6 ENVIRONMENTAL AND SOCIAL IMPACT OF THE PROJECT

6.1 CLIMATE RESILIENCE

6.1.1 SCOPE

The Intergovernmental Panel on Climate Change (IPCC) has defined climate resilience as the "capacity of a system to anticipate, absorb, accommodate or recover from the effects of climate variability and climate change in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions".

AMEA Power and Sumitomo Corporation has appointed WSP to undertake a climate risk and vulnerability assessment (CRVA) for the Amunet Wind Power Project (the Project) in the Arab Republic of Egypt (Egypt).

To determine the resilience of the Project to future climate change, it is essential to understand the exposure, vulnerability and susceptibility of the Project and its components to changes in climate. This will help us to determine and develop preventative and adaptative responses to climate change risks and events.

The assessment has been undertaken considering the Equator Principles relating to climate change (No.2 (Environmental and Social Assessment)) and as such has assessed the potential physical risks to the Project. A transition risk assessment has not been deemed necessary for this assessment (refer to Section 3.9.2).

6.1.2 APPROACH

This CRVA has been undertaken based on relevant guidance and provides the following:

- Document review of available Project design information;
- Identification of Project assets and their design lives, within the scope of the climate resilience assessment;
- Identification of the relevant legislative and guidance framework;
- Detail of the climate baseline, including current observed climate data and future climate projections;
- Climate risk and vulnerability assessment as a function of sensitivity and exposure;
- Measures included within the design to avoid climate change risks and recommendations for further measures to enhance resilience; and
- Evaluation of vulnerability and summary of residual risk.

A certain amount of climate change is expected over the lifetime of the Project due to historic greenhouse gas (GHG) emissions and the lag in the climate system which may cause adverse risks to the Project in the long-run.

Maintaining operations, safety, security and reliability of the Project requires understanding of the risks and vulnerability (to changes in climate) that it will be subject to over time. It is vital to plan for, manage and adapt to known climate-related effects, information gaps and therefore potential risks.

6.1.3 SCOPE OF ASSESSMENT

The Project is understood to comprise the following components:

Table 6-1 - Project Components

Asset	Details	Design Life
Construction		
Machinery and equipment	Such as excavators, cranes, trucks, lighting towers.	The construction works will last approximately 28 — 30 months.
Construction materials	Turbine columns, wings, concrete, foundation materials, prefabricated shell for buildings and housing of substation.	
Temporary site infrastructure	Storage units for construction materials and equipment, Facilities for workers and site operations buildings	
Operation		
Wind Turbines & Transformers	77 (6.5MW) wind turbines, 94.5m hub height, 180m tip height*. Secured with a concrete foundation reinforced with structural corrugated steel. One transformer is located within each turbine.	Minimum of 25 years.
Wind monitoring Masts	6 new wind monitoring meteorological masts operated by the Project partners located across the site. 80m in height.	
Substation	Contains several high voltage electrical equipment (e.g., transformers, circuit breakers).	
Underground Cables	Underground medium voltage cables connecting each turbine to the substation. Fibre Optic Communication Cables connecting each turbine to the communication and monitoring facility on site.	
Overhead transmission lines (OHTL)	Generation Capacity of 500.5MW (energy)*. Connecting the Substation to the national Grid line.	
Roads	Track roads would be used during construction, maintenance and operation of the Project.	
Buildings	Security and communication offices, control room.	

** This may change subject to the ongoing discussions with regulators related to variation of turbine tip height.*

6.1.4 IDENTIFICATION OF THE VULNERABLE PROJECT RECEPTORS

The vulnerability of assets and receptors to climate change is a function of:

- The sensitivity of receptors to climate variables – based on literature review and expert judgement and rated as high, medium or low; and
- The exposure of receptors to projected change in climate variables – based on the baseline information presented above and rated as high, medium or low.

The vulnerability of receptors to climate variables is determined from the combination of the sensitivity and exposure ratings, using the matrix shown in **Table 6-2**. At this point, climate variables in the construction and operation phase to which the Project is likely to have a low vulnerability to are scoped out of further assessment. Climate variables to which the assets are likely to have a medium or high vulnerability are taken forward for further assessment.

This is a qualitative assessment informed by expert opinion and supporting literature.

Table 6-2 - Vulnerability Matrix

Sensitivity	Exposure		
	Low	Medium	High
Low	Low vulnerability	Low vulnerability	Low vulnerability
Moderate	Low vulnerability	Medium vulnerability	Medium vulnerability
High	Low vulnerability	Medium vulnerability	High vulnerability

The sensitivity of the receptor/receiving environment is the degree of response of a receiver to a change and a function of its capacity to accommodate and recover from a change if it is affected, see Table 6-3. Sensitivity does not take into account any design measures which may improve the tolerance of receptors to climate change (this is considered after).

