Exploratory Drilling at Karkar Geothermal Site, Armenia

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT AND MANAGEMENT PLAN

Draft ESIA and ESMP

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ABBREVIATIONS AND ACRONYMS

AMD	Armenian Dram
asl	Average Sea Level basis (reference altitude measurements)
BOP	Blowout Preventer
CFP	Chance Finds Procedure
dBa	An expression of the relative loudness of sounds in air as perceived by the human ear
EA	Environmental Assessment
EECCA	Countries of Eastern Europe, Caucasus and Central Asia
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
GEF	Global Environment Facility
GoA	Government of Armenia
H_2S	Hydrogen Sulfide
IBA	Important Bird Area
IBRD	International Bank for Reconstruction and Development (World Bank)
IP	Investment Plan
IPP	Independent Power Producer
Ka	Thousands of Years Ago (Geology)
L/s	Liters per second
M2	Public paved highway routed by Villages of Tsghuk, Sarnakunk, and Spandaryan
Ma	Millions of Years ago (Geology)
Marz	Administrative Unit, comparable to County or State
MENR	Ministry of Energy and Natural Resources
MNP	Ministry of Nature Protection
MoC	Ministry of Culture
MT	Magneto-telluric Sounding Survey
NAS	National Academy of Sciences
R2E2	Renewable Resources and Energy Efficiency Fund
RoA	Republic of Armenia
RE	Renewable Energy
RPF	Resettlement Policy Framework
SEI	State Environmental Inspectorate
SREP	Scale Up Renewable Energy Program
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
WHO	World Health Organization
WWF	World Wildlife Foundation

Executive Summary

Armenia is located in a zone of high tectonic activity and recent volcanism, which is frequently the source of geothermal energy resources. Several preliminary assessments carried out in the 1990s and 2000s, both with donor support and by the Ministry of Energy and Natural Resources (MENR), which confirmed the existence of geothermal resources in various parts of the country and identified potential areas where resources could be suitable for power generation.

The Geofund 2: Armenia Geothermal Project, approved in 2009, provided financing to carry out comprehensive field investigation studies of the most promising geothermal sites, Gridzor and Karkar, in order to assess the feasibility of exploratory drilling at the site with the highest potential. Studies included geological field scouting, magneto-telluric sounding surveys for both sites and interpretation of their results, and a 3D MT survey and interpretation of its results for the Karkar site, which was deemed to have the highest geothermal potential. This Karkar site has been selected for exploratory geothermal resource test drilling to confirm the quality and quantity of the local resource. The exploration program is the subject of this ESIA.

Exploratory drilling project recommendations were made on the basis of expert World Bank visits in September 2013 and September 2014. These evaluations resulted in suggested well locations and descriptions of additional surface studies recommended to establish the exact siting of the wells, options for types of test wells, and indication of necessary civil works to be completed in preparation for drilling.

The second expert team recommended incorporation of less expensive preliminary drilling of core, or "slim," wells to indicate the value of more advanced and expensive "exploration" or "production" wells. Slim wells will be drilled to a depth of 1,000m and advanced well to 1,800m.

If results from the first slim well are inconclusive, then the second slim well will be drilled. Depending on the information obtained from the first or second slim well, the following scenarios may result:

- Scenario 1: If the results from the first or second slim well show that reservoir temperature is below 110^{o} C, the project should stop (given that such low temperatures are not suitable for power generation) and the SREP funds should be reallocated to other priority technologies.
- Scenario 2: If the results from the first or second slim well show that the reservoir temperature is around 110-250^{o} C, GoA should decide whether it wants to build a binary geothermal power plant (which is the only option for such temperatures) considering potential estimated levelized energy costs from such a plant. If the Government decides to pursue construction of such a binary power plant, then MENR should proceed to drill one production-size well.
- Scenario 3: If the results from the first slim well show that the reservoir temperature is above 250^{o}, then MENR should pursue construction of Flash Cycle power plant, which will very likely have levelized energy cost competitive with costs of other RE and gas-fired generation considered by the Government. Thus, MENR should proceed to drill one production-size well.

The Karkar site is located in Syunik Marz, the southernmost Marz in Armenia. The main highway to and through Syunik Marz is Highway M2, and a primitive dirt road northward from M2 leads to the exploration site, 18km away.

The exploration works will require improving the access road to accommodate heavy equipment and hauling trucks. Some sections may need to be widened and/or covered with gravel, and culverts or other drainage control will need to be installed at several seasonally dry stream crossings. One or two drill pads will be established at the test-drilling site, initially 20m x 20m and then 50m x 75m size, assuming the program will proceed to the larger wells. Drilling of slim wells is not water-intensive and water will be collected at a refurbished Soviet-era well locate about 8 km from the side and stored in containers at the site. Water for drilling of production-size wells will come via pipe from a refurbished Soviet-era well located about 8 kilometers (by road) from the site. This will require installation of pump(s) and a pipeline that will run alongside the road, as well as construction of one or more temporary lined reservoirs in pre-existing natural land depressions near the drilling site. Drilling fluids and cuttings will be stored and ultimately disposed in lined sumps located in natural depressions near the wells. The site may also require temporary worker living facilities, depending on Contractor options. Limited temporary housing may also be available on Highway M2.

In these mountains the average summer temperature ranges between +10 and +22°C, and in the winter temperatures range between +2 and -14 °C. In plain lands the average January temperature is -5 °C, and July temperature is +25 °C. Winter temperatures limit the work season to early July – early October. Precipitation rates are high in this region, and snow accumulates in colder months, providing snowmelt for seasonal streams in early warmer months.

The relief of Armenian mountain meadows is diverse. Plains and slopes of variable steepness are encountered here. Frequent significant areas are covered with crags, screes and chaotic conglomerations of boulder fields. The specific Karkar area consists of gently rolling meadows with scattered higher worn peaks, and boulder fields. These emerge as a result of tectonic processes and centuries-old erosive water activity that washes soil down to the valleys below.

The Karkar project site is located in the subalpine and alpine meadow and carpet habitat of the Artsakh Highlands, at altitudes of 2500-3000m asl. These types of meadows support distinct assemblages of grasses, includes tall grass, motley grass, and meadows with layer shrubs *Festuca, Bromus*, matgrass, fescue, legumes and sedge. The meadows are used for summer pastures by shepherds who live in several nearby seasonal camps. The drilling site area is devoid of forests or even shrubs, and there are no legally protected wetlands, although there is seasonal spring fed and snowmelt surface water in areas similar to wetlands. These will not be affected.

No officially designated protected areas occur in or near the exploration zone. Livestock grazing has largely supplanted use of the area by larger fauna, at least in the summer months, but some species could occur here in winter times, such as the brown bear and Caspian snow cock. Armenian mouflon generally utilize the area south of Highway M2, but has not been reported in the Karkar area.

Grazing pressure has caused significant changes in both vegetation cover and species composition. Some protected plant species such as *Potentilla* in the rose family and the flowering herb *Delphinium foetidum* have been noted in similar habitats, although none were observed during site visit. Preconstruction surveys will be conducted to verify there are no protected specimens or populations in the project footprint, or to allow micro-location of facilities to avoid impacts.

A detailed inventory of historical and cultural sites has not yet been conducted in this area period. A 12th Century B.C. tomb located nearby, and a survey will need to be conducted by the Ministry of Culture before construction of the drill pads.

The nearest communities are the villages of Tsghuk, Sarnakunk, and Spandaryan, all located on Highway M2. These villages have a combined population of <1,500 people, almost 4,500 sheep, and >3,000 bovine cattle. Animal husbandry is by far the most important livelihood of the local population. Crops are grown, including many vegetables for local use, and cereals and fodder crops for winter livestock feed. Pasturelands surrounding the Karkar exploration site are important to the well being of these villages.

The lands in question are owned by the three local villages, which apportion pastureland use at their discretion among their local citizens. Local authorities do not expect the geothermal exploration activities, or any future development, to interfere with pasture use. To the contrary, they are anxious for the access road improvements to occur, as the improved road will enable easier transit by shepherds and cattle. In addition, there is a hot spring in the highlands that citizens sometimes visit for pleasure and for its attributed medicinal benefits. The improved road will enable more frequent visitation to this resource.
Local authorities also responded favorably to the proposition of future full development of a geothermal resource as a means of providing employment and local revenue-generating opportunities.

This ESIA effort concludes that the Karkar geothermal exploration program will have low to modestly adverse environmental impacts, which will be limited, localized, and manageable by provisions of the EMP. Similarly, development of a geothermal power plant should not result in unacceptable impacts. Permitting of the geothermal operations will be under the jurisdiction of the MENR, while environmental considerations will be the purview of the MNP.

1 Project Description

The proposed project development objective is to confirm if the geothermal resource at the Karkar site is suitable for power generation and, if confirmed, to initiate development of geothermal power plant.

Figure 1-1. Karkar Site Map

The proposed project is intended to support the Government of Armenia in confirming whether the Karkar geothermal site has resources good enough for commercial power generation. This ESIA covers drilling wells for exploration and possibly for future production. If an exploitable resource is found and the decision is made to proceed with development of a geothermal power plant, a separate ESIA would evaluate potential impacts.

The drilling program evaluated in this ESIA includes the following components:

Component 1: Construction of access road and drill pad. This will include: (a) improvement to portions of the 18 kilometers of existing road by widening and covering with gravel to allow for proper drainage and safe transportation of equipment and other materials to the site; and (b) preparation of a 20 x 20 meter (later 50 x 75m) drill rig pad where the drilling rig, associated equipment and small work camp will be placed. Most of the current unimproved road crosses bedrock or other stable ground, but at least 10 percent, and up to 50 percent, of the 18km would need to be covered with gravel, widened, and/or supplied with culverts to allow ephemeral waterways to pass water unimpeded. Construction of the drill pad(s) will involve clearing vegetation, recovering and storing topsoil, and placing gravel on the ground surface to a depth of about 15-25cm. Gravel would come from one or more licensed quarries located along the main road up to 40 km from drill pads and would be transported in trucks to where it is needed.

Component 2: Drilling of slim-line exploratory wells. This will include drilling of one or two slim wells, diameter about $3^1/_2$ inches, to a depth of about 1000 meters. If the first well encounters temperatures between 110 and 250 degrees C, a second drill pad will be constructed in a location up to about one kilometer from the first pad, and another slim well will be drilled. If either well encounters temperatures under 110 degrees C, the project will stop and the well(s)

will be plugged and closed. If temperatures are over 110 degrees C, the Government would decide whether to proceed to Component 3.

Component 3: Drilling of production-size well—this will also be an exploratory well, but could be converted to production if the decision is made to proceed to development. If the first or second slim well encounters temperatures over 110 degrees C and thus confirms an exploitable resource, a production-size well will be drilled to a depth of about 1800 meters - the well would have a diameter of $6^1/_8$ inches if slim-well temperatures are 110-250 degrees C or 8½ inches if over 250 degrees. Development of a production-size well will require one of the drill pads to be enlarged to 50 x 75m, and will require a continuous water supply of up to 25-35 liters per second for the drilling operation. A temporary pipeline will be laid for about 8 kilometers alongside the road to bring water from an abandoned Soviet-era well/pump station that exploited an aquifer that historically produced 200-250 l/sec. (This water was conveyed in a buried pipe to near the project area and used for irrigation. After the collapse of Soviet collective farming, the well/pump station was abandoned and the pipe has been removed but the channel in which it was buried is open at least part of the way to the site.) Continuous water flow of 25-35 liters per second will be required for production-size well drilling (water for slim wells would be brought to the site in trucks). If the abandoned Soviet-era well does not yield the water required, then 50 meters deep slim wells will be drilled at the drilling site to use underground waters. The water required for drilling will be stored in above ground 50 m^3 water tank. In addition, a lined sump will be constructed to contain drilling muds and cuttings – this sump will cover an area of about 600 square meters and hold 1,500m^3 (for production-size well) and will have an HDPE plastic liner 1-1.5mm thick, laid over a prepared surface covered with sand. Also, 350m^3 above ground mud tanks will be installed. Each well will likely produce some amount of brine, or "produced water". This will be stored and re-injected.

Up to seven or eight workers will live on the site for the 30-60 days of drilling.

After completion of Component 3, the Government will decide whether to develop a geothermal power plant, either a flash cycle plant if temperatures are over 250 degrees C or a binary plant if temperatures are between 110 and 250 degrees. Power plant development would be subject to a full-scale feasibility study and ESIA. The present ESIA (Chapter 7) describes hypothetical plants that could be developed in order to evaluate whether there are likely to be unacceptable impacts with full development.

The exploration well site is located approximately 18km north of the nearest useable paved public road No. M2 (15km direct line, 18km as the road goes). The only accessible path to the proposed drilling site is by a country road/path about 2.5m wide, which is used by farmers' trucks and wagons (Figures 1-2 and 1-3). As noted, 10 percent or more of this road will need improvement by covering with gravel, and/or installation of drainage –culverts, rock ditches, or some other controls at a number of places where ephemeral streams cross. Cattle and sheep ranging occurs in much of the adjacent land, which is largely otherwise unexploited. There are 8-10 shepherd camps in the area, and shepherds use dogs to control their flocks/herds. Interviews with local authorities indicated that the lands crossed by this path are public property.

