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WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

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ENVIRONMENTAL CONSIDERATIONS REPORT FOR RUSSEIFAH AREA 3 REMEDIATION
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Submitted to:

USAID Jordan

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AECOM

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LIST OF ACRONYMS

Bq/kg	becquerel(s) per kilogram; a measure of radioactivity
Bq/m^3	becquerel(s) per cubic meter
BSS	basic safety standards
Cd	cadmium
CO	carbon monoxide
CO_2	carbon dioxide
°C	degrees Celsius
dBA	A-weighted decibel(s)
DOA	Ministry of Tourism / Department of Antiquities
ECR	environmental considerations report
EIA	environmental impact assessment
EMMP	environmental management and monitoring plan
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEE	initial environmental examination
JNRC	Jordan Nuclear Regulatory Commission
JPMC	Jordan Phosphate Mines Company
JS	Jordan Standard
MOA	Ministry of Agriculture
MoEnv	Ministry of Environment
MOH	Ministry of Health
MoMA	Ministry of Municipal Affairs
mSv	millisievert(s); a measure of radiation dose
mSv/yr	millisievert(s) per year
MWI	Ministry of Water and Irrigation
$\mu g/m^3$	microgram per cubic meter
NO_2	nitrogen dioxide
NRA	Natural Resources Authority
O_3	ozone
P_2O_5	phosphate
Pb	lead
$PM_{2.5}$	fine particulate matter
PM_{10}	respirable particulate matter
ppm	part(s) per million
SO_2	sulfur dioxide
TENORM	technologically-enhanced, naturally-occurring radioactive materials
Th	thorium
TOR	terms of reference
TSP	total suspended particulates
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WRECP	Water Reuse and Environmental Conservation Project

1 INTRODUCTION

1.1 Project Background and Need for the Project

The United States Agency for International Development (USAID) Water Reuse and Environmental Conservation Project (WRECP) works throughout Jordan in institutional capacity building, pollution prevention for industries, solid waste and wastewater management, and water reuse. The project is implemented by AECOM and a team of international and Jordanian partner firms. This five-year project has four primary tasks:

- Task 1 – Institutional and Regulatory Strengthening
- Task 2 – Pollution Prevention and Industrial Water Management
- Task 3 – Disposal Sites Rehabilitation and Feasibility Studies
- Task 4 – Water Reuse for Community Livelihood Enhancement

One of the main project components (Task 3) focuses on rehabilitation of historic disposal sites. The Russeifah Site was one of the locations selected for disposal site rehabilitation as part of Task 3. The Russeifah Site is composed of six individual contaminated areas, as described below. The contamination in each area is directly or indirectly the result of the development and operation of the phosphate mining industry, which began in the mid-1930s:

- **Tunnels**. The initial mining began with the hand excavation of exposed seams of phosphate-rich ore. This created a number of abandoned tunnels, called Area 5 (Tunnels).
- **Overburden**. In the mid-1950s, phosphate mining intensified through open pit mining. The material that lay on top of the phosphate-containing geological layers was removed. This material, called “overburden,” was placed in a location now called Area 6 (Overburden Piles).
- **Phosphate Stockpile**. The phosphate ore was then excavated and placed in a large stockpile near the phosphate ore processing plant. Throughout the intervening years, portions of the stockpile were processed and hauled off; however, the bulk of the pile remains and is called Area 3 (Phosphate Stockpile).
- **Landfill**. As a result of the excavation of the phosphate ore, a large and deep open pit remained. In the mid-1980s, the Greater Amman Municipality began using a portion of the open pit as a solid waste landfill. This landfill operation continued until 2003, when the landfill operation was curtailed. The resulting filled area of the open pit is referred to as Area 1 (Landfill).
- **Pit**. The unfilled area of the open pit is referred to as Area 2 (Pit).
- **Lagoon**. During the processing of phosphate, the process wastes were disposed of into a small wadi, which drained to the Zarqa River causing sedimentation and complete blockage of the wadi. As a result, a stormwater drainage lagoon was created, called Area 4 (Lagoon).

With the development of the phosphate mining industry, the City of Russeifah saw rapid population growth. As a result, the residential area is encroaching on Areas 3, 4 and 5, while businesses and industry are pressing on Areas 1, 2 and 6. None of the areas is now in direct use by the phosphate industry. This report assesses the potential impacts of proposed remediation at Area 3.

Figure 1-1. Phosphate Stockpile (Area 3)

The Russeifah Area 3 phosphate stockpile (Figure 1-1) is a large phosphate ore stockpile, consisting mainly of low-grade phosphate. The stockpile's volume is approximately 4.5 million cubic meters, and the stockpile covers an area of 350,000 square meters. It is a result of the aggressive open pit mining conducted between 1963 and the mid 1980's which caused this and other dramatic changes in the topography.

The phosphate ore stockpile has become an aesthetic, environmental, and health concern over the years. It poses risks associated with slope stability and radiation hazards. The average concentrations of the ore material found throughout the site exceed the International Atomic Energy Agency (IAEA) exemption criteria and, thus, pose potential radiation threats to the neighboring communities and future users of the site.

Slope stability analyses showed that the factors of safety for the representative sections were generally below the acceptable limits. This makes the greater part of the area unsafe and presents the need for remediation measures to provide slope stability.

The Russeifah region continues to grow in population. There is a need to remediate the area not only from public aesthetics and environmental perspectives, but also from the perspective of beneficial reuse. The ultimate remediation of Area 3 (Phosphate Stockpile) would significantly improve the quality of life for the residents of Russeifah.

1.2 Environmental Considerations Report (ECR) Objectives

A screening process was conducted for the WRECP according to USAID's Environmental Compliance Procedures, Title 22, Code of Federal Regulations, Part 216. USAID conducted an initial environmental examination (IEE) for the various components of the WRECP, including a threshold decision for the proposed Russeifah Area 3 remediation. As USAID's action is limited to the funding of a feasibility study and preparation of design documents, the IEE concluded that USAID's actions (i.e., studies/design) would not have the potential for significant adverse environmental impact. However, USAID recognized that implementation (e.g., construction) of recommendations made in the feasibility study and depicted in design documents could have potential adverse impacts if not implemented with appropriate controls, or if environmental monitoring is not incorporated into the project. The IEE noted that an environmental mitigation and monitoring plan, hereafter referred to as an environmental management and monitoring plan (EMMP), should be prepared to minimize adverse impacts on human health and the environment for these activities. Further, the IEE determined that the environmental assessment process should be followed in accordance with USAID's Environmental Compliance Procedures.

The present report is an environmental considerations report (ECR). This ECR was not prepared to be a formal environmental assessment; instead, it was prepared to demonstrate that potential environmental impacts were considered by the design team while making a decision on the recommended plan and during development of the preliminary design. This ECR includes an EMMP to facilitate the implementation of the proposed action in a manner that enhances and sustains the natural and human environment. During implementation of the proposed remediation final design and construction, an environmental impact assessment (EIA) in compliance with Ministry of Environment (MoEnv) regulations and any other funding nation regulations, as appropriate, must be prepared and should incorporate the major results, conclusions, and recommendations of this ECR.

This ECR plays a central role in assessing the social and environmental implications – including water resources implications – of the proposed remediation project and identifying the measures necessary to protect resources and related ecosystems. The ECR is concerned not only with impacts on the natural environment, but also with effects on the social environment.

The ECR describes various components of the environment of the area to be affected by the remediation alternative under consideration. Data and analyses in the ECR are commensurate with significance of the impact. The ECR includes discussions of direct and indirect effects and their significance, polices and controls for the areas concerned, the reuse and conservation potential of the recommended alternative, and mitigation measures. For significant adverse impacts, the mitigation discussions propose measures that would minimize their magnitude and severity.

The main objectives of this ECR for the remediation of Russeifah Area 3 are summarized below:

- Determine that the project would not have irreversible negative impacts on the natural and human environments
- Identify the potential environmental impacts, including the positive and negative, and direct and indirect impacts of the proposed project
- Propose mitigation and monitoring measures for minimizing the potential adverse impacts of the project on the affected environment

2 REGULATORY FRAMEWORK

This chapter describes the applicable regulatory framework in Jordan, including relevant laws, regulations, and standards. If the proposed project is implemented, an EIA would be prepared in accordance with the Jordan EIA Regulations identified in this section.

2.1 Laws

2.1.1 Environment Protection Law (No. 52 of 2006)

In 2006, the Jordanian Law for Protection of the Environment was decreed. Article 5 of this law states that the MoEnv, in cooperation and coordination with the authorities concerned with environmental affairs at the local, Arab and international levels, shall be responsible for the protection of the environment elements and components from pollution. A set of complementary regulations and instructions were issued pursuant to the Law.

Article 4 of this law specifies the following responsibilities of MoEnv as related to mining:

> *For the purpose of achieving the goals of environmental protection and the improvement of its various Elements in a sustainable manner the Ministry, in cooperation and coordination with the competent parties, shall carry out the following duties:*
>
> *D- Issuing environmental instructions necessary to protect the Environment and its components and the conditions to establish agricultural, commercial, industrial, housing, mining and other projects and all services relating thereto for compliance therewith and the adoption thereof within preconditions for the licensing or renewal of licensing thereof in accordance with the legal principles in force."*

Article 13 highlights the role of the Ministry in monitoring and supervision to promote compliance with environmental specifications and measurements and the set technical standards. It also highlights the role of the Ministry in monitoring and measuring of environmental components and follow-up through scientific centers. The Environmental Protection Law is currently in the process of being reviewed and any modifications or additions to the law will be announced by the MoEnv. Until such time, the requirements of the existing law should continue to be followed.

2.1.2 Natural Resources Affairs Law (No. 12 of 1968)

The following sections of this law are relevant to and govern mining activities:

Per Clause (b) of Article 57*:*

> *"The* [Natural Resources] *Authority may maintain, operate and otherwise manage any completed or partially completed project until such project is transferred to, and responsibility for maintenance and operation is fully assumed by the village or municipality or any other public body. The Authority shall not remove the control on any project until sufficient assurances are given that the project will be operated and maintained in a manner to ensure maximum useful life of the project."*

Per Article 44 of this law:

> *"The holder of an exploration license or mining right shall not appropriate or take water from any lake, river, source or flow of water or canal bordering or passing through licensed land or change its course without the written permission of the President* [of the Authority] *after obtaining the agreement of the owners (if any)."*

2.1.3 Public Health Law (No. 47 of 2008)

The Ministry of Health (MOH) is the entity responsible for applying the Public Health Law in Jordan. The MOH is also authorized to take all necessary measures to protect public health. Article 47 considers activities that affect human health or cause a health nuisance by releasing solid or liquid waste or emitting gases. Article 48 states that entities responsible for creating health nuisance are given seven days' notice to apply corrective measures. If nothing is done, the ministry of health will carry out the required actions at the expense of the activity owner.

2.1.4 Archaeology Law (No. 21 of 1988)

Issued by the Ministry of Tourism / Department of Antiquities (DOA), this law details the main responsibilities of the DOA. These include, but are not limited to, determining the archaeological sites along with their importance, carrying out archaeological excavations, and maintenance, preservation and restoration of archaeological sites. Article 13 of this law bans construction of any structure within a distance of 5 to 25 meters from an archaeological site. Article 15 states that any chance finds should be reported to DOA or the Public Security Directorate within 10 days. Article 27 sets the penalties for failing to report chance finds.

2.1.5 Water Authority Law (No. 19 of 1988)

The Water Authority Law and its amendments established the Water Authority of Jordan (WAJ) as an autonomous agency responsible for all water and wastewater issues in the country. WAJ's mandate includes connecting the public to the water and sewer networks, as well as maintaining, operating, and managing these networks.

2.1.6 Agriculture Law (No. 44 of 2002)

This law identifies the responsibilities of the Ministry of Agriculture (MOA) in regulating and developing the agricultural sector, in cooperation with the relevant authorities. In addition, Article 57 governs the protection of wild animals and birds and prevents the hunting, killing or capture of birds useful for agriculture, as well as birds and animals of prey. The types and species subject to this regulation are specified by the Minister. This law further governs the protection of agricultural land and pastures.

2.1.7 Law of Planning of Towns and Villages and Buildings (No. 79 of 1966)

By virtue of this law the Higher Planning Council is responsible for regional planning and planning zones. This law applies to all kinds of land uses including buildings and any construction works undertaken. It also applies to any reconstruction conducted by any governmental or local authority, public or private institution. This law provides many sections that regulate licensing, plans for land distribution, pollution prevention, solid waste disposal and sewage, as well as traffic control.

2.1.8 Labor Law (No. 8 of 2002)

The key component of this law is stated by Article 56 paragraphs (A) and (B) regarding the right of the laborer to not work more than eight hours per day. Furthermore, Article 73 of this law bans the employment of individuals less than 16 years of age. This law also outlines that projects shall comply with article 78 related to occupational health and safety, and provides essential precautions and arrangements to protect the workers from the risk of hazards, including the supply of personal protective equipment.

2.2 Bylaws and Regulations

The following summarizes the bylaws and regulations that are relevant to remediation of Area 3. This summary includes, for some of the bylaws and regulations, a reference to specific language in the bylaws and regulations relevant to the proposed project.

2.2.1 Air Protection Bylaw (No. 28 of 2005)

This bylaw was issued in accordance with Article 23 of the Environmental Protection Law (No.1 of 2003). The aim of the Air Protection Bylaw is to protect public health and the

environment from pollution resulting from human activities by controlling air pollutants emitted from stationary and mobile sources. It states that for any facility, the leak or emission of air pollutants should not exceed the maximum allowable limits. The MoEnv classifies establishments according to the quality and quantity of air pollutants and contaminants resulting from their activities, and their effects on the environment and public health; consequently, the appropriate location of the facility is determined. The MoEnv is responsible for detecting any excesses and for monitoring the compliance with this bylaw.

Per Article 4 of this bylaw, the following applies to this project:

> *"The Ministry shall classify the facilities from which Air Pollutants are emitted according to the type and quantity of the emitted pollutants and their effect on the Environment and public health, and shall also determine the areas subject to air pollution and the required monitoring programs, and the necessary procedures to control or prevent environmental damage."*

Per Clause (A) of Article 5, the following applies to this project:

> *"The Minister, upon the recommendation of the Secretary General, shall form a technical committee consisting of experts from the Ministry and concerned entities, that shall identify those Facilities in existence at the time of the coming into force of these Regulations, and that must realign to become in compliance with the provisions hereof within the period set by it, provided that such period does not exceed five years."*

Per Article 12, the following applies to this project:

> *"The Ministry, in cooperation and coordination with the Jordan Nuclear Energy Commission, shall take the necessary measures to ascertain the fulfillment of public safety conditions and requirements, radiation prevention, nuclear safety, protection of the Environment, and human health and property from pollution hazards and exposure to ionized radiation."*

2.2.2 Soil Protection Bylaw (No. 25 of 2005)

Article 3-E of this bylaw states that the MoEnv, in coordination with the relevant authorities, is responsible for protecting soil from the harmful effects of industrial dust, solid waste, industrial waste, and untreated wastewater. The regulation further states that the MoEnv, in cooperation with the MOA, is responsible for studying the sites of development projects and project impacts on land and natural resources, as well as preparing the necessary programs for the rehabilitation of waste dumping sites and their cultivation with appropriate crops.

Article 3-H of this bylaw states:

> *"The Ministry, in cooperation with the Ministry of Agriculture and any other entity concerned with soil protection shall carry out the following tasks and authorities:*
>
> *H- To prepare the necessary programs for rehabilitation of quarries and sand mines, and mining areas the waste dumping sites after their reclamation, exploitation and cultivation with the appropriate crops."*

2.2.3 Environmental Impact Assessment Regulations (No. 37 of 2005)

The EIA regulations were issued to ensure that the anticipated impacts of any development project on the social, economic, and natural environment in Jordan are identified. Their aim is to limit these impacts in order to achieve sustainable development in the country. The regulations apply to all industrial, agricultural, commercial, construction, residential, and

tourism projects. The level and type of EIA study is determined by the MoEnv consistent with the lists of Category 1 and Category 2 projects specified in Annex 2 and Annex 3 of the regulation. This regulation also states that the EIA review period for the MoEnv is 45 calendar days. The MoEnv is currently reviewing the EIA regulations, including the EIA classification system, and will issue any changes to the regulations or additional guidance as appropriate.

2.2.4 Mining Regulation (No. 131 of 1966)

With respect to this regulation, the following applies to this project:

> *"A detailed geological, physical and hydrological study should be carried out for the area in which mining shall take place to include the following:*
>
> *a- Thickness of the mineral to be extracted, its distribution, gradient, distance from the surface and hardness.*
>
> *b- Vertical cross sections every 200 meters showing the type of rocks, thickness, hardness and gradient over and under the minerals to be extracted.*
>
> *c- Cracks and folds which may affect the nature of mining in the area.*
>
> *d- The highest underground water table which may be found in the area and how far from ground surface.*
>
> *e- Main water course in the area and the highest level to which the water table may rise in these courses calculated on basis that the rate of annual rainfall is 1000mm."*

2.2.5 Regulation for the Prevention of Health Nuisances (No. 72 of 2009)

The provisions of this regulation prohibit anyone from causing any health nuisances within municipal areas. It identifies the types of nuisances and the measures to be undertaken to prevent the occurrence of health nuisances.

2.2.6 Regulation for the Protection and Safety of Workers from Machineries and Workplaces (No. 43 of 1998)

The provisions of this regulation obligate any institution to take precautions and procedures for the prevention of occupational accidents. It identifies types of safety risks at work sites, including mechanical, chemical and electrical machinery and industrial equipment.

2.2.7 Regulation of Preventive and Therapeutic Medical Care for the Workers in Establishments (No. 42 of 1998)

The provisions of this regulation obligate any institution to confirm the medical capability of workers via preliminary and regular medical examinations.

2.2.8 Environmental Monitoring and Inspection Regulation (No. 65 of 2009)

This regulation was issued pursuant to the Environmental Protection Law No. 52 of 2006. It categorizes three levels of operational facilities based on their risk to cause environmental pollution. This categorization is reflected in the frequency of environmental inspections stipulated in the regulation. In cases where environmental inspections carried out by the MoEnv reveal violation of stated environmental quality requirements, the MoEnv is authorized to request an environmental audit from the facility, which under Article 9 of the regulation is obliged to submit its audit reports to the MoEnv.

2.2.9 Regulation for Protecting the Environment from Pollution in Emergency Situations (No. 26 of 2005)

This regulation sets out the plan for "protecting the environment and controlling pollution in emergency situations and the methods of implementation thereof, subject to the specific international and regional protocols in this regard to which the Kingdom is party". In addition, MoEnv is responsible for managing the emergency plan and following up on its execution, as well as identifying the necessary resources and conducting the required surveys and studies.

2.2.10 Groundwater Control Regulation (No. 85 of 2002)

This regulation was issued pursuant to Articles 6 and 32 of the Water Authority Law No. 18 of 1988. It governs groundwater extraction and designates groundwater as exclusive government property. The regulation additionally controls the drilling of wells and the licensing thereof, as well as quality and pollution control and remediation. Furthermore, Criminal Law No. 16 of 1960 stipulates the protection of water resources and sets out the penalties in the case of violations.

2.2.11 Water Protection Regulation of 2004

This regulation aims at protecting water sources from pollution. It stipulates that the Ministry of Water and Irrigation (MWI) is to set the environmental conditions to be fulfilled if permission and authorization are to be given for the development projects covered by the environmental impact assessment regulation.

Additionally, Article 6 of the regulation states that no waste dump sites can be constructed without the MWI's authorization and states that MWI in coordination with the concerned entities should set the environmental criteria, conditions and requirements for such a facility. Article 11 further highlights the role of MWI and other concerned entities in setting the environmental conditions for the collection, storage and transportation of all liquid and solid waste in order to prevent the pollution of water sources.

2.2.12 Regulation of Land Use of 2007

This regulation, which applies to all land uses, including buildings and any construction works undertaken, makes the Higher Planning Council responsible for regional planning. It sets outs the different land use categories and defines the relevant allowable activities.

2.2.13 Hazardous Materials and Wastes Management, Transfer and Circulation Regulation (No. 24 of 2005)

This regulation prohibits dealing with hazardous waste or dangerous substances unless a permit is obtained from MoEnv. Per this regulation, the Ministry should form a committee that classifies hazardous waste or dangerous substances, and prepare instructions to determine the basis and conditions for the handling, collection, storage, treatment and disposal of hazardous waste and dangerous substances.

2.2.14 Solid Waste Regulation (No. 27 of 2005)

This regulation specifies several responsibilities of the MoEnv in relation to solid waste management, including the following:

- Prepare plans for solid waste management and develop programs to implement them
- Determine the specifications of the equipment used to manage solid waste and the circumstances of waste collection, sorting, transporting, storage, recycling, treatment and disposal
- Determine methods of rehabilitation upon the closure of landfills
- Conduct studies and gather information on solid waste management case studies, organize the studies, assess and propose suggestions for each
- Conduct programs for training and public awareness regarding SWM

In addition, this regulation specifies that any party responsible for solid waste management shall:

- Provide qualified staff to manage solid waste and safety of employees
- Provide the machinery, containers and equipment needed for solid waste management
- Control solid waste collection and identify the trucks transferring the waste to its allocated disposal sites
- Placement of containers in appropriate places, maintenance and replacement of damaged ones
- Take necessary measures to prevent dumping hazardous waste in solid waste containers

2.2.15 Regulation for the Formation of Committees and Moderators of Occupational Safety and Health (No. 7 of 1998)

The provisions of this regulation obligate any institution that has more than 20 employees to form a functionally specialized committee for the occupational safety and health of the employees. The size of the committee so formed should be commensurate with the size of the institution. This regulation also specifies the responsibilities of this committee.

2.3 Instructions, Standards and Codes

2.3.1 Instructions for the Protection of Workers and Institutions from Workplace Risks and Hazards of 1998

These instructions specify mitigation measures that should be taken within trades, industries and crafts to ensure the occupational safety and health of workers and reduce risk factors in facilities.

2.3.2 Instructions for Preliminary Medical Testing of Workers of 1998

These instructions designate types of industries in which workers should be subject to a preliminary medical examination to check their capability to perform their assigned work.

2.3.3 Instructions for Regular Medical Testing of Workers of 1998

These instructions designate types of industries in which workers should be subject to certain medical examinations regularly.

2.3.4 Instruction for the Management and Handling of Consumed Oil of 2003

These instructions identify the oils that are refined from crude oil or synthetic oils and those that have been used and have become contaminated waste and therefore must be disposed of or treated to be reused. These instructions prohibit the discharge of these oils into sewage systems or septic tanks or surface water sources or groundwater or to the environment, and specify all the requirements for the proper handling and disposal of these oils.