Table 6-3 - Sensitivity Descriptors

Sensitivity	Sensitivity Description
High	Receptor is highly susceptible to be altered by the projected changes to climate (e.g., lose much of its original function and form).
Moderate	Receptor is able to tolerate some climatic conditions without being fully altered though remains susceptible to being altered to some extent.
Low	Receptor is not susceptible to be altered by the projected changes to climate as the climatic factors have little influence on the receptor.

Source: Adapted from IEMA guidance[56]

Table 6-4 identifies how the Project's assets may be sensitive to the climate variables.

[56] Institute of Environmental Management and Assessment (2020) EIA Guide to Climate Change Resilience and Adaptation

Table 6-4 - Sensitivity of Project Assets to Climate Change Vulnerability Matrix

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground Cables	Overhead Transmission Lines	Track Roads	Buildings
Precipitation	Change in annual average	**Low:** Due to the short timescales of construction, such changes would pose minimum risks to the construction phase.	**Moderate:** rain driven infiltration can increase the deterioration of material structure and fabric**.**			**Low:** rain driven infiltration would have minor impacts on buried underground cables.	**Moderate:** rain driven infiltration can increase the deterioration of material structure and fabric.		
	Drought	**Moderate:** dry periods increase the risk of dust build-up and overheating of machinery used in construction.	**Moderate:** prolonged dry periods may lead to drying out and cracking of earthworks and soils. This has the potential to destabilise the turbine foundations, increasing the risk of collapse.			**Low:** drought conditions are unlikely to impact on buried underground cables.	**Low:** drought conditions are unlikely to affect this receptor.	**Moderate:** prolonged dry periods may lead to drying out and cracking of earthworks and soils, resulting in degradation of the road.	**Moderate:** prolonged dry periods may lead to drying out and cracking of earthworks and soils. This has the potential to destabilise the foundations, increasing the risk of collapse.

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground Cables	Overhead Transmission Lines	Track Roads	Buildings
	Extreme precipitation events	**Moderate:** damage to machinery and construction progress from flash flooding events.	**High:** deterioration of material structure and concrete foundations caused by flash flooding and rain infiltration. Potential for ground saturation and ground movements. **Moderate:** inundation of electrical components and damage to structure housing electrical equipment resulting in loss or disruption of supply.			**High:** inundation of electrical cables resulting in loss or disruption of supply. Potential for ground saturation and ground movements.	**High:** rain driven infiltration resulting in loss of power / deterioration of overhead lines. Damage to the infrastructure supporting overhead lines from flash flooding events destabilising the foundations of the structures.	**High:** difficulty accessing the road as a result of flooding. Deterioration of surfaces, leading to deterioration of materials and increased maintenance requirements.	**Moderate:** deterioration of structural and foundation materials. Risk from flashing flooding to buildings and equipment.
Temperature	Changes in annual average[57] Extreme temperat-ure events.	**High:** risk of heat stress to machinery and health and safety risk to workers on site from continuous	**Moderate:** faster rate of deterioration of materials from increase in UV radiation (e.g., fading, brittleness, erosion of	**Moderate:** deterioration of materials and equipment from increase in UV radiation and heat stress (e.g., fading, brittleness,	**High:** risk of overheating and heat stress causing disruption of supply and shutdown of equipment.	**Low:** temperatures are unlikely to affect this receptor due to it being buried at depth.	**High:** expansion and sagging of OLE and risk of de-wiring in high temperatures. Additional risk from daily expansion and	**Moderate:** potential melting and deformation of road surfaces.	**Moderate:** deformation and deterioration from UV radiation. (e.g., fading, brittleness, erosion of

[57] World Bank Group (2021) Climate Change Knowledge Portal: Egypt, SSP2 Projections , Red Sea Region, 1940-2059 Very Hot Days [online] Available at: Egypt - Climatology | Climate Change Knowledge Portal (worldbank.org) (Accessed on 24/02/2022)

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground Cables	Overhead Transmission Lines	Track Roads	Buildings
		high temperatures in excess of 35°C.	coatings, discolouring).	erosion of coatings, discolouring).			then night time temperature drops in cooling the wires.		coatings, discolouring).
Wind	Gales and extreme wind events	**Moderate:** risk to safety for those working at height. Risk to the stability of structures, particularly temporary structures used for accessing at height and partially complete wind turbine columns before completion.	**High:** risk of destabilisation and turbines cutting out in strong winds. Risk of dust and sand deterioration and erosion from of powerful Khamsin winds which can reach gusts of 140km/h[58].	**High:** increased risk to structures and equipment of breakage. Deterioration from windblown dust and sand carried from strong Khamsin hot windstorms.	**Moderate:** risk of deterioration from wind-blown sand and dust from strong winds and gusts.	**Low:** due to their underground location, gales and strong winds and storms events are unlikely to affect this receptor.	**High:** risk of deterioration and de-wirement from wind-blown sand and dust from strong winds and gusts and overhead lines blown out of alignment.	**Moderate:** deterioration of road surface from windblown sand and increased maintenance costs	**Moderate:** deterioration from wind-blown sand and dust. Increased maintenance requirements.