Figure 1-2. Connecting Road Map

Significant heavy equipment will be required to drill the intended exploratory wells, and will have to be trucked to the site. Loads of up to 60 metric tons are anticipated. Since the existing road crosses bedrock for much of its length, little or no improvement will be needed for up to 90 percent of the 18km.

The designed thickness of the road in the sections to be improved will be determined by the contractor. The final average thickness of gravel over the course of an assumed 50 percent of this road (a conservative assumption, in that perhaps only 10 percent are considered to need improving) is expected to be about 25cm, or 0.25m. Thus up to 9,000m^3 of gravel will be required.

There are a small number (3-5) of shallow spring water flow depressions that must be crossed (Figure 1-4), which will require installation of fill and culverts large enough to accommodate spring flow without interruption.

Figure 1-3. Existing Rural Road 4km from M2

Figure 1-4. Dry Streambed across Existing Road 10km from M2

In addition to road construction, drill pads must be constructed. Drilling a slim well requires a pad size of approximately 20m x 20m, while the pad required for production-size wells is about 50m x 75m. This ESIA assumes the larger drill pads will be utilized. It is anticipated that these pads will be paved with gravel about 25cm deep. For a pad 50 x 75m, a total of 937.5m^3 would be needed.

Assuming improvement to 50 percent of the 18km road and construction of two production-size drill pads, the estimated volume of gravel is 10,875m^3. Capacity of trucks used to haul gravel would be about 7m^3. Thus, about 1,550 truckloads will be required, If construction takes 40 working days, there would be 39 truckloads per day, or less than an average of four per hour.

Gravel will be purchased at one or more of the region's many registered established gravel quarries, at the Contractor's discretion. Only gravel from dry quarries will be utilized. Prior to purchasing gravel, any quarry would be inspected to ensure it is properly licensed and is operating in compliance with the license. No gravel will be sourced from rivers or other waterways.

The proposed schedule for this program, years 1 and 2 of which are the primary subject of the current ESIA, is:

Year 1	Construction of access road and slim well rig pad(s); drilling of one or two slim wells. The construction season would be from May or June to October.
Year 2	Construction of water supply infrastructure required for production-size wells; construction of enlarged drill pads; drilling of one production-size well.
Year 3	Decommissioning if not resource is found, or feasibility study and separate ESIA if a resource is found.
Years 4-n	Development of the geothermal power plant.

1.1 Scope of the Study

Chapters 1-6 of this ESIA cover the exploration program for year 1, 2, and 3. Chapter 7 then describes in general terms the development that could occur in future years and indicates whether there are likely to be unacceptable impacts.

To prepare this ESIA, site visits were followed by discussions with appropriate authorities and stakeholders, both in Yerevan and in local villages. Consultations were held with several

agencies, including the Ministry of Nature Protection (MNP), R2E2, the Armenian National Academy of Sciences (NAS) including the NAS Institute of Geological Sciences and the NAS Institute of Botany, the Armenian Ministry of Culture (MoC), and WWF of Armenia (Annex 1).

1.3 Procedures and Methodology

In order to preserve local procedural continuity, this ESIA uses an evaluation procedure utilized in a previous ESIA[1]. This is a transparent and reliable method for assessing a project's impacts on the environment. It includes identification, prediction (e.g. duration, intensity, severity, status, and reversibility of the impact) and evaluation of the significance of the impacts based on legal requirements. The focus of this evaluation procedure is to determine whether the Project is likely to cause significant adverse environmental effect resulting from its construction, operation, and decommissioning.

For the purpose of a transparent presentation and evaluation, a tabulated evaluation matrix is applied. On the basis of a point scale, the severity of the particular environmental impact together with its general trend - that is negative or positive - is described. The evaluation scale applied is as follows (Table 1-1):

Table 1-1. Notation System for Environmental Sensitivity and Impact

Extent of Sensitivity		Extent of Impact	
■	= Low	■	= Low
■■	= Medium	■■	= Medium
■■■	= High	■■■	= High
		O	= Nil
		→	= Locally Positive
		→→	= Regionally Positive

For guiding this judgement, international standards from the World Bank and World Health Organization (WHO) etc. are used (see Chapter 2.3) supported by national Armenian standards (see Chapter 2.1). According to these standards the evaluation of impacts is done as follows (Table 1-2):

Table 1-2. Gradation of Environmental Impact using International Standards

Extent of impact	Reason
High	International and national standards are exceeded
Medium	Between international and national standards, international and national standards are barely met
Low	International and national standards are met

This method clarifies which environmental impacts are most important and for which impacts mitigation measures must be applied in order to reduce negative environmental and social effects.

[1] Transmission Line Reconstruction Project Hrazdan to Shinuhair Corridor, Armenia, ESIA Draft, March 2011

2 Legal and Policy Framework

2.1 Institutional Framework and National Requirements

Following independence in 1991, Armenian environmental legislation was reviewed with the aim of developing a more comprehensive national policy for ecological protection and sustainable resource use. To this end, a series of laws were developed, including regulations relating to protected areas, a land code (both 1991) and a forest statute (1994). From 1999 to today, a number of national laws of the Republic of Armenia (RoA) were implemented to regulate the protection of the environment. A summary is provided in Table 2-1 below.

Table 2-1. RoA Environmental Laws

Law/policy	Date	Key areas
The Law on Specially Protected Areas	2006	This Law defines levels of protection of different kinds on specially protected territories and puts management responsibility on the state. The current, active law "on specially protected territories" was adopted on November 27, 2006. According to the new law, a national park is "a territory of international and/or national significance where there are nature protective, scientific, historical-cultural, aesthetic, and/or recreational values which, due to the integration of natural landscapes and cultural values, can be used for scientific, educational, recreational, cultural and economic purposes and for which a special regime of protection is foreseen". The law also foresees the following functional zones within the national park: reserve; sanctuary; recreation; and economic use (where economic activities consistent with the conservation objectives of the national park are allowed). The project will not affect any protected areas, and so this law does not apply.
The Land Code	2001	The Land Code defines the main directives for use of the lands allocated for energy production, water infrastructure (water supply, sanitation, pumping stations, reservoirs, etc.), and other purposes. The Code defines the lands under the specially protected areas as well as forested, watered and reserved lands. It also establishes the measures aimed at protection of the lands as well as the rights of state bodies, local authorities, legal entities and citizens towards the land.

Law/policy	Date	Key areas
Water Code	2002	This act mainly regulates water-use relations. Article 3 provides that "The State ensures the conservation and protection of water from negative impacts and its use for the sake of the security of all persons". Important principles of water management include: the need to satisfy the daily requirements of present and future generations; protection and redemption of volume of national water resources; protection of water and adjacent ecosystems and their biodiversity; acceptance of integrity, interconnectivity of interrelations of land, air, water and biodiversity; regulation of water utilization by means of permits for water extraction. Permit will be required for water extraction and use, and for management of sanitary water.
Law on Protection of Atmospheric Air	1994	The objective of the law is early warning and elimination of air pollution, and international cooperation in the field of air protection. Important elements of the law include: norms for maximum permissible concentrations of emissions, regulation of polluting emissions, location and design of enterprises, and audit, monitoring and control of air quality. This law applies to the project. Air emissions will be controlled as necessary to ensure compliance.
Act on Forests	1994	According to the Act, the forest is the exclusive property of the Republic until it grows up to industrial utilization volume. Currently, Armenian forests are subject to protection, rehabilitation, recreation and sustainable utilization only. Only temporary utilization (up to 5-10 years) under supervision of a state authorized body and local authority is allowed. The project will not affect any forest, so the law will not apply.
The Law on Payments for Nature Protection and Use of Natural Resources	1999	This law defines the concepts of nature protection and use fees, the scope of the payers, types of fees, procedures for calculations and payment of the fees, the liability in case of violation of this law and other relations connected to the fees. The types of nature protection fees are: a) For releasing harmful substances into the environment (aerial and water basins) b) For disposal of industrial and consumption wastes in the environment, according to defined procedures c) For industry of products that are harmful for the environment. This law will require payments for water use and for waste generation/disposal.
The Act on Flora	1999	The law on Flora defines the State policy of the Republic of Armenia on scientifically motivated protection, maintenance, reproduction and use of natural flora. This law identifies protected species. The law applies to all projects, including this one. The project will affect flora in a relatively small area that is modified by grazing and human use, but will not have an adverse effect on protected species or populations.

Law/policy	Date	Key areas
The Act on Fauna	1999	The Law on Fauna aims to: ensure conservation of animals and their genetic diversity, maintain the integrity of animal populations, protect animals from inappropriate disturbance, protect migration routes and regulate use of animal species. The responsibilities of different agencies (including the government, ministries and other State bodies, local authorities and local self-government institutions) are outlined. The law makes provision for listings of animals and their use; elaboration of the Red Data Book for animals; setting goals for animal conservation; measures for dealing with disputes; and international agreements relating to animal conservation issues. The law applies to all projects, including this one.
The Law on Alienation of Property for Social and State Needs	2006	The constitutional base for the expropriation of property for public and state purposes is the exceptional prioritized public interest. Constitutional conditions for the expropriation of property for public and state purposes are: a) Expropriation should be provided within law regulation. b) The equivalent compensation against expropriated property should be provided in advance. The project will require small amounts of land for the drill pads. A Resettlement Policy Framework has been developed for the project and will ensure compliance with this law.
Law of the Republic of Armenia on Environmental Impact Assessment and Expert Examination	2014	This new law supersedes the Law on Environmental Impact Assessment of 1995. See description below.
Underground Resources Code	2002	Contains the main directives for use and protection of mineral resources and underground water. A permit will be required for the exploration works.
Law on Waste	2004	The law provides the legal and economic basis for collection, transportation, disposal, treatment, re-use of wastes as well as prevention of negative impacts of waste on natural resources, human life and health. The law defines the roles and responsibilities of the state authorized bodies as well as of waste generator organizations in waste management operations. According to this law, the waste generated by the project activities should be recycled as appropriate, or disposed of in designated locations.
Law on the Protection and Use of Fixed Cultural and Historic Monuments and Historic Environment	1998	Requires an application to the Ministry of Culture to survey project sites to identify cultural resources, and approval by the Ministry of a chance find procedure. An application has been submitted and the Ministry will conduct a survey in early spring 2015.

EIA requirements

Any stipulated activity or concept /program/ in the Republic of Armenia, potentially impacting environmental values may be required to undergo a process of Environmental Impact Assessment and Expert Examination.

Legislation governing this process was recently changed by enactment of the Law of the Republic of Armenia on Environmental Impact Assessment and Expert Examination (July 22, 2014).

The new law is founded on three basic principles:

- The right of human beings to health, and availability of a favorable environment for living and creating;
- Standards for the efficient, integrated and rational use of natural resources; and
- The need for maintaining ecosystem balance and to protect all types of flora and fauna existing in nature, in consideration of the public interests of present and future generations.

The law contains the standard steps of the environmental assessment process for various projects and activities in Armenia.

Chapter One (Articles 2-7) defines the legal, economic, and organizational principles for conducting the mandatory state assessment for various project types, providing operative definitions, purposes and objectives of the law

Chapter Two (Articles 8-13) specifies administrative roles of several government entities, including the GoA, Territorial Authorities and Local Authorities.

Chapter Three defines the types of proposed activities subject to EIA and Expert Examination according to anticipated level of impacts and requisite EIA effort required**.** Types of proposed activities are grouped by sectors into three categories: "A", "B" and "C" by severity of environmental impact in diminishing order.

The exploration program will qualify as a Category A project in several categories, including Geological Surveys by Means of Drilling a Borehole at depths of more than 1,000m, Use of Fresh Groundwater Deposits, and Exploitation of mineral and ground water resources for business purposes.

If the decision is made to proceed to development of the geothermal power plant, it would be considered Category B under this law, as Geothermal Water Extraction or Energy Production with capacity of 8MW or more and (depending on whether the transmission line is 35kV or larger) possibly Electricity Transmission Lines 110kV (with total estimated length of 13 km; to be finalized during the design of potential geothermal power plant) and above).

The environmental assessment process includes two phases: a Preliminary Examination Phase and a Main Environmental and Human Health Impact Assessment Process. The Preliminary Examination Phase is initiated by submission by the Developer of a preliminary assessment application to the Competent Authority, and will be completed within 30 working days thereafter. During the Preliminary Examination Phase, government authorities will identify the scope of potential environmental impact of the development or activity concept, as well as the content and reporting requirements of the Main Environmental and Human Health Impact Assessment. The scope of stakeholders will be determined, and the terms of reference for impact assessment will be drafted and provided to the developer. The Developer will then commission an appropriately licensed natural or legal person to conduct the main impact assessment. Articles 17-21 consider the contents and process of the Main Examination. The present ESIA has been prepared specifically to meet World Bank requirements. After acceptance by the World Bank, it will be translated and submitted to the Competent Authority. It is expected the Competent Authority will consider that the TOR and this ESIA meet the

requirements for a Category A project. Thus, the primary remaining activities will be public disclosure and consultation with stakeholders.