2.3.5 Instruction for Management and Handling of Hazardous Waste of 2003

These instructions identify all types of hazardous wastes and prohibit the discharge of these wastes into sewage systems or surface water or groundwater or to the environment. They also specify all the requirements and steps for proper handling, storage, transportation and disposal of these wastes.

2.3.6 Instructions for Noise Prevention of 2003

These instructions address ambient noise and were issued by the MoEnv in 2003. Article 6 of the instructions specifies the maximum allowable level of noise for the different types of areas, both during the daytime and at night.

According to the Instructions for Controlling and Preventing Noise, construction works that use noisy equipment like mixers and shakers and any other similar equipment between 8 pm and 6 am are prohibited except for cases approved by the MoEnv.

Table 2-1 displays the allowable maximum limit of the equivalent volume level in A-weighted decibels (dBA) per area.

Table 2-1. Maximum Allowable Noise Levels

Area	Maximum limit for equivalent sound level (dBA)	
	Day	Night
Residential areas in cities	60	50
Residential areas in suburbs	55	45
Residential areas in villages	50	40
Residential areas that have some workshops or simple vocations or business and commercial and administrative areas and downtown	65	55
Industrial areas (heavy industrial)	75	65
Tuition, worshipping and treatment places and hospitals	45	35

2.3.7 Ambient Air Quality Standards (Jordan Standard [JS] 1140 of 2006)

These standards designate ambient air pollutants and the maximum allowable concentration for each of those pollutants in the atmosphere, in addition to approved methods of measurement. Table 2-2 shows the maximum allowable limits for some of the ambient air pollutants listed in JS 1140/2006. The project should comply with these limits during construction and during operations.

2.3.8 Radiation Protection Standards

The following standards pertain to the IAEA's *Safety Guide for the Management of Radioactive Waste from the Mining and Milling of Ores* (No. ES-G-1.2):

> 1.1 "*The radioactive waste generated in mining and milling activities, especially those involving uranium and thorium (U, Th) ores, differs from that generated at nuclear power plants and most other industrial operations and medical facilities. Waste from mining and milling activities contains only low concentrations of radioactive material but it is generated in large volumes in comparison with waste from other facilities. The management methods to be employed are therefore different and will usually involve waste disposition on or near the surface, in the vicinity of the mine and/or mill sites. Furthermore, the waste will contain long lived radionuclides, and this has important implications for its management because of the long time periods for which control will be necessary.*"

Table 2-2. Allowable Limits of Ambient Air Pollutants

Pollutant	Averaging Period	Maximum Limit	Number of Times Limit is Allowed to be Exceeded
Sulfur Dioxide (SO_2)	1 hour	0.3 ppm*	3 times in any 12-month period
	24 hours	0.14 ppm	Once a year
	Annual	0.04 ppm	-
Carbon Monoxide (CO)	1 hour	26 ppm	3 times in any 12-month period
	8 hours	9 ppm	3 times in any 12-month period
Nitrogen Dioxide (NO_2)	1 hour	0.21 ppm	3 times in any 12-month period
	24 hours	0.08 ppm	3 times in any 12-month period
	Annual	0.05 ppm	-
Ozone (O_3)	1 hour	0.12 ppm	-
	8 hours	0.08 ppm	-
Respirable Particulate Matter (PM_{10})	24 hours	120 µg/m^3 **	3 times in any 12-month period
	Annual	70 µg/m^3	-
Fine Particulate Matter ($PM_{2.5}$)	24 hours	65 µg/m3	3 times in any 12-month period
	Annual	15 µg/m3	-
Total Suspended Particulates (TSP)	24 hours	260 µg/m^3	3 times in any 12-month period
	Annual	75 µg/m^3	-
Lead (Pb)	Seasonally	1 µg/m^3	-
	Annual	0.5 µg/m^3	-
Phosphates (P_2O_5)	24 Hours	100 µg/m^3	3 times in any 12–month period
	Annual	40 µg/m^3	-
Cadmium (Cd)	Annual	0.005 µg/m^3	-

Notes: * ppm indicates part(s) per million.
**µg/m^3 indicates microgram(s) per cubic meter.
Source: Jordan Ambient Air Quality Standards (JS 1140/2006)

According to the *Administrative, Legal and Regulatory Framework* section of the same Guide, the following is relevant:

> 2.8 "*After closure of a mining and milling facility and assurance that the operator has fulfilled its obligations, the regulatory body should ensure that responsibility for the waste is transferred from the operator to an appropriate body with the powers to implement any required institutional control. In many cases, the body having the greatest potential for maintaining these controls is a governmental organization. The regulatory framework should provide a mechanism for this transfer of responsibility. A mechanism should also be provided to ensure that the funding necessary to support institutional control is, and continues to be, available. These mechanisms or plans for their establishment should be identified early in the development of operations.*"
>
> 2.9 "*The regulatory body should ensure that a mechanism is established to advise prospective purchasers of land affected by waste from the mining and milling of ores of all relevant details including:*

(a) The nature of the waste and the extent to which the land is affected;

(b) Any restrictions on the use of the land;

(c) Any obligations of the landowner with respect to monitoring, surveillance and maintenance."

Whereas the section on the *Protection of Human Health and the Environment* states:

3.1 "*The management of mining and milling waste is required to include the implementation of measures that will provide acceptable protection of human health and the environment, in compliance with the requirements and recommendations of the IAEA and the International Commission on Radiological Protection (ICRP)."*

3.2 "*The management of mining and milling waste is part of the management of a practice as defined in the Basic Safety Standards (BSS) and radiation protection considerations are therefore governed by the principles of justification, optimization and dose limitation. The generation and management of this radioactive waste do not need to be justified since this will have been taken into account in the justification of the entire mining practice."*

3.3 "*It has generally been accepted that the application of measures for the radiological protection of human health, in compliance with the requirements of the BSS, is sufficient to ensure that other species are not put at undue risk. Regulatory bodies should develop criteria for their particular situations where this may not be the case."*

3.16 "*A combination of engineering and institutional controls may be used to attain a level of radiological protection that meets the dose or risk constraints determined by the regulatory body. Regardless of the combination of engineering and institutional controls used, there should be reasonable assurance that these controls will remain effective for a specified period. During this period of effective engineering and institutional controls, the closed facility should meet the dose and risk constraints determined by the regulatory body. The period of institutional control should be proposed by the operator in the licensing process and supported by the safety assessment. The proposal should be submitted to the regulatory body for approval. The regulatory body's decision may be based not only on technical grounds, but also on societal considerations, and should be made on a case-by-case basis. The regulatory body should be given reasonable assurance that the controls will remain in place for the required period."*

Per the section on *Strategy for Waste Management*; the following is relevant:

4.2 "*The development of a waste management strategy is usually a complex process that has the aim of achieving a reasonable balance between two, often conflicting, goals: maximization of risk reduction and minimization of financial expenditure. The process is one of optimization of protection in which the available alternatives for siting, design and construction, operation, management of waste streams, and closure are evaluated and compared, with account taken of all associated benefits and detriments and any constraints (such as an annual dose constraint) that are required to be imposed. The characteristics of the alternatives (or options) that should be considered include:*

(a) The radiological and non-radiological impacts on human health and the environment during operation and in the future;

(b) The requirements for monitoring, maintenance and control during operation and after closure;

(c) Any restrictions on the future user of property or water resources;

(d) The financial costs of the various alternatives and the resources available for implementing the alternatives;

(e) The volumes of the various wastes to be managed;

(f) The socioeconomic impacts, including matters relating to public acceptance;

(g) Good engineering practices."

The IAEA BSS establish generally applicable dose limits (Table 2-3) for exposure of trained workers and members of the public from radiation hazards resultant from "practices." These BSS standards define the applicability and exemptions for various types for exposures, such as those associated with technologically-enhanced, naturally-occurring radioactive material (TENORM). In addition to the BSS, IAEA publishes standards governing specific industry practices, such as, in this case, the mining industry.

The BSS Section 2.5 specifically addresses exposures to natural sources that result in 1) public exposure to effluent discharges or the storage of radioactive waste; or 2) radon exposures to workers at the site (similar to the situation with the Russeifah phosphate ore stockpiles). The IAEA publishes specific radionuclide concentrations, below which sources are normally exempt from the regulatory requirements for practices. If not exempted from the BSS requirements, the legal person or entity responsible for the site and associated practice must register or license the site according the regulatory authority. The registrant or licensee is required to establish the technical and managerial structure to ensure compliance with the applicable radiation protection standards.

Table 2-3. IAEA Recommended Standards for Radiation Protection Limits and Constraints

Exposure Route	Exposure Group	IAEA Recommendations	
Exemption of ores from regulatory requirements	N/A	≤ 1000 Bq/kg	Uranium and/or Thorium (IAEA, 2004)
Total effective dose	Public	1 mSv/yr	0.5 mSv/y for sensitive members (e.g., children)
		5 mSv	in one year so long as the average over 5 years does not exceed 1 mSv/yr (IAEA, 1996)
Airborne Effluent – Uranium*	Public	3.5 x10^{-2} Bq/m^3	average in one year
		1.7 x10^{-1} Bq/m^3	average in one year if 5 year average does not exceed 3.5 x 10^{-2} Bq/m^3 (IAEA, 2004)
Radon Exposure	Public	600 Bq/m^3	radon in dwellings
		1000 Bq/m^3	radon in workplaces (IAEA, 1996)
Total Effective Dose	Workers	20 mSv/yr	average over 5 years
		50 mSv	in one year
		150 mSv	to the lens of the eye in one year (IAEA, 1996)
Occupational Exposure to Airborne Uranium	Workers	10.4 Bq/m^3	derived air concentration (DAC), average concentration for continuous workplace exposure, 2,000 hour work-year (IAEA, 2004)

Notes: Bq/kg indicates becquerel(s) per kilogram; a measure of radioactivity.
Bq/m^3 indicates becquerel(s) per cubic meter.
mSv indicates millisievert(s); a measure of radiation dose.
mSv/yr indicates millisievert(s) per year.

Source: IAEA, 1996 and IAEA, 2004

2.3.9 Jordanian Building Codes

In 1993, the Government of Jordan issued the Building Code Law No. 7 of 1993, which led to the creation of the Jordan Building Code Commission. The Commission, led by the Ministry of Public Works and Housing, was designated the responsibility of preparing building codes for the country. Since then, the Commission has published 32 building codes regarding the design and construction of buildings in Jordan. For any building design to obtain clearance in Jordan, it has to be approved by the Jordanian Engineers' Association, Civil Defense Directorate, and the Earthquake Commission. These agencies ensure that the design abides by these codes, many of which address environmental, health, and safety issues and are relevant to the building. They are as follows:

- Jordanian Code No. 3: Loads and Forces (Section 4: Earthquake Actions)
- Jordanian Code No. 15: Fire Protection
- Jordanian Code No. 16: Natural Ventilation

- Jordanian Code No. 17: Natural Lighting
- Jordanian Code No. 18: Water Supply for Buildings
- Jordanian Code No. 19: Wastewater for Buildings
- Jordanian Code No. 20: Beautification of the City
- Jordanian Code No. 21: Solid Waste
- Jordanian Code No. 22: Public Safety during Construction
- Jordanian Code No. 23: Electrical Installation
- Jordanian Code No. 27: Fire Alarm Systems
- Jordanian Code No. 32: Building Requirements for the Physically Challenged

2.3.10 Jordanian Code No. 22: Public Safety during Construction

The Code of Public Safety during Construction, Jordanian Code No. 22 of the *Building Code Law No. 7 of 1993*, describes the required measures to be taken in order to safeguard the work environment during construction works. This includes sanitation, toilet facilities, drinking water, medical services, protection from fires, lighting, ventilation, noise, gasses, electrical wiring, openings and edges, transporting workers, solid waste collection and disposal, and insects and harmful animals. For example, noise levels and exposure periods permitted for workers are set forth under this code.

3 INSTITUTIONAL FRAMEWORK

This chapter describes the applicable institutional framework in Jordan. Municipal administration is provided by Governorates and Municipalities. Governorates are the executive authority for the implementation of central government policies at the local level and are responsible to the Ministry of Interior for the provision of services outside the municipality areas and some regional planning. Municipalities are responsible to the Ministry of Municipal Affairs (MoMA) for municipal administration and land use planning.

3.1 Zarqa Chamber of Industry

The Zarqa Chamber of Industry serves around 6,000 industrialists from 10 sectors in Zarqa and Mafraq Governorates consisting of small and medium size enterprises (the City of Russeifah is located in the Zarqa Governorate). The chamber also sets trade standards and studies industrial issues.

3.2 Ministry of Environment (MoEnv)

The MoEnv is the main body responsible for environmental laws and regulations per the *Environment Protection Law No. 52 of 2006.* MoEnv is the entity accountable for protecting various environmental components across the Kingdom, in addition to being responsible for environmental compliance. It aims to improve the environment, conserve Jordan's natural resources, and achieve sustainable development.

MoEnv is the entity that would be responsible for reviewing EIA studies and granting the approval for the project, as well as being the entity ensuring and monitoring environmental compliance and protection of environmental components throughout the construction and operation of the project. Furthermore, MoEnv is the entity responsible for handling environmental complaints. The relevant MoEnv laws, regulations, and instructions to be complied with were discussed previously in Section 2.

3.3 Jordanian Natural Resources Authority (NRA)

In accordance with the provisions of the Natural Resources Affairs Law (No. 12 of 1968), the NRA is responsible for "prospecting, geological and economic studies needed for the natural resources, supervising technically the methods of mining, and exploiting such …." From a legal standpoint, the NRA is the responsible body for all that relates to mining. However, with regards to environmental issues, the NRA consults with the MoEnv.

3.4 Ministry of Water and Irrigation, including Water Authority of Jordan and Jordan Valley Authority

The MWI and its respective authorities — the WAJ and the Jordan Valley Authority — are specifically responsible for the protection of water resources. The main objective of the MWI is to maintain sustainable water resources with the purpose of achieving national water security and meeting the Ministry's development objectives.

The jurisdiction of the WAJ encompasses water and wastewater in Jordan, and the authority's objectives include protecting water resources from pollution and depletion, and protecting soils from degradation. The Jordan Valley Authority is responsible for the socioeconomic development of the Jordan Rift Valley, including water resource development and the distribution of irrigation.

3.5 Ministry of Health (MOH)

MOH is the entity accountable and responsible for public health and safety monitoring and control and assumes the responsibility for all health affairs across the Kingdom.

Of particular relevance to the project are the Occupational Health Directorate and the Environmental Health Directorate. The Occupational Health Directorate is responsible for

ensuring the safety of the work environment from pollutants and occupational hazards, in addition to the evaluation of the work environment. The Environmental Health Directorate is responsible for ensuring compliance with environmental health requirements and implementing the provisions of the Public Health Law through the relevant monitoring programs developed.

3.6 Ministry of Agriculture (MOA)

MOA is the entity responsible for regulating and permitting all agricultural activities in Jordan and has a particular mandate for regulating soil fertilizers and agricultural input material.

Part of MOA's role involves ensuring the sustainability of the agricultural use of natural resources without harming the environment, in addition to creating the suitable atmosphere for investment in the agricultural sector, as well as rural development and increasing the incomes of farmers and improving their lives.

3.7 Ministry of Municipal Affairs (MoMA)

MoMA's mandate includes a responsibility for public health and safety monitoring and control via the management and operation of solid waste collection and disposal. It carries out its duties through its implementing arms: the municipalities and the Joint Services Councils. For this project, the relevant municipality and implementing arm of MoMA would be Russeifah Municipality. Within its area of jurisdiction (which includes the project area), Russeifah Municipality is authorized to undertake the needed measures to prevent the occurrence of health nuisances.

3.8 Ministry of Labor

The Ministry of Labor is the entity responsible for ensuring occupational health and safety, as well as providing the indoor air quality requirements that need to be complied with.

3.9 The General Directorate of Jordan Civil Defense

The general directorate of Civil Defense in Russeifah is the entity to be contacted in the case of fires or accidents.

3.10 The Royal Society for the Conservation of Nature

The Royal Society for the Conservation of Nature is a non-profit, non-governmental organization that aims to conserve the Kingdom's natural resources.

3.11 International Atomic Energy Agency (IAEA)

The IAEA is an intergovernmental organization that is part of the United Nations. The organization develops nuclear safety standards and promotes safety in applications of nuclear energy as well as protection of human health and the enviroment from ionizing radiation.

3.12 Jordan Nuclear Regulatory Commission (JNRC)

The JNRC is the body responsible for radiation protection standards in Jordan and typically follows IAEA recommendations and standards.

3.13 International Commission on Radiological Protection (ICRP)

The ICRP is an international organization that has developed the International System of Radiological Protection, which is used as the basis for standards, legislation, and guidelines.

4 DESCRIPTION OF THE PROPOSED PROJECT

This chapter describes the project location, objectives, and recommended design alternative for the remediation of Russeifah Area 3.

4.1 Project Location

The City of Russeifah is located in the Zarqa Governorate, 15 kilometers northeast of Amman, in the middle of Jordan and north of the highway connecting Amman and Zarqa. The city is approximately 665 m above sea level, with an approximate latitude and longitude of 30.0167°N and 36.05°E. The general location can be seen in Figure 4-1.

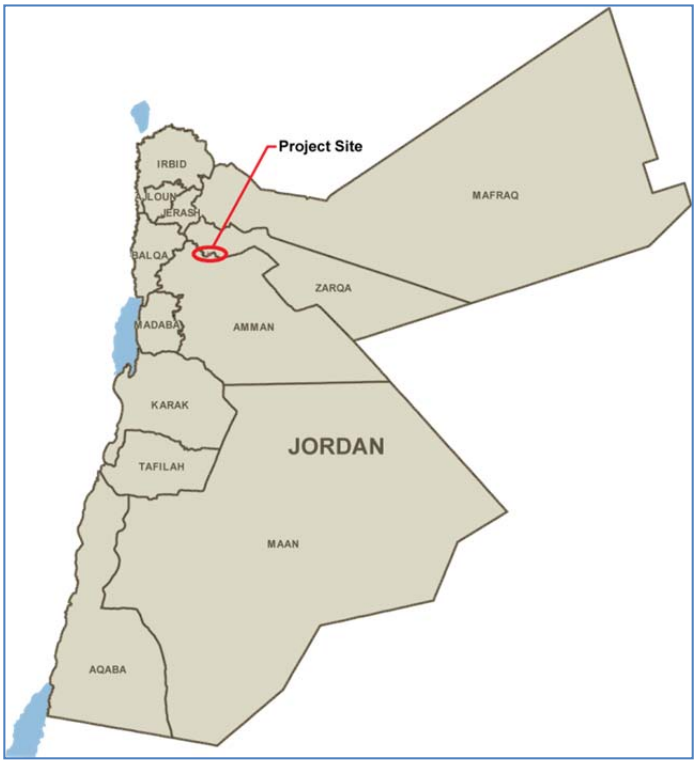


Figure 4-1. General Site Location

The phosphate mining area within Russeifah was one of the largest mining areas in Jordan. The Jordan Phosphate Mines Company (JPMC) was established in 1952 and was granted a concession area of approximately 13,478 donum (1,348 hectares). The southern part of the concession area, with an approximate area of 10,355 donum (1,036 hectares), falls within the border of the Greater Amman Municipality. The remaining 3,123 donum (312 hectares) are within the borders of Russeifah Municipality (RM). Of the total concession area, approximately 2,720 donum (272 hectares) have been abandoned and require rehabilitation and/or redevelopment (RSS, 1995); it is divided into the following six areas:

- Area 1: Russeifah landfill
- Area 2: Mining pit
- Area 3: Phosphate ore pile
- Area 4: Lagoon
- Area 5: Tunnels
- Area 6: Overburden piles

Each area is shown in Figure 4-2. The primary purpose of this report is to assess the social and environmental implications of the proposed remediation project for Area 3. The implications of the remediation projects proposed for Areas 1 and 2 are presented in a separate ECR.

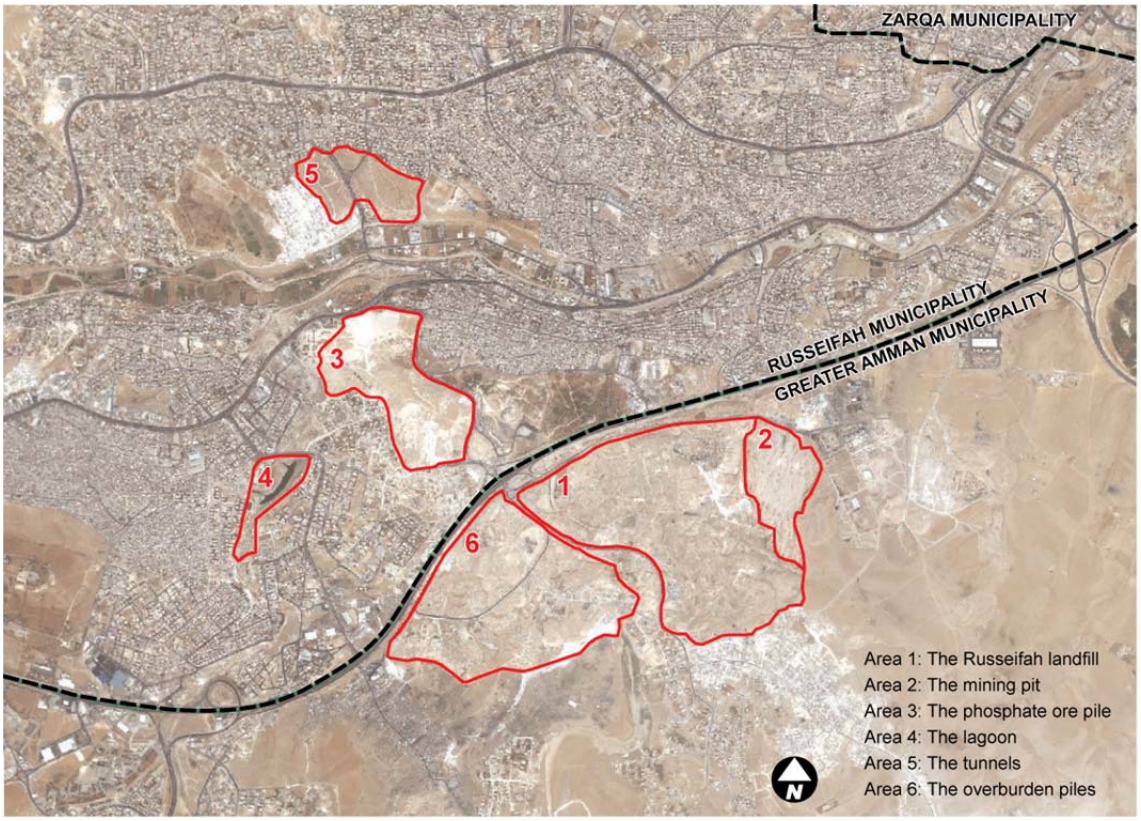


Figure 4-2. Russeifah Site Areas

4.2 Project Objectives

4.2.1 Site Issues

Field investigations conducted at Area 3 as part of the remediation feasibility and design efforts included a site topographic survey, field geotechnical investigation and slope stability analysis, and a radiation study. These investigations identified the following site issues to be addressed by the remedial design:

- Radiation exposure to site users
- Radiation exposure to nearby residences through inhalation of radioactive fugitive dusts
- Questionable physical stability of the pile due to steep and unstable side slopes
- The random nature of the site topography, which makes the area unsuitable for development

4.2.2 Design Objectives

In an attempt to address the aforementioned issues, the design objectives were set to encompass the following:

- Stabilize the slope of the pile to provide stability in both static and dynamic conditions
- Cover the pile material such that the risk of radiation exposure and dust migration to the immediate vicinity is reduced

4.3 Project Alternatives

The following three main remediation alternatives were analyzed:

- Remove the pile completely
- Sieve the pile on-site

- Leave the pile in place

These three alternatives are described below.