[58] Egypt Third National Communication, UNFCCC (2016) Climate Profile [online] available at: Imprimir (unfccc.int) (Accessed 25/2/2022).

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground Cables	Overhead Transmission Lines	Track Roads	Buildings
	Storms (e.g., hail, lightning)	**High:** risk to machinery from occurrence of lightning strike. Risk to safety from working in storms.	**High:** risks to turbine stability from storms and lightning strike.	**High:** risk to structures and equipment from storms and lightning strikes.	**Moderate:** risk from occurrence of lightning strike.	**Low:** due to their underground location, lightning and storm events are unlikely to affect this receptor.	**High:** asset failure as a result of lightning strikes and electrical surges. Storms could blow overhead lines out of alignment.	**Moderate:** deterioration of road surface from storms and wind-driven infiltration.	**Moderate:** rain and wind driven infiltration can increase the deterioration of material structure and fabric.
Sea level Rise		**Low:** The Project's distance from the Red Sea coast presents no medium to long term risk from sea level rise and coastal flooding.							

6.1.4.1 Exposure

Based on the climate change projections presented in **Table 6-4** and **Table 6-5** summarises the exposure of the Project to change in climate variables.

Table 6-5 - Exposure of Climate Variables to Change

Climate Variable		Exposure
Precipitation	Change in annual average	Low
	Drought	Low
	Extreme precipitation events (flooding)	High
Temperature	Changes in annual average	Medium
	Extreme temperature events	High
Wind	Gales and extreme wind events	Medium
	Storms (hail, lightning)	Low

The sensitivity and exposure analyses are combined, in line with the vulnerability matrix presented in **Table 6-2**, to provide an overall assessment of vulnerability for each of the Project's assets as detailed in **Table 6-6**. High and medium vulnerabilities are considered to be at risk from climate change and should be assessed in further detail.

For the aspects of the Project which have been deemed of medium or high vulnerability, design documents have been reviewed and **Table 6-7** presents the measures integrated into the design to reduce the risk of the potential effects. Furthermore, recommendations and assumptions have been highlighted where design measures are unknown or have not been located.

Table 6-6 - Vulnerability Assessment

Climate Variable		Construction Phase	Wind Turbines	Wind Monitoring Masts	Substation	Underground Electrical Cables	Overhead Transmission Lines	Track Road	Buildings
Precipitation	Change in annual average	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability
	Drought	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability
	Extreme precipitation events	Medium vulnerability	High vulnerability	High vulnerability	Medium vulnerability	High vulnerability	High vulnerability	High vulnerability	Medium vulnerability
Temperature	Changes in annual average[59]	Medium vulnerability	Medium vulnerability	Medium vulnerability	Medium vulnerability	Low vulnerability	Medium vulnerability	Medium vulnerability	Medium vulnerability
	Extreme temperature events	High vulnerability	Medium vulnerability	Medium vulnerability	High vulnerability	Low vulnerability	High vulnerability	Medium vulnerability	Medium vulnerability
Wind	Gales, Khamsin winds and extreme wind events	Medium vulnerability	Medium vulnerability	Medium vulnerability	Medium vulnerability	Low vulnerability	Medium vulnerability	Medium vulnerability	Medium vulnerability
	Storms (hail, lightning)	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability	Low vulnerability

[59] The projected change in monthly temperature for the Red Sea region for 2040-2059 is in the range of 17.39°C to 37.95°C under high emission scenarios SPP5 8.5. The sensitivity of the assets to this increase is as presented for 'extreme temperature events' within the 90th percentile range albeit to a lesser severity.

