
Nature	**Negative**	Positive	Neutral		
	Potential impacts to groundwater would be considered to be adverse (negative).				
Type	**Direct**	Indirect	Induced	Cumulative	
	Impacts to groundwater would be direct impacts from Project activities.				
Duration	Temporary	**Short-term**	Long-term	Permanent	
	The construction phase will last approximately 22.5 months. However, groundwater abstraction will only be required until the water pipeline is operational. The duration of impacts is therefore short-term.				
Extent	**Local**	Regional	International		
	Potential impacts would be limited to the aquifer in the Project area and neighbouring area, and hence would be considered to be local.				
Scale	An average of 700 m^3/month of groundwater will be required, with a total consumption of 15,000 m^3 during the construction phase.				
Frequency	Groundwater abstraction would take place throughout the duration of the construction phase.				
Magnitude	Positive	Negligible	**Small**	Medium	Large
	The quantities of groundwater that will be used are comparatively low. Potential impacts to groundwater levels due to groundwater abstraction are expected to be of small magnitude.				
Receptor/ Resource Sensitivity	Low	**Medium**	High		
	Given the high dependency of the local community on groundwater for domestic purposes, the resource sensitivity is determined to be Medium.				
Significance	Negligible	**Minor**	Moderate	Major	
	The combination of a Medium Resource Sensitivity and Small Impact Magnitude will result in an overall Minor Impact.				

Mitigation and/or Management Measures

The following additional mitigation, management and monitoring measures will be implemented to reduce the impacts:

- Monitor the quantity of groundwater abstracted and associated draw down;
- Address and respond to any community complaints regarding Project impacts on groundwater availability.

Residual Impacts

Based upon the implementation of the above measures, residual impacts would remain Minor. This is due to the fact that they are aimed at directly monitoring the impact. Should community complaints be addressed through measures that directly reduce the scale or extent of the impact (such as providing alternative sources of water) then it may be reduced to **negligible**.

Soil and Groundwater Contamination due to Potential Leaks, Spills and Use of Contaminated Fill Material during Project Construction

Soil and groundwater contamination may occur on all parts of the Project (power plant, electricity transmission line, river water supply pipeline and gas supply pipeline) during the construction phase due to accidental leaks or spills of chemicals or hazardous materials such as oils, lubricants or fuel from heavy equipment, and improper chemical/fuel storage. Spills and leaks may occur during vehicle/equipment operation, fuelling, and maintenance. Temporary storage of fuels, oils, lubricants and other hazardous waste types is also a source of spills and leaks. Any such spills can impact groundwater quality due to leaching through soil during periods of rainfall. This is particularly the case during the initial phases of construction where machinery will be undertaken works on exposed soils. Contaminated or polluted soil can directly affect human health through direct contact with soil, or via the infiltration of soil contamination into the aquifers known to occur under the site. Given that the surrounding communities rely on groundwater sources exclusively for all their domestic uses, they are particularly sensitive to any changes in groundwater quality.

Based on experience with similar projects, the total approximate quantities of hazardous materials that could be a potential source of impact during this stage include:

- 30,000 L/month diesel fuel (intermittent, not stored continuously)
- Small, infrequent quantities of lubricants, oil

The significance of potential impacts to groundwater due to contamination from accidental spills and leaks during the construction phase are assessed in the following table, and mitigation measures are presented.

Table 12.3 Soil and Groundwater Contamination due to Potential Leaks, Spills and Use of Contaminated Fill Material during Project Construction

Impact	Soil and Groundwater Contamination due to Potential Leaks, Spills and Use of Contaminated Fill Material during Project Construction			
Nature	**Negative**	Positive	Neutral	
	Potential impacts to soil and groundwater would be considered to be adverse (negative).			
Type	**Direct**	Indirect	Induced	Cumulative
	Impacts to soil and groundwater would be direct impacts from Project activities.			
Duration	Temporary	Short-term	**Long-term**	Permanent
	The construction phase will last approximately 22.5 months. However, if a groundwater aquifer is impacted, it may take a long time for natural recovery, unless active measures are taken to remove the contaminants. The duration is therefore long-term.			
Extent	**Local**	Regional	International	
	Potential impacts would be limited to the aquifer in the Project area and neighbouring area, and hence would be considered to be local; however substances could have the potential to be transmitted within the aquifer via groundwater movement.			
Scale	Based on experience with similar projects, the total approximate quantities of hazardous materials that could be a potential source of impact during this stage include: • 30,000 L/month diesel fuel • Small, infrequent quantities of lubricants, oil The scale of potential impacts due to release of hazardous materials is potentially large due to the quantities present during this stage, but accidental release is an unlikely, unplanned occurrence. The amounts of fuels, oil, chemicals or waste spills/leaks, if they occur are expected to be small and are already reduced with the existing controls.			
Frequency	Potential impacts would be expected to be infrequent, only taking place during rainfall, after loss of containment or accidental spills.			