4.3.1 Complete Removal of Pile

Ideally, the land under the phosphate ore pile (Area 3) should be returned to its natural undisturbed state. To achieve this aggressive objective of complete pile removal, a tremendous amount of excavation and transportation would be required. Currently, there are two possible destinations to which the ore pile could be relocated. These destinations are the phosphate mines in Hassa, located in the south of the Kingdom, or the nearby Russeifah Area 2 mining pit. This pit area is currently being used by the Greater Amman Municipality as a construction and demolition debris landfill. A recent survey showed that the pit's remaining capacity is large enough to accept the majority of the phosphate ore pile located at Area 3. The remaining pit capacity was found to be more than 5.5 million cubic meters, whereas the total pile volume is approximately 4.5 million cubic meters.

The major limiting factor for removal of the phosphate pile is expected to be the road traffic capacity and cost of removal. To estimate the time needed for complete removal of the pile to the Area 2 mining pit location, it was assumed that the road capacity could on average accommodate an additional 25 trucks per hour. This means that the daily removal would be approximately 2,000 cubic meters per day. Therefore, the total time required to remove the pile is around 2,250 working days, or approximately 9 years. Even if it were feasible to increase the average to 50 trucks per hour, approximately 1,125 working days, or 4.5 years, would be required. Work could be done at night, but in all conditions, pile removal would create tremendous amounts of dust that, as concluded from the radiological study, would present a radiation exposure risk to the neighboring areas. Therefore, the alternative of completely removing the pile was eliminated.

4.3.2 On-site Sieving of the Pile

Onsite crushing and sieving of the pile would make it possible to extract the phosphate ore and use the remaining crushed aggregate for construction projects. This alternative is also expected to generate tremendous amounts of dust and, thus, has potentially serious environmental ramifications. Dust control for this type of activity requires large amounts of water, which are not readily available at the site. Also, the generated aggregate should be carefully controlled because of its radioactive nature, and it should not be used for house construction.

This remediation alternative is nonetheless an option for the phosphate company, if they decide they wish to use the ore. The JPMC would be given the opportunity to use the phosphate ore in the pile but must adhere to strict environmental dust control conditions. JPMC would be required to prepare a technical study for the rehabilitation of the phosphate piles and present it to MoEnv for approval. If JPMC does not agree to conduct the effort according to the environmental provisions set out by the MoEnv concerning dust control and environment management during project implementation, MoEnv has the right to decide on the fate of the pile.

If the JPMC does not conduct the environmentally safe removal of the pile, then the pile would need to stay where it is, but it should be remediated as discussed in the following section.

4.3.3 Pile to Remain in its Location

Leaving the pile in place would require that the following components be considered, at a minimum:

- Re-shaping quantities and final design (cut and fill)

- Slope stabilization
- Stormwater management
- Soil cover to protect from the naturally occurring radiation

Two stabilization alternatives were studied:

- Stabilization by grouted riprap (loose stones or rubble held together by a mortar or paste)
- Stabilization via geo-grid (a synthetic material used to reinforce soils and similar materials)

The grouted riprap alternative is the lowest cost alternative and achieves the same benefits as the geo-grid alternative. Therefore, it was determined to be the recommended alternative.

4.4 Project Components

The recommended remediation strategy focuses on reducing the risk of dust inhalation and direct exposure to radiation, while providing the geotechnical stability and radiological safety of the site for future development. As such, the following design components were considered based on the results of the field investigations and studies conducted for the project:

- Pile reshaping and slope stabilization
- Radiation and dust control
- Stormwater management and drainage

The remediation strategy would involve grading the side slopes of the main stockpile to 2:1 grades (2 units horizontal change to 1 unit vertical change) and the addition of a grouted riprap cover for slope stabilization and to eliminate the risk of fugitive dust inhalation. The top of the pile would then be flattened and covered with one of two engineered covers designed to serve as a radiological buffer and a foundation for both hardscape and landscape development activities. Terraces of 3 meter width would be created at every 10 meters of elevation and, like the top face of the flattened pile, be covered with the same materials to achieve radiological protection.

Side ditches and chutes would be integrated into the side slope cover with the purpose of effectively managing stormwater and surface runoff. The stormwater management component of the remedial design is of critical importance to protect the engineered cover from erosive forces and provide performance integrity over time.

A modeling exercise was carried out in order to test the long-term effectiveness of the proposed remedial design with respect to reducing onsite and offsite exposure to radiation. The modeling methods and results are discussed in Section 5.8.

4.4.1 Slope Stability

As evident from the results of the topographic survey and geotechnical investigation, the side slopes of the phosphate pile are irregular and highly unstable. Therefore, the current state of the pile makes it unsuitable for development and calls for regrading to help stabilize the pile slopes, requisite to site remediation and rehabilitation. Detailed geotechnical investigations and modeling exercises were carried out to verify the long-term stability of the pile with slopes graded to 2:1 grades.

Furthermore, the addition of grouted riprap as a cover material for the side slopes (and the required addition of terraces and further grading) contributes significantly to enhancements in the stability of the stockpile. The use of riprap for slope stabilization of fine textured, non-cohesive soil slopes is common practice (e.g., Maine Department of Environmental

Protection, 2003) and is expected to be effective in the context of Russeifah Area 3 due to the physical and textural similarities between the pile contents and the soil types in typical riprap applications.

4.4.2 Radiation and Dust Control

The radiological assessment issued in May 2013 concluded that the average concentrations of uranium 238 in the ore are high enough to warrant regulatory controls based on criteria established by the IAEA (> 1000 Bq/kg) (IAEA, 2004).

The radiological assessment indicated that the greatest radiological hazard results from the suspension of airborne particulates (and to a lesser extent, direct exposure and radon emanation resulting from the uranium decay chain). According to air modeling results, several local sub-areas may be exposed to radiation doses higher than the IAEA recommended long-term exposure doses (IAEA, 1996). Therefore, dust control at the pile site is deemed essential to protect nearby residents.

A notable radiological component of Russeifah Area 3 is the release of radon gas. Radon is a naturally-occurring radioactive gas associated with the uranium decay chain (United States Environmental Protection Agency, 2013). Furthermore, radon is known to be a heavy gas and subsequently tends to accumulate in low-lying areas. Despite the fact that the majority of the measured radon emanation rates at various locations at the Area 3 site, and all of the averages for the identified subareas were below United States Environmental Protection Agency recommended guidelines for remediation planning (0.74 Bq/m2-s), that agency states that even the slightest exposure to radon is associated with damage to sensitive lung tissue and an increased risk of cancer (United States Environmental Protection Agency, 2013).

With that in mind, the radiological component of the remedial design (schematically summarized in Figure 4-3) focused on:

- Preventing the suspension of dust particles (brought about by erosion)
- Attenuating the release of radon gas
- Providing sufficient shielding from direct exposure to gamma radiation
- Developing post-remedial site development recommendations aimed at minimizing prolonged direct exposure and sustaining the effectiveness of the engineered design

4.4.3 Stormwater Management System

Drainage systems are designed to protect the site from runoff generated from external catchments and urban development both within and surrounding the site boundaries.
The project site is a synthetic hill where the runoff of the surrounding drainage basins flows in away from the project area. Furthermore, the low permeability of the riprap and clay covers is expected to produce significant volumes of runoff during rainfall events. In order to reduce the potential of flooding and extreme runoff, drainage system components were integrated into the stockpile cover. Based on these catchments, the stormwater management system was designed to intercept and convey the generated runoff away from the stockpile, ultimately discharging to two evaporation ponds.

The engineered stormwater management system consists of a combination of pipe culverts, riprap protected variable-depth ditches, and concrete chutes with plunge pools that have been integrated into the cover design and ultimately drain to two evaporation ponds, located at the low elevation points of the site.

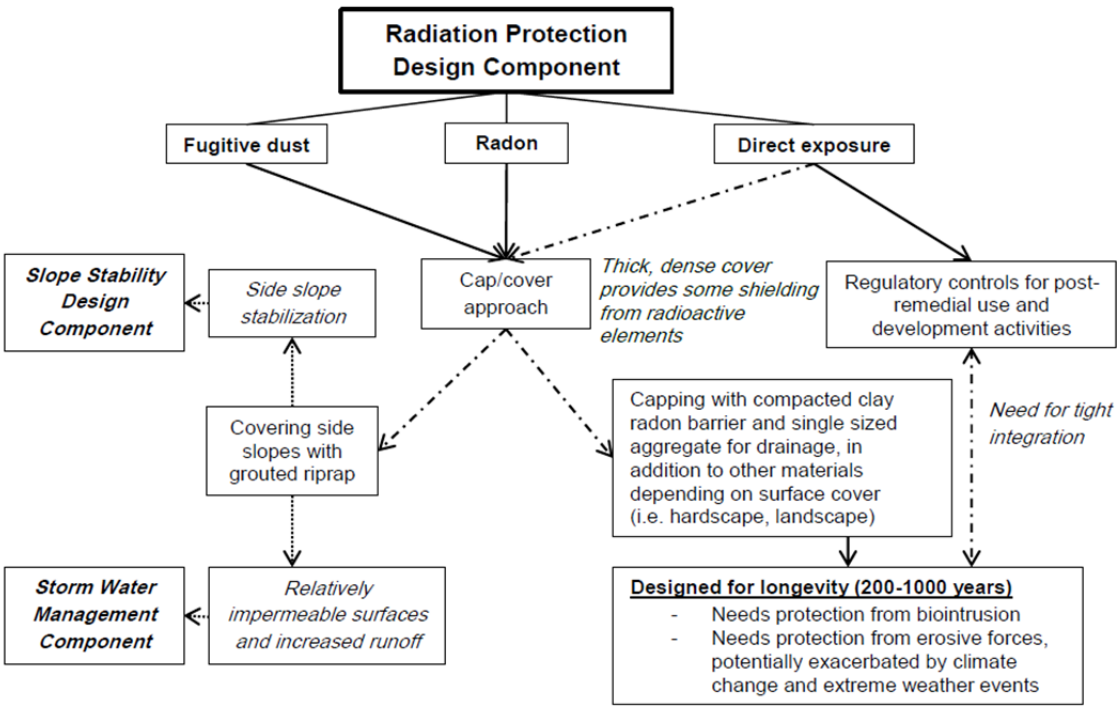


Figure 4-3. System design approach addressing radiological components of Russeifah Area 3

5 DESCRIPTION OF THE STUDY AREA

This chapter details the existing environmental conditions for the project area.

5.1 Climate

The climate of Jordan in general is of East Mediterranean type, characterized by warm, dry summers and mild, wet winters. Since 2003, annual average temperatures at the Amman Airport (meteorological station near the study area) have ranged from 8.9 to 27.1 degrees Celsius (°C), peaking in the month of August. Annual rainfall varies widely throughout the year within the Amman area; with precipitation occurring during the winter months (October to May), while the summer months are essentially dry. The average annual precipitation is about 236.5 millimeters per year, and the area is classified as an arid region (USAID, December 2014). The prevailing wind direction at Amman Airport is westerly and the majority of the winds are within +/- 22.5 degrees (USAID, May 2013).

Available climate measurements recorded between 2003 and 2013 at the Amman Airport meteorological station were averaged and are presented in Table 5-1. Daily precipitation values from 2003 to 2013 were analyzed to calculate the mean monthly precipitation, shown in Figure 5-1 (USAID, December 2014).

5.2 Geology

The project site (Area 3) is completely covered by artificial fill material composed of old excavated phosphate mine waste products, with approximate thicknesses ranging from 1 to 40 meters. According to the available geological maps of the project area, at a scale of 1:50,000, the geological formations at the project area belong to the Late Cretaceous Ajlun and Balqa groups (AZ ZARQA sheet no. 3254-III, NRA, 2001). Quaternary Pleistocene and Holocene sediments also cover part of the project area. A general geological map of the project site is shown in Figure 5-2.

The sequence of the exposed geological formations in the area is characterized by the following formations:

- Alluvial Deposits
- Amman Silicified Limestone Formation (ASL) and Al-Hisa Phosphorite Formation (AHS)
- Wadi Umm Ghudran Formation (WG)
- Wadi As Sir Limestone Formation (WSL)

These formations are described in more detail below.

5.2.1 Alluvial Deposits

The superficial deposits comprise alluvial (wadi) sediments. The thicknesses, distribution, physical, chemical, and mineralogical properties of the superficial deposits depend mainly on the type of the parent material, time, climate, and topography.

The soil deposits are formed by the dissolution of Cretaceous bedrock and consist of three parts: upper, middle, and lower. The upper part of the soil is dark to grayish brown, soft to stiff silty clay, containing gravel, cobbles, and boulders of chert and silicified limestone. The middle part of the soil is brown, soft to firm silt. The lower layer is reddish brown, soft to firm silty clay, containing angular gravel, cobbles, and boulders of chert.

Table 5-1. Average data from Amman Airport Meteorological Station: E 35 59', N 31 59', Elevation= 780 m (2003-2013)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean Air Temperature (ºC)	8.9	9.9	13.1	17.4	21.9	25.3	27.0	27.1	24.8	21.5	15.4	10.4	18.6
Mean Maximum Air Temperature (ºC)	13.2	14.4	18.4	23.4	28.3	31.4	32.9	33.1	30.9	27.3	20.7	15.1	24.1
Mean Minimum Air Temperature (ºC)	4.5	5.4	7.8	11.3	15.4	19.1	21.2	21.1	18.7	15.6	10.1	5.7	13.0
Total Rainfall (millimeters)	62.8	73.5	25.4	10.7	2.1	0.0	0.0	0.0	0.1	4.0	18.5	39.4	236.5
Mean Relative Humidity (%)	69.0	69.1	59.2	49.1	40.5	38.4	40.4	43.7	49.9	51.9	57.1	63.4	52.6
Mean Wind Speed (Knot)	4.8	5.7	5.5	5.8	5.9	6.3	6.7	5.6	4.6	3.5	3.1	3.9	5.1
Total Evaporation, Class "A" Pan (mm)	52.7	63.9	110.6	166.5	245.5	301.3	326.1	289.4	224.3	159.4	87.7	59.8	173.9

Source: Amman Airport Meteorological Station (2003-2013)

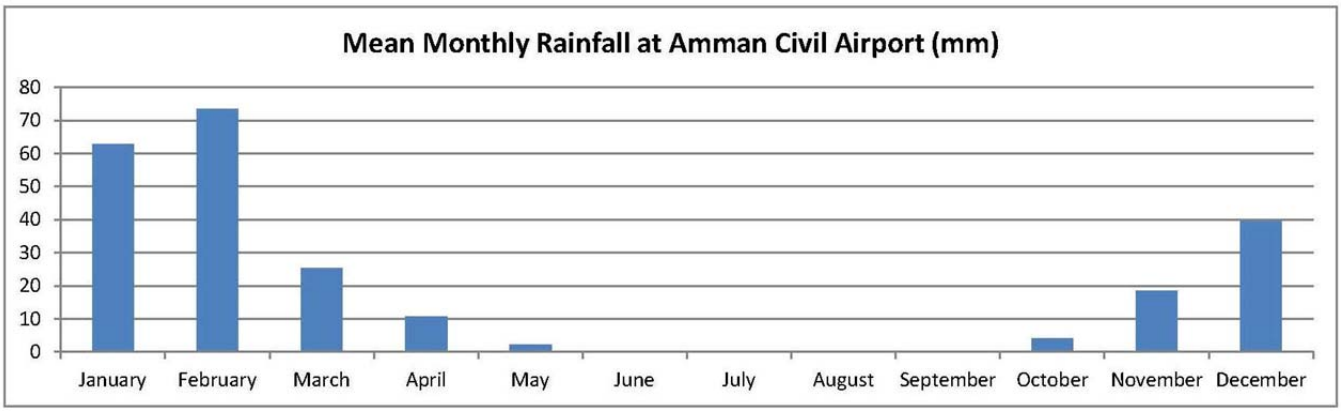


Figure 5-1. Mean monthly precipitation in the study area (2003-2013)

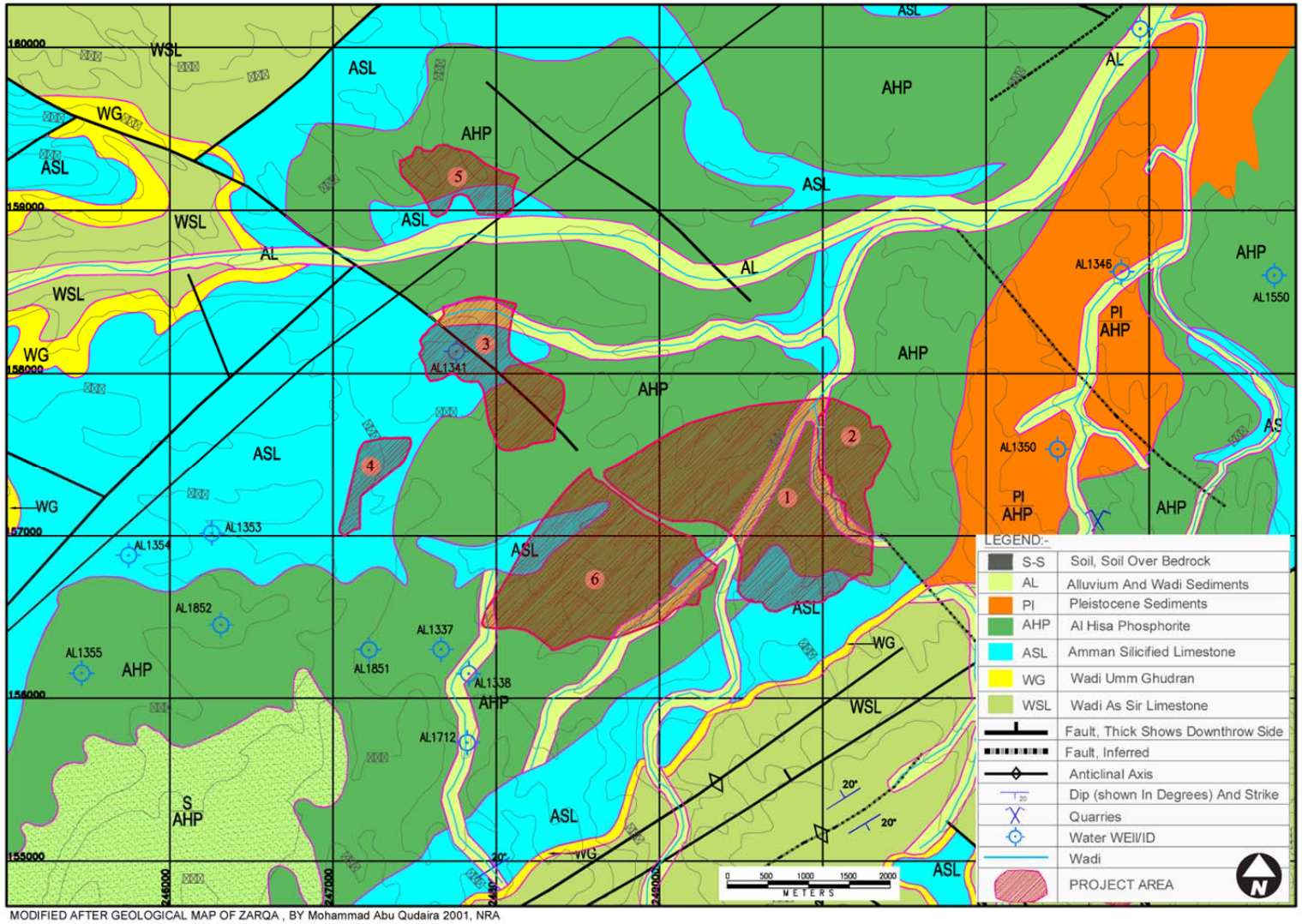


Figure 5-2. General Geological Map of the Project Area

5.2.2 Amman Silicified Limestone Formation and Al-Hisa Phosphorite Formation

These formations consist of gray to brown, thin to medium bedded chert, exhibiting a variety of textures ranging from homogenous to brecciated and inter-bedded with limestone, dolomite limestone, marl, silicified chert, and phosphate. The thickness of the Amman Silicified Limestone Formation reaches up to 40 meters, while that of the exposed part of the Al-Hisa Phosphorite Formation reaches up to 20 meters. The Amman Silicified Limestone Formation is characterized by sedimentary undulations, which were caused by tectonic processes simultaneously with sedimentation. The decrease in chert content and increase in trace fossils, including fossils of bivalves, gastropods, and ammonites, characterize the Al-Hisa Phosphorite Formation. These two formations were deposited in subtidal to shallow shelf environment.

5.2.3 Wadi Umm Ghudran Formation

This formation is named after Wadi Umm Ghudran Ed Dib located southeast of Irbid. The Wadi Umm Ghudran Formation consists of an upper and a lower part. The lower part consists of thinly bedded, yellow to white grey locally pink grey, soft, massive chalky limestone; whereas, the upper part consists of limestone and chalky marl that is typically pink to yellow grey, hard, medium to thin bedded, fossil-ferrous to coquinal limestone, with thin bands or concretions of chert alternating with yellow to white grey chalky marl. This formation forms distinctive yellow to white grey gentle slopes between the underlying Wadi As Sir Limestone Formation and the overlying Amman Silicified Limestone Formation.