Table 6-7 - Measures Included within the Design to Avoid Climate Change Risks

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground cables	Overhead transmission lines	Track Roads	Buildings
Precipitation	Extreme precipitation events	**Potential effect:** deterioration of materials and machinery. Infiltration of materials and waterlogging of site. Flooding of concrete foundations from flash flooding. Risk to site workers. **Design measures**: No design measures are specified for drainage beyond the permeation of rainfall through the soil. Construction remains at risk from flash flooding particularly in the northern section of the Project's site.	**Potential effect:** deterioration of material structure and fabric due to rain driven infiltration. Flooding of concrete foundations. Potential for ground saturation and ground movements. **Design measures**: Turbine material design selected to withstand modification as a result of precipitation infiltration (The corrosion protection would be C4. This is the highest standard for corrosion protection).	**Potential effect:** deterioration of material structure and fabric due to rain driven infiltration. Flooding of concrete foundations from flash flooding. **Design measures**: No design measures are specified for drainage beyond the permeation of rainfall through the soil. **Recommendations/assumptions:** It is assumed that drainage provisions have been/will be implemented across the site.	**Potential effect:** inundation of electrical components resulting in loss or disruption of supply. **Design measures:** No design measures are specified for drainage beyond the permeation of rainfall through the soil. **Recommendations/assumptions:** It is recommended that drainage provisions are based on modelling and include an allowance for climate change.	**Potential effect:** inundation of electrical cables resulting in loss or disruption of supply. Potential for ground saturation and ground movements. **Design measures:** all cablings will be suitably housed in protective casing to international standards that include being sealed, resistant to, and tested against water ingress. This would be designed as per legal and technical standards and are part of the already	**Potential effect:** Rain driven infiltration resulting in loss of power/deterioration of overhead lines. **Design measures:** overhead lines would contain electrical insulation and therefore would be resistant to water ingress. Design measures are considered sufficient to reduce risk.	**Potential effect:** Risk of flash flooding and washing away of road surfaces. Preventing accessibility to the site increasing maintenance requirements. **Design measures:** No design measures are specified for drainage beyond the permeation of rainfall through the soil. **Recommendations/assumptions:** It is recommended that a monitoring regime is in place to inspect ground conditions following precipitation events (e.g., heavy rainfall,	**Potential effect:** Flooding of foundations. Potential for ground saturation and ground movements. **Design measures:** No design measures are specified for drainage beyond the permeation of rainfall through the soil. **Recommendations/assumptions:** It is assumed that drainage provisions have been/will be implemented across the site. It is recommended that drainage provisions are based on modelling and include an

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground cables	Overhead transmission lines	Track Roads	Buildings
		Recommendations/assumptions: It is assumed that drainage provisions have been/will be implemented across the site.	**Recommendations/assumptions:** It is assumed that drainage provisions have been/will be implemented across the site.			approved designs by TUV Sud. Design measures are considered sufficient to reduce risk.		flash flooding). It is assumed that drainage provisions have been/will be implemented across the site.	allowance for climate change.
Temperature	Changes in annual average Extreme temperature events	**Potential effect:** overheating of machinery and risk of fire. Deterioration of equipment and materials on site such as turbine structures awaiting assembly. Risk to site workers of heat related illness. **Design measures:** no mitigatory design measures specified. **Recommendations/assumptions:** it is recommended	**Potential effect:** faster rate of deterioration of materials from increase in UV radiation (e.g., fading, brittleness, erosion/weathering of coating and discolouring). Derating or shut down of turbines in hot weather. **Design measures:** Turbine material design has been selected to withstand modification from high temperatures.	**Potential effect:** faster rate of deterioration of materials from increase in UV radiation (e.g., fading, brittleness, erosion/weathering of coating and discolouring). **Design measures:** Design measures are considered sufficient to reduce risk.	**Potential effect:** overheating of electrical components resulting in loss or disruption of supply. Potential risk of fire. **Design measures:** the substation will contain an air-insulated cooling system and temperature sensors to avoid the risk of electrical components overheating. All electronics equipment would be housed	n/a — identified as low vulnerability.	**Potential effect:** expansion and sagging of OLE and risk of de-wirement in high temperatures. **Design measures:** the design and material selection of the overhead lines would allow for variations in temperature including heat and cold. Design measures are considered sufficient to reduce risk.	**Potential effect:** Potential melting and deformation of road surfaces. **Design measures:** material selection would allow for variations in temperature. **Recommendations/assumptions:** It is recommended that a monitoring regime is in place to inspect ground conditions following extreme precipitation and temperature events (e.g., heavy rainfall,	**Potential effect:** faster rate of deterioration of materials from increase in UV radiation (e.g., fading, brittleness, erosion/weathering of coating and discolouring). Overheating of electrical components resulting in loss or disruption of supply. Potential risk of fire. **Design measures:** Design measures are considered sufficient.