Expert review and approval of ESIA

The expert examination conclusion will consist of introductory, descriptive, argumentative and concluding parts. Positive expert examination can contain binding requirements or conditions, for which time limits are established. In case of failure to comply with the specified requirements or conditions within the time limit expert examination will be repealed. Positive expert examination will be issued for the period specified in mainframe paper or planned activity documents, if another period is not defined in the conclusion, which should have a reasonable excuse.

Underground Resources Code

This code contains main directives for use and protection of mineral resources and underground water. A permit will be required for the exploration works.

This geothermal exploration program will require approvals by the Ministry of Energy and Natural Resources and the Ministry of Nature Protection. The Lead Agency for licensing / permitting exploration activities will be MENP. It is anticipated that the Implementing Agency (in this case, R2E2) will require a general project license, likely based partially on this ESIA, and Contractors will require permits for some of their specific activities.

MENP, in consultation with MNP and other relevant authorities, will establish license/permit conditions for environmental protection, hygiene and sanitary epidemiological safety and/or fire safety.

Once the license is issued, a schedule of taxes on its environmental pollution parameters and product charges will be established, and the licensee has to comply with this tax payment schedule.

2.2 International Agreements ratified by the Republic of Armenia

Armenia has ratified a number of international agreements and conventions relating to the protection of the environment and biodiversity.

- Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention, 1971). Armenia ratified the Ramsar Convention in 1993. The project will not affect wetlands recognized under Ramsar.
- Convention concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention, Paris, 1972). This convention was ratified in 1993. The project will not affect a UNESCO site.
- Convention to Combat Desertification (UNCCD, Paris, 1994). The UNCCD was ratified by Armenia in 1997. A project is currently being developed to meet obligations under this convention. This project will not contribute to desertification and so is not subject.
- Framework Convention on Climate Change (UNFCCC, Rio de Janeiro, 1992). The UNFCCC was ratified by Armenia in 1993, and production of a Country Study on Climate Change is underway. The drilling program would not contribute significant amounts of CO_2 or other greenhouse gases. Full-scale development could result in CO_2 emissions, and this would be examined in the separate ESIA if development is to take place.
- Convention on Biological Diversity (UNCBD, Rio de Janeiro, 1992). This convention was ratified by Armenia in 1993, and the first stage of implementation is currently being undertaken including the development of a National Biodiversity Strategy and Action Plan, and this first National Report (incorporating a Country Study of Biodiversity) to

meet reporting requirements to the convention. This project will not have a significant effect on biodiversity.

2.3 Other Requirements

The following World Bank Operations/Bank Policies and World Bank Group Guidelines will also apply to the project:

- OP/BP 4.01 + Annexes 'Environmental Assessment'. This project was originally considered to be Category B, but in general this ESIA was developed as if it were Category A.
- OP/BP 4.04 'Natural Habitats'. Although the land is used as pastureland and grazed by local farmers, it does support native grass and forb species and could be considered 'natural habitat'. Only small amounts of land will be converted, however, less than 2-3 hectares in total within a vast area of similar land.
- OP/BP 4.12 + Annexes 'Involuntary Resettlement'. There will be no physical displacement, although a few farmers may experience minor economic displacement due to disturbance during construction and minor take of public lands. A Resettlement Policy Framework has been developed for the project.
- OP/BP 4.11 'Physical Cultural Resources'. A chance find procedure will be developed.
- Handbook for Preparing a Resettlement Action Plan, IFC Environmental and Social Department. See OP 4.12 above.
- World Bank Group General EHS Guidelines. Drilling contractor will be required to implement mitigation from the Guidelines.
- World Bank Group General EHS Guidelines for Geothermal Power Generation, 2007. Drilling contractor will be required to operate in accordance with the Guidelines.

3 Physical and Natural Environment

3.1 General Environmental and Ecology

3.1.1 Investigation Area

The Karkar geothermal exploration site is located in Syunik Marz, the southernmost Marz of Armenia (Figure 3-1).

Figure 3-1. Map of administrative Marzes in Armenia

The general location of the geothermal exploration site is illustrated in Figure 1-1. A topographical representation of the site is presented here as Figure 3-2. For reference, the horizontal dimension on the map grid is equal to 1.0km. (The "old well" in 4-2 is the Soviet-era geothermal exploratory well (but not the old water well that will be exploited by the project). Surface water shown on the map derives from snowmelt from May to July and from shallow groundwater from mid-late autumn until winter; limited or no water is present from August to October. This water is used by domestic animals and wildlife but not by humans.)

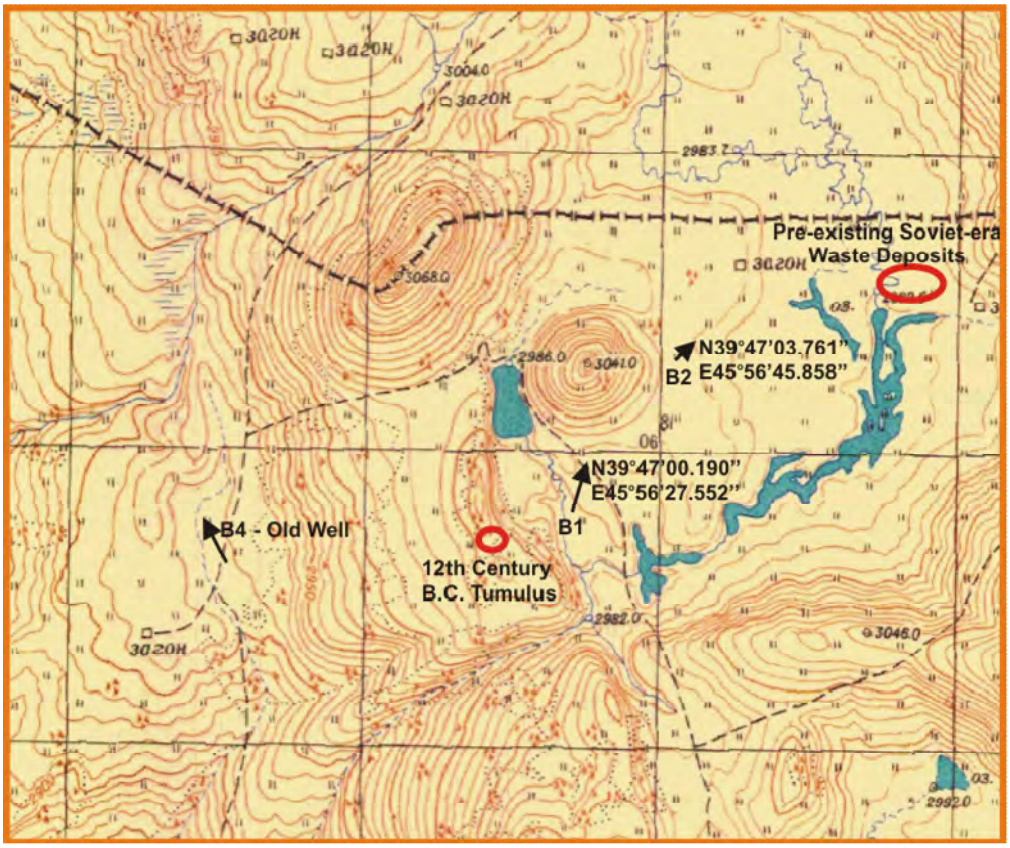

Figure 3-2. Topographic Map of the Karkar Geothermal Exploration Site

The slim-line exploratory well drill sites are at approximately 2,950m altitude asl, and are identified as B1 (Figure 3-3) and B2 (Figure 3-4).

Figure 3-3. Drill Site B1 with test trench

The location of pre-existing waste deposits from a Soviet-era geothermal test well is represented in the NE corner of the map. These wastes should not be confused with impacts associated with the current exploratory program.

The 12th Century B.C. Tomb located approximately 300m SW of B1 has been noted and reported to the Ministry of Culture. Project plans have been designed to avoid any interaction or impact on this archaeological site.

Figure 3-4. Drill Site B2

3.1.2 Geography

Syunik Marz is a green but mountainous area. The high-water major rivers are the Meghri, Voghdji, and Vorotan, none of which impinge the Karkar geothermal exploration site. Water from the exploration area does not flow to local rivers. The water either infiltrates or evaporates and does not connect or discharge to other surface waters. Summertime temperatures can reach more than 40 °C, although the average temperature is around 22 °C.

Syunik Marz is situated in the south of the Republic of Armenia (Figure 3-5). In the North the marz borders with Vayots Dzor Marz. In the South it borders Iran, (the length of border is 42 km), in the West, Nakhijevan, and in the East, Azerbaijan. Its border with Nakhchivan to the west is defined by the Zangezur Mountains. Its northern border follows the contours of the Artsakh Highland.

Syunik Marz is the richest Marz of the republic in mineral resources. The most important of them are non-ferrous metals (copper, molybdenum, zinc and others) and precious metals (gold, silver) and also non-metal useful minerals (construction and decorative stones, basalt raw materials, limestone and burnt shale marble and granite resources). Syunik Marz occupies a strategic, geographically, and politically important position, having rich resources of natural raw materials, significant industrial capacity, and being one of the largest administrative and economic regions of the republic. It is, however, sparsely inhabited in rural areas, exacerbated by its great distance from the capital, Yerevan, and lack of diverse modes of transport and communication. Its most developed economic components are the minerals industry and agriculture.[2]

Figure 3-5. Main Geographic Areas of Armenia

The main occupations of Syunik Marz industry are mining and production of electric energy. The Vorotan River hydroelectric station cascade dominates the production of electric power in the Marz. The agriculture of the Marz consists mainly of crops, primarily grains and potatoes, and animal husbandry, primarily cattle and sheep.

The territory of Syunik Marz consists of 4,506km^2, including 7 urban communities, 102 rural communities, 7 towns, and 127 villages. Its total population (December 2012) is 141,700, with 95,300 in urban environments and a rural population of 46,400.[3] There are three villages about 18km away, including Tsghuk (population 453), Sarnakunk (500), and Spandaryan (496).

[2] http://www.ada.am/rus/about-armenia/general-info/geography/syunik/

[3] http://www.armstat.am/file/article/marz_14_32.pdf

3.1.3 Geology, Seismic Situation and Soil

Geology

Twenty-five million years ago, a geological upheaval pushed up the Earth's crust to form the Armenian Plateau, creating the complex topography of modern Armenia. The Lesser Caucasus range extends through northern Armenia, runs southeast between Lake Sevan and Azerbaijan, then passes roughly along the Armenian-Azerbaijani border to Iran.

The morphogenetic evolution of the Lesser Caucasus has been strongly influenced by Plio-Quaternary volcanic and tectonic events and Pleistocene glaciations. Fluvio-lacustrine environments, indicated by diatomaceous deposits, prevailed in the Syunik region of southern Armenia during the Pliocene and Pleistocene. Pleistocene diatomaceous deposits at 1200-2200m contain leaf impressions and pollen, allowing local palaeo-climatic reconstructions. Before 1.21 Ma, tectonic movements (antecedents of the lower part of the Vorotan Valley) generated extensive lake formations with diatomaceous deposits. From 993 ka, volcanic eruptions produced lava flows covering the fluvio-lacustrine accumulations. In subsequent years, glaciers and fluvio-glacial deposits were probably present over all the principal uplands and valleys of southern Armenia. At 53.7 ka, 12.6 ka, 10.8 ka, and 4.1 ka, the development of travertines on some slopes and in some valleys highlights temperature and humid climate phases. Palaeobotanical studies of leaf and pollen flora show that the vegetation changed several times from forested to steppic phases in response to the climate oscillations of the Lower Pleistocene.[4]

Figure 3-6 provides an overview of Armenian geological structure.