5.2.4 Wadi As Sir Limestone Formation

This formation is named after Wadi As Sir town located west of Amman. It consists of three units: lower, middle, and upper. The lower unit is comprised of dolomite, dolomitic limestone, and locally recrystallized limestone. The bed of the lower unit is characterized by its red color, which is due to the presence of secondary iron oxides. The middle unit of this formation consists of relatively soft marly limestone and limestone. The upper unit consists of thick bedded to massive limestone including fossil-ferrous beds. Wadi As Sir formation is rich in calcite veins and thin beds of oysters. This formation forms steep slopes and cliffs of limestone of grey-weathering colors intercalated with marly limestone and marl (USAID, March 2014).

5.3 Topography

A topographic survey was performed in October 2011, as presented in the *Russeifah Site (Area 3) Remediation Pre-Feasibility Study* (USAID, December 2011) (Figure 5-3). The survey data was used to design new site grading plans and to estimate the total volume of earth work needed. The total area that the site covers is approximately 35 hectares and the site contains approximately 4,500,000 cubic meters of ore material (USAID, December 2011).

5.4 Soils

The underlying soil deposits in the vicinity of the general site area are formed by the dissolution of Cretaceous bedrock and consist of three parts: upper, middle, and lower. The upper part of the native soil is dark to grayish brown, soft to stiff silty clay and contains gravel, cobbles, and boulders of chert and silicified limestone. The middle part of the soil is brown, soft to firm silt. The lower layer is reddish brown, soft to firm silty clay, containing angular gravel, cobbles and boulders of chert. However, the majority of the site is covered by the low-grade radioactive phosphate ore from past mining operations (USAID, March 2014).

Figure 5-3. Russeifah Area 3 Existing Contour Layout

5.5 Surface Water

The Zarqa River is located to the north of Area 3. The river generally flows to the north before heading west and finally discharges into the Jordan River at an elevation of 1,090 meters lower than its origin. The river's summer base flow is approximately 2 to 3 million cubic meters per month and rises to 5 to 8 million cubic meters per month during the winter. The total basin area of the river is 3,900 square kilometers and is the largest in Jordan (Figure 5-4).

Within the Russeifah Phosphate mining area, the Zarqa River lies to the north of the phosphate ore pile. The river is dry most of the year, but when it flows the major direct water uses are crop and grazing land irrigation, in addition to livestock watering (USAID, March 2014). No wadis pass through Area 3 (USAID, December 2014).

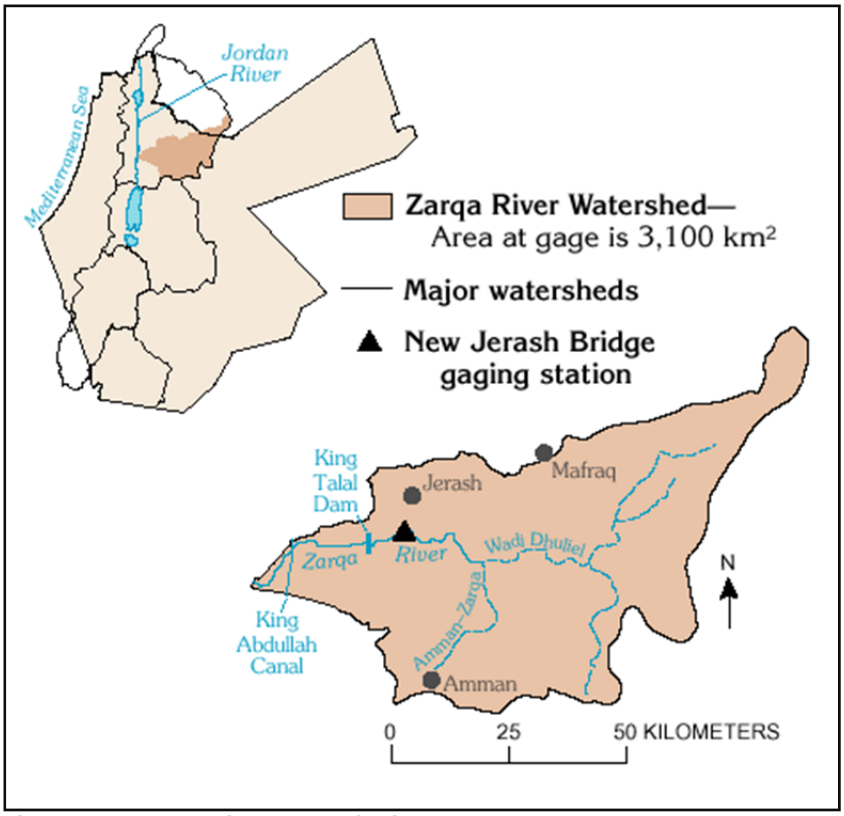


Figure 5-4. Zarqa River Watershed
(Adopted from Executive Action Team (EXACT), Multilateral Working Group on Water Resources)

5.6 Groundwater

5.6.1 Hydrogeology of Jordan

The groundwater aquifers in Jordan are classified into three main categories: the deep aquifer complexes, middle aquifer complexes, and shallow aquifer complexes. The latter is considered the most exploited (MoEnv, March 2006). In Jordan, a total of 12 groundwater basins were identified, based on the configuration of renewable groundwater divides. Figure 5-5 shows these groundwater basins. The arrows represent the direction of flow of the main renewable groundwater in the upper aquifer system (USAID, March 2014).

Within the 12 identified groundwater basins, only the southern aquifer in the Disi area is considered nonrenewable, while the remaining 11 are considered renewable aquifers. A groundwater resource is termed nonrenewable if the present-day aquifer replenishment is

very limited, but aquifer storage is very large (Foster and Loucks, 2006). According to the 2006 National Water Master Plan of Jordan (as cited in USAID, March 2014), the primary over-exploited aquifers include Amman-Zarqa, Yarmouk, Dead Sea, Jordan Valley, Jafr, and Azraq Basins.

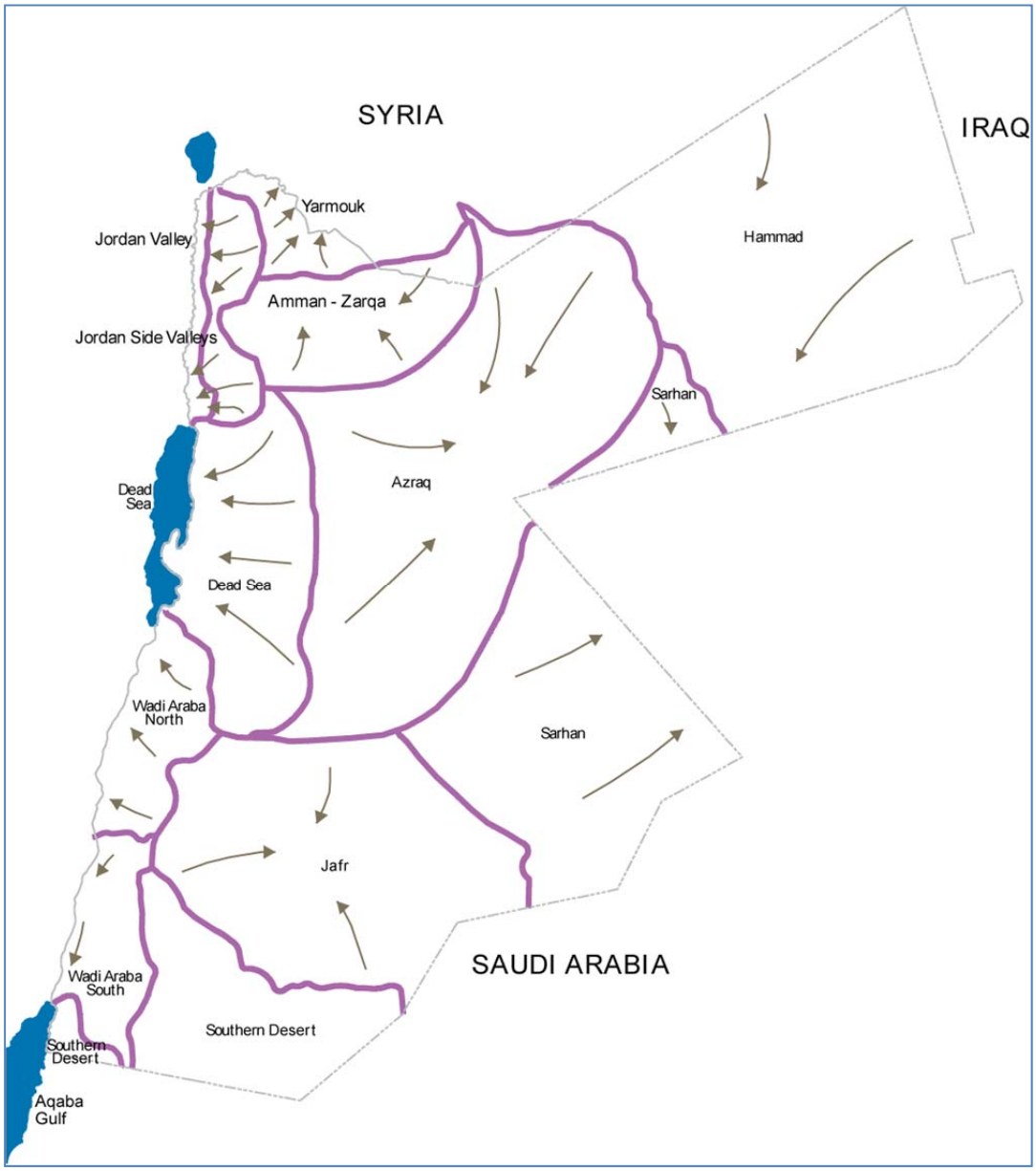


Figure 5-5. Groundwater Basins in Jordan

5.6.2 Hydrogeology of the Study Area

The project area falls within the Amman-Zarqa Groundwater Basin. The basin is considered one of the most renewable groundwater basins in Jordan. Its extent is large and continuous, with a relatively high permeability. The two main aquifers in the Amman-Zarqa Basin are the Amman/Wadi Sir Formation (B2/A7), known as the Upper Aquifer, and the Hummar Formation (A4) to the west of Amman, known as the Lower Aquifer. Figure 5-6 and Table 5-2 summarize the geological and hydrological classifications of rock units in the Amman-Zarqa area.

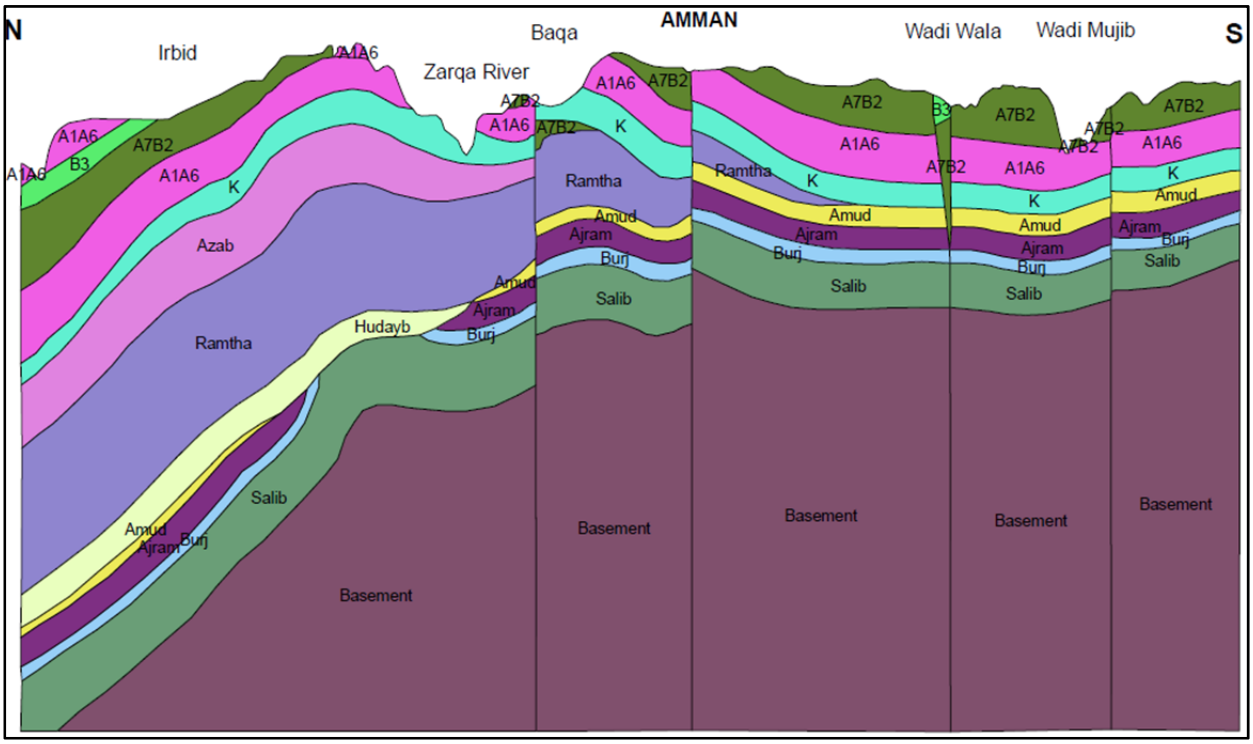


Figure 5-6. Geological Cross Section Covering Amman–Zarqa Area
(Adapted from WAJ and Millennium Challenge Corporation, 2010)

Table 5-2. Geological and Hydrogeological Classification of the Rock Units in Amman-Zarqa Area

Epoch	Age	Group	Formation	Symbol	Rock Type	Thickness (meters)	Aquifer Potentiality	Permeability (meters per second)
Upper Cretaceous	Holocene	Balqa	Alluvium	Qal	Soil, sand and gravel	10-40	Good	2.4×10^{-7}
	Pleistocene		Basalt	V	Basalt	0-50	Good	-
	Mastrichtain		Muwaqqar	B3	Chalk, marl and chalky limestone	60-70	Poor	-
	Campanian		Amman	B2	Chert, limestone with phosphate	80-120	Excellent	10^{-5} to 3×10^{-4}
	Santonian		Um Ghudran	B1	Chalk, marl and marly limestone	15-20	Poor	-
	Turonian	Ajlun	Wadi As Sir	A7	Hard crystalline limestone. dolomitic and some chert	90-110	Excellent	1×10^{-7} to 1×10^{-4}
	Cenomanian		Shueib	A5-6	Light grey limestone interbedded with marls and Marly limestone	75-100	Fair to poor	6.3×10^{-5} to 7.2×10^{-4}
			Hummar	A4	Hard dense limestone and dolomitic limestone	40-60	Good	8.1×10^{-7} to 7.6×10^{-4}
			Fuheis	A3	Gary and olive green soft marl. Marly limestone and limestone	60-80	Poor	5.3×10^{-7} to 1.7×10^{-5}
			Na'ur	A1-2	Limestone interbedded with a thick sequence of marl and marly limestone	150-220	Poor	2×10^{-8} to 3.1×10^{-5}
Lower cretaceous	Albian–Aptian		Kurnub	K	Massive white and multicolored sandstone with layers of reddish silt and shale	300	Good	6.9×10^{-3} to 5.2×10^{-2}

Source: El-Naqa et al, 2006, as cited in USAID, December 2011

Recharge of the B2/A7 aquifer occurs in the western highlands. Its main outcrop areas generally coincide with the area of high precipitation, which is the main recharge source for the aquifer. Rainfall reaches 400 millimeters per year to the west of Amman, whereas it rarely exceeds 150 millimeters per year in the study area. The regional groundwater flow in the B2/A7 is influenced by the recharge/discharge areas, the topography, and the structural characteristics in the region. A main recharge mound exists a few kilometers to the west of Amman and on the southwestern side of the project area. A portion of the groundwater flows towards the west and increases the discharge level of the springs in the Wadi Sir area. The remainder of the groundwater flows northeastward down the Amman-Zarqa syncline, recharging the upper aquifer and/or flowing further to the east, as illustrated in Figure 5-7.

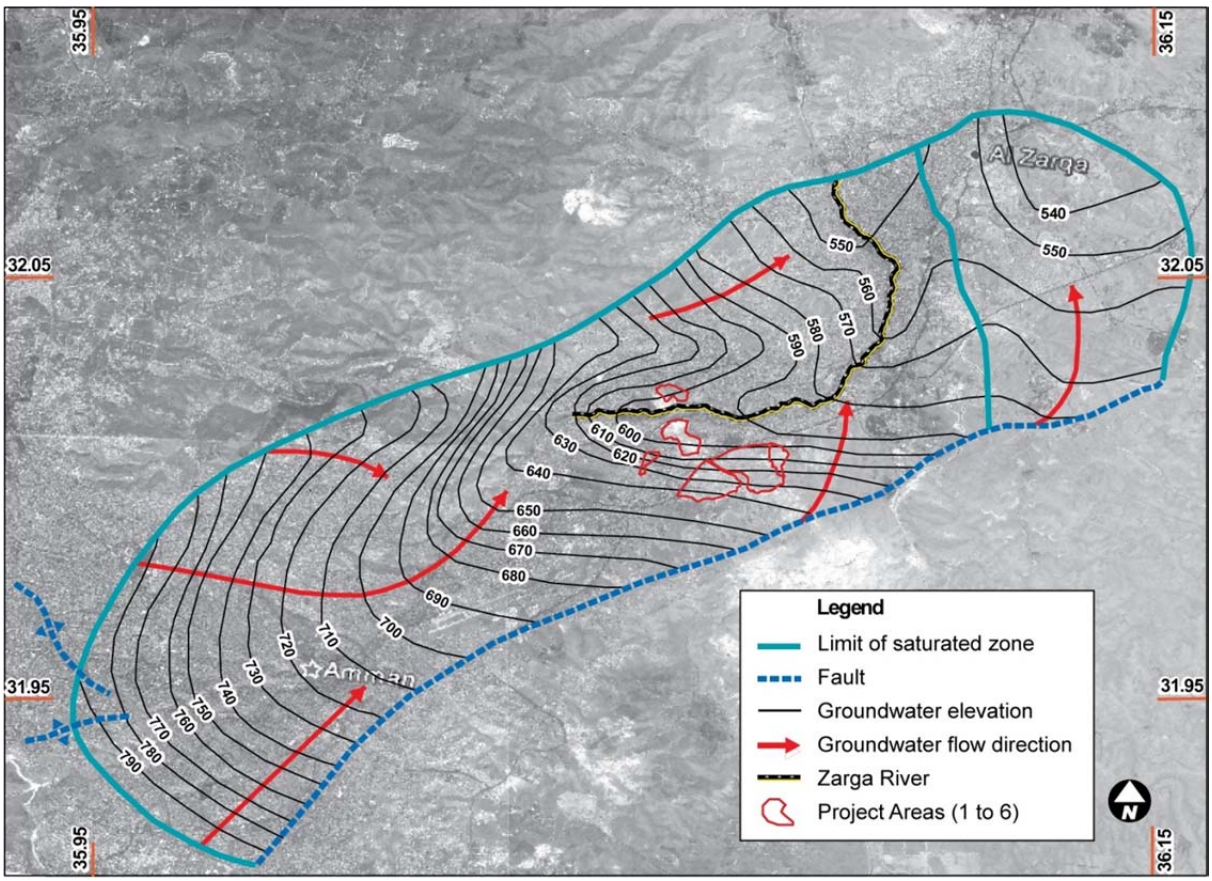


Figure 5-7. Regional Groundwater Contour Map of the (B2/A7) Aquifer (Kuisi, 1992)

The Amman-Zarqa Basin includes the fastest growing region in Jordan, in terms of both industry and population. Groundwater is the primary water supply source in the basin. The 2006 National Water Master Plan estimated the safe yield of the basin to be in the range of 60 to 70 million cubic meters per year. This calculation was based on the estimated recharge and base flow depletion, as summarized in Table 5-3.

Groundwater well extraction reached its peak in the year 1996, at approximately 161 million cubic meters per year. It decreased by 15 percent in year 2001 to 138 million cubic meters per year. This extraction rate is twice as high as the safe yield (2006 National Water Master Plan, as cited in USAID, March 2014). As a result, the MWI has developed a stepped reduction strategy for groundwater extraction in order to reach the safe yield by the year 2020.

Table 5-3. Calculation of Safe Yield for Amman-Zarqa Groundwater Basin

Item	Volume (million cubic meters per year)
Recharge from Rainfall	72
Inflow from Syria	+30
Base flow	−40
Estimated safe yield	=62
Range of safe yield	60 to 70

Source: 2006 National Water Master Plan, as cited in USAID, March 2014

Using pump test data obtained from the MWI databank (El-Naqa et al., 2006), the hydraulic parameters of some groundwater wells near the Russeifah landfill were calculated. The locations of the groundwater wells near the Russeifah landfill are shown in Figure 5-8, and the results are shown in Table 5-4.

The transmissivity value of the B2/A7 aquifer system ranges from 33.9 to 409 square meters per day. Hydraulic conductivity ranges from 0.38 to 5.18 meters per day. The hydraulic gradient of the area, calculated based on difference in head of three groundwater monitoring wells inside the landfill, is approximately 2.0 x 10^{-3}. Assuming an aquifer porosity of 0.35, the groundwater velocity was calculated (based on estimated hydraulic conductivity and hydraulic gradient) at 0.029 meters per day.

The static water levels recorded in 2006 at various groundwater wells near the Russeifah landfill site ranged between 30 and 60 meters. Recent static water level data ranging from 30 to 50 meters was obtained from the WAJ for the Amman-Zarqa basin (USAID, March 2014).