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground cables	Overhead transmission lines	Track Roads	Buildings
		that a monitoring regime be in place to inspect temperature conditions and the conditions of the equipment, machinery and materials. This should be integrated with any construction management regimes such as a Construction Management Plan which would outline measures to reduce the risk of heat stress to site workers.	(The corrosion protection would be C4. This is the highest standard for corrosion protection). Design measures are considered sufficient to reduce risk.		indoors away from direct contact from solar radiation. **Recommendations/assumptions:** it is recommended that a monitoring regime be in place to inspect temperature conditions and the conditions of the equipment housed within the substation following extreme temperature events and during prolonged heatwaves.			heatwaves and drought conditions).	
Wind	Gales, Khamsin winds and extreme wind events	**Potential effect:** Damage to materials awaiting construction and assembly on site. Deterioration of machinery and materials from windblown sand and dust and	**Potential effect:** Risk of breakage and risk to safety of structures in the event of extreme wind events. Deterioration of materials from windblown sand and dust.	**Potential effect:** Risk of breakage and risk to safety of structures in the event of extreme wind events. Deterioration of materials from windblown sand	**Potential effect:** damage to electrical components and disruption of supply from dust and sand blown into the substation.	n/a – deemed as low vulnerability.	**Potential effect:** overhead lines blown out of alignment. **Design measures:** the design of the overhead lines would consider wind loading	n/a – deemed as low vulnerability.	**Potential effect:** damage and deterioration of structures from wind and windblown dust and sand. **Design measures:**

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground cables	Overhead transmission lines	Track Roads	Buildings
		possible failure of equipment as a result of infiltration. Risk to site workers working at height. **Design measures:** no mitigatory design measures specified. **Recommendations/assumptions:** It is recommended that a monitoring regime be out in place to inspect the conditions of the machinery and that materials at risk be placed in cover to reduce risk of damage and deterioration prior to assemble. This should be integrated with any construction management regimes such as a	**Design measures:** the turbines will have an operational wind speed capacity which exceeds the average wind speed for the area. Turbines have a cut-out wind speed of 27.0 m/s over 10-minute intervals. **Recommendations/assumptions:** It is recommended that a monitoring regime be out in place to inspect the conditions of the turbines following such events and emergency shutdown measures be in place to prevent breakage and collapse.	and dust and possible failure of equipment attached to monitoring masts as a result of infiltration and deterioration. **Design measures:** the masts have been designed to withstand high winds and Khamsin windstorms. **Recommendations/assumptions:** It is recommended that a monitoring regime be out in place to inspect the conditions of the turbines following such events and emergency shutdown measures be in	**Design measures:** this is an air insulated substation which prevents sand from getting into the internal components of the system. Design measures are considered sufficient to reduce risk.		including orientation to prevailing wind direction and maximising the protective features of topography and naturel features. Design measures are considered sufficient to reduce risk.		Design measures are considered sufficient to reduce risk. **Recommendations/assumptions:** It is recommended that a monitoring regime be out in place to inspect the buildings following such events.

Climate Variable		Construction Phase	Wind Turbines & Transformers	Wind Monitoring Mast	Substation	Underground cables	Overhead transmission lines	Track Roads	Buildings
		Construction Management Plan. Construction monitoring and management should be included in Contractor requirements.		place to prevent breakage.					

6.1.5 EVALUATION OF VULNERABILITY

The Project has the potential to be vulnerable to climate change throughout its design life. The design of some of the assets include measures that would reduce the associated potential risks as detailed in **Table 6-7**.

Table 6-8 presents a summary of Project assets which remain at risk (residual risk) and as such recommendations have been made as part of this assessment to increase their resilience to climate change. For the assets where their resilience to climate change is uncertain among the design considerations, these are considered to be at risk and the assumptions made in **Table 6-7** should be confirmed and/or updated by the Project designers to ensure that the assets are do not remain at risk.

Table 6-8 - Summary of Residual Climate Risk

Climate Variable		Construction	Wind Turbines	Wind Monitoring Masts	Substation	Underground Electrical Cables	Overhead Distribution line	Track Road	Buildings
Precipitation	Extreme precipitation events	R	R	R	R	✓	✓	R	R
Temperature	Changes in annual average Extreme temperature events	R	✓	✓	R	n/a	✓	R	✓
Wind	Gales, Khamsin winds and extreme wind events	R	R	R	✓	✓	✓	n/a	R

Key:

✓	Design measures are considered sufficient to reduce risk, asset is considered to be of Low vulnerability to climate change risks.
R	Recommendations have been made for integration into the design, asset is considered to be of Medium vulnerability to climate change risks in the absence of these recommendations.
R	Recommendations have been made for integration into the design, asset is considered to be of High vulnerability to climate change risks in the absence of these recommendations.
n/a	Asset deemed as Low vulnerability.