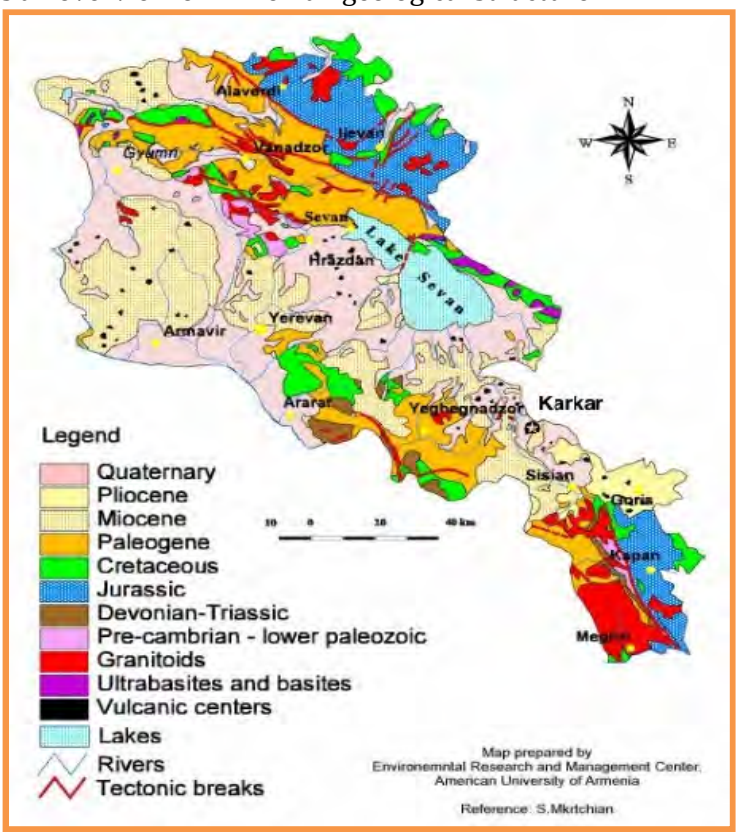

Figure 3-6. Geological Map of Armenia

[4] Ollivier, V., S. Nahapetyan, P. Roiron, I. Gabrielyan, B. Gasparyan, C. Chataigner, S. Joannin, J.-J. Cornée, H. Guillou, S. Scaillet, P. Munch, And W. Krijgsman. 2010. Quaternary volcano-lacustrine patterns and palaeobotanical data in southern Armenia. Quaternary International 223-224. P 312-326.

Seismology

The Caucasus Region is one of the most active segments of the Alpine-Himalayan seismic belt. It is also a collision zone between the Arabian and Eurasian tectonic plates. This collision is responsible for the complex deformation and associated intense earthquake activity affecting the region, including active mountain building in the Caucasus in general and the territory of Armenia in particular.

Practically all of Armenian territory is situated in an active seismic zone. The size of earthquakes ranges up to Richter 7.1 (according to instrumental recordings) and Richter 7.5 (according to historical and palaeo-seismic estimations). Focal depth is 10 km on average. The average recurrence interval of large earthquakes (Richter >5.5) is 30-40 years, both in the territory of Armenia and in the region as a whole, i.e. the Arabian and Eurasian plates collision zone.

Maximum seismic risk is in the area around the city of Yerevan, where active faults exist. Here, the Garni earthquake of 1679 was the most destructive, with a magnitude oscillating between Richter 5.5 and 7. Another destructive earthquake (Richter 6.9) occurred in Spitak in 1988.[5] Only recently (February 27, 2011), an earthquake of magnitude 3.2 occurred 37 km north of Gyumri.[6]

An overview of seismic faults in Armenia is provided as Figure 3-7.

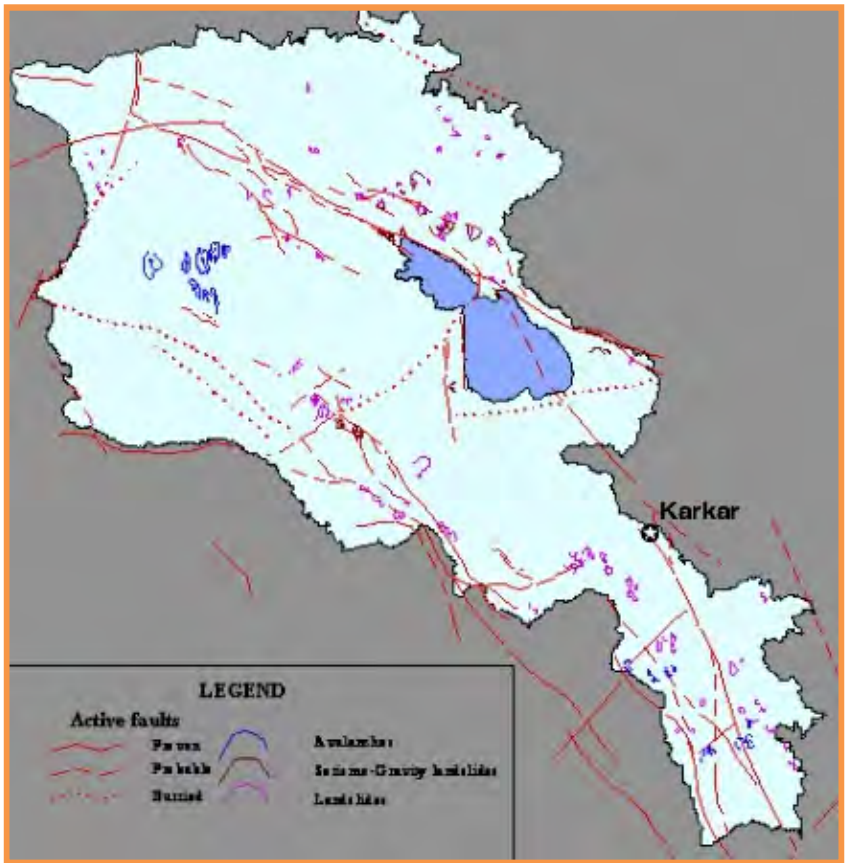

Figure 3-7. Map of Geological Fault Zones in Armenia

[5] http://www.nssp-gov.am/spitak_eng.htm

[6] http://www.emsc-csem.org/Earthquake/earthquake.php?id=210376

Soils

More than 15 soil types occur in Armenia, including light brown alluvial soils found in the Aras River plain and the Ararat Plain, poor in humus but still intensively cultivated; rich brown soils, found at higher elevations in the hill country; and black earth soils, which cover much of the higher steppe region. Much of Armenia's soil—formed partly by residues of volcanic lava—is rich in nitrogen, potash, and phosphates. Despite richness of soil, the labor required to clear the surface stones and debris from the soil has made farming in Armenia difficult.

Soil cover is very varied. All kinds of zonal soil types, shaped in mountainous districts of the Great Caucasus, can be encountered. Throughout the territory there are 5 classes, 15 genetic types, 33 pseudo/sub-types, several hundred appearance/form types of soil as well as soils of 135 origins. Zonal expansion is characteristic of 8 types out of the identified 15 genetic types. They occupy 91 percent of the territory. The remainder is covered by intra-zonal and azonal soils.

The most common of the zonal types are: mountain-meadow, mountain-meadow-steppe, mountain brown forest-soil, mountain chernozem, mountain chestnut and mountain-brown soils. In the areas where zonal types of soil were formed, the intrazonal types are also spread: fluvial-swamp, fluvial-grassland, irrigated meadow-brown, meadow-chernozem, turf-carbonated soils. Despite apparent vertical zonality being characteristic of soil cover, all soil types depend on the altitude of the district (Figure 3-8).

Figure 3-8. Map of Armenian Soil Zones

Soil erosion is a severe and increasing problem caused by poor agricultural practices, overgrazing, and uncontrolled deforestation. It affects approximately 60 percent of agricultural land. Total soil loss in Armenia is estimated to be about 8 m tons/year (0.3 tons/ha/year) varying from 40 tons/ha/year for denuded lands to 1 ton/ha/year for closed forests and well-managed pasture lands.[7]

[7] Biodiversity Assessment for Armenia. Task Order under the Biodiversity & Sustainable Forestry IQC (BIOFOR). USAID Contract # LAG-I-00-99-00014-00. Chemonics, Inc. Feb. 2000.

3.1.4 Meteorology

Armenia's climate is regionally diverse. The country is located in the subtropical zone, among ridges of the central part of the Lesser Caucasus Mountains. Despite this the subtropical climate is experienced only in the southern part of Armenia (Meghri region). It is an area of such subtropical plants as oranges, lemons, olives and other plants.

In other regions of Armenia the climate is markedly continental. Summer is dry and sunny, lasting from June to mid-September. Winter is short and quite cold with plenty of snow. In the mountains the average summer temperature ranges between +10 and +22°C, and in the winter temperatures range between +2 and -14 °C. In plain lands the average January temperature is -5 °C, and July temperature is +25 °C.

In autumn and spring frosts are frequently strong, and the soil temperature can fall to –28 °C at that. Heat distribution in Armenia depends on the height of the place. Even within a city the temperature between two neighboring districts can differ by 2-3 °C.

More than 90% of Armenia lies above 1,000 meters asl, which largely defined the climate. The average temperature in Armenia, as in other mountainous countries, falls by about one degree for every 200 meters of ascent.

The yearly precipitation amount depends on the height of the area: 200-800 mm on the average. The first rainy season in Armenia lasts from spring to early summer while the months of October and November experience the second spell of rain. In winter, mountain areas receive a lot of snowfall (up to 100-150 mm), which lies on the slopes until March-April and all year round on tops of the highest mountains. As a result, the site is only accessible from May to November.

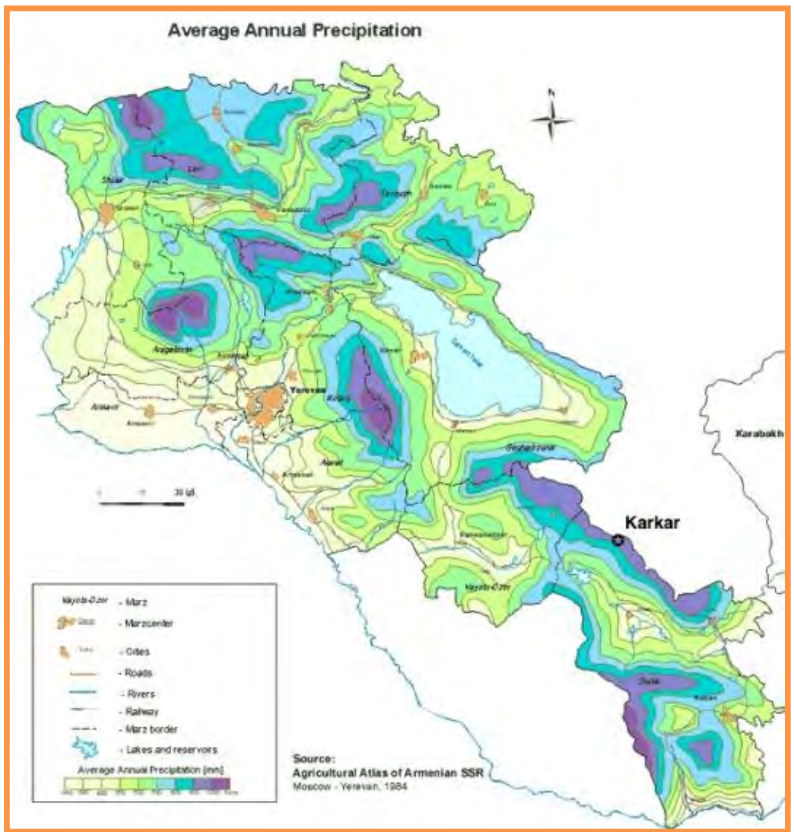

Figure 3-9. High Precipitation Rate in Karkar Area

3.1.5 Forests and Wetlands

Most Armenian forests are found in mountainous terrain between 500 and 2200m asl. The northeastern and southeastern parts of the country, and the eastern shore of Lake Sevan, have the most favorable climatic and environmental conditions for forest growth. Forest cover is generally highly fragmented, approximately 62% being in the northeast, 36% in the southeast and only 2% in the central region of the country.

Armenian forests are predominantly composed of complex mixes of broadleaf deciduous tree species (mostly Oak *Quercus* spp., beech *Fagus orientalis*, and hornbeam *Carpinus betulus* and *C. orientalis*).

The primary forested areas of Armenia are depicted in Figure 3-10. None of these areas exist in the Karkar project area.

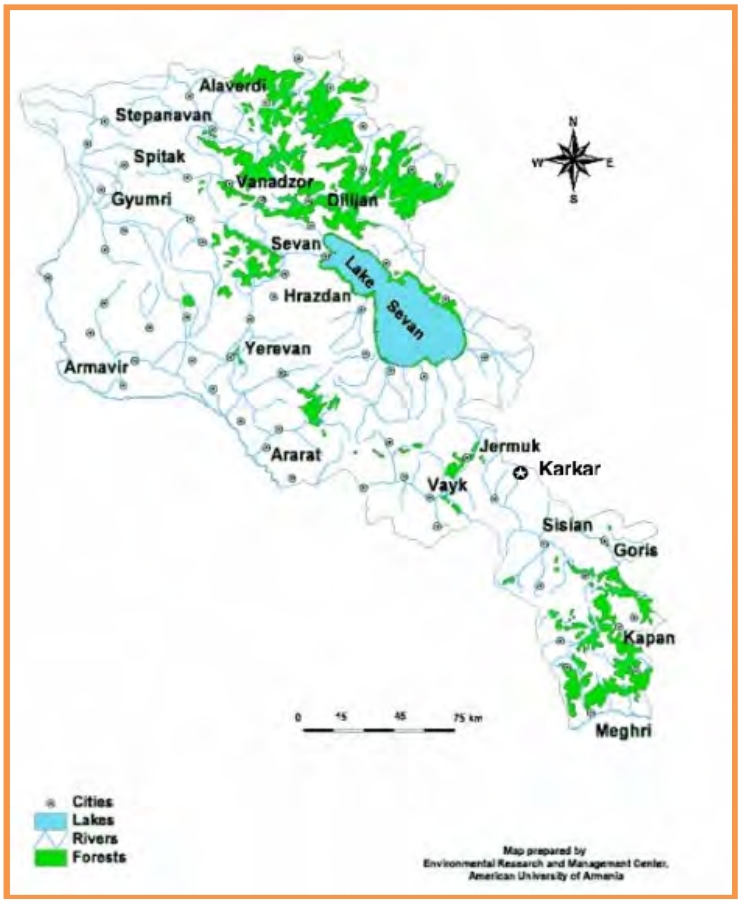

Figure 3-10. Primary Forested Lands of Armenia

Similarly, no major wetlands occur in the Karkar project area (Figure 3-11). The areas covered by and near the seasonal surface water shown on Figure 3-2 could be considered wetlands, although they are not subject to legal protection.