<table>
<tr><td rowspan="2">Magnitude</td><td>Positive</td><td>Negligible</td><td>Small</td><td>Medium</td><td>Large</td></tr>
<tr><td colspan="5">Potential reduction of groundwater quality in Project area is expected to be of Small magnitude, given that any spills of fuels, oil, chemicals or wastes, if they occur are expected to be very localised and small.</td></tr>
<tr><td rowspan="2">Receptor/ Resource Sensitivity</td><td>Low</td><td colspan="2">Medium</td><td colspan="2">High</td></tr>
<tr><td colspan="5">Given the high dependency of the local community on groundwater for domestic purposes, the resource sensitivity is determined to be High.</td></tr>
<tr><td rowspan="2">Significance</td><td>Negligible</td><td>Minor</td><td>Moderate</td><td colspan="2">Major</td></tr>
<tr><td colspan="5">The combination of a High Resource Sensitivity and Small Impact Magnitude will result in an overall Moderate Impact.</td></tr>
</table>

Additional Mitigation and/or Management Measures

Measures are to be put in place specifically to ensure that spills and leaks of equipment do not occur. These measures include:

- Unloading and loading protocols will be developed to ensure that staff are able to undertake these tasks in a manner that minimises the risks of spills occurring;
- Fuel tanks and chemical storage areas will be sited on sealed hardstand areas, provided with locks to prevent unauthorised entry where appropriate.
- Secondary containment, with appropriate drainage connection and/or provision for removal of spilled liquids, will be provided around places of fuel and hazardous materials storage such as oil filled transformers, oil pumps and tanks, generators, chemical storage houses etc. to contain any hazardous spills and to exclude surface water run-off from entering the contained area. The containment capacity of these areas is to accommodate 110% of the volume of the largest container;
- Any refuelling activities will only take place within a designated hard stand area with spill kits present.
- All mobile equipment is to be equipped with spill or drip trays to contain spills and leaks;
- Equipment and vehicle maintenance scheduling is to be undertaken such that they are continually monitored for potential or actual leaks;
- Storage of all inert concrete waste will be undertaken in a dedicated laydown area near the concrete batching plant, and reuse of these wastes under floors or roads;
- A dedicated storage area for construction material will be developed to minimise the potential for damage or contamination of the material.
- Sufficient space will be left between all waste containers so as to identify any spills or leaks.
- Mobile toilets are to be provided throughout the construction are for use by workers. No sanitary effluent is to be disposed of on, or adjoining the site.
- A training program will be implemented to familiarise staff with measures to be taken to prevent spills and leaks, and for emergency procedures and practices related to contamination events;
- A construction materials inventory management system will be implemented to minimise over supply of and construction materials (hazardous and non-hazardous), which may lead to disposal of the surplus materials at the end of the construction period;
- Appropriate management, storage and disposal of all waste streams will be implemented in accordance with the measures developed within ***Chapter 13*** – Waste and ***Chapter 9*** – Surface Water Quality;
- A Hazardous Materials Management Plan and a Construction Waste Management Plan will be developed to integrate all these measures.

Should any of the above measures fail to prevent spills or leaks occurring, the follow are also to be in place to ensure that any contamination is swiftly cleaned:

- Specific guidelines and procedures for immediate clean-up actions following any spillages of oils, fuels or chemicals is to be developed;
- A site specific Emergency Response Plan will be prepared for soil clean-up and decontamination;
- All mobile vehicles are to be equipped with spill control kits to contain and clean small spills and leaks;
- For any spills or leaks, once the initial emergency response has been implemented, an appropriate mean up and monitoring plan is to be developed. This is to take into account the type of spill and its extent. It is also to include provisions for monitoring of soil and groundwater quality to track potential or actual migration of the contamination through the soil and groundwater profiles.

Residual Impacts

Based upon the implementation of the above measures, it is considered that impacts can be reduced to **negligible**, as the frequency (prevention of spills and leaks), scale (detailed measures for spill clean up to prevent spread) and thus extent would all be considerably reduced. This would reduce the magnitude to negligible and thus lower the overall impact to **negligible** regardless of the fact that the receptor/resource sensitivity remains high.