Following this Climate Risk Review, it has been identified that based on the information available, a number of assets are considered to be at risk to climate change throughout the Project life. Recommendations have been identified to reduce such risks and are strongly advised to be integrated into the design. In this assessment, WSP has adopted a 'high emissions' scenario to provide a 'worst-case' scenario against which to assess the resilience of the Project and thus has followed the precautionary principle. It should be noted that there are inherent uncertainties associated with climate projections and that the potential impacts identified cannot be guaranteed to occur and, conversely, may be more severe than anticipated.

A number of the recommendations made have been in relation to monitoring. Monitoring of asset performance is important, particularly following climatic events, to ensure that climate-induced changes to ground conditions or the integrity of equipment do not pose additional risks or result in disruption to operations. A comprehensive monitoring programme will help inform the operator of alterations that need to be made to the Project to ensure its smooth running and continued resilience to extreme weather events.

As noted above, a transition risk assessment has not been deemed necessary for this assessment (refer to Section 3.9.2). It is recommended that the need for this assessment be reviewed as the Project progresses.

6.1.6 RECOMMENDATIONS

- ESAP Action 1.14: A monitoring programme to assess the impacts of climate on the assets should be developed and implemented, particularly following climatic events, to ensure that climate-induced changes to ground conditions or the integrity of equipment do not pose additional risks or result in disruption to operations.

6.2 HYDROLOGY

6.2.1 FLOOD RISK

The flash flood of October 2016 and the reported increase in flash floods in general indicates there is potential for the scheme to be impacted by flooding during the construction and operation phases of the project.

The potential sources of flooding are the five main wadis that traverse the site, surface water flooding from the shallow ephemeral channels that traverse the site and groundwater flooding.

Wadi Hawashiya is the largest wadi that crosses the northern section of the site and based on its drainage area represents the greatest flood risk to the site. Furthermore, there are three dams along the wadi which were constructed after 2016 that also represent a potential risk.

WSP acknowledges that the analysis in the ESIA demonstrates that the reservoir storage exceeds the October 2016 storm runoff based on a water budget approach, however it is advised that more detailed analysis based on a design storm is required to: a) confirm that the dams provide mitigation to the design storm event; and b) any site drainage is designed accordingly. To this effect, clarification should be sought on the design storm return period to be used to assess surface water drainage requirements.

In the Hydrology Risk Assessment[42], RCREEE, ECOI Consult and Green Plus Environmental Solutions concluded that "..there is no chance to expect dangerous flash floods at the outlet of wadi Hawashiya in case of heavy rain fall storms where, the amounts of rain that can be expected during severe rainstorms do not collect and discharge suddenly at the downstream part of the Wadi." This statement should be treated with some caution given the paucity of hydrological data and the lack of information presented on the flood mitigation structures.

There are recorded instances of dam failures in Egypt during flash floods (Wadi Dahab, 2012 and extensive flooding in the Red Sea governate in May 2014) and therefore the risk of a spill event or dam failure must be considered. This is particularly pertinent given the most downstream dam is located immediately upstream of the project area.

It is likely that the flood mitigation structures have been designed to retain at least a 100-year design flood, but this should be confirmed with the authorities. Furthermore, the operating and maintenance regime for the structures needs to be confirmed such that the residual risk of a spill event or in an extreme case a dam failure can be ascertained.

No quantitative information is available on flood levels in the five wadi channels and therefore at this time the constraints mapping[60] has not been based on the risk of flooding.

6.2.1.1 Construction

During construction, the issues that must be considered include:

- The safety of site personnel and the provision of procedures for evacuation;
- Potential damage to site facilities;
- The risk of stored materials being damaged; and
- The risk to the coastal road and the Wadi Hawashiya culverts.

The construction programme should avoid activities in the channels of the five main wadis that cross the site especially during the months of October and May. The constraints mapping indicates the locations of these channels[60]. Site facilities and storage areas should be located away from these channels.

A flood management plan should be developed to establish protocols should a flash flood occur. The plan must set out appropriate precautionary measures for the storage of materials, the location of site cabins and facilities, monitoring the potential occurrence of a flood and the safe evacuation of site operatives. Particular attention must be given to establishing safe working procedures between October and February in case of flooding. Particular attention should be given to monitoring water levels impounded behind the third dam on Wadi Hawashiya upstream of the project area. The plan should be developed through liaison with the Red Sea Governorate who it is believed are responsible for operating the dams and responding to flash floods in the region.

6.2.1.2 Recommendations

- ESAP Action 1.10: AWPC to support the EPC to develop a flood management plan to establish protocols should a flash flood occur. The plan must set out measures for the safe evacuation of site operatives and liaising with the Authorities to manage risks to the coastal road. Particular attention must be given to establishing safe working procedures between October and May in case of flooding. As part of the plan, the Project will demonstrate consultation with the respective authorities on the design criteria of the retention basin, resilience to climate change variation, and

[60] AMUNET 500 MW WPP IN RAS GHAREB, EGYPT. Wind farm layout design constraints for 120m TTH. March 2022, Version 0.

operating and maintenance regime to ascertain the structural integrity of the three dams and any residual risks.