3.1.6 Flora and Fauna

The Karkar project site is located in the alpine meadow and carpet habitat of the Artsakh Highlands, at altitudes of 2500-3000m asl (Figure 3-12). Subalpine and alpine plant associations in Armenia are found mainly between 2200-3600m. A severe climate is characteristic of the alpine zone, with minimum temperatures of about -27°C. The warmest month in this zone is August, when maximum temperatures reach 17-18°C. The vegetation growth period is of short duration and characterized by large daily fluctuations in relatively low temperatures.

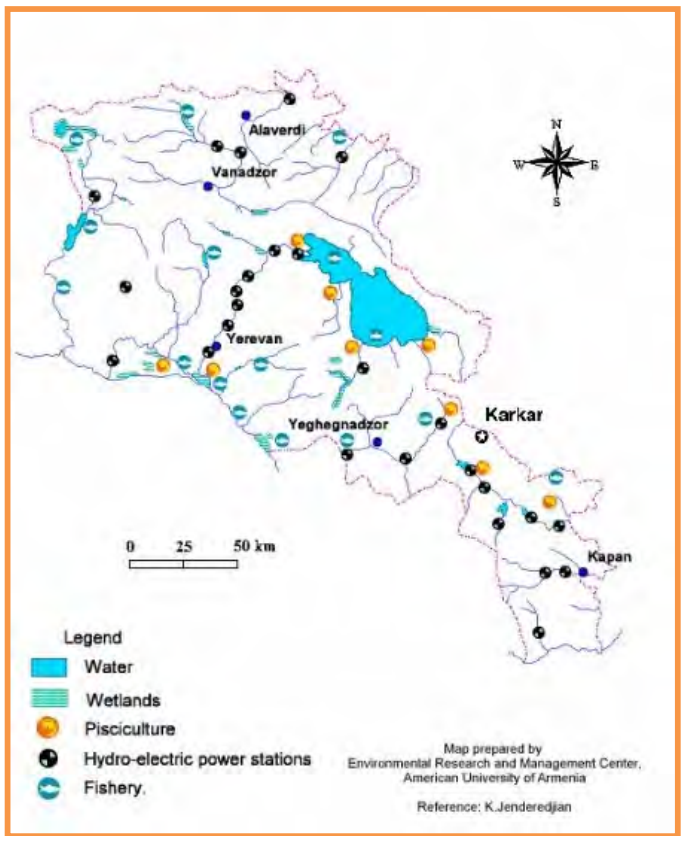

Figure 3-11. Primary Wetland Areas of Armenia

Figure 3-32. Vegetation and Habitat Zones of Armenia

The relief of mountain meadows is diverse. Plains and slopes of variable steepness are encountered here. Frequent significant areas are covered with crags, screes and chaotic conglomerations of boulder fields. These emerge as a result of tectonic processes and centuries-old erosive water activity that washes soil down to the valleys below. Significant rock fields are found near the snowfields where numerous streams originate throughout the frost-free snowmelt season.

The road will cross subalpine meadows, which are found at altitudes of 2,300 - 2,800 m, and generally support a distinct assemblage of grasses, particularly in northern regions, and are extremely important for local economies. These lands frequently are used as summer pastures, and several plants are often collected and used as sources of vitamins and medicines. Almost 500 plant species have been recorded from this habitat type[8] throughout Armenia. Typical subalpine vegetation includes assemblages of tall grass, motley grass, and meadows with layer shrubs *Festuca, Bromus*, matgrass, fescue, legumes and sedge.

The drill pad sites (and any future plant site) will be in alpine meadows, which occupy the highest altitudes above subalpine meadows (up to 3,200 m in the north and 3,400 m in the south) and represent the principal pasturelands of the country, covering about 28 percent of its territory. Alpine vegetation is characterized by its distinctively short but quick growth and ability to form carpets of dense grass (Figure 3-13). Most of the alpine plants are perennials with short sprouts and some of these are able to overwinter with green leaves. Alpine meadows generally comprise assemblages of fescue, matgrass, *Bromus,* and *Poa*, as well as mountain sedge and motley grass. Cliff and rocky outcrops with accumulations of soil in crevices and wind-eroded areas are occupied by high mountain rock xerophytes. In areas shadowed by rocky massifs and in the depths of boulder field, groups of moss and lichens develop.[9]

Figure 3-43. Typical Autumn Alpine Habitat of the area

Grazing pressure has caused significant changes in both vegetation cover and species composition, which was evident to the project team. Significant areas of alpine meadows, including the project area, are experiencing an overall decline of productivity, and disappearance of important and desirable plant species such *as Campanula tridentata, Poa*

[8] 2000. Chemonics, Inc. Biodiversity Assessment for Armenia. Task order under the Biodiversity & Sustainable Forestry OQC (BIOFOR), USAID Contract # LAG-I-00-99-00014-00, USAID Environment and Natural Resources Division.

[9] http://www.armeniabirding.info/mnt_mdw.html

araratica, and *Plantago saxatilis*. Climate change also appears to be impacting species distribution, with pasturage being displaced by invasive species unsuitable as fodder, especially *Tripleurospermum transcaucasicum*.[10]

High-altitude bird species include lammergeier (*Gypaetus barbatus*), Caspian snowcock (*Tetraogallus caspicus*), alpine chough (*Pyrrhocorax graculus*), wallcreeper (*Tichodroma muraria*) and snowfinch (*Montifringilla nivalis*). Wild goats survive in the less accessible areas. Very numerous small mammal burrows were noted during field visits, most likely inhabited by the common Ural field mouse, *Apodemus uralensis (IUCN Least Concern)*.

The 1999 Biodiversity Report indicates that 24 species of endemic plants and 94 species of rare or endangered plants occur in Syunik Marz (Figure 3-14). Typically the project area's plants of conservation concern would be found in rocky areas that are unattractive to domestic animals. The history of grazing in the wider area has left very few areas with shrubs, but where they do remain, they are of conservation importance. However, there are no shrubs along the road or near where the drilling pads (and possibly the plant site) will be located, and so no shrubs will be affected.

A relict dwarf perennial legume, *Vavilovia formosa* (endangered species), two low growing flowering shrubs in the rose family, *Potentilla cryptophila (*endangered species) and *Potentilla porphyrantha* (critically endangered endemic species), and a perennial flowering herb, *Delphinium foetidum* (vulnerable species) occur in similar habitats and may occur locally[11], although they were not identified during site visit. A pre-construction field inventory to mark and delineate any occurrence of individual specimens and/or populations of protected species in and near development areas will be conducted during the spring growing season prior to construction to allow micro-location of project elements to avoid damage to individual plants or populations.

Figure 3-14. Endemic and Threatened Flora Distribution
White = Numbers of Endemic Species
Black = Numbers of Rare & Endangered Species

[10] Fifth National Report of the Republic of Armenia to the Convention on Biological Diversity, Sept. 2014.
[11] Institute of Botany, Armenian National Academy of Sciences, Personal Communication.

The area is not noted as a special faunal habitat (Figure 3-15) but some protected species may occur in the area at times, including the Brown Bear, *Ursus arctos* (Listed in Red Book; small vulnerable Armenian population); the Armenian mouflon (Figure 3-16), *Ovis orientalis orientalis* (Red Book endangered species; IUCN vulnerable species), and the Caspian Snow Cock, *Tetraogallus caspius* (Species of Special Concern: threatened status)[12]. The Armenian Mouflon has been observed south of Highway M2, but is not documented north of the highway. Because dogs are present in warm months, it is unlikely that large mammals would be present, so if they do occur, it would be in winter.

In addition, the site's remote location and presence of surface water springs make it attractive for seasonal use as a rest stop for migrating birds. This has been reported anecdotally but no such use has been documented in the literature or observed during site visits.

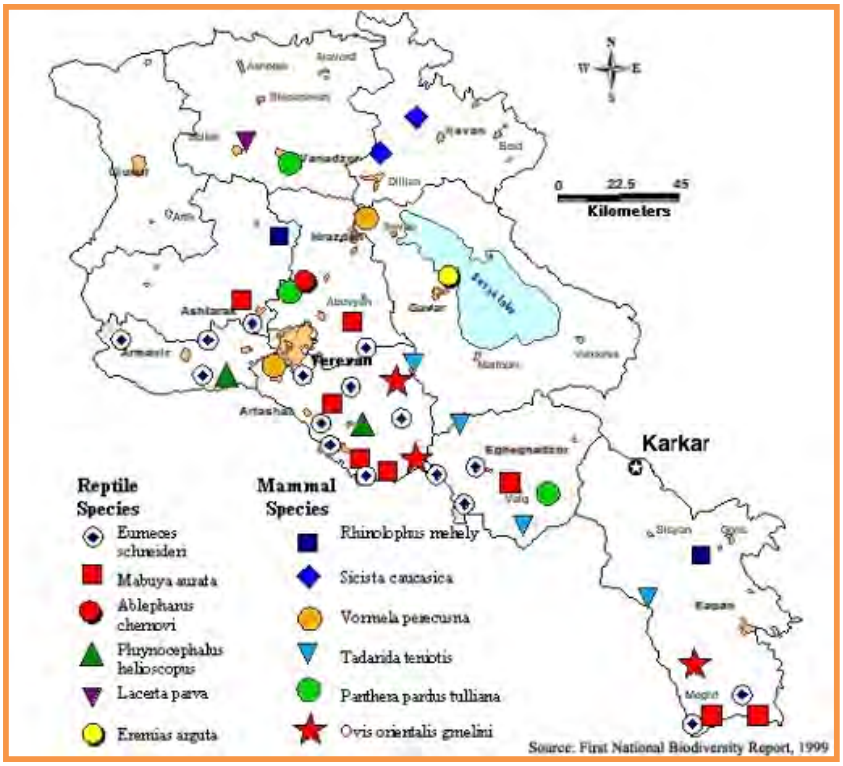

Figure 3-15. Distribution of some Threatened Fauna

Figure 3-56. Armenian Mouflon

[12] WWF-Armenia, Personal Communication

3.1.7 Protected Areas

Although Armenia has numerous areas set aside for biodiversity protection, none are in the immediate area of the proposed geothermal exploration program at Karkar (Figure 3-17). The nearest Important Bird Area designated by BirdLife International is near Gorayk, about 15km to the northwest. Its primary conservation value is as a breeding and hunting ground for Lesser Kestrel (*Falco naumanni)* – listed as Least Concern on the IUCN Red List, Vulnerable on the Armenian Red List.

Figure 3-17. Protected Areas nearest the Geothermal Exploration Project

3.2 Socio-Economic Conditions

3.2.1 Population within the Investigation Area

Three villages lie on the M2 Highway in the proximal range of the geothermal exploration area: Tsghuk, Sarnakunk, and Spandarian (Figure 3-18).

Figure 3-68. Villages in Karkar Environs

These three villages have a combined population of fewer than 1,500 people, who are almost exclusively engaged in agricultural pursuits, particularly in husbandry of sheep and cattle (cows and bulls). The populations of these communities are shown in Table 3-1, based upon figures provided by community leaders during personal communications.

Table 3-1. Village Populations[13]

Category	Tsghuk	Sarnakunk	Spandaryan
People	453	500	496

3.2.2 Historical and Cultural Sites

The Armenian Ministry of Culture has not surveyed the Karkar specific area for presence of historical and cultural sites, but project activities determined there is a single 12th Century B.C. tomb located near the exploratory drilling area, as depicted in Figure 3-2.

Nevertheless, the history of this region is rich, and the potential for discovery of historical and cultural sites is genuine. The recorded history of Syunik Marz begins in the 1st Century A.D., and extends uninterrupted to the present day. It is well known and acknowledged that the area was populated for several thousand years before this, as supported by the existence of the single known 12th Century B.C. located approximately 300m SW of drill Site B1.