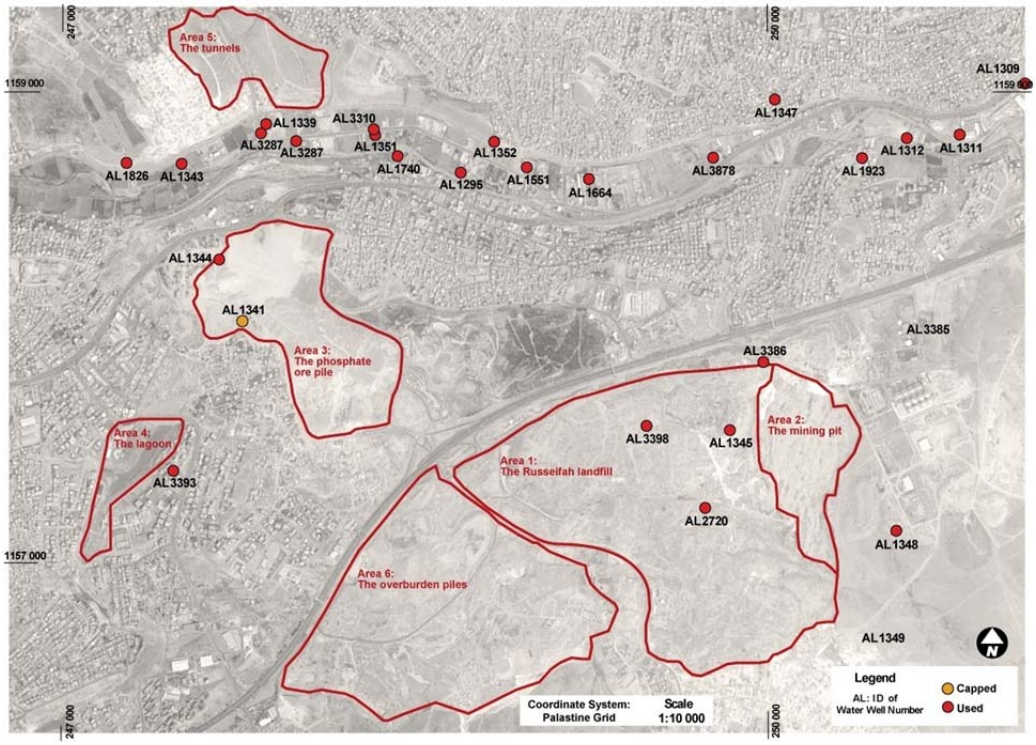


Figure 5-8. Location of Water Wells – Russeifah Mine and Landfill

Table 5-4. Hydraulic Parameters of Selected Groundwater Wells in the Study Area

Code	Name	Surface Water Level (meters)	Drawdown (meters)	Specific Capacity (cubic meters per hour per meter)	Groundwater Level (meters)	Yield (cubic meters per hour)	Transmissivity (square meters per day)	Hydraulic Conductivity (meters per day)
AL1295	Ain El-Russeifah	NA	NA	NA	NA	NA	NA	NA
AL1345	Phosphate No. 7	42.6	4.6	16.96	595.4	78	247	2.47
AL1346	Phosphate No. 8	46	4.1	14.63	573.0	66		
AL1350	Phosphate No. 10	14.8	40	NA	644.2	NA	33.9	0.38
AL1352	Russeifah Municipality	24	4.0	31.5	598	NA	NA	NA
AL2720	Waste Disposal	29.6	1.63	40.5	590.4	NA	409	5.18
AL3287	Russeifah Deep	96.3	101.2	0.86	503.7	NA	NA	NA
AL1551	Russeifah Municipality	20.9	0.84	142.86	-	120	247	NA
A 105	-	NA	NA	NA	574	NA	1673.2	53.12
A 73	-	NA	NA	NA	598	NA	2.88	0.21
A 83	-	NA	NA	NA	585	NA	NA	NA
AL3385	Russeifah Landfill monitoring well No.2	62.9	NA	NA	592.1	NA	NA	NA
AL3386	Russeifah Monitoring well No.3	31.1	NA	NA	623.9	NA	NA	NA

Source: El-Naqa et al, 2006, as cited in USAID, December 2011

5.7 Air Quality

The MoEnv has established 12 air monitoring stations in the Amman, Zarqa, and Irbid governorates to monitor air quality and measure concentrations of gas and dust emissions (The Jordan Times, 2012). An air monitoring station was established approximately 20 kilometers south of the project area at Sahab and was operated for two years. An additional MoEnv air monitoring station is located near the Jordan Petroleum Refinery Company facility in Al Hashimiyah, northeast of the project area.

Fugitive dust from the phosphate ore stockpile and other nearby sources of dust contribute to diminished air quality in the vicinity of the project site. Some of this dust is radioactive, and radon has also been linked to ore material in the project area (see Section 5.8) (USAID, April 2015; USAID, 2012). Emissions from vehicles on the nearby Amman-Zarqa highway and secondary roads, and from vehicle movements in Area 3 also contribute to diminished air quality in the project vicinity.

5.8 Radiological

One of the prominent issues at the site is radiation concerns. A radiological field assessment was carried out to provide an initial determination of the range of radiological risks from TENORM contained in the phosphate ore stockpiles and wastes present throughout Russeifah Area 3. Modeling was performed to gauge the TENORM exposure of workers during construction and the post-remedial conditions at the site.

This section presents key points of interest pertaining to the radiological assessment; the report for existing conditions, as well as the report for post-remedial conditions, is an appendix to the *Russeifah Phosphate Pile (Area 3) Site Remediation Design Report* (USAID, December 2014). The construction-phase and operation-phase radiological impacts are presented in Sections 6.1.5 and 6.2.5, respectively. However, for clarity, the radiological assessment activities, methods, and results that enable characterization of existing conditions for Area 3, and the anticipated conditions during construction and operation are all described here, in Section 5.8.

The radiological measurement and related modeling assessments for this project evaluated the separate contributions to radiological exposure of workers and nearby residents contributed by:

- maximum rates of direct radiation from surfaces
- inadvertent ingestion of contaminated soils
- predicted inhalation of fugitive airborne dusts from the Russeifah site

The scope of the radiological assessment included the following activities:

An external radiation survey at 151 locations to assess the total external dose rates present throughout the site, including natural local background levels.

A gamma walkover survey to map the relative external radiation exposure contributions from TENORM surface soil concentrations present throughout the site. Static one minute counts were obtained at soil and ore sample locations to estimate the calculated underlying uranium concentrations.

Soil sampling and analysis at 27 locations to:
- Correlate the survey instrument response to surface radioactivity levels

- Characterize the radionuclide concentrations and properties of the materials found on the site, including the stockpiles and any surrounding contamination

Environmental air sampling, using high volume air samplers to assess airborne concentrations of re-suspended TENORM. Air samples were taken at the site boundary and in the vicinity of simulated construction activities (excavation, loading). Five ambient samples were collected during a normal pre-operation day and another five were collected over two days of simulated construction activities, to support a preliminary assessment of current vs. potential compliance with public and occupational airborne concentration limits**.**

Personal air sampling (using lapel samplers) to measure breathing zone airborne TENORM exposure to workers during construction activities simulated at an Ore Loading Operations area.

Radon sampling using 150 canisters to characterize radon emanation rates present in the different previous use areas.

Air modeling of potential worst case exposures from fugitive dusts was performed using a short-term air transport simulation model (SCREEN3) to compare with field measurements and to support estimation of maximum annual average airborne exposures to workers and visitors. A more refined long-term simulation model (AERMOD) was used to predict the maximum annual fugitive dust exposures to nearby neighborhood residents. (Estimates for long-term exposures to any workers having long-term assignments at the site are also more accurately estimated by this more refined modeling method.)

Radiological dose and related risk assessment (screening analysis) of likely exposure scenarios in the vicinity of the study area.

5.8.1 Methods

In order to obtain representative data during surveying and sampling, Area 3 was evaluated as four separate areas, based on the different conditions found in each. The four areas are as follows:

- **Ore Stockpile Area**: This area consists of the stockpiled, unprocessed ore material. The area appears to be composed of one large pile of ore with an approximate area of 166,000 square meters and a height of approximately 25 to 40 meters above the surrounding grade. The stockpiled ore material ranges in size from fine materials (dirt or dust), to gravel (1- to 2-centimeter diameter), to larger rocks (approximately 30- to 50-centimeter diameter).
- **Fine Aggregate Processing Area**: This area consists of piles of processed ore material. The ore material appears to have resulted from mechanical grinding of ore, resulting in the fine, dust-like ore aggregate stockpiled in this area. The fine aggregate is stockpiled in multiple mounds ranging in height from 1 to 3 meters. The total area encompassing the fine aggregate piles is approximately 11,000 square meters.
- **Park Area**: The Park Area is approximately 65,000 square meters of compacted ore material. The area is relatively flat and level with the adjacent King Abdallah I road. The eastern portion of the park contains a football field. A small area (approximately 2,000 square meters) adjacent to King Abdallah I road is covered with a 2- to 4-centimeter thick layer of dark soil.

- **Background Area**: The background area for external exposure measurements was a field area approximately 1 kilometer east of the site. (The refined air transport modeling reported below suggests that this area may still receive some inhalation dose contributions from airborne fugitive dusts when the mining site is upwind).

Survey, sampling, and modeling results were then used in a dose modeling (screening) exercise to identify receptors and assess exposures from the ore stockpiles and process materials at the site. The following receptor groups were studied:

- **Outdoor Worker.** This long-term receptor is a full-time employee of the site owner. This receptor spends most of the workday outdoors conducting various activities. For this assessment, the outdoor worker is not primarily involved with construction activities (e.g., excavation/loading of ore material). This receptor is exposed to surface and shallow subsurface soils. This receptor is exposed via incidental ingestion of soil, inhalation of fugitive dusts, and external exposure to contaminant radiation emissions. The applicable IAEA recommended dose limit of 20 millisievert per year (mSv/yr) assumes that this worker has training in procedures to control radiation exposures.
- **Construction Worker.** This is an adult receptor that is exposed short-term to soil contaminants during the work day for the duration of a single construction project (typically a year or less). If multiple non-concurrent construction projects are anticipated, it is assumed that different workers would be employed for each project. The activities for this receptor typically involve substantial on-site exposures to surface and subsurface soils. The construction worker is expected to have a very high soil ingestion rate and is assumed to be exposed to contaminants via the following direct and indirect pathways: incidental soil ingestion, external exposure to radiation emissions, and inhalation of fugitive dust. The applicable IAEA recommended dose limit of 20 mSv/yr assumes that this worker has training in procedures to control radiation exposures.
- **Park Visitor.** This is a child resident receptor exposed during short duration (4 hour) visits to the park area of the site one evening per week. The activities of the receptor include playing, eating, and drinking on the site. This receptor is exposed to ore material via incidental soil ingestion, external exposure to radiation emissions, and inhalation of fugitive dust. The applicable IAEA recommended dose limit for children and other sensitive members of the public is 0.5 mSv/yr.
- **Off-site Resident.** The off-site resident is exposed to contaminants transported off site, both during and after construction, for a total of 30 years. This receptor is assumed to have no direct contact with on-site soils. Thus the only exposure pathway evaluated for this receptor is the inhalation of fugitive dust, which is likely to be somewhat exacerbated during periods of short-term construction as a result of dust generated from related activities. The applicable IAEA-recommended dose limit for adults is 1.0 mSv/yr; but for children and other sensitive members of the public the recommended dose is 0.5 mSv/yr.
- **Farm Market.** This receptor area was considered as a special case of interest, as it is almost surrounded by the elevated stockpile area at the eastern end on the Russeifah site. It is assumed that adults working there may be members of the public who visit that area for up to 10 hours a day for the work week, a similar exposure period to the Outdoor Worker. Their annual exposure estimate is adjusted to reflect the potential inhalation of fugitive dust from the surrounding stockpiles. As this is considered a public area, where workers are not trained regarding radiation exposure precautions, it is assumed that the IAEA 1.0-mSv/yr recommended dose limit for an adult off-site resident will apply.

The three exposures routes contributing radiation dose to the receptors (direct external exposure, inhalation, and ingestion) were evaluated to find a worst-case dose for each receptor and subsequently judge the current and potential future status of the TENORM-contaminated site.

5.8.2 Results

The average uranium 238 concentration in the ore material found throughout the site (1,154 ± 239 becquerel per kilogram [Bq/kg]) was greater than the IAEA exemption criteria of 1,000 Bq/kg (IAEA, 2004). Given that the ore material at the site does not meet this IAEA exemption criteria, the radiation protection guidelines and limits are applicable for current and future planned activities at the site and cannot be excluded without an appropriate evaluation of proposed activities at the site and potential remediation needs to facilitate intended uses. Therefore, the radiological evaluations described in this report and the radiological assessment were conducted.

The gamma walkover survey results show that the radiation emission rates and underlying soil and ore uranium concentrations are relatively uniform throughout the site. The soil samples taken at various area locations are considered representative of the entire site. The results also provide the concentrations of TENORM radioisotopes in the source terms used in the dose evaluations.

The predicted long-term exposure doses for only one of the five types of exposure scenario receptors analyzed (the maximum **Off-site Resident**) exceeded the annual dose limit for members of the public of 1 millisievert (mSv) by a significant margin, with a maximum value close to 6 mSv/yr. Fortunately, that particular location is in a primarily industrial location with few residences present.

Most off-site residents, even those close to the facility boundaries under the current conditions, were predicted to have annual exposure dose rates at least a factor of three lower than the maximum case of 5.95 mSv/yr, or less than 2 mSv/yr. Only one very close neighborhood to the northeast of the site may experience these annual dose rates on the order of 6 mSv/yr. However, it should be emphasized that these higher levels are model predictions driven by potential transport and inhalation of fugitive dusts eroding from the stockpile areas. The radiological field assessment did measure the concentration of the soils and the direct radiation from the surface gamma and radon exposures in one off-site area (assumed to represent a relative background location). However, it was beyond the scope envisioned for the 2012-2013 screening study to characterize dust emissions reaching more distant residential locations under a wide range of meteorological conditions. Such an analysis would require a long-term air monitoring program.

Based on early public concerns, the particular exposures to the neighborhood of several homes on the southwestern side of the stockpile area (virtually within the site) were reviewed, and according to the dose mapping exercise**,** they had predicted exposures within +/- 20 percent of the IAEA dose rate guideline for adults of 1 mSv/yr. This would not be generally considered a significant deviation from that guideline. However, for non-school children spending 100 percent of their time in this neighborhood, the inhalation exposures would likely exceed the recommended 0.5 mSv/yr limit. The IAEA limits allow annual public exposures above 1 mSv/yr if the average over five years is below 1 mSV, and the maximum dose in one year is less than 5 mSv. Although virtually all but one location for predicted doses is below 5 mSv per year, over 90 percent of these estimated doses are a result of re-suspension of the ore material (wind erosion) that comprises the entire site. Thus, management of erosion is the key to lowering all predicted results.

The **Park Visitor**, who is also identified to be a resident child, is the least exposed of the evaluated scenarios, due to the relatively short duration and limited frequency of assumed exposure times. The total annul exposure of 0.06 mSv/yr for this activity scenario is insignificant, especially when compared to the same individual's exposure while at home, if the residence is within a few hundred meters of the site boundary (as described above).

Additional interest in the potential exposures at the livery **Farm Market** area on the southeast edge of the stockpile area led to more careful analysis of those calculated exposures. Site and vicinity annual exposure dose prediction models indicate that dose rates might be in the 2 to 3 mSv/yr range if occupied 24 hours per day; but the more limited time assumed for daily visits there leads to a calculated exposure dose from inhaled uranium 238 that is 0.96 mSv/yr, just slightly below the 1 mSv/yr limit for adult residents.

Similarly, for the **Outdoor Worker** who regularly works in either the present Park area, or who may work part of the time in any area of the stockpile developed for recreational purposes in the future, calculations show that this worker would be expected to experience exposures resulting in a total dose of 0.94 mSv/yr. This dose is also just below the IAEA guide for adult residents, even though as a (trained) worker, the applicable guideline is 20 mSv/yr.

For the **Construction Worker** considered in this analysis, both the measurements reported for the simulation tests, as well as the short- and long-term exposure doses calculated with the two models, indicate that the maximum annual levels should be well within the IAEA 20-mSv/yr guideline for trained workers, with a maximum estimate equal to 2.6 mSv/yr.

The IAEA contemplates regulation of sites such as Russeifah Area 3 in the Safety Guides on Occupational Radiation Protection and Occupational Radiation Protection in the Mining and Processing of Raw Materials. The latest Basic Safety Standards document now contains more detailed requirements for regulatory oversight.

Table 5-5 presents a summary of the results obtained from the radiological assessment of existing site conditions. Results highlighted in bold exceed IAEA recommended dose limits and warrant remedial action.

Table 5-5. Comparison of dose modeling results to applicable IAEA dose limits

Scenario	Applicable IAEA Recommended Dose Limit	Existing Conditions
Off-site Resident	1 mSv/yr (adult)	**5.95 mSv/yr**
Park Visitor	0.5 mSv/yr (children)	0.06 mSv/yr
Outdoor Worker	20 mSv/yr (trained worker)	0.94 mSv/yr; max. 5.45 mSv/yr
Farm Market	1 mSv/yr (adults) 0.5 mSv/yr (children)	0.96 mSv/yr

5.8.3 Recommendations and Conclusion

Final results indicate that the average uranium concentration of the ore material found at Russeifah Area 3 is greater than the IAEA recommended criteria for exemption from regulatory controls. The dose assessments conducted for exposure scenarios of likely receptors indicate the possibility that workers and members of the public could receive doses up to approximately 6 mSv/yr (not including contributions from radon). With the

exception of exposures estimated for the nearest residential locations, none of the risk levels predicted for each receptor group would be considered to be extraordinarily high for the situations represented, but some are high enough to warrant continued review and potential improvement.

Assessment of individual facilities is required to evaluate the radon exposure to workers and residents. Such exposures to workers in facilities at Russeifah Area 3 are subject to the requirement of protective practices according to IAEA standards.

The assumptions used in the initial site survey measurement and preliminary risk assessment study were intentionally conservative. Future users of the site should compare actual planned site operations to the scenarios modeled in this report to gauge relative predicted dose. In addition, the complementary air modeling performed to help interpret how typical the measured results might be, compared with other days and wind conditions, led to further prediction of long-term estimates of total exposures to nearby public areas, as well as on-site work areas (USAID, December 2014).

5.9 Noise

Area 3 is bounded on the north by a roadway (King Abdullah I) while other roadways lie to the south of the site (Al Shaheed, etc.). Some noise from vehicles using these roadways are expected to a minor degree at the site. However, there are no official activities taking place at Area 3 at present. Illegal access of the site by trucks either dumping debris or removing material from the pile could contribute some noise in the project area while those activities are taking place.

5.10 Flora and Fauna

The project area is located within the Mediterranean realm (Figure 5-9), which is represented by the mountain ranges extending from the north near Irbid, to Ras an Naqb to the south. The Mediterranean realm includes areas of forested vegetation, with an abundance of juniper trees (*Juniperus phoenicea*), white weeping brooms (*Retama raetam*), pistachio trees (*Pistacia atlantica*), pine trees (*Pinus halepensis*), Palestine oak (*Quercus calliprinos*), kermes oak (*Quercus coccifera*), and tabor oak (*Quercus ithaburensis*). Open areas are characterized by high cover of the thorny burnet (*Sarcopoterium spinosum*). However, vegetation in the region near the Russeifah project area is characterized by a very sparse vegetative cover, often composed of plants that can resist hot conditions. The majority of plants are either small shrubs or annual or perennial herbs. This type of sparse vegetation is typically found scattered around the watersheds of small wadis in Jordan.

The mammals of the region around the project area represent most of the mammals found in the Mediterranean Zoogeographic Zone, including the striped hyena (*Hyaena hyaena*) and caracal (*Caracal caracal*). Birds within the general region near the project area include greater sand plover (*Charadrius leschenaultia*), cream-colored courser (*Cursorius cursor*), pin-tailed sandgrouse (*Pteroles alchata)*, common crane (*Grus grus*), lesser short-toed lark (*Calandrella rufescens*), and Temminck's lark (*Eremophila bilopha*) (USAID, April 2015).

5.11 Antiquities

Hundreds of archaeological sites are located within the Zarqa Governorate. However, as indicated in Figure 5-10, the closest documented archaeological site to Area 3 is over 2 kilometers away (MEGA-Jordan, 2015). Also, the director of the Zarqa Environment Office and the manager of the Russeifah Municipality Office have confirmed that no known archaeological sites are located within the Area 3 project area (Majdalawi, 2015).