- ESAP Action 1.11: The EPC contractor to liaise with the the authorities responsible for the Wadi Hawashiya flood mitigation structures to establish contingency procedures at times of high flood risk.

6.2.1.3 Operation

The Hydrology Risk Assessment concludes that there are no operational flood risks on the basis that the flood mitigation structures have sufficient capacity to impound the largest storm on record (October 2016). There are some important gaps in the information presented with respect to the design storm and the flood mitigation structures. These gaps are listed below:

- No quantitative analysis to determine the depths and extents of flooding in the five wadis for the design storm;
- Clarity over which authority is responsible for the maintenance and operation of the flood mitigation structures in Wadi Hawashiya to confirm the procedures comply with national regulations and methodologies and good international industry practice;
- The approach to climate change given the recent trend in flash floods in the region; and
- Assessment of the residual flood risk due to a breach of the flood mitigation structures or a more severe flood event than the design flood.

6.2.1.4 Recommendations

- ESAP Action 1.12: AWPC to ensure the EPC undertakes a more detailed analysis based on a 100-year storm event to confirm that the dams provide mitigation to the design storm event and any site drainage is designed accordingly. This will include undertaking further hydrological analysis to determine the extent and depth of flash flooding in all wadis for the design storm with an allowance for climate change. The flood risk assessment should include a statement on the residual flood risks such as a potential breach of a flood mitigation structure.

  EPC contractor to liaise with the Authorities to establish a protocol for monitoring information on flood levels behind the flood mitigation structures and to provide early warnings of a potential spill event.

6.2.2 SHALLOW EPHEMERAL CHANNELS

As noted in the baseline description, the site is traversed by many shallow dry channels become wet following storm rainfall. The catchments of these channels drain the eastern slopes of the coastal hills and in many instances do not extend beyond the eastern boundary of the project area.

They do not represent a significant flood risk due to the catchment sizes and the permeable nature of the alluvial deposits.

6.2.3 GROUNDWATER

There is no information on potential groundwater flood risk. The hydrology risk assessment makes no reference to depths to water table and no published information on groundwater flood risk was located for this study. The 2020 geotechnical investigation identified no continuous shallow groundwater systems, with only limited perched and brackish waters (see Section 4.2.3).

It is not unreasonable to assume that there is no significant risk of groundwater flooding given the attention given to flash flooding.

6.2.4 EROSION & SEDIMENTATION CONTROL

Land clearing activities, excavation, grading, etc. during construction may disturb soil, exposing it to increased erosion during rainfall events. Inadequate control of this process may result in siltation of surface water.

The ESIA and ESMP describe required mitigation measures for construction, including the following:

- Avoid executing excavation works under aggressive weather conditions;
- Place clear markers indicating stockpiling areas for of excavated materials to restrict equipment and personnel movement, and limit the physical disturbance to land and soils in adjacent areas;
- Erect erosion control barriers around work site during site preparation and construction to prevent silt runoff where applicable; and
- Return surfaces disturbed during construction to their original (or better) condition to the greatest extent possible.

The QHSE requirements (understood to be attached to the contract) have a brief statement that storm water, erosion and sediment control is required, but no further detail. The ESMS manual makes no reference to erosion and sediment control.

6.2.4.1 Recommendations

- Ensure that contract requirements stipulate the controls required to be implemented by EPC contractors to prevent erosion and sedimentation during construction activities; this can be incorporated into the Soil Management Plan.

6.2.5 GEOLOGY & HYDROGEOLOGY

6.2.5.1 Potential Existing Ground Contamination Impacts from Historical Oil & Gas Exploration & Extraction

There is potential for the presence of potential existing ground contamination impacts from historical oil & gas exploration & extraction on and near the project site & potential ground contamination impacts migrating onto or beneath the Project area associated with historical, active, or future oil and gas exploration / extraction activities by third parties on nearby land.

With reference to historical and current aerial mapping, as well as the findings of the recent WSP site walkover, there are known to be remnants of historical oil and gas exploration / extraction infrastructure (former drilling / derrick rig sites and associated buildings and road networks) on the Project Area. Residual ground contamination, in the form of hydrocarbon (oil) impacted soils and materials are apparent in these areas (see following photographs taken during the recent WSP walkover). Wider areal disposition of hydrocarbon impacted finer soils by winds is also expected across the Project Area.