The potential for the existence of historical and cultural sites is acknowledged and responded to in the EMP.

3.2.3 Indigenous Peoples

There are no records of indigenous peoples in the strict sense of the term in Armenia; 97.5% of the population is Armenian. A few minorities can be found, such as Kurds, Yazidis, Russians and Georgians. It is possible that some of these minorities might exist in a situation of vulnerability, but there is no record of a systematic discrimination or of a general vulnerability situation in Armenia or in Syunik Marz.

3.2.4 Gender Aspects

The Republic of Armenia grants women equal rights under the law, including equal entitlement to education, health care, employment and certain anti-discrimination measures. However, such legislation is not widely applied since Armenia does not have a public agency designed to deal with gender issues.

Due to frequent out-migration of men from the investigation area, the number of female single headed households is considerable. Female-headed households are particularly vulnerable to falling into extreme poverty since women are left alone with the burdens of income generation, household and childcare responsibilities. Another consequence of male migration has been the growth in "parallel families", where migrant male workers establish another family in their new location. This increases the vulnerability of women especially when men return home in poor health or infected with sexually transmitted diseases.

The National Action Plan 2004-2010 on Improving the Status of Women and Enhancing Their Role in Society emphasizes the need for effective institutions to address women's issues. The Plan also highlights the unequal participation of women in the country's political and social spheres and calls for women's increased involvement in democratization and the development of civil society. To improve the social and economic condition of women, the Plan recommends expanding business opportunities for women, especially in rural areas.

[13] Based on current numbers obtained by personal interviews with village leaders in November, 2014.

3.2.5 Land Use Patterns and Agriculture

The land extending from Highway M2 to the Karkar geothermal exploration site is virtually all dedicated to open pastureland, which is owned by the three local villages and parsed among local shepherds for efficient and fair distribution of use. The pasture is used generally from late June/July to September/early October, depending upon seasonal weather.

3.2.6 Livelihood and Housing

Despite economic reforms and some recent growth, unemployment and poverty remain widespread in Armenia. Agriculture is the country's largest labour sector, followed by services and industry. The UNDP report (2002) notes that rural poverty used to be lower than urban poverty, and access to land has been important in the explanation of this phenomenon. However, rural poverty in 2003 has surpassed its urban counterpart, stagnating at a level similar to 1996. While access to land is still widespread in rural Armenia, amongst farm households, the poor and extreme poor are those who own very little land, or the landless. The poorest Armenians are found in rural areas with the least favourable conditions for agricultural activities. There is a stark contrast between the city of Yerevan and the remote rural areas in terms of socio-economic opportunities.

Within the southeastern region of Armenia, Syunik Marz has a lower rate (2010 figures) of poverty at 34.6% than does neighbouring Vayots Dzor, with a 42.9% rate.

For employees, wages are higher in Syunik region than in Vayots Dzor. This reflects the high percentage of urban population in Syunik and the proximity to Iran and the main trade route. Vayots Dzor region is more remote and rural, despite its growing tourism potential. However, most households do not have a regular wage-based income, but depend on their agricultural produce in a sort of extended subsistence based economy.

Leaders of the Villages Tsghuk, Sarnakunk, and Spandaryan indicated that supplies of electricity and water are adequate and dependable in their villages.
The population of the three nearby villages is engaged almost exclusively in agricultural pursuits, particularly in husbandry of sheep and cattle. The geothermal exploration area and the territory crossed by the access road are particularly important as pasture supporting these endeavors. The numbers of cattle and sheep are estimated in Table 3-2, based upon figures provided by community leaders during personal communications.

Table 3-2. Numbers of Domestic Animals in Nearby Villages[14]

Category	Tsghuk	Sarnakunk	Spandaryan
Sheep	1,230	2,000	1,200
Cattle	1,142	1,000	1,000

Other important local crops include fodder crops to feed sheep and cattle in winter months, cereals for local use including barley and spelt (See Text Box), and vegetables and potatoes for local consumption.

Village Sarnakunk also operates a local cheese shop that exports its product to Yerevan.

[14] Based on current numbers obtained by personal interviews with village leaders in November, 2014.

4 Potential Impacts of the Exploration Program

The following evaluation assumes that the exploration program will include two slim wells and one production-size well.

The following symbols are used in Tables 4-1 and 4-2. The extent of impacts shown in the tables is what could be experienced after the mitigation described in Chapter 5.

Table 4-1. Scoring Symbols

Extent of Sensitivity		Extent of Impact	
■	= Low	■	= Low
■■	= Medium	■■	= Medium
■■■	= High	■■■	= High
		O	= Nil
		→	= Locally Positive
		↠	= Regionally Positive

4.1 Potential Impacts of Construction of Exploration Program Components

Table 4-2.Impacts During Design and Construction Phases

Impact of/on	Sensitivity	Extent of Impact on/by	Duration of Impact	Direct/ Indirect	Comments
Access road routing and construction	■■■	■	Long term	Direct	The route of the road will follow the existing road, and nearby areas are heavily modified by grazing. There is a small possibility that improvements to and use of the road could affect individual specimens or small populations of protected flora due to small re-routings or installation of drainage. Construction and traffic will also generate noise and disturbance that will displace any nearby wildlife.
Drill Pad(s) Construction	■■■	■	Long term	Direct	Drill pads will cover and destroy covered flora. Year 1 drill pads for slim well coring need only be 20m x20m in size. However, these drill pads may be enlarged to 50m x 75m for Year 2 drilling, if required. Thus, they will be sited as if their size will be 50m x 75m at startup. Construction and traffic will also generate noise and disturbance that will displace any nearby wildlife. If not controlled, nearby surface water and wetland-like areas could be disturbed by construction activities and workers.
Drilling Mud Sumps and Water Reservoirs	■■	■	Short term	Direct	A lined mud sump pit of at least 1,500m^3 capacity will be constructed to store drilling wastes, using natural depression to minimize excavation. Flora in the affected areas will be destroyed, and in the surrounding areas could be damaged. Construction and traffic will also generate noise and disturbance that will displace any nearby wildlife.
Truck Traffic	■	○	Short term	Indirect	This project will involve significant truck traffic (up

Table 4-2.Impacts During Design and Construction Phases

Impact of/on	Sensitivity	Extent of Impact on/by	Duration of Impact	Direct/ Indirect	Comments
					to 14 round-trips per day for rock) on Highway M2 through village Tsghuk, primarily to bring rock from quarries to the road during the construction of the access road. This could disturb residents and create a safety hazard to local pedestrians and traffic, as well as to domestic animals and wildlife.
Soil & Erosion	■	O	Short term	Direct	Disturbance of the vegetation cover could lead to erosion and loss of topsoil in early spring and in wet weather, although the gently rolling, largely flat land would prevent any lost-distance transport and loss. Failure to save and store topsoil could prevent long-term restoration of native species after decommissioning.
Landscape and Visual Aspects	■	■	Short term&Long term	Direct	All construction will be at ground level, including the road, drill pads, water handling facilities, and waste handling. Construction phase influence on landscape and temporary visual aspects will be limited to construction equipment silhouettes. Only a short distance of the road is visible from M2, and the drill pads will not be visible from any populated area or road.
Noise	■■	■	Short term	Direct	Primary sources of noise include heavy equipment used for road, drill pad, and sump pit construction, vehicle traffic.. Except on the main highway, there are no human receptors except workers and on occasion a few shepherds. During peak construction periods, any nearby wildlife would be disturbed and likely displaced.
Air Quality	■	■	Short term	Direct	Traffic on earthen and gravel roads and the temporary exposure of bare ground at the drill pads will generate dust, and vehicles and equipment engines will generate combustion

Table 4-2.Impacts During Design and Construction Phases

Impact of/on	Sensitivity	Extent of Impact on/by	Duration of Impact	Direct/ Indirect	Comments
					emissions.
Ground water	■	■■	Long-term	Direct	Up to 35 l/sec groundwater will be extracted from a Soviet-era well. Spills or improper waste and materials management could contaminate shallow groundwater. Drilling muds could contaminate aquifers penetrated by the drill string. Aquifers are localized, so there will be no transboundary effects.
Surface water	■■■	■	Short-term	Direct	Seasonal waterways crossed by the road and seasonal surface water near the drill pads could be contaminated by erosion or fuel spills, or by ground disturbance if approached by heavy equipment.
Flora	■■	■	Long term	Direct	Any road widening or re-routing would cover and destroy flora. Construction of drill pads will require vegetation to be removed.
Fauna	■■	■	Short term	Indirect	Large animals will avoid construction areas where there are noise and human disturbance. Small animals near human activity will be displaced and those in the project footprint will be displaced or killed. Construction disturbance could cause waterfowl and other seasonal migrants that use nearby surface water to avoid the area. The 6.5-km pipeline could present a barrier to wildlife movement across the road.
Protected Areas and Wetlands	O	O	N/A	N/A	No protected area or Important Bird Area will be affected. Erosion or spills could contaminate or otherwise affect several small and seasonal ponds and streams that could provide wildlife support near the drill pads.
Solid Waste generated by construction	■■	■	Short term	Direct	Wastes could include spoil from clearing land, nonhazardous construction debris, oily debris and

Table 4-2.Impacts During Design and Construction Phases

Impact of/on	Sensitivity	Extent of Impact on/by	Duration of Impact	Direct/ Indirect	Comments
					other hazardous materials used in vehicle and equipment maintenance, contaminated soil and cleanup media from spills, drilling muds, sanitary water and domestic waste. Improper waste management could contaminate soils and water and create an attractive nuisance for domestic animals and wildlife.
Health and Safety of Workers	■	O	Short term	Direct	Workers could be injured or killed by improper use of vehicles and equipment or in accidents. Transport of people and materials to and from the site will also expose workers to the risk of injury or death in traffic accidents.
Health and Safety of Local Population	■	O	Short term	Direct	Increased traffic would present the only potential risk to local populations.
Historical & Cultural Sites	■■	O	Long term	Direct	Excavation could damage or destroy historic or prehistoric artifacts. The nearby tomb and its artifacts could be removed, damaged, or destroyed by workers. The nearby medicinal spring could be disturbed.
Land Use, Land Acquisition, and Loss of Livelihoods	■	O	Short term	Direct	Construction activities could disturb livestock grazing, and the areas around the drill pads (up to several hectares surrounding the 50 x 75m drill pads) and the much smaller sumps will be removed from grazing use. The 6.5km water pipeline could provide a barrier to livestock crossing the road and thus reduce livestock access to land.
Involuntary Physical Displacement	O	N/A	N/A	N/A	This project will cause no involuntary displacement.
Gender Aspects	■	O	N/A	N/A	This project would have no adverse gender implications and could provide opportunities for

Table 4-2.Impacts During Design and Construction Phases					
Impact of/on	**Sensitivity**	**Extent of Impact on/by**	**Duration of Impact**	**Direct/ Indirect**	**Comments**
					women
Vulnerable People	■	→	Long term	Direct	There should no effect on vulnerable people.
Local Workforce	■	→	Short term	Direct	The local workforce may realize temporary employment opportunities.
Local Amenities	■	→	Long term	Direct	No effect on electricity or water utilities. The improved road will provide better access to pastures.