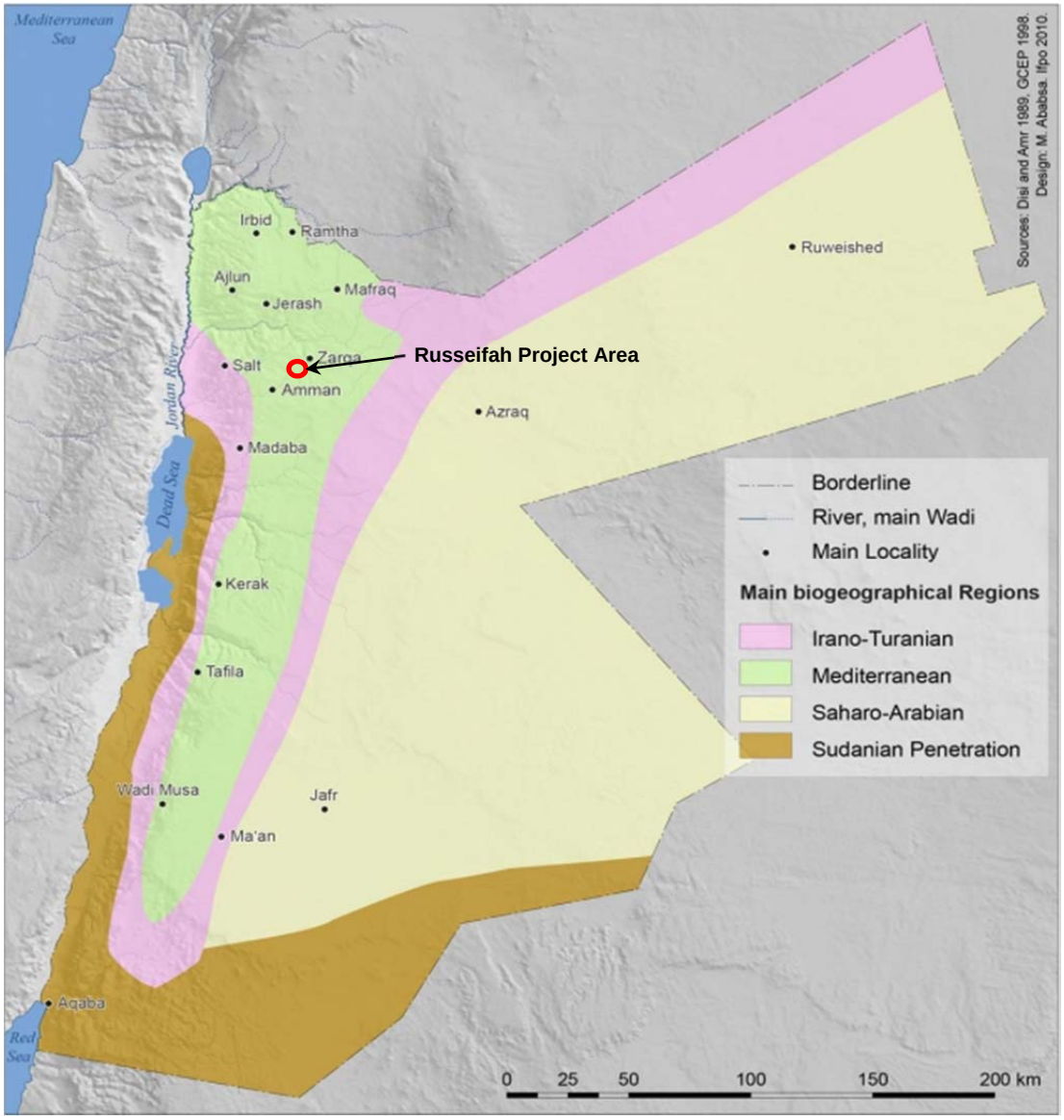
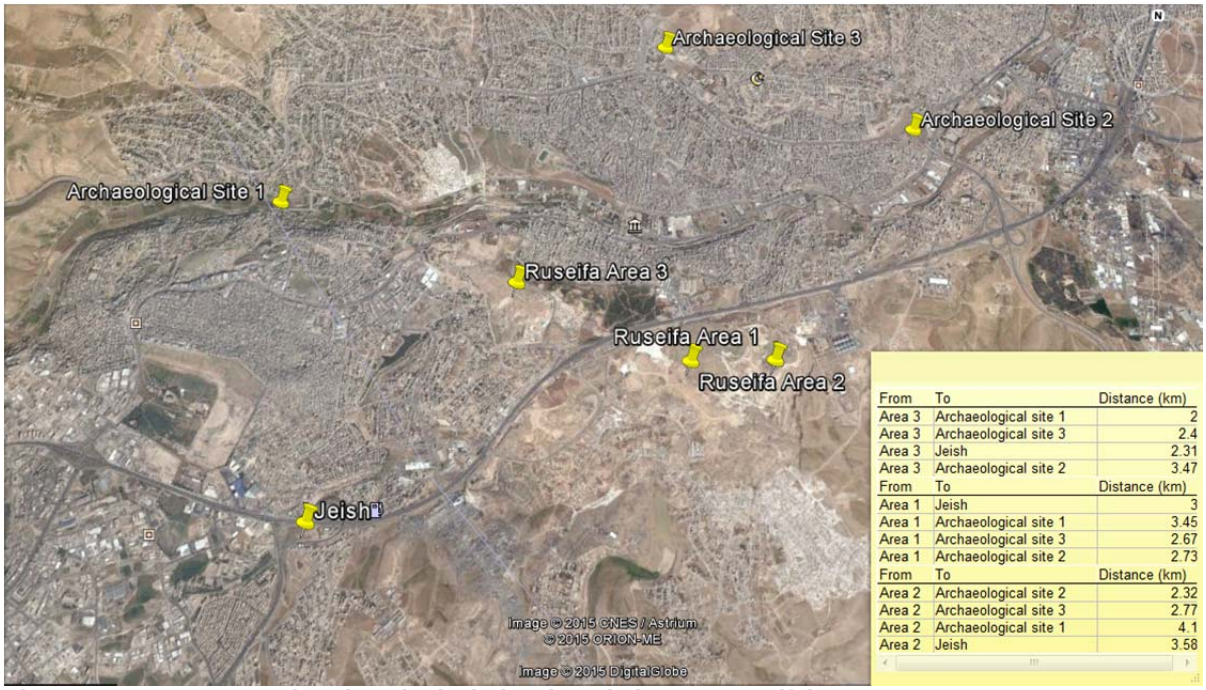


Figure 5-9. The Biogeographical Regions of Jordan Encompassing the Russeifah Project



From	To	Distance (km)
Area 3	Archaeological site 1	2
Area 3	Archaeological site 3	2.4
Area 3	Jeish	2.31
Area 3	Archaeological site 2	3.47
From	To	Distance (km)
Area 1	Jeish	3
Area 1	Archaeological site 1	3.45
Area 1	Archaeological site 3	2.67
Area 1	Archaeological site 2	2.73
From	To	Distance (km)
Area 2	Archaeological site 2	2.32
Area 2	Archaeological site 3	2.77
Area 2	Archaeological site 1	4.1
Area 2	Jeish	3.58

Figure 5-10. Documented Archaeological Sites in Relation to Russeifah Area 3

5.12 Land Use

Area 3 is comprised of a phosphate stockpile resulting from earlier phosphate mining activities. Land ownership of Area 3 is divided among several public entities and the privatized Jordan Phosphate Mines Company (Majdalawi, 2015).

The primary surrounding land uses are residential, commercial, and industrial. There is also a small area of agriculture use. Figure 5-11 shows the relationship of the various Russeifah Areas and the existing land uses of their surroundings (USAID, January 2012).

5.13 Population and Major Economic Activities

In terms of population, Zarqa Governorate is the third largest governorate in Jordan, and Russeifah is the second largest city in the Zarqa Governorate (Majdalawi, 2015). Since the mid-1930s, the Russeifah area has seen a significant increase in population, with increases in the number of residences, as well as commercial and light industrial businesses (USAID, January 2012). The city continues to experience rapid population growth. Between 2009 and 2014, Russeifah's population increased 11.6 percent from approximately 312,560 to an estimated 348,870 (Department of Statistics, 2010, 2014, as cited in Majdalawi, 2015).

Zarqa Governorate is characterized by the presence of heavy industries, such as oil refining, electrical power production, and chemical and steel industries, as well as light industries, such as small-scale food factories and workshops (Majdalawi, 2015). Agricultural activities occur in limited areas within the governorate. The major economic activities in the City of Russeifah are commercial and industrial, with limited agricultural activities.

Several light and heavy industries are found near the phosphate mining areas (USAID, January 2012). These include the Jordan Silos and Supply General Company, which operates and maintains government grain silos and is located east of Area 2. Brick factories and a gas storage area are located south and west of Area 1. Light industries dedicated to car maintenance and a car impoundment area are located west and south of Area 3, respectively. A livestock market also is located in the vicinity of the phosphate mining area (Majdalawi, 2015) and, during several visits to Area 1, shepherds were observed moving their flocks across the closed Area 1 landfill (USAID, January 2012).

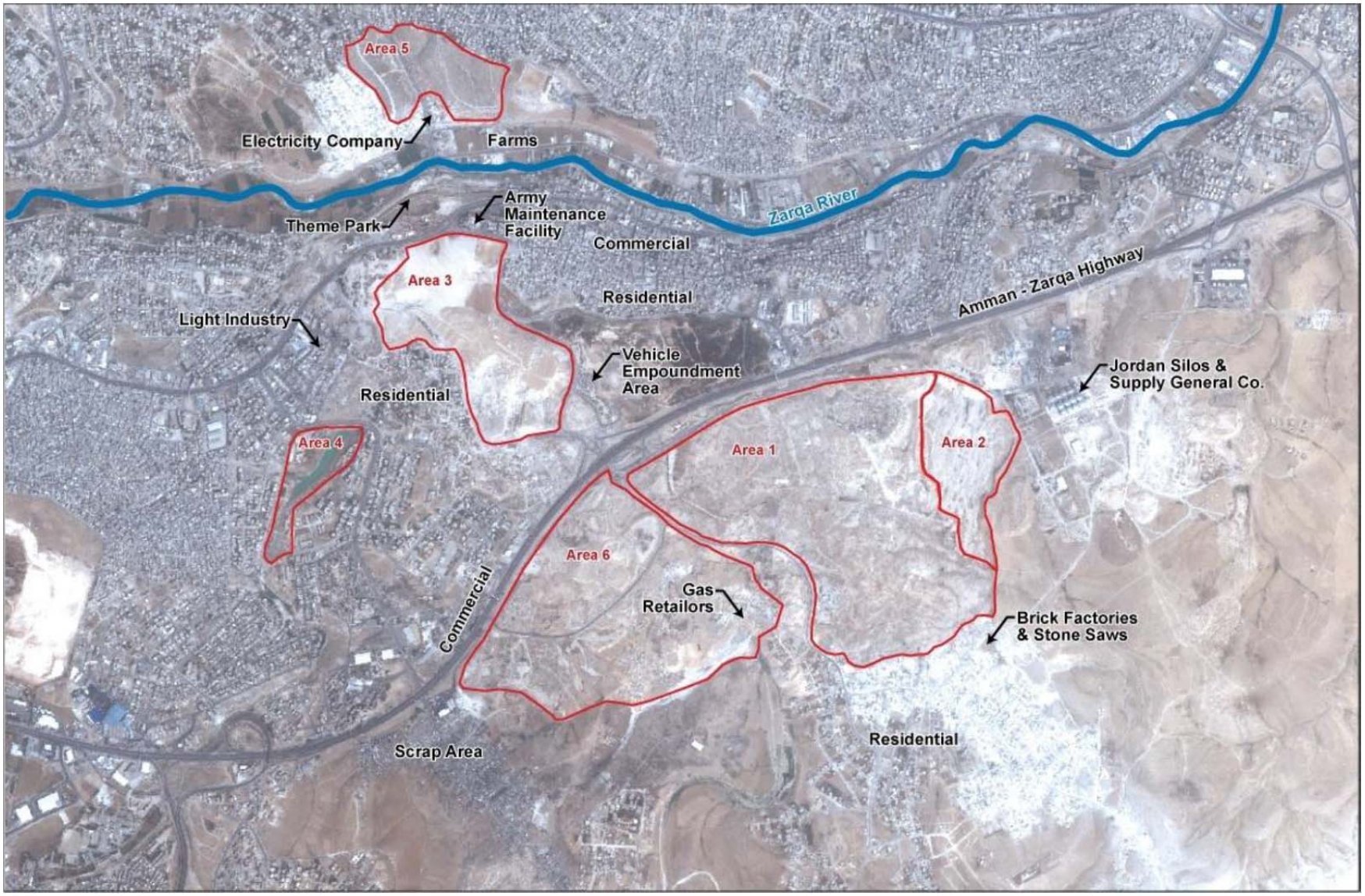


Figure 5-11. Aerial Photo Showing Surrounding Land Uses

Table 5-6 shows the relative distribution of average monthly household income in Zarqa Governorate and in Russeifah District, based on Department of Statistics 2008 data. Compared to the governorate overall, larger proportions of households in Russeifah had average monthly incomes in the brackets representing incomes equal to or less than 500 Dinars; whereas, a smaller proportion of households in Russeifah had incomes in the greater than 500 Dinars bracket.

Table 5-6. Distribution of Households by Average Income (percent)

Monthly Average Income (Jordan Dinars)	Zarqa Governorate	Russeifah District
Less than 150	1.7	2.9
150 to 199	4.5	4.6
200 to 299	19.2	20.0
300 to 500	36.7	42.4
Greater than 500	37.9	30.1

Source: Department of Statistics, 2008, as cited in Majdalawi, 2015

5.14 Transportation

The road network in the Zarqa Governorate is in generally good condition and connects most cities and villages in the governorate, and connects the governorate with the rest of Jordan. The Amman-Zarqa highway crosses through the Russeifah phosphate mining area. The highway is located north of Areas 1, 2, and 6 and south of Areas 3 and 4. The highway is a primary access route in Jordan. There are also secondary and village roads in the project area. Public transportation, including buses, microbuses, cars, and taxis, are available and used for local trips as well as longer distance travel to Zarqa City and other destinations in Zarqa Governorate and elsewhere in Jordan.

Area 3 is accessible from the Amman-Zarqa Highway and from local, secondary roads. Area 3 site access is not controlled (USAID, December 2011).

5.15 Water and Electricity Supply

Groundwater is the primary water supply source in the Zarqa basin. The safe yield of the basin is estimated to be in the range of 60 to 70 million cubic meters per year (Table 5-3), and the aquifer is used as a primary source of potable water in the kingdom (Majdalawi, 2015).

The groundwater level in the project area is relatively shallow, at 30 to 50 meters below local ground level (USAID, March 2014). The water supply quantity is limited, especially during the summer months when there is little to no precipitation (Table 5-1). During this time, water supply to customers is restricted. In order to maintain their supplies, most residents have rooftop water storage tanks with a typical capacity of 1,000 to 2,000 liters (1 to 2 cubic meters) (Majdalawi, 2015). The groundwater supply is supplemented with water from Zarqa River. The WAJ mixes water from the Zarqa River with groundwater, because the salinity of water in the river is high. In the past, villagers depended on springs for local consumption and irrigation.

The Zarqa Governorate receives electricity from the Hussein Thermal Power Station and the Samra Thermal Power Station (Majdalawi, 2015). Electricity is available for all houses and factories in the project area.

5.16 Solid Waste

The primary solid waste at the site consists of the phosphate ore pile that is the subject of the proposed project at Area 3. This stockpile of primarily low-grade phosphate ore has a volume of approximately 4.5 million cubic meters and covers an area of 35 hectares. It is a result of aggressive open pit mining conducted between 1963 and the mid-1980s and has become an aesthetic, environmental, and health concern over the years. The stockpile poses risks associated with slope stability and radiation hazards. The average uranium concentrations in the ore material found throughout the site exceeds the IAEA exemption criteria and, thus, poses potential radiation threats to neighboring communities and future users of the site (USAID, December 2014).

5.17 Human Health

The most common ailments in the project area are related to respiratory infections (asthma, allergies, etc.), which are likely related to air pollution issues in the area (Majdalawi, 2015). As discussed in Section 5.7, fugitive dust from the phosphate ore stockpile and other nearby sources of dust contribute to diminished air quality in the vicinity of the project site. Some of this dust is radioactive, and radon has also been linked to ore material in the project area (see Section 5.8). Emissions from vehicles on the nearby Amman-Zarqa highway and secondary roads also contribute to diminished air quality in the project vicinity.

One of the prominent issues at the site is radiation concerns. As described in Section 5.8, a radiological field assessment was carried out to provide an initial determination of the range of radiological risks from TENORM contained in the phosphate ore stockpiles and wastes present throughout Russeifah Area 3.

The average uranium 238 concentration in the ore material found throughout the site (1,154 ± 239 Bq/kg] was greater than the IAEA exemption criteria of 1,000 Bq/kg (IAEA, 2004). Given that the ore material at the site does not meet this IAEA exemption criteria, the radiation protection guidelines and limits are applicable for current and future planned activities at the site and cannot be excluded without an appropriate evaluation of proposed activities at the site and potential remediation needs to facilitate intended uses.

The predicted long-term exposure doses for only one of the five types of exposure scenario receptors analyzed (the maximum Off-site Resident) exceeded the annual dose limit for members of the public of 1 millisievert (mSv) by a significant margin, with a maximum value close to 6 mSv/yr. Fortunately, that particular location is in a primarily industrial location with few residences present. Most off-site residents, even those close to the facility boundaries under the current conditions, were predicted to have annual exposure dose rates at least a factor of three lower than the maximum case of 5.95 mSv/yr, or less than 2 mSv/yr. Only one very close neighborhood to the northeast of the site may experience these annual dose rates on the order of 6 mSv/yr.

Based on early public concerns, the particular exposures to the neighborhood of several homes on the southwestern side of the stockpile area (virtually within the site) were reviewed, and according to the dose mapping exercise, they had predicted exposures within +/- 20 percent of the IAEA dose rate guideline for adults of 1 mSv/yr. This would not be generally considered a significant deviation from that guideline. However, for non-school children spending 100 percent of their time in this neighborhood, the inhalation exposures would likely exceed the recommended 0.5 mSv/yr limit. The IAEA limits allow annual public exposures above 1 mSv/yr if the average over five years is below 1 mSV, and the maximum dose in one year is less than 5 mSv. Although virtually all but one location for predicted doses is below 5 mSv per year, over 90 percent of these estimated doses are a result of re- suspension of the ore material (wind erosion) that comprises the entire site. Thus, management of erosion is the key to lowering all predicted results.

6 INITIAL ASSESSMENT OF ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

This chapter addresses the anticipated environmental impacts of the implementation of the proposed Russeifah Area 3 Remediation. The analysis is qualitative in nature and is based on professional judgment and experience. Environmental impacts are considered and detailed according to the two project phases:

- Construction phase
- Operations phase

Mitigation measures for these environmental impacts also are recommended.

6.1 Construction Phase

6.1.1 Geology, Topography and Soils

6.1.1.1 Impacts

The surface geology, topography, and soils at Area 3 have been significantly modified by past stockpiling of phosphate ore. The proposed project would reshape the existing phosphate ore pile and modify the topography of the pile to accommodate the proposed grouted rip-rap cover and drainage system. The proposed side slopes of the pile would be graded to 2:1 grades. There is potential for soil and ore pile erosion during construction. Additionally, soil contamination may occur as a result of oil and fuel leakage or spills from vehicles or machines, or improper disposal of excess construction materials.

6.1.1.2 Mitigation

The contractor should develop and implement a soil erosion prevention plan, a spill management plan, and a hazardous material management plan. These plans should include all the necessary measures, main concerns, and actions, as well as responsibilities, to prevent soil erosion and pollution.

During construction, soil contamination can be avoided by isolating fueling and maintenance areas, as well as vehicles parking areas, on an impermeable surface. Any leakage or spill incidents should be dealt with immediately by using spill kits and cleaning up and removing the top contaminated soil. Such contamination accidents should be reported.

Hazardous materials should be labeled, used, and disposed of properly and according to the plan. Hazardous materials should be stored within double-skinned tanks to prevent any spills or leaks to the environment. Solid and liquid wastes should be collected regularly and disposed of at the closest available disposal site to prevent soil contamination.

6.1.2 Surface Water

6.1.2.1 Impacts

The construction phase of the project is not anticipated to impact surface water as the nearest body of water, when flowing, is the Zarqa River. The Zarqa River is located north of the site, beyond the limits of work for Area 3. As noted in Section 5.5, no wadis pass through Area 3 (USAID, December 2014).

6.1.2.2 Mitigation

As project construction is not anticipated to impact surface water, no specific mitigation is proposed for surface water.

6.1.3 Groundwater

6.1.3.1 Impacts

As recent static water level data indicate groundwater in the general project area at depths of 30 to 50 meters (USAID, March 2014), it is unlikely that earthwork for reshaping and capping the ore pile, or stormwater system or pond construction, would result in an impact to groundwater. If large quantities of groundwater are used for dust suppression during construction, the use of this water could further deplete available groundwater. There would likely also be an increase in water demand for the various construction activities and domestic water uses at site offices. In addition, potable water might be used to wash construction equipment and tools.

If the contractor would be trucking water to the site, the contractor should be required to consider the effects on the source supply. Groundwater contamination resulting from construction activities, including the use of hazardous chemicals, is unlikely to happen.

6.1.3.2 Mitigation

The contractor should develop and implement a water resource management plan. In the pre-construction stage, a water source for construction activities should be identified to confirm that use of water by the contractor would not affect the water supply of the local community or of others relying on the source supply. The contractor should provide water from tankers rather than using water from the public network. Construction crews should conserve water during all construction activities and handle water efficiently.

As discussed above, the contractor should develop and implement a hazardous material management plan. Hazardous materials should be labeled, stored, used, and disposed of properly and according to the plan.

6.1.4 Air Quality

6.1.4.1 Impacts

Fugitive dust from the phosphate ore stockpile at Area 3 and other nearby sources of dust contributes to diminished air quality in the vicinity of the project site. Some of this dust is radioactive, and radon has also been linked to ore material in the project area. Air quality would likely be temporarily impacted during construction as a result of fugitive dust, and construction vehicle and equipment emissions.

6.1.4.2 Mitigation

Dust control measures should be implemented to limit resident and worker exposures during construction.

The contractor should develop and implement a fugitive dust management plan. All necessary dust abatement measures should be identified in the plan, including but not limited to:

- Minimizing dust generation during dry and dusty weather, and scheduling dust-generating activities according to the weather conditions
- Suppressing dust using a non-water-dependent dust control product given the scarcity of water in the region
- Covering all stockpiles and trucks transporting soil and other construction materials
- Controlling vehicles movement and speeds on unpaved roads and, as practicable, paving heavily-used roads
- Following good housekeeping within the site and its perimeters
- Providing workers with dust protection equipment

- Undertaking and recording inspections to verify compliance with fugitive dust management plan requirements, daily during periods of high activity or prolonged dry, windy weather and weekly otherwise during construction

To minimize air pollutant emissions, heavy machinery and construction vehicles should be maintained in good working condition and vehicle idling times should be minimized. Spill cleaning equipment should be available at all times. All air quality complaints by residents and on-site workers should be recorded, and the causes should be identified and corrected.

6.1.5 Radiological

6.1.5.1 Impacts

As indicated above, one of the prominent issues at the site is radiation concerns. Construction activities would likely exacerbate radioactive fugitive dust temporarily in the vicinity of Area 3, and construction workers would be exposed to the ambient radioactivity of the phosphate ore during project construction activities.

Comparison of the modeled rates of natural dust emission with those generated by construction readily shows that control of natural erosion dust is more important than the additional dust generated by construction, except in close proximity to the construction equipment. In these close locations, the principal concern is minimizing the exposure to the workers operating the construction equipment as the concentrations are highest for them and the frequency of exposure is daily for the duration of those activities. The exposures to the surrounding neighborhoods, in contrast, are limited to the 10- to 30-day periods that these activities are operating in the immediate area. The progression of the remediation project would result in a gradual reduction of the predicted long-term exposure doses to workers both in the areas which would require initial construction and in those areas that would require ongoing park maintenance to support future visitation from the public (USAID, May 2015).

6.1.5.2 Mitigation

Dust control is a primary requirement for the ultimate outcome of the remediation plan, and a priority during the remediation activities, as the tailings and processed ore residuals still contain traces of naturally occurring radioactivity material, due to uranium and its radioactive decay products content. A proactive dust control and monitoring program, when activated, can reduce the construction-related dust generation by 25 to 75 percent, depending on the practices employed. Pre-treatment of all work areas near the periphery of the site with polymer coating materials and/or water can provide significant benefits to both the workers and the public. A control plan with pre-treatment should be used along with a real-time dust monitoring program to dynamically assess the effectiveness of the control measures being employed. Sub areas should be prioritized and then mitigated generally in priority order to minimize their impact on neighboring areas, while maintaining flexibility for operational efficiency. A possible strategy includes early covering of those areas closest to nearby populated neighborhoods (USAID, May 2015). Implementation of construction sequencing, dust reduction procedures, air monitoring, and worker protection requirements could effectively mitigate short-term impacts during construction.