Figure 6-1 - Residual Infrastructure from Oil & Gas Exploration & Extraction

It does not appear that any ground contamination remediation works were undertaken as part of the decommissioning of these former oil exploration / extraction activities. The extent of associated subsurface ground contamination, is not known.

As discussed in Section 4.2.3, no continuous shallow groundwater system has been identified below the site, with only limited perched and brackish water aquifers. Therefore, groundwater is considered of low sensitivity. Therefore, the more significant receptor would be shallow soils, particularly those in locations subject to periodic floodwater inundation.

6.2.5.2 Recommendations

- ESAP Action 3.13: It should be confirmed that the landowner (not the Project Sponsor) is contractually responsible for any historical ground contamination on or beneath the Project Area associated with historical oil and gas exploration / extraction activities by third parties. This responsibility includes any associated (i) abnormal development costs realised during the Project (during construction and operational phases) and (ii) any associated regulatory, third-party, or commercial contaminated land liabilities.

  Note: This includes any oil exploration of extraction related hydrocarbon impacted soils or groundwater impacts which might extend across a wider area (either due to areal dispersal of impacted finer soils, surface water mobilisation of any contamination through the leaching of impacted soils via existing Wadis during periods of heavy rainfall, or contaminant migration via groundwater).
- ESAP Action 3.14: Descriptions of the type and location of all former oil and gas exploration / extraction infrastructure across the Project Area should be accurately confirmed on mapping to establish if there is any planned cross over with planned Project infrastructure.
- ESAP Action 3.15: ground contamination watching brief and remediation protocol should be devised so that appropriate procedures can be followed should associated ground contamination be identified as part of the inground earthworks phase of Project construction. The contractor's site surveys should also consider ground contamination.

  Note: The EPC contractor may need extra time/resource to deal with contaminated ground during construction, which may impact project cost and timeline. The Sponsor should ensure clarity in the EPC contract on how ground contamination is dealt with. The contractor's site surveys should also consider ground contamination.
- ESAP Action 3.16: Dependent upon the degree of assurance provided by the landowner regarding liability for any historical ground contamination on or beneath the Project Area, consideration should be given to the design and undertaking of a contaminated land ground investigation to establish a more accurate baseline of the character of ground contamination across the project area, with which more informed discussions can be held with the landowner / relevant third parties prior to Project commencement.

6.2.5.3 Potential for Ground Contamination Impacts as Part of an Agreement with General Petroleum Company for an Oil Exploration and utilisation concession across the Project Area

The following is indicated in Section 7.2.2. of the ESIA:

‘General Petroleum Company

The area in general includes petroleum mining activities that are operated mostly by the General Petroleum Company. A Work Coordination Agreement has been signed between NREA and the General Petroleum Company in 2005 for an area of 700km^2 in which wind farm developments will take place. The Agreement includes several articles for the development projects to include for example:

The General Petroleum Company has agreements for oil exploration and utilisation within concession areas located within the agreed 700km^2 area.’

The above agreement suggests that General Petroleum Company has right of access to, and an ability to undertake oil exploration and extraction activities across (parts of) the Project Area during construction and operation phases, which could give rise to ground contamination and associated risk / liabilities, if appropriate controls are not exercised.

6.2.5.4 Recommendations

- ESAP Action 3.17: Co-ordination should be undertaken with the General Petroleum Company on implementation of the Work Coordination Agreement both at construction and operation stages, to ensure that the development is designed and constructed in accordance with the agreement, and that access protocols and communication processes are established.

  The terms of this agreement should be clarified, including any potential contractual obligations upon GPC for ground contamination controls as part of such activities, and responsibilities for any associated contaminated land liabilities, including negative effects on the Projects operation, should they transpire.

6.2.5.5 Potential Impacts during Construction and Operational Phases

Potential impacts to ground and controlled waters could occur through improper housekeeping practices / management of construction and operational activities.

Generally, such impacts can be adequately controlled through the implementation of general best practice housekeeping measures as highlighted in the ESIA reports and the ESMS Manual, and which are expected to be implemented by the EPC Contractor throughout construction phase and Project Operator during the operation phase. In summary, these best practice housekeeping measures include staff / worker EHS training & awareness, EHS inspection & monitoring, EHS meetings and reporting.

The specific mitigation and monitoring requirements as detailed in the ESMP[61] and ESHS-MS[62] for waste management (solid and wastewater) and hazardous waste / material management, for the planning and construction, and operational Project phases, to protect soil and ground / controlled waters (geology, hydrology, and hydrogeology), appear reasonable.

Mitigations for hazardous materials and wastes are discussed in other sections of this Chapter.

[61] Environmental and Social Management Plan
[62] Environmental and Social, Health and Safety Management System