12.10 OPERATION AND MAINTENANCE PHASE

The operation phase is expected to continue for approximately 22 years. The average number of permanent workers present during operation is expected to be approximately 80. The assessment of operational phase impacts includes those arising both from routine operations and maintenance of the Power Plant. During the operation phase, potential groundwater impacts may arise from inappropriate waste storage and disposal, and accidental spills and leaks.

- Loss of soil due to increased erosion potential during operations;
- Soil and groundwater contamination due to potential leaks, spills and leaks;
- Soil and groundwater contamination due to improper construction waste storage and disposal; and
- Soil and groundwater contamination due to improper discharge of waste water discharges and run-off.

As for the construction impacts, it is noted that soil and groundwater contamination due to improper construction waste storage and disposal would be the result of contaminated surface water run-off being discharged from waste storage and disposal areas. The production and discharge of this contaminated surface water is assessed extensively within ***Chapter 9*** – Surface Water Quality. It is considered that this impact has therefore already been covered and will not be re-assessed within the context of impacts to soil and groundwater. This is also the case with the impacts due to improper discharge of waste water and runoff which if direct to either a surface water, groundwater or soil receptor would all be subject to similar impacts and thus mitigation, management and monitoring measures.

Loss of soil due to increased erosion potential during operations

During the operation phase, the physical footprint of the Power Plant and gas supply pipeline will increase the impermeable area of the Project, resulting in changed hydrological characteristics, such as reduced water infiltration to the soil, which could create additional surface run-off (and increase the flow velocity of this run-off), as well as reducing infiltration into subsurface aquifers.

The total area of the Project's footprint will be as follows:

- Main Power Plant: 8.6 ha
- River Water Pipeline : 14 km x 2 m = 3 ha
- Gas Line : 1 km x 1.5 m = 0.15 ha
- Transmission Line : 2.524 km x 21 m = 5.3 ha

As discussed in ***Chapter 9*** regarding impacts to surface water, the increased impervious surfaces from the Project footprint are expected to cause maximum rainfall runoff rates of 0.58 m^3/hr. This increased flow rate has the potential to cause soil erosion and sedimentation. However, if the drainage channel surrounding the Project is designed with enough capacity to accommodate this increased flow rate, then the potential impacts can be minimized.

The significance of potential impacts to soil due to erosion from increased run-off from impervious surfaces during the operation phase are assessed in the following table, and mitigation measures are presented.

Table 12.4 Loss of Soil due to Increased Erosion Potential during Operations

Impact	Potential for soil erosion due to altered hydrology due to an increase in impervious surfaces in the Project area.				
Nature	**Negative**	Positive	Neutral		
	Potential impacts to soil would be considered to be adverse (negative).				
Type	Direct	**Indirect**	Induced	Cumulative	
	Impacts to soil would be indirect impacts due to the presence of the Project footprint.				
Duration	Temporary	Short-term	**Long-term**	Permanent	
	The operation phase will last approximately 22 years. The duration of potential impacts is therefore long-term.				
Extent	**Local**	Regional	International		
	Potential impacts would be limited to the Project site footprint, as well as areas downstream of the Project site, and hence would be considered to be local.				
Scale	The estimated runoff from Project surfaces for a worst case 15-minute duration storm with a return period of 100 years, would be approximately 0.000162 m^3/s, or 0.58 m^3/hr.				
Frequency	Impacts to soil due to erosion from increased rainwater runoff would occur during rainfall events, and will be more frequent during the rainy season.				
Magnitude	Positive	Negligible	**Small**	Medium	Large
	Potential impacts to soil in the Project area due to increased rainfall runoff from impervious surfaces are expected to be of Small magnitude.				
Receptor/ Resource Sensitivity	Low	**Medium**	High		
	Existing soil quality in the Project area is generally fair, but soil is susceptible to erosion. Overall sensitivity is rated as Medium.				
Significance	Negligible	**Minor**	Moderate	Major	
	The combination of a Medium Resource Sensitivity and Small Impact Magnitude will result in an overall Minor Impact.				

Additional Mitigation and/or Management Measures

- Ensure that drainage channel and irrigation canal have enough capacity to accommodate the increased rainfall runoff from the Project's impervious surfaces.

Residual Impact Level

If the recommended mitigation measures are implemented, residual impact significance would be **negligible**.