6.1.6 Noise

6.1.6.1 Impacts

Noise levels are anticipated to temporarily increase during the construction phase, due to operation of heavy machinery. Noise levels would vary throughout construction according to the activities executed and the combinations of machines and equipment used. Some neighborhoods in close proximity to Area 3 may experience a temporary increase in noise levels during construction, although typically noise-generating construction activities would

be distant from these neighborhoods and construction workers are anticipated to be the most affected from construction noise.

6.1.6.2 Mitigation

The contractor should comply with the Jordanian Instructions for Controlling and Preventing Noise, which prohibit loud noise-generating construction activities between 8 pm and 6 am. In addition, hearing protection equipment should be provided to workers. Multiple noise-generating activities should be conducted simultaneously to prevent prolonged periods of noise. Heavy machinery should be maintained and greased regularly to minimize unnecessary noise. Motorized equipment should be muffled and, where possible, noise sources should be enclosed.

6.1.7 Flora and Fauna

6.1.7.1 Impacts

As the site contains very little vegetation in general, vegetation loss as a result of project construction would be minor. If any fauna use the phosphate pile as habitat, this habitat would be lost during pile reshaping and covering. Construction activities may also discourage bird usage of the area, although fauna usage in general at the site is anticipated to be minimal.

6.1.7.2 Mitigation

Some habitat loss as a result of construction is inevitable and cannot be mitigated. However, the following would avoid or minimize impacts to flora and fauna:

- Construction vehicles should be restricted to using previously disturbed land and roads in order to avoid disturbing and damaging the surrounding habitat.
- Construction activities should be restricted to one area at a time, wherever possible, to allow the movement of fauna species to undisturbed nearby areas.
- Construction workers should not trap or hunt any existing animals or bird species within Area 3.
- If capturing of an animal is needed to enable construction, any caught animals should be moved to nearby undisturbed areas.
- Generation of noise and fugitive dust, and chemical and hazardous material spills and discharges should be controlled and minimized as much as possible, to prevent negative impacts on the biodiversity of the area.

6.1.8 Antiquities

6.1.8.1 Impacts

As no documented archaeological sites are located within the project area and Area 3 has been previously disturbed, no impacts to antiquities are anticipated as a result of construction activities.

6.1.8.2 Mitigation

While no impacts are anticipated, a letter should be submitted to the Antiquities Department of Zarqa requesting whether there is reason to believe an undocumented archaeological site may be located within the limits of construction. Construction work should be halted if any artifacts are encountered, and appropriate measures should be carried out in consultation with the Antiquities Department of Zarqa and the DOA.

6.1.9 Land Use

6.1.9.1 Impacts

The adjacent land uses would be subject to elevated levels of dust and noise from construction activity, including grading and capping of the phosphate pile and increased truck traffic. These impacts are discussed in Sections 6.1.4.1 and 6.1.6.1.

6.1.9.2 Mitigation

Dust and noise control measures should be implemented to limit impacts to adjacent land uses during construction. See Sections 6.1.4.2 and 6.1.6.2 for details regarding dust and noise control measures.

6.1.10 Population and Economic Activities

6.1.10.1 Impacts

Implementation of the project would result in short-term benefits for the local economy. Construction activities would generate temporary jobs during the construction period and would contribute to local earnings and induced spending.

The number of workers that would be required for project construction has not been estimated. The number of local people hired for project construction would be determined substantially by the availability of local, suitably skilled labor. Those temporary, construction-related jobs that are not filled by people in the local economy would be filled by people not currently residing in the project area. This project construction-related employment would result in a temporary increase to employment and population in the project area overall.

During construction, project personnel who live outside the project area or its vicinity would stay in temporary accommodations or in the home of local residents within acceptable commuting distances of the project site, generating local revenue. Depending on the duration of project construction and the construction-related employment opportunities, dependent family members may accompany the incoming non-local workers. The project personnel and their dependents would contribute to induced spending on goods and services locally and throughout the overall project area.

Project construction would result in economic benefits not only for the project workers, but also for the communities in which the workers live. In addition to the direct positive economic effects on the project workers, indirect positive effects could be expected as a result of the ‘multiplier effect.’ In other words, direct gains in jobs and earnings would be felt further down the line as workers spend much of their money in the local economy on such things as supplies, food, other merchandise, and various services. Because the anticipated economic effects would occur only for the duration of the construction period, no permanent or long-lasting economic effects are anticipated as a result of construction.

6.1.10.2 Mitigation

As no negative demographic or economic impacts are anticipated during construction, no mitigation is recommended. However, the project proponent should require that the contractor promote the hiring of local labor throughout project construction. Specifically, the project proponent could require that the contractor reserve non-skilled employment positions for local labor and use available, suitably skilled, local labor for semi-skilled and skilled positions.

6.1.11 Transportation

6.1.11.1 Impacts

Project construction at Area 3 would lead to an increase in truck and car traffic in the project area. However, the increase in construction-related vehicles would be temporary. At the conclusion of construction, vehicle trips and transportation demand levels at Area 3 could be similar to current conditions, depending on the ultimate reuse of the area.

6.1.11.2 Mitigation

The contractor should prepare and implement a traffic management plan suitable for the construction site conditions.

6.1.12 Water and Electricity Supply

6.1.12.1 Impacts

There would be an increase in water demand for the various construction activities, such as dust control and washing construction equipment and tools. If the contractor trucks in water from another location, it is expected that there would be no impact on the local water supply.

The demand on electricity would also increase during the construction phase, which would result in a temporary increase the amount of power supplied to the project area. However, it is anticipated that a sufficient supply is available and there would be no adverse impact as a result of construction of the project.

6.1.12.2 Mitigation

The contractor should prepare and implement a water management plan. During the pre-construction stage, a water source for construction activities should be identified to confirm that use of water by the contractor would not affect the local water supply. Construction crews should conserve water during all construction activities and handle water efficiently to minimize overall water use.

As project construction is not anticipated to impact the local electrical supply, no mitigation is proposed.

6.1.13 Solid Waste

6.1.13.1 Impacts

As discussed above, the primary solid waste at the site consists of the phosphate ore pile that is the subject of the proposed remediation at Area 3 and has become an aesthetic, environmental, and health concern. The construction phase of the project would impact the ore pile by reshaping it, stabilizing it, and covering it with an engineered cap.

Construction, therefore, would result in a positive impact on waste management at Area 3, although there is potential for ore pile erosion and fugitive dust generation during construction. Construction waste and municipal waste generated by workers would likely be produced during construction activities.

6.1.13.2 Mitigation

Movement and reshaping of the ore pile and other construction activities should be conducted to minimize fugitive dust from the ore pile. Construction waste and any municipal waste generated by workers at the site should be collected and disposed of regularly. The contractor should develop and implement a waste management plan. The plan should identify a waste collection schedule, storage locations, qualified carriers, and the final disposal facility.

6.1.14 Human Health

6.1.14.1 Impacts

As indicated above, one of the prominent issues at the site is radiation concerns, and there is a potential health risk related to inhalation of fugitive radioactive airborne dust particles. Construction activities would likely exacerbate radioactive fugitive dust temporarily in the vicinity of Area 3, and construction workers would be exposed to the ambient radioactivity of the phosphate ore during project construction activities.

Comparison of the modeled rates of natural dust emission with those generated by construction shows that control of natural erosion dust is more important than the additional dust generated by construction, except in close proximity to the construction equipment. In these close locations, the principal concern is minimizing the exposure to the workers operating the construction equipment, because the concentrations are highest for them and the frequency of exposure is daily for the duration of those activities. The exposures to the surrounding neighborhoods, in contrast, are limited to the 10- to 30-day periods that these activities are operating in the immediate area (USAID, May 2015).

Emissions from construction vehicles and equipment would contribute to diminished air quality in the project vicinity, potentially contributing to respiratory ailments, particularly in combination with background vehicle emissions.

Project construction would expose the construction workers to the various, typical hazards associated with construction activities, such as falls, accidents involving construction vehicles and equipment, and prolonged exposure to sun, heat, dust, and loud noises. Construction at Russeifah Area 3 would present additional risks associated with the steep slopes of the ore pile and potential exposure to radioactive airborne dust.

6.1.14.2 Mitigation

Dust control is a primary requirement for the ultimate outcome of the remediation plan, and a priority during the remediation activities. A proactive dust control and monitoring program, when activated, can reduce the construction-related dust generation by 25 to 75 percent, depending on the practices employed. Pre-treatment of all work areas near the periphery of the site with polymer coating materials and/or water can provide significant benefits to both the workers and the public. A control plan with pre-treatment should be used along with a real-time dust monitoring program to dynamically assess the effectiveness of the control measures being employed. Sub areas should be prioritized and then mitigated generally in priority order to minimize their impact on neighboring areas, while maintaining flexibility for operational efficiency. A possible strategy includes early covering of those areas closest to nearby populated neighborhoods (USAID, May 2015). Implementation of construction sequencing, dust reduction procedures, air monitoring, and worker protection requirements could effectively mitigate short-term impacts during construction.

The contractor should prepare and implement an occupational health and safety plan, suitable for the construction site conditions.

6.2 Operations Phase

6.2.1 Geology, Topography and Soils

6.2.1.1 Impacts

As the goals of the project include the stabilization of the ore pile slopes and to cover the pile with an engineered cap to reduce the risk of radiation exposure and dust migration, no negative impacts to geology, topography, or soils are anticipated for the project following construction.

6.2.1.2 Mitigation

As no negative impacts are anticipated for geology, topography, or soils following construction, no mitigation is recommended.

6.2.2 Surface Water

6.2.2.1 Impacts

The engineered stormwater management system at Area 3 that would operate post-construction would consist of a combination of pipe culverts, riprap protected variable-depth ditches, and concrete chutes with plunge pools. These features would be integrated into the cover design and would discharge to two onsite stormwater evaporation ponds (USAID, December 2014; USAID, May 2015). As a result, no impact to existing surface water bodies is anticipated.

6.2.2.2 Mitigation

As no existing surface water bodies are anticipated to be impacted by the proposed project, no surface water mitigation is recommended.

6.2.3 Groundwater

6.2.3.1 Impacts

As groundwater lies approximately 30 to 50 meters below the project site (USAID, March 2014), and surface water would be collected from the covered pile and discharged to surface evaporation ponds, impacts to groundwater post-construction are not anticipated for the project.

6.2.3.2 Mitigation

As no impacts to groundwater are anticipated during operation, post-construction mitigation for groundwater is not proposed for the project.

6.2.4 Air Quality

6.2.4.1 Impacts

As the goals of the project include stabilizing the ore pile slopes and covering the pile with an engineered cap to reduce the risk of radiation exposure and dust migration, no negative impacts to air quality are anticipated for the project following construction. The purpose of the engineered pile cover includes reducing the amount of fugitive dust, thereby improving air quality conditions in the vicinity of the site.

6.2.4.2 Mitigation

As the project would improve air quality after construction as a result of dust suppression by the engineered cap and slopes, no post-construction mitigation is proposed for air quality.

6.2.5 Radiological

6.2.5.1 Impacts

The long-term operation of the project would result in the marked reduction of fugitive dust and radioactivity in the surrounding project area. The phosphate ore pile would be covered with a grouted riprap cap to prevent exposure to radiological hazards through direct contact and inhalation of wind-blown particulates, substantially diminishing predicted long-term exposure dose impacts from the site relative to the project not being implemented.

6.2.5.2 Mitigation

As discussed above, the purpose of this project is to mitigate the negative effects of the Russeifah phosphate ore pile, including radiological exposure of the ore pile for the benefit of human health and the environment. No further mitigation is recommended.

6.2.6 Noise

6.2.6.1 Impacts

Following the completion of Area 3 remedial activities, the remediated site is not anticipated to generate noise; therefore, no noise impacts are anticipated post-construction. Post-remedial redevelopment of the site may generate some noise, but the level of noise generated would depend on that specific future use (trails, roadways, parking lots, buildings, etc.).

6.2.6.2 Mitigation

As no noise impacts are anticipated during operation, mitigation for noise from Area 3 post-construction are not recommended for this project.

6.2.7 Flora and Fauna

6.2.7.1 Impacts

Any flora or fauna habitat present prior to construction would be permanently impacted/displaced following construction as a result of the permanent engineered slopes, cap, ponds, and other site features. However, the magnitude of impacts to flora and fauna following construction are anticipated to be minimal as the area presently contains little vegetation and has been highly disturbed in the past, as a result of previous use of the site and the placement of the ore pile.

Although the loss of some flora and fauna habitat would occur as a result of the project, the evaporation ponds, while they contain stormwater prior to drying completely between storm events, may provide temporary habitat for wildlife. Any temporary surface water may serve as an important site feature for some fauna, particularly avian species.

6.2.7.2 Mitigation

As only minimal, unavoidable impacts to flora and fauna are anticipated, no mitigation is recommended.

6.2.8 Antiquities

6.2.8.1 Impacts

Archaeological resources on the project site would be encountered during the construction phase, if at all. The operations phase is not expected to result in impacts to archaeological resources.

6.2.8.2 Mitigation

As project operation is not anticipated to impact archaeological resources, no mitigation is proposed.

6.2.9 Land Use

6.2.9.1 Impacts

Remediation of Area 3 would allow the site to be redeveloped in the future. Land-ownership likely would change over the course of the service life of the remedial cover, and it is not clear at this time what the future use of the remediated Area 3 may ultimately be. Based on the results of the existing and post-remedial radiological assessments, it is desirable that post-remedial land use take into account that receptors are least exposed during transient, short-term, or recreational activities. This stems from the fact that exposure doses are heavily contingent on the duration in which a receptor is exposed to radioactivity (USAID, December 2014).

The MoEnv has proposed the development of an Eco-Park on an area of approximately 100 donum (10 hectares) in the northern part of Area 3 (USAID, December 2014). The park is currently in the planning phase. The proposed park project aligns well with the preferred type of reuse for the site.

Remediation of Area 3 would minimize the risk of exposure to radiation for adjacent land uses. Also, future beneficial reuse of Area 3 would result in a positive impact to the surrounding land uses.

6.2.9.2 Mitigation

Post-remedial development activities for Area 3 should be regulated and controlled to enhance public well-being, the long-term functionality of the remedial design, and its integration within the urban fabric of Russeifah.

6.2.10 Population and Economic Activities

6.2.10.1 Impacts

Implementation of the project would result in long-term benefits for the local economy. Reuse of Area 3 could generate permanent jobs and would contribute to local earnings and induced spending.

The reuse scenario for Area 3 has not been determined, and the number of new workers that would be required for future site use has not been estimated. The number of local people hired would be determined substantially by the availability of local, suitably skilled labor. Those permanent, reuse-related jobs that are not filled by people in the local economy would be filled by people not currently residing in the project area. This reuse-related employment could result in an increase to employment and population in the project area overall.

Personnel who live outside the project area or its vicinity would relocate to new residences within acceptable commuting distances of their new jobs, generating local revenue. Dependent family members may accompany the incoming non-local, long-term employees. The reuse personnel and their dependents would contribute to induced spending on goods and services locally and throughout the overall project area.

Area 3 reuse would result in economic benefits not only for the reuse employees, but also for the communities in which the employees live. In addition to the direct positive economic effects on the employees, indirect positive effects could be expected as a result of the ‘multiplier effect.’ In other words, direct gains in jobs and earnings would be felt further down the line as workers spend much of their money in the local economy on such things as supplies, food, other merchandise, and various services.

6.2.10.2 Mitigation

As no negative demographic or economic impacts are anticipated during operation, no mitigation is recommended. However, the project owner/operator should promote the hiring of local labor throughout project operation, reserving non-skilled employment positions for local labor and using available, suitably skilled, local labor for semi-skilled and skilled positions.

6.2.11 Transportation

6.2.11.1 Impacts

The reuse scenario for Area 3 has not been determined, and the number of new workers that would be required for future site use has not been estimated. Therefore, it cannot be determined whether reuse of Area 3 would lead to a substantial increase in transportation demand and resulting vehicle trips. The MoEnv has proposed the development of an Eco-

Park in the northern part of Area 3 (USAID, December 2014). The park is currently in the planning phase. The proposed park, if developed, is not expected to lead to a substantial increase in transportation demand and vehicle trips. No negative transportation impacts are anticipated during operation.

6.2.11.2 Mitigation

As no negative transportation impacts are anticipated during operation, no mitigation is recommended.

6.2.12 Water and Electricity Supply

6.2.12.1 Impacts

Remediation of Area 3 is not anticipated to result in operational impacts to water and electricity supply. However, implementation of the project would allow the site to be redeveloped in the future. The ultimate reuse of the site could result in water and electricity supply impacts, which would vary depending on the nature of the reuse and the scale and design of the project. The assessment of impacts associated with the future reuse of Area 3 is outside the scope of this ECR, but should be considered in subsequent reuse planning and assessment efforts.

6.2.12.2 Mitigation

As no adverse operational impacts to water and electricity supply are anticipated as a result of the project, no mitigation is recommended.

6.2.13 Solid Waste

6.2.13.1 Impacts

The post-construction state of the project would have a positive impact on solid waste at the site (the ore pile), as it would reduce fugitive dust and radiological exposure to nearby inhabitants and the environment.

6.2.13.2 Mitigation

The purpose of the project is to remediate the phosphate ore pile. No additional mitigation is recommended.

6.2.14 Human Health

6.2.14.1 Impacts

Implementation of the proposed project is anticipated to result in long-term positive impacts to human health due to the marked reduction of fugitive dust and radioactivity in the surrounding project area. The phosphate ore pile would be covered with a grouted riprap cap to prevent exposure to radiological hazards through direct contact and inhalation of wind-blown particulates, substantially diminishing predicted long-term exposure dose impacts from the site relative to the project not being implemented. The remediation project would result in a reduction of the predicted long-term exposure doses to onsite construction and maintenance workers in the areas that support future reuse of Area 3 (USAID, May 2015).

6.2.14.2 Mitigation

As discussed above, the purpose of this project is to mitigate the negative effects of the Russeifah phosphate ore pile, including radiological exposure of the ore pile for the benefit of human health and the environment. No further mitigation is recommended.

7 INITIAL ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

The Initial EMMP was developed from the mitigation measures detailed in Chapter 6, Initial Assessment of Environmental Impacts and Mitigation Measures, to address the anticipated environmental and social impacts of the project. The main objectives of the EMMP are the following:

- Provide detailed guidance for implementing the mitigation measures and associated monitoring
- Assign responsibilities for implementation
- Facilitate efficient auditing and monitoring throughout the different project phases

The EMMP would assist the project proponent/owner, contractors, and government authorities in undertaking the required mitigation measures throughout the progress of the project, and guiding monitoring activities intended to verify that the mitigation measures are implemented and have the desired effects.

Table 7-1 presents an initial list of recommended environmental mitigation and monitoring measures to implement the project in a safe and environmentally sound manner during project construction. The recommended mitigation measures address the anticipated environmental and social impacts of the project. They are actions that are not already included in the proposed project evaluated in this ECR and are not integral to the design, construction, and operation of the project. Unless otherwise noted in Table 7-1, it is expected that the construction contractor would be responsible for implementing construction phase mitigation and monitoring measures in accordance with MoEnv requirements. As no adverse operational impacts are anticipated as a result of the project, as documented in Section 6.2, no environmental mitigation and monitoring measures are recommended for the operation phase of the project.

If the decision is made to implement the proposed project, the project proponent should prepare an EIA in accordance with MoEnv requirements, and the project EIA team should develop a more detailed, binding EMMP. The construction-phase environmental mitigation and monitoring measures specified in that EMMP should be incorporated into the tender documents provided to the construction contractor, and the specified operation-phase measures should be incorporated into the operation manuals for the project facilities.

Table 7-1. Recommended Construction-Phase Environmental Mitigation and Monitoring Measures

Anticipated Impact	Mitigation / Monitoring Measure
Soil and ore pile erosion	**Mitigation** Develop and implement a soil erosion prevention plan. Restrict construction vehicles to previously disturbed land and roads. Pave roads and parking areas where heavy vehicle traffic/use is expected.
	Monitoring Monitor compliance with the soil erosion prevention plan. Inspect soil erosion and sedimentation control measures weekly.
Soil contamination from oil and fuel leakage or spills, or improper disposal or storage of waste and construction materials	**Mitigation** Develop and implement a spill management plan. Develop and implement a waste management plan. Establish designated waste and construction material storage areas on site. Establish designated fueling, and vehicle and equipment maintenance areas on site. Establish designated, paved vehicle parking areas on site. Dispose of waste in approved disposal facilities off site.
	Monitoring Monitor compliance with the spill management plan. Monitor compliance with the waste management plan. Document leaks and spills, and other incidents that may impact soil.
Increased groundwater demand to support construction activities	**Mitigation** Develop and implement a water management plan. Supply water from approved off-site sources.
	Monitoring Monitor compliance with the water management plan. Inspect water management measures weekly.

Groundwater contamination from hazardous materials used during construction	**Mitigation** Develop and implement a spill management plan. Develop and implement a hazardous material management plan.
	Monitoring Monitor compliance with the spill management plan. Monitor compliance with the hazardous material management plan. Document leaks and spills. Document discharges of hazardous materials.
Fugitive dust	**Mitigation** Develop and implement a fugitive dust management plan. Develop and implement a soil erosion prevention plan. Pave roads and parking areas where heavy vehicle traffic/use is expected. Cover stockpiles of and cover vehicles that carry dry spoil and other dust-generating cargo.
	Monitoring Inspect adherence to fugitive dust management plan requirements daily during periods of high activity or prolonged dry, windy weather, and weekly otherwise. Monitor compliance with the soil erosion prevention plan. Inspect soil erosion and sedimentation control measures weekly. Document dust complaints.
Construction machinery and vehicle air pollutant emissions	**Mitigation** Maintain machinery and vehicles in good working condition. Minimize vehicle idling time.
	Monitoring Inspect machinery and vehicles monthly. Document air quality complaints.