4.2 Potential Impacts of Drilling and Decommissioning

Table 4-3. Impacts During Drilling and Decommissioning

Impact of/on	Sensitivity	Extent of Impact on/by	Duration of Impact	Direct/ Indirect	Comments
Drill Mud Sumps	■■	■	Short term	Direct	Mud and free water would be attractive to wildlife, birds, and domestic animals. Liner leaks could contaminate soil and/or groundwater.
Wastes	■■	■	Short term	Direct	Drilling wastes would include hydraulic fluids, drilling fluid and muds, mud additives, geothermal fluids (reject fluids), pipe dope, used oils and oil filters, rig wash, spilled fuel, drill cuttings, drums and containers, spent and unused solvents, paint and paint washes, sandblast media, scrap metal, solid waste, and garbage. Improper management could contaminate soil, shallow ground water, and surface water, and could present a hazard to workers.
Truck Traffic	■	■	Short term	Direct	Truck traffic during drilling will be much reduced compared to construction, but could still disturb residents or present a safety hazard on M2, or could have minor impacts on wildlife or domestic animals along the access road.
Soil & Erosion	■	O	Short term	Direct	Erosion could be caused by off-road vehicle use or unauthorized disturbance of area vegetation.
Landscape and Visual Aspects	■	■	Short term &Long term	Direct	The drill pads are not visible from any road or populated area, so there will be no landscape or visual impacts.
Noise	■	■	Short term	Direct	Primary sources of noise will include generator and drilling rig engines, which could reach 80 to 115 decibels at the site boundary. Other than a few transient shepherds, there will no off-site human receptors. Noise will disturb susceptible wildlife for some distance away from the drill pad (and its

Table 4-3. Impacts During Drilling and Decommissioning					
Impact of/on	**Sensitivity**	**Extent of Impact on/by**	**Duration of Impact**	**Direct/ Indirect**	**Comments**
					associated construction camp).
Air Quality and Climate Change	■	■	Short term	Direct	Emissions would come from engines, including those of vehicles and equipment, generators, and drill rig. There could also be releases of geothermal vapors, typically including hydrogen sulfide, carbon dioxide, mercury, arsenic, and boron, depending on downhole conditions. This could expose workers to dangerous levels of some vapors. Traffic on the access road could generate local dust. Emissions would not have a measurable impact on air quality or climate change. The remoteness of the site from human habitation will prevent impacts on surrounding populations.
Groundwater Resources	■■	■	Short term	Direct	The wells will almost certainly encounter and penetrate freshwater and brackish or brine aquifers Drilling into the reservoir can create pathways for geothermal fluids, which are under high pressure, to rise and mix with shallower groundwater. Impacts of these pathways could include the alteration of natural circulation of geothermal fluids and usefulness of the resource. Geothermal fluids may also degrade the quality of freshwater aquifers. Drilling muds may also contaminate aquifers. Improper well closure/abandonment would also present the potential to contaminate groundwater by leaving open pathways to shallow and deep aquifers. Surface spills and improper management of drilling mud, wastes, or hazardous materials (fuels, etc.) could contaminate shallow ground water. Withdrawals from the old Soviet water well should

Table 4-3. Impacts During Drilling and Decommissioning

Impact of/on	Sensitivity	Extent of Impact on/by	Duration of Impact	Direct/ Indirect	Comments
					not affect groundwater table, as the withdrawal rate will be far below historic rate that were sustained over many years.
Surface Water Resources	■	■	Short term	Direct	There will be no use or removal of surface water. Surface water in nearby ponds/streams could be contaminated by erosion or spills, or by unauthorized access by workers, any of which could in turn affect wildlife, birds, and/or domestic animals.
Flora	■■	■	Long term	Direct	There should be no additional impacts on flora due to drilling absent unauthorized ground disturbance or vegetation cutting. Native vegetation will be restored following decommissioning, if no geothermal resources are found.
Fauna	■	■	Short term	Indirect	Fauna will avoid the exploration site in reaction to noise and human presence. If left open and accessible, sumps containing high concentrations of minerals and chemicals from drilling fluids could adversely impact wildlife, birds and livestock. There would be no impact on migrating birds, as drilling will not start until early summer, after the spring migration is done, and the area would not be attractive to birds in the fall migration season since there is limited or no surface water.
Protected Areas and Wetlands	O	O	N/A	N/A	No protected areas will be affected. The nearby wetland-like area will not receive any intentional discharges or other physical disturbance but could be affected by uncontrolled run-off and erosion.
Health and Safety of Workers	■	O	Short term	Direct	Workers could be exposed to drilling muds, geothermal fluids or steam, hydrogen sulfide, and hazardous materials such as petroleum, oils, and lubricants; and to construction-related hazards.

Table 4-3. Impacts During Drilling and Decommissioning					
Impact of/on	**Sensitivity**	**Extent of Impact on/by**	**Duration of Impact**	**Direct/ Indirect**	**Comments**
Health and Safety of Local Population	O	O	Short term	Direct	No health and safety risks to local populations are realistically anticipated. All operational activity will be remote from villages and local farms, and no inhabitants should be at risk.
Historical & Cultural Sites	■		Long term	Direct	No potential effects absent unauthorized activity by workers.
Land Use,, Land Acquisition, Livelihood	■	O	Short term	Direct	No effects beyond those described for construction: the small areas around the drill pad and sumps, and along the road, would be avoided by grazing animals. This will not result in significant loss of livelihoods and is addressed in the Resettlement Policy Framework.
Involuntary Displacement	O	O	N/A	N/A	No physical displacement.
Gender Aspects	O	O	N/A	N/A	No foreseeable gender implications.
Vulnerable People	O	O	Long term	Direct	Local inhabitants will be largely unaffected by the exploratory efforts,
Local Workforce	■	→	Short term	Direct	Possibly temporary employment opportunity for one or two workers, possible economic opportunities to local suppliers (e.g., food).
Local Amenities	■	→	Long term	Direct	No effect on electricity or water utilities. However, the improved access road will provide for enhanced access to pastures and other nearby areas.

5 Impact Mitigation

Approaches to avoid, reduce, or otherwise mitigate potential impacts from the Karkar exploration program are discussed below. These concepts form the basis of the Environmental Management Plan (EMP) presented in Chapter 6.

The final design of some elements of the project remains to be completed. This includes the specific locations where the road will need improving, the precise locations of the drill pads exact components of the drilling muds, design of on-site living quarters, etc. As such, this provides the flexibility to consider changes to the final designs in order to minimize impacts. The Contractor(s) will be obliged to comply with the environmental impact mitigation provisions discussed below.

Table 5-1. Required Impact Mitigation Measures

Issue	Environmental Issue	Reference Sections
1	Floral Biodiversity Protection	5.1.1
2	Faunal Biodiversity Protection	5.1.2
3	Cultural Resource Protection & Chance Finds Procedure	5.1.3
4	Water Supply and Management	5.1.4
5	Well Construction & Groundwater Protection	5.1.5
6	Erosion Control and Soil Conservation	5.1.6
7	Drilling Fluids Management	5.1.7
8	Mud Sump Construction & Management	5.1.8
9	Local Consultation	5.1.9
10	Fuel and Hazardous Materials Management	5.1.10
11	Solid & Liquid Waste Management	5.1.11
12	Materials Storage/Staging Area Management	5.1.12
13	Living Facilities Management	5.1.13
14	Vehicular Traffic	5.1.14
15	Worker Health & Safety	5.1.15
16	Worker Code of Conduct	5.1.16
17	Emergency Preparedness & Response	5.1.17
18	Winterization & Spring Opening	5.2
19	Decommissioning	5.3

5.1 Mitigation Measures

5.1.1 Floral Biodiversity Protection

Construction of road improvements outside the current footprint and of the drill pads will require the destruction of flora and possibly some short-lived burrowing rodents and smaller fauna. Although site visits did not identify species of concern, the possibility that protected species may be present will be addressed through pre-construction surveys by qualified experts. If specimens or populations of protected flora are identified, they will be inventoried and their locations marked as being off-limits, and project elements will then be "micro-located" to avoid disturbance or destruction. This could involve small adjustments to either small road re-routing or to the design of improvements (by reducing the extent of graveling, for example) and also adjustments to the exact location of drill pad boundaries.

The pre-construction surveys will be completed at a time of warming spring temperatures coinciding with active seasonal growth of local flora, which will enhance the ability to identify protected plant species. During these evaluations, protected species will be inventoried along the entire route of the roadway, and all identified protected plants and populations that are deemed at risk of impact from road construction must be clearly marked with stakes, colorful tapes, or other demarcations that can be readily seen by project staff and workers. Occurrence of threatened or endangered floral species along lengths of the road that require improvements or the installation of drainage may require the routing of the road to be adjusted, even by a few meters, to avoid damaging the flora. Contractor design engineers will accompany the biodiversity expert(s) to ensure locations are selected that are suitable for their purposes while at the same time avoiding impacts on protected species.

The same procedure will be followed for siting of drill pads and any associated storage and staging sites and employee living facilities. Drill pads for Year 1 drilling may only be 20m x 20m in size, but the drill pads will be sited as for the larger 50m x 75m drill pads that would be required if the project proceeds to Year 2 drilling. In consultation with design engineers, locations of drill pads and surrounding areas that could be disturbed will be selected to avoid protected species.

All workers will receive training concerning the meaning of the flora markings and the need to avoid impacting these areas.

If the geothermal resource is discovered to be appropriate for development of a geothermal power plant, the drill pads will be left in place pending Government decisions concerning development. If discovered resources are insufficient for geothermal power development, or if the Government ultimately decides against development of geothermal power, then the drill pad areas will be reclaimed. All equipment will be removed and transported for recycling or disposal at off-site locations approved by the Ministry of Nature Protection. Topsoil reserved from pad construction will be replaced over the gravel and other disturbed area. Seeds and roots retained in the topsoil may be adequate for cover regrowth, but the replaced topsoil will be replanted with native seeds or plants if so advised by flora experts. [See also Soil & Erosion section below.]

5.1.2 Faunal Biodiversity Protection

Past visits did not detect the presence, nor signs of past presence, or large mammals or protected fauna species. However, to ensure there is no possibility that individuals or populations will be adversely affected, the same procedure will be followed as for flora, at the same time. Experts will evaluate the road and the prospective drill pad locations for the presence (or signs of past presence) of fauna, in particular large mammals and protected species. If locations of particular concern (hibernation or rearing dens, for example) are identified, they will be demarcated as being off-limits, and project elements will be micro-located to avoid these areas during time periods of concern. Workers will be trained to avoid any such areas.

The water pipeline from the water supply well to the exploration well(s) could serve as a barrier to wildlife movement across the road. In areas where it cannot be placed in the existing ditch that held the original pipe, the pipe will be covered with soil and rock every 100 meters to allow crossing.

5.1.3 Cultural Resource Protection

As is true for flora, cultural resources cannot readily be moved, so their existing sites must be preserved and protected. As a project prerequisite, the Armenian Ministry of Culture requires that R2E2 and/or the Contractor(s) receive a permit from the Ministry. This requires a direct

application, which initiates a physical inspection of the site by Ministry experts to determine the presence of archaeological, historical, or cultural resources, and to decide acceptable development attributes to protect these resources. For timing purposes, it is advisable to submit this application at the earliest practical date, and it has been submitted so the Ministry can conduct its inspection in the spring of 2015.

The Contractor(s) must also negotiate with the Ministry an acceptable Chance Finds Procedure (CFP) that describes Contractor and Worker responsibilities and actions if potential cultural artifacts are discovered. This will be done before any construction occurs. If significant articles such as fabrics, coins, artifacts, structures, or other geographic or archeological relics are discovered, the CFP will require the designated contact at the Ministry to be notified immediately. Excavation will then be halted until the Ministry approves resumption of activity.

5.1.4 Water Supply and Management

Drinking and domestic water required of project workers will be trucked in from outside sources in bottles or other containers.

Freshwater required for drilling slim wells in Year 1 could reach up to approximately 2L/s and for production-size well in Year 2 could be up to approximately 35/s. At present, it is expected that a Soviet-era well about 6.5km from the site (about 8 km by road) will supply water for drilling the production-size well. The old well will be re-opened and a pipe laid alongside the road from the well to the site, in the open channel in which the original pipe was located where the channel still exists. There is no direct connection between the aquifer exploited by this well and the Vorotan River, and there is not expected to be any reduction in Vorotan flows due to a resumption in pumping this well; thus, there will be no transboundary impacts. The lack of connection between this abandoned well and the Vorotan River was confirmed by the Institute of Geological Sciences of the National Academy of Sciences[15].

If reopening this well proves not to be possible (which is very unlikely), the fall-back option is to drill another slim well (50 m deep) at the drilling site to use underground water. Water required during the drilling will be stored in above ground 50 m^3 water tank.

Interviews with officials of Tsghuk Village indicated that local inhabitants enjoy the use of certain local surface water springs for “medicinal” purposes. These springs are located more than 1.0km southwest of the drilling area and more than 500m from the existing road, so they are in little danger of direct impact from the exploration project. However, the exact location(s) of these springs will need to be confirmed in consultation with local representatives so that they and their use by local citizens are preserved. If the slim wells encounter temperatures that suggest further development may be practical, additional studies will be undertaken to ensure that full development would not threaten these medicinal wells.

Prior to construction, engineers will accompany biodiversity experts in surveying the road to identify areas where the road needs graveling, widening or re-routing, and/or installation of drainage control. They will select the least-impact means of enabling road crossings over seasonal waterways and other obstacles, in all cases avoiding impacts to protected species. Where fill is needed to create crossings, permanent culverts will be installed with flow capacity in excess of expected maximum flows expected to occur in the future.

[15] Arkady Karaghanyan, Director of the Institute of Geological Sciences of the National Academy of Sciences of RA, personal communication, February 18, 2015.

5.1.5 Well Construction & Groundwater Protection

The Contractor will be required to provide a detailed rig pad design; a detailed drilling, cementing, operational, and decommissioning program; a produced water management plan; and a construction plan for the mud pit. All of these must be approved by R2E2 before the start of drilling. The mud sump pit design must also be approved by the State Environmental Inspectorate prior to construction to assure the design is adequate for permanent storage and disposal of used drilling fluids.

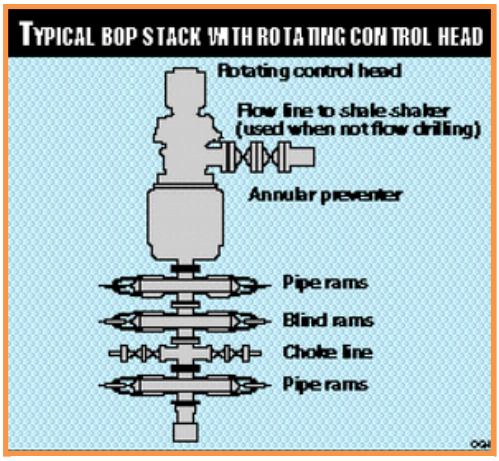

Figure 5-1. Blowout Preventer

A detailed Logging Program must be provided by the geophysical logging and flow-testing Contractor.