<u>Soil and groundwater contamination due to potential leaks and spills</u>

Accidental releases from operational activities and SF6 insulant chemicals from operation of the transmission line, have the potential to impact surrounding soil and surface water, which could subsequently impact groundwater. In addition, there is the potential for deoxygenation of the soil and groundwater due to natural gas leaks from the gas supply pipeline. Leakage from chemical storage facilities may also result in contamination. A further risk to groundwater during the operational phase is from a potential spill of back up fuel (should this be used to provide a backup fuel supply during breaks in the gas supply). These discharges may have a direct impact on the soil quality and surface water, which in turn may cause secondary impacts to groundwater.

The significance of potential impacts to groundwater due to contamination from accidental spills and leaks during the operation and maintenance phase are assessed in the following table, and mitigation measures are presented.

Table 12.5 Soil and Groundwater Contamination due to Potential Leaks and Spills during Operations

Impact	Soil and groundwater contamination due to potential leaks and spills during operations.				
Nature	**Negative**	Positive	Neutral		
	Potential impacts to groundwater would be considered to be adverse (negative).				
Type	**Direct**	Indirect	Induced	Cumulative	
	Impacts to groundwater would be direct impacts from Project activities.				
Duration	Temporary	Short-term	**Long-term**	Permanent	
	The operation phase will last approximately 22 years. The duration of potential impacts is therefore long-term.				
Extent	**Local**	Regional	International		
	Potential impacts would be limited to the aquifer in the Project area and neighbouring area, and hence would be considered to be local; however substances could have the potential to be transmitted within the aquifer via groundwater movement.				
Scale	Based on experience with similar projects, the total approximate quantities of hazardous materials that could be a potential source of impact during this stage include: • 4,000 L/month diesel fuel • Small, infrequent quantities of lubricants, oil • Hydrostatic testing chemicals The scale of potential impacts due to release of hazardous materials is potentially large due to the quantities present during this stage, but accidental release is an unlikely, unplanned occurrence.				
Frequency	Potential impacts would be expected to be infrequent, only taking place during rainfall, after loss of containment or accidental spills.				
Magnitude	Positive	Negligible	**Small**	Medium	Large

	Potential impacts to groundwater quality in the Project area due to accidental releases are expected to be of Small magnitude.			
Receptor/ Resource Sensitivity	Low	Medium	**High**	
	Given the high dependency of the local community on groundwater for domestic purposes, the resource sensitivity is determined to be High.			
Significance	Negligible	Minor	**Moderate**	Major
	The combination of a High Resource Sensitivity and Small Impact Magnitude will result in an overall Moderate Impact.			
Mitigation Measures	Periodic soil monitoring programme, as specified in HSEMS.			
Residual Significance	**Negligible**	Minor	Moderate	Major
	If the recommended mitigation measures are implemented, residual impact significance would be Negligible.			

Additional Mitigation and/or Management Measures

The measures outlined for management of spills and leaks during the construction phase are to be directly carried across into the operations phase (as appropriate) and embodied within the following plans:

- Hazardous Materials Management Plan;
- Hazardous Waste Management Plan;
- Emergency Response Plan; and
- Guidelines and Procedures are to be developed specifically in relation to spills and leaks management and clean-up.

In addition to the above, the following measures specific to the operations phase are to be put in place:

- To minimise use of antifouling and corrosion inhibiting chemicals, appropriate depth of water intake will be maintained, and use of screens will be ensured.
- Minimum required quantities of chlorinated biocides or alternatively intermittent shot dosing of chlorine will be practised rather than continuous low level feed.
- All drainage/tanks, etc. will be positioned on concrete hard standing to prevent any seepage into ground.
- As part of the facility-wide HSEMS, SOPs will be prepared to manage any oil spills, leaks and/or seepages. SOPs will cover transport, handling, storage, use and disposal of oil/ oil wastes/ empty drums etc. Operating personnel will be trained on the SOPs and monitored in their use on a daily basis.
- Acids and other hazardous materials will be stored in a dedicated room as per their MSDS specifications with adequate ventilation.
- A groundwater monitoring plan (including groundwater wells installed at strategic locations) is to be developed and implemented through the life of the Project to detect any changes in groundwater quality that may be contributed to spills and leaks from the Project

Residual Impacts

Based upon the implementation of the above measures, it is considered that impacts can be reduced to **negligible**, as the frequency (prevention of spills and leaks), scale (detailed measures for spill clean up to prevent spread) and thus extent would all be considerably reduced. This would reduce the magnitude to negligible and thus lower the overall impact to **negligible** regardless of the fact that the receptor/resource sensitivity remains high.