Radiological exposure	**Mitigation** Develop and implement a fugitive dust management plan. Develop and implement a soil erosion prevention plan.
	Monitoring Inspect adherence to fugitive dust management plan requirements daily during periods of high activity or prolonged dry, windy weather, and weekly otherwise. Monitor compliance with the soil erosion prevention plan. Inspect soil erosion and sedimentation control measures weekly. Sample concentrations of airborne TENORM daily. Sample personal breathing zone airborne TENORM daily.
Increased noise	**Mitigation** Prohibit loud noise-generating construction activities between 8 pm and 6 am. Provide hearing protection equipment to construction workers. Conduct multiple noise-generating activities simultaneously. Maintain machinery and vehicles in good working condition.
	Monitoring Monitor compliance with the Instructions for Controlling and Preventing Noise daily. Inspect machinery and vehicles monthly. Document noise complaints.
Flora and fauna impacts	**Mitigation** Develop and implement a soil erosion prevention plan. Restrict construction vehicles to previously disturbed land and roads. Restrict construction activities to one area at a time. Prohibit trapping or hunting. Move captured animals to nearby undisturbed areas. Control and minimize noise and fugitive dust generation, and hazardous material spills and discharges.
	Monitoring Monitor compliance with the soil erosion prevention plan. Inspect soil erosion and sedimentation control measures weekly. Inspect adherence to fugitive dust management plan requirements daily during periods of high activity or prolonged dry, windy weather, and weekly otherwise. Monitor compliance with the Instructions for Controlling and Preventing Noise daily. Document discharges of hazardous materials.

Dust and noise impacts on adjacent land uses	**Mitigation - Dust** Develop and implement a fugitive dust management plan. Develop and implement a soil erosion prevention plan. Pave roads and parking areas where heavy construction vehicle traffic/use is expected. Cover stockpiles of and cover vehicles that carry dry spoil and other dust-generating cargo. **Mitigation - Noise** Prohibit loud noise-generating construction activities between 8 pm and 6 am. Conduct multiple noise-generating activities simultaneously. Maintain machinery and vehicles in good working condition.
	Monitoring - Dust Inspect adherence to fugitive dust management plan requirements daily during periods of high activity or prolonged dry, windy weather, and weekly otherwise. Monitor compliance with the soil erosion prevention plan. Inspect soil erosion and sedimentation control measures weekly. Document dust complaints. **Monitoring - Noise** Monitor compliance with the Instructions for Controlling and Preventing Noise daily. Inspect machinery and vehicles monthly. Document noise complaints.
Construction-related traffic	**Mitigation** Develop and implement traffic management plan.
	Monitoring Monitor compliance with the traffic management plan.
Increased water demand to support construction activities	**Mitigation** Develop and implement a water management plan. Supply water from approved off-site sources.
	Monitoring Monitor compliance with the water management plan. Inspect water management measures weekly.

Solid waste generation	**Mitigation** Develop and implement a waste management plan. Establish designated waste storage areas on site. Dispose of waste in approved disposal facilities off site.
	Monitoring Monitor compliance with the waste management plan.
Health risk from radiological exposure	**Mitigation** Develop and implement a fugitive dust management plan. Develop and implement a soil erosion prevention plan. Develop and implement an occupational health and safety plan.
	Monitoring Inspect adherence to fugitive dust management plan requirements daily during periods of high activity or prolonged dry, windy weather, and weekly otherwise. Monitor compliance with the soil erosion prevention plan. Inspect soil erosion and sedimentation control measures weekly. Monitor compliance with the occupational health and safety plan.

8 PROPOSED ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY AND SCHEDULE

If the decision is made to implement the proposed project, the project proponent should prepare an EIA in accordance with Jordan Regulations No. (37) of 2005, Environmental Impact Assessment Regulations, and Title 22, Code of Federal Regulations, Part 216, USAID's Environmental Compliance Procedures; and consistent with the requirements of any lending organization that provides financing for the project. The project EIA team should conduct field investigations, desktop research, and consult with experts (when needed) in order to efficiently assess the existing environment, address all the significant environmental and social impacts related to the project, and formulate an EMMP to mitigate the significant negative impacts and define the institutional responsibilities for implementing these measures. The EIA should accomplish the following:

- Specify the project designs, plans, and activities that would be associated with environmental and social conditions
- Identify the environmental and social regulations, standards, policies, and administrative framework
- Describe the environmental and socioeconomic baseline conditions of the project area and the affected communities
- Inform and obtain input from stakeholders (e.g., governmental authorities and the public), and document their relevant issues and concerns
- Assess the environmental and socioeconomic impacts that would result from the project activities during construction, operation, and decommissioning
- Identify mitigation measures to address the impacts identified
- Analyze the different project alternatives according to their environmental and socioeconomic effects, both positive and negative
- Develop an EMMP that sets a comprehensive plan for mitigation measure implementation, including monitoring and institutional management

8.1 Desktop and Field Studies

Desktop research and field studies will need to be undertaken as part of the project EIA. The objectives of the desktop and field studies are to provide a detailed description of the affected environment and establish the environmental and socioeconomic baseline that will be used in impact assessment.

8.1.1 Literature and Data Review

The desktop research studies will entail thorough literature reviews for all of the resource areas covered in the EIA. One of the primary purposes of the desktop review will be to further evaluate data from secondary sources, according to:

- The extent to which available baseline information covers all areas potentially impacted by the project
- Whether the current existing baseline data is still valid and sufficient or should be updated and extended through primary research
- The extent to which baseline data meets requirements to complete an EIA to the applicable standards and guidelines

The EIA team should review all available, relevant data about the project and the project area. This will include review of studies and investigations related to the proposed Russeifah Area 3 remediation, and environmental and socioeconomic conditions on the project site and throughout the surrounding project area. Literature and data review also should include

consulting web-based resources. Data will be collected by reviewing several pertinent documents including, but not limited to the following:

- *Russeifah Site (Area 3) Remediation Pre-Feasibility Study*, USAID WRECP 29 December 2011, including associated appendices
- *Russeifah Phosphate Pile (Area 3) Remediation Feasibility Study*, USAID WRECP 30 March 2014, including associated appendices
- *Russeifah Phosphate Pile (Area 3) Site Remediation Design Report*, USAID WRECP December 2014, including associated appendices
- *Russeifah Phosphate Pile (Area 3) Site Remediation Design Report Addendum*, USAID WRECP May 2015, including associated appendices
- Data from the Department of Statistics publications
- Jordan Climatological Handbooks and Bulletins, Meteorological Department
- *Handbook of the Geology of Jordan*, Burden 1959
- *Geology of Jordan*, Bender 1974
- *Geology of Jordan*, Abed 2000
- *Jordan Country Study on Biological Diversity*, General Corporation on Environmental Protection 1998
- *Jordan Country Study on Biological Diversity: Jordan Ecology, Ecosystems, and Habitats*, General Corporation on Environmental Protection 2000
- *Jordan Country Study on Biological Diversity: Mammals of Jordan*, General Corporation on Environmental Protection 2000
- *Jordan Country Study on Biological Diversity: Plant Biodiversity and Taxonomy*, General Corporation on Environmental Protection 2000

A comprehensive review of the relevant legal requirements and regulatory constraints in Jordan should also be conducted and described. Relevant environmental laws, by-laws, guidelines, and standards should be addressed.

For some resources, desktop studies will be sufficient for the impact analysis. For several resources, however, field studies are expected to be necessary to provide sufficient information for the required level of EIA, as detailed in the following section.

8.1.2 Field Investigations and Analyses

Structured site visits, field surveys, and stakeholder consultations should be undertaken to collect primary data from the site and directly from stakeholders in order to garner their perceptions about the project's predicted impacts. Site visits, field surveys, and stakeholder consultations are expected to contribute to determining the following:

- Environmental and human health baseline and current situation
- Stakeholders' perceptions of the project and the anticipated impacts
- Stakeholders' views and recommendations on the mitigation of predicted negative impacts
- Roles and responsibilities associated with the EMMP

Data should be collected firsthand through several field visits to the project site. Field investigations, including "walkover" surveys, should be conducted during the preparation of the EIA document to acquire a comprehensive understanding of the environmental conditions at the site. During the field investigations, the potential impacts on the project area should be considered and mitigation measures to be implemented during project construction, operation, and decommissioning should be proposed.

8.1.3 Air Quality and Noise Studies

In order to establish a baseline for the concentrations of air pollutants and noise levels, air quality and noise testing should be carried out. Sampling should be conducted for several testing points inside and outside the proposed facility boundaries. Measurements should be performed at the following locations:

- At minimum, one point at the Area 3 site boundary
- Additional points located where people would be exposed to air emissions and noise during project construction, operation, and decommissioning, including residential areas and sensitive receptors such as schools and hospitals

Air quality samples should be taken and analyzed according to the JS 1140/2006 Ambient Air Quality Standards. Key air quality parameters that should be tested include the following:

- Sulfur dioxide (SO_2)
- Carbon monoxide (CO)
- Nitrogen dioxide (NO_2)
- Ozone (O_3)
- Carbon dioxide (CO_2)
- Respirable particulate matter (PM_{10})
- Fine particulate matter ($PM_{2.5}$)
- Total suspended particles (TSP)
- Phosphate (P_2O_5)

Desktop activities should include developing an inventory of the sources, types, and magnitude of air and noise emissions that would be generated by construction, operation, and decommissioning of the proposed project. Equipment and vehicle emissions, and noise levels anticipated during the construction, operation, and decommissioning phases should be assessed qualitatively. Fugitive dust levels anticipated during the construction, operation, and decommissioning phases should be assessed quantitatively.

8.1.4 Radiological Assessment

A radiological field assessment was carried out to provide an initial determination of the range of radiological risks from TENORM contained in the phosphate ore stockpiles and wastes present throughout the Russeifah Area 3 site. A second modeling effort was performed to gauge the benefits that are likely to be obtained by proceeding with the then current proposal to grade and cover much of the site. These previous radiological assessments are documented in the following reports:

- Russeifah Area 3 Ore Stockpile Radiological Assessment, USAID WRECP May 2013
- Air and Radiological Modeling Update for Russeifah Area 3 Remediation Cover Planning, USAID WRECP October 2014

The EIA team should determine whether the previous radiological assessments are sufficient to characterize the radiological risks from TENORM that would result from the proposed project. If substantial information and data gaps are identified and additional assessment is needed, the EIA team should update the air modeling and radiological dose assessment to determine the radiological risks associated with the remediation activities and the post-remediation conditions under the proposed project.

8.1.5 Human Health Assessment

The objective of the human health assessment should be to identify, assess, and manage the potential future effects of the proposed project on the health of communities within the project area. The assessment should include the following components:

- Conducting desktop investigations and scoping to identify potential communities that would be affected by the proposed project and key health issues
- Developing a plan to gather additional data needed to conduct the assessment, using both existing information and input from health experts
- Collecting the additional data, as necessary, using interviews with key health experts, health service providers, community organizations, and local leaders
- Assessing the potential health effects of the project
- Developing a management plan for addressing those effects

8.1.6 Ecological Assessment

An ecologist should conduct a site visit in order to evaluate the existing ecological conditions. As the project site is located within an urban area and the site is highly disturbed, a single reconnaissance-level investigation likely would be sufficient, although additional investigations should be programmed if warranted by the initial visit.

The ecological assessment should focus on obtaining baseline data of the biological environment in the project area. This is to support analysis of potential impacts to biological resources that may result from implementation of the proposed project during the construction, operation, and decommissioning phases. If needed, the study should recommend approaches to reduce any potential threats to rare or endangered species, thus bolstering compliance with national and international protection requirements.

8.2 Scoping

If required, scoping gives stakeholders an opportunity to learn about the project, raise concerns, understand the potential effects, and comment on the project. Through scoping, key issues to be investigated and assessed are identified, and the range and extent of the studies to be conducted are determined. The key objectives of scoping are to:

- Identify stakeholders and inform them of the project and the EIA process
- Provide stakeholders with the opportunity to identify any issues and concerns associated with the project
- Identify areas of likely impact and environmental issues that may require further investigation in the EIA
- Determine the need for specialist baseline and impact assessment studies in response to initial stakeholder input

During scoping, desktop analyses, stakeholder interviews, and public meetings should be conducted to ascertain whether additional information is needed to evaluate baseline conditions and potential impacts within the project area. The desktop evaluation should include reviews of pertinent environmental and social data collected from external sources and previous studies of the project area. The project proponents should meet with stakeholder groups (e.g., local governmental agencies, non-governmental organizations, and representatives of local communities) to discuss the scopes of the proposed studies, including alternatives and the criteria for the impact assessment, and determine if additional baseline data will be required for a comprehensive analysis.

Public consultations should be conducted. This includes a scoping consultation session with the main objective of reviewing the EIA scope of work with stakeholders, and obtaining stakeholders views on the issues that need special attention during the field investigations and the analysis. Additionally, plenary public consultation sessions should be organized after drafting the EIA in order to validate and review the study findings with the relevant stakeholders and groups potentially affected by the project.

The EIA should document the names of participants, the details of the scoping session activities, and the results of the public consultations.

8.3 Environmental Impact Identification and Assessment

During environmental impact identification and assessment, the EIA team should determine the impacts and effects of the proposed project, reasonably practicable alternatives, and a no-action alternative. To assess the potential environmental impacts of the proposed project and its alternatives, the EIA team should undertake the following:

- Provide a detailed description and assessment of the negative and positive potential environmental impacts of the project and its alternatives for all phases of the project (construction, operation, and decommissioning)
- Provide details of the methods/assessment tools used to estimate impacts for each technical parameter, as appropriate
- To the extent practicable, assess the scale or quantity of potential impacts anticipated from all aspects of the project throughout each phase of the project (construction, operation and decommissioning)
- Evaluate the type and magnitude of impact relative to quantitative or qualitative criteria, and any regulatory standards or other performance standards, and determine whether the anticipated impact meets or exceeds the standards or criteria
- Identify which technical parameters have the potential to be significantly affected by the project

Also during environmental impact identification and assessment, the EIA team should develop mitigation measures that would eliminate or reduce adverse impacts that may be caused by the proposed project. Mitigation measures should be developed for each adverse impact anticipated during the construction, operation, and decommissioning phases. The measures selected should:

- Target the impact of concern
- Be feasible to implement and cost effective
- Incorporate best available technology when possible or when mandated by permit approval
- Address cumulative impacts that by themselves would not be considered significant

8.4 Environmental Management and Monitoring Plan Development

The EIA team should prepare an EMMP to manage environmental and social issues during the construction, operation, and decommissioning phases of the project. The EMMP should be developed from the mitigation measures detailed during environmental impact identification and assessment to address the anticipated environmental and social impacts of the project. The EMMP will assist the project proponent/owner, contractors, and government authorities in ensuring that the required mitigation measures are fully executed and sustained throughout the progress of the project, and that the monitoring activities intended to verify that the mitigation measures are implemented and have the desired effects likewise are fully executed and sustained.

Although the EMMP is an integral part of EIA, in accordance with the Jordan Regulations No. (37) of 2005, Environmental Impact Assessment Regulations, it should be a separate, standalone report from the EIA document. For all phases of the project (construction, operation, and decommissioning), the EMMP should address each project activity to which an environmental limitation or other requirement applies, or for which a mitigation measure will be implemented. For each project phase, the EMMP should:

- Identify the aspect/resource to be monitored
- Identify specific mitigation and monitoring measures
- Provide information on the anticipated effectiveness of the mitigation
- Define the location, period, and frequency of monitoring
- Describe monitoring requirements as commitments
- Identify the responsible party for monitoring
- Describe reporting and record keeping requirements
- Consider anticipated expectations or requirements of other stakeholders who may have involvement once construction or operation begins
- Include reporting frequency and type
- Discuss what will happen if monitoring indicates that impacts are not reduced
- Confirm sufficient resources (funds, staff) are available to conduct monitoring
- Reference applicable Jordanian legislation and/or regulations, or applicable international standards
- Include additional general requirements
- Include a signature by an authorized representative of the project proponent
- Include a statement that the project proponent or owner is required to implement all items stated in the EMMP

The EMMP should be continually updated as needed as the project goes to construction, operation, and long-term monitoring, and must provide sufficient information for the MoEnv Inspection Department to use during the inspection process. The construction-phase environmental mitigation and monitoring measures specified in the EMMP should be incorporated into the tender documents provided to the construction contractor, and the specified operation-phase measures should be incorporated into the operation manuals for the project facilities.

8.5 Approvals

Following review of the Initial EIA, the MoEnv will decide whether to grant the Environmental Approval or, if significant impacts are anticipated, to require further study in a Comprehensive EIA. If a Comprehensive EIA is required, a preliminary terms of reference (TOR) document should be prepared by the project proponent. The TOR document should explain how the EIA will be conducted and should identify potential impacts and proposed mitigation measures for the purposes of discussion at a scoping session.

Using information acquired in the scoping session, in which interested stakeholders participate, the proponent writes a scoping report and finalizes the TOR document. The MoEnv may approve the revised TOR or request modifications. When the TOR is approved, the Proponent conducts the EIA study and prepares the Comprehensive EIA document. The MoEnv reviews the document and may request modifications. After completing the document review, the MoEnv either issues Environmental Approval or rejects the project.

8.6 Disciplines Required

The following experts are expected to participate in the preparation of the EIA:

- Environmental Task Leader
- Environmental Specialist
- Groundwater Hydro-geologist
- Air Quality Expert
- Radiologist
- Noise Expert
- Ecologist
- Archaeologist

- Socio-economist
- Solid Waste Management Engineer
- Health and Safety Specialist

Curricula vitae of involved experts should be provided in the EIA report.

8.7 Proposed EIA Report Outline

The MoEnv recently developed a guidance document for preparing EIA reports. This guidance provides detail on the organization, format, and general level of detail required to be provided in EIA documents. In addition, the MoEnv has prepared individual technical guidance documents to assist project proponents and their consultants to conduct some of the more complex analyses required to determine the potential effects of their respective projects. These guidance documents (*Technical Guidance Protocols Annex* to: *Guidance for Preparing Environmental Impact Assessments*, October 2014) are available from the MoEnv.

8.8 Schedule

Figure 8-1 summarizes the anticipated schedule for implementing the EIA for the project.

Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9
Literature and Data Review									
Field Investigations and Analyses									
Environmental Impact Identification and Assessment									
EMMP Development									
EIA Final Preparation									

Figure 8-1. Schedule for Implementing the EIA

9 CONCLUSIONS

The existing phosphate ore stockpile at Russeifah Area 3 is an aesthetic, environmental, and health concern and poses risks associated with slope stability and radiation hazards. Based on the findings of this ECR, although some potentially adverse impacts would be associated with the proposed remediation of the phosphate ore stockpile, the proposed project is not expected to result in significant adverse environmental or social impacts during construction or operation. The anticipated adverse impacts would be temporary and can be mitigated, providing implementation of the mitigation and monitoring measures outlined in the preceding initial EMMP.

Overall, the proposed remediation of the Area 3 phosphate ore stockpile is expected to substantially reduce the environmental and human health risks currently associated with the stockpile, and improve the quality of life for the residents of Russeifah.

10 REFERENCES

Abed, A.M. (2000). *Geology of Jordan*. Jordanian Geologists Association, Amman.

Bender, F. (1974). *Geology of Jordan*.

Burden, D.J. (1959). *Handbook of the Geology of Jordan*.

Department of Statistics (2008). Census of Agriculture Report.

Department of Statistics (2010). Annual Report.

Department of Statistics (2014). Annual Report.

El Naqa, A., N. Ammouri, and M. Kuisi (2006). GIS-based evaluation of groundwater vulnerability in the Russeifah area, Jordan. *Revista Mexican de Ciencias Geologicas* 23(3):277-287.

Foster, Stephen, and Daniel P. Loucks (2006). *Non-Renewable Groundwater Resources: A Guidebook on Socially-Sustainable Management for Water-Policy Makers*. United Nations Educational, Scientific and Cultural Organization, Paris.

General Corporation on Environmental Protection (1998). *Jordan Country Study on Biological Diversity*. General Corporation on Environmental Protection, Amman.

General Corporation on Environmental Protection (2000a). *Jordan Country Study on Biological Diversity: Jordan Ecology, Ecosystems, and Habitats*. General Corporation on Environmental Protection, Amman.

General Corporation on Environmental Protection (2000b). *Jordan Country Study on Biological Diversity: Mammals of Jordan*. General Corporation on Environmental Protection, Amman.

General Corporation on Environmental Protection (2000c). *Jordan Country Study on Biological Diversity: Plant Biodiversity and Taxonomy*. General Corporation on Environmental Protection, Amman.

International Atomic Energy Agency (1996). *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Standard Series No. 115.* Vienna: IAEA.

International Atomic Energy Agency (2004). *Occupational Radiation Protection in the Mining and Processing of Raw Materials, Safety Standard Series No. RS-G-1.6.* Vienna: IAEA.

Kuisi, M. (1992). Assessment of the physical and inorganic chemical parameters of surface and groundwater resources in Amman–Zarqa area, strip of the Zarqa river basin: University of Jordan, MSc. Thesis, 450 pp.

Maine Department of Environmental Protection (2003). *Maine Erosion and Sediment Control BMPs*. Augusta: Maine Department of Environmental Protection, Bureau of Land and Water Quality.

Majdalawi, Dr. Mohammad Issa (2015). Socioeconomic Analysis of Russeifah Phosphate Pile (Area 3) and Russeifah Site (Areas 1 and 2) Projects.

MEGA-Jordan (2015). MEGA-Jordan website: http://megajordan.org/, accessed May 2015.

Ministry of Environment (March 2006). *Environmental Profile of Jordan*. Amman: MoEnv.

The Jordan Times (1 September 2012). Air monitoring stations established in congested, industrial areas. (http://jordantimes.com/air-monitoring-stations-established-in-congested-industrial-areas).

United States Agency for International Development (29 December 2011). *Russeifah Site (Area 3) Remediation Pre-Feasibility Study*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (19 January 2012). *Russeifah Area 1 (Landfill) and Area 2 (Pit) Remediation Feasibility Study*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (December 2012). *Environmental Considerations Report for Sahab Industrial Wastewater Treatment Plant*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (May 2013). *Russeifah Area 3 Ore Stockpile Radiological Assessment*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (March 2014). *Russeifah Phosphate Pile (Area 3) Remediation Feasibility Study*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (October 2014). *Air and Radiological Modeling Update for Russeifah area 3 Remediation Cover Planning*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (December 2014). *Russeifah Phosphate Pile (Area 3) Site Remediation Design Report*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (April 2015). *Environmental Considerations Report for Zarqa Industrial Wastewater Treatment Plant*. USAID Water Reuse and Environmental Conservation Project.

United States Agency for International Development (May 2015). *Russeifah Phosphate Pile (Area 3) Site Remediation Design Report Addendum*. USAID Water Reuse and Environmental Conservation Project.

United States Environmental Protection Agency (13 February 2013). *Radon*. Radiation Protection website: http://www.epa.gov/radiation/radionuclides/radon.html, accessed 26 August 2014.

Water Authority of Jordan and Millennium Challenge Corporation (2010). *Feasibility Study and Environment and Social Impact assessment for Zarqa Water wells Rehabilitation, Draft Feasibility Study*. Volume 2.