Wells will be designed to prevent contamination of soil and groundwater supplies. Designs provided by Contractor will include conceptual schematic drawings of well profiles, including locations and specifications of all casings, centralizers, float collars and shoes, and liners. Detailed conceptual guidance is provided in a separate World Bank document.[16]

Blowout preventers (BOP) are required for drilling activities (Figure 5-1). BOP specifications will include double ram preventers, an annular BOP, and a rotating head BOP with gate valve on the flow line.

Expert well logging must be required in order to estimate temperature, pressure and stability of the formations. Changes in underground temperature regimes and quickly developing pressure differentials between gases and fluids can result in sudden energy releases, or blowouts. They frequently provide early warning of potential blowout conditions, enabling prevention of a catastrophe and protecting program success. Expert well logging is therefore among the most important functions of this program.

The contractor will also be required to develop for R2E2 approval an emergency response plan in case of blowout or major incidents involving equipment failure or the release of drilling fluids.

5.1.6 Erosion Control and Soil Conservation

Soil erosion is always a concern for construction projects, particularly in highlands. However, in this particular area, the land is characterized by a gently rolling, largely flat vista covered by thick motley and carpet grass that stabilize the surface. It is anticipated that soil erosion problems can be avoided by careful design and controls.

All topsoil that is cut or scraped for construction purposes will be salvaged and stored for future use and revegetation and erosion control efforts. Whenever possible, this material will be reserved as intact sod, which contains plant and root remains, as well as seeds, all of which promote effective revegetation.

The road construction Contractor is obligated to provide a construction plan detailing the exact route of the planned road, incorporating consultations with environmental and hydraulic experts described elsewhere, and providing specifications concerning materials, thickness of the completed roadbed, and plans for shaping the roadbed to avoid soil erosion. If land scarring

[16] May, 2014. Karkar geothermal exploratory drilling program: Technical Aspects, Cost and Contracting. Technical advice to the Government of Armenia. The World Bank. 79 p.

occurs outside the paved roadway from construction activities, these scars will be protected from eroding by replanting with local grasses or sod.

Soils on drill pad sites and soil excavated to create sump pits will be reserved for later reclamation. Subsoil will be saved separately from topsoil to enable reconstruction of the soil profile as nearly as possible to the original profile upon decommissioning of the drill sites. To the extent possible, the topsoil will be saved in the form of intact sod, so as to preserve surface growth and seed content to the maximum practical extent.

Excepting the above requirements, the Contractor will be prohibited from earth borrowing and piling.

All vehicular traffic will be confined to roads and existing tracks. Road and drill pad construction fill will be provided as needed, and used directly from transport trucks without the use of large storage piles.

There will be no blasting.

5.1.7 Drilling Fluids Management

Every effort will be taken to prevent drilling fluids and geothermal fluids from being released to the environment. All used drilling muds and excess mud materials will be collected in a mud sump pit for ultimate disposal (see 5.1.8 below). Reject water, produced water, and excess sample water and other spent geothermal fluids will be re-injected into the geothermal formation, or will be collected in the mud sump pit and treated and disposed identically to the mud wastes. Other waste drilling fluids and cuttings will also be collected in the mud sump pits.

The drill pad(s) will be (a) curbed to contain spills of oil, lubricants, and other materials during drilling operations, or (b) graded with a gentle slope toward a drain and surfaced with impervious soil protection cloth to collect such spills. The drain will incorporate a container capable of collecting such wastes for reuse or ultimate off-site disposal. If control of such spills relies on curbing, drill pad surface materials with resulting contamination will be removed upon decommissioning, before reserved topsoil is replaced.

For acid treatment of wells, leak-proof well casings to a depth appropriate to the geological formation will be used to avoid leakage of acidic fluids to groundwater.

Hydrogen sulfide comprises the main potential air pollutant from geothermal resources. Emissions may occur during well drilling and flow testing activities, and via the open contact condenser/cooling tower systems. To minimize these emissions, they will be pumped out of the condenser and re-injected into the reservoir along with reject geothermal fluids to the extent practical.

During drilling operations, adequacy of the mud pits' capacity will be monitored. All fluid wastes will be collected in these pits, excluding produced water, which will be re-injected into the underground reservoir system. If it is determined that the sump capacity is in prospect of becoming overwhelmed, additional pit capacity will be constructed to accommodate the overage.

Wastes include hydraulic fluids, drilling fluid and muds, mud additives, geothermal fluids (reject fluids), pipe dope, used oils and oil filters, spilled fuel, drill cuttings, drums and containers, spent and unused solvents, paint and paint washes, sandblast media, scrap metal, solid waste, and garbage. All wastes other than drilling and geothermal fluids, muds and cuttings will be collected and frequently disposed in the registered municipal landfill in Sisian City. Transport

will be effective and safe, leaving no trace of lost wastes on the access roadway. Drilling and geothermal fluids, muds and cuttings will be stored and disposed in the mud sumps.

5.1.8 Mud Sump Construction and Management

A mud sump pit of at least 1,500m^3 capacity will be dug into the ground to store drilling wastes at each drill pad. Topsoil and excavated soils will be isolated and reserved for reclamation. Potential sump pit areas would be surveyed for protected flora and fauna, and areas would not be selected if they provide conservation value for such species. Ministry of Nature Protection regulations do not consider drilling fluids as hazardous waste, and require the safe disposal of drilling waste on site, in the mud sump pits. Therefore, designs for the mud sump pit(s) must be approved by the State Environmental Inspectorate prior to beginning construction.

In general, pit liners will be of a synthetic material that is impervious, has high puncture and tear strength, and is resistant to deterioration by ultraviolet light, weathering, hydrocarbons, aqueous acids, alkali, fungi, or other substances in the produced water. All systems will be designed, constructed, installed, and maintained according to manufacturers' specifications and good engineering practices. Similarly, field seams must be installed and tested according to manufacturer specifications and good engineering practices.

The synthetic or fabricated liner will cover the bottom and interior sides of the pit with the edges secured with at least a 30cm deep anchor trench around the pit perimeter. The anchor trench will be deigned to secure and prevent slippage or destruction of the liner materials.

The foundation of the liner will be constructed with soil free of sharp rocks or other materials capable of puncturing the liner. The soil foundation will have a minimum thickness of 30cm after compaction, covering the entire bottom and interior sides of the pit.

Incorporation of these recommendations, as well as all other components of sump designs, must be pre-approved by the State Environmental Inspectorate before construction.

After completion of each year's drilling activity, the sump pit will be surrounded by sturdy animal-proof fence and covered with sturdy netting to prevent birds from landing in them. After contents have evaporated, the contents will be landfilled in place. It is provisionally recommended that at least one meter of subsoil be packed on top of the dried contents, and a surface of topsoil applied. These recommendations and all procedures used for this disposal must be pre-approved by the State Environmental Inspectorate. The Inspectorate will also audit disposal performance.

If the disposal practice fills the existing mud sumps to near-capacity, additional pits may be designed for construction in Year 2.

5.1.9 Local Consultation

R2E2 and Contractors will actively engage in consultation with local village authorities and inhabitants to assure their understanding and acceptance of the program, and to assure an effective audience and response to their concerns.

Specific issues that will be considered in local consultations include:

- Potential for traffic noise and congestion. Discussions to date indicate no concern about these issues, but opinions may change as the program progresses.
- Confirming the location of springs utilized by local people as medicinal retreats, and assuring their protection.

- Identifying opportunities for local employment and local candidates for such opportunities.
- Identifying local services and goods that may be applied to the support of the program, such as locally grown foodstuffs. Providing opportunities for local inhabitants to visit the exploration site(s) to better understand the program.
- Creating better understanding of use patterns of local pastureland areas in the neighborhood of exploration activities, and issues that may arise that may be avoided with planning or preventative action.
- Any other issues that may be of concern or benefit to the local populace.

Effects on village air quality are considered a very remote and unlikely probability. Shepherds and livestock will be discouraged from visiting too near the site for personal safety, by informing local authorities of the need and relying on them to inform local shepherds. It is emphasized that this is not considered an acutely urgent issue, but this precaution will be followed in consideration of an abundance of caution.

5.1.10 Fuel & Hazardous Materials Management

On-site fuel storage will be restricted either to storage tanks specifically designed for fuel storage, or to dedicated on-site fuel transport truck(s). The fuel storage area and the vehicle fueling area will be impermeable and will be graded so that spilled fuel may be collected in containers for that purpose. All fuel and hazardous wastes will be stored in containers or tank vehicles constructed of substance-inert materials and constructed according to international shipping and storage standards.

Storage areas will be constructed by application of the selected development option Section 5.1.12). The ground surface of liquid handling areas will be lined with an impermeable synthetic liner, and surfaces will be graded to drain to a material collection container. Both liquid and solid hazardous materials spills will be cleaned up and properly stored immediately upon detection. Each emergency spill will be documented in writing and reported to Contractor's onsite manager for resolution and facility or protocol alterations avoiding future such events. A copy of each such spill event report will be provided to R2E2 to facilitate oversight of practice changes.

5.1.11 Solid & Liquid Waste Management

All solid waste must be collected and disposed in the registered municipal landfill in Sisian City. No solid waste will remain on-site. The removal schedule should be frequent, not allowing wastes to accumulate over extended time.

All wastes generated in living quarters, including garbage, food containers, and all other solid waste will be regularly collected in receptacles and also transported frequently to the registered Sisian City municipal. No waste will remain on site. Sanitary wastes will be disposed off-site on a frequent basis into the Sisian City sewage system.

Grey water and other liquid wastes will be collected in storage tanks and transported for disposal to the Sisian City sewage system on a regular and frequent basis. Tanks will be regularly checked to prevent overloading or overflowing. Transport equipment will be so constructed and operated as to prevent spillage of liquid wastes while en route from the work site to the disposal site.

Hazardous wastes must be collected, and stored separately from non-hazardous waste. Hazardous waste may include, but not be limited to, unused chemicals or additives, paints,

solvents, varnishes, cleaners, degreasers, and similar ignitable products; aerosol cans, and compressed gas containers or cylinders; oils, fluids (transmission, hydraulic, brake, etc.); fuels, automotive additives, batteries (including lead, mercury, nickel-cadmium, etc.); acids and bases; toxics, poisons, pesticides; antifreeze; and other ignitable, corrosive, reactive, toxic, problem or unknown wastes. Hazardous waste must be disposed of as directed by the State Environmental Inspectorate. Decisions regarding disposal sites and methods will depend upon the specific materials and volumes involved.

All waste materials will be collected and stored on site in specifically prepared waste holding areas, which will be constructed by scraping and reserving topsoil, preferably as intact sod, for later reclamation. The bare ground will be lined with an impermeable synthetic liner, and surfaces will be graded to drain to a material collection container.

5.1.12 Materials Storage / Staging Areas

Specific areas within the drill pad area must be delineated for storage of pipe and other drilling supplies and equipment, work areas, generators, vehicle parking, and worker living facilities.

5.1.13 Living Facilities Management

It is expected that the Contractor's will plan for there to be on-site worker living facilities. If this is the case, they must be self-contained, portable, and avoid utilizing local resources, such as water. Potable water must be trucked in and stored on site. Grey waters must be collected within the living unit or in collection tanks, and disposed of into the Sisian City sewage system.

Sanitary wastes must be collected in a separate system from grey waters, and frequently transported for off-site sanitary disposal into the Sisian City sewage system, even if composting toilets are used. All food wastes must be collected in containers covered with wildlife-proof tops and stored until removed for off-site disposal.

5.1.14 Vehicular Traffic

This project will involve significant truck traffic on Highway M2 and the new access road during initial construction, but much less during drilling. Although no concern has been expressed by local village inhabitants, the indirect impact of traffic noise may be minimized by restricting traffic to daylight hours, avoiding night-time impacts on people as well as farm animals.

Contractors will be required to carefully design and mark the exit from Road M2 onto the project road, in order to minimize congestion or disruption of local M2 traffic.

Speed limits will be enforced for trucks and other project vehicles. Drivers will be provided with orientation training to familiarize them with vehicle operation policies.

Loads in vehicles delivering construction materials will be covered to prevent excess dust.

All vehicular traffic in the project area will be restricted to paved roads, marked road tracks, drill pads, or specified storage and support areas. No free-ranging vehicular activity will be allowed.

5.1.15 Worker Health & Safety

Contractors will be required to have approved safety plans to protect workers from normal operational activities and foreseeable emergencies. Safety plans must include locations of medical facilities and plans to transport workers as needed. Safety plans will include H_2S monitoring in the workplace and living areas, as well as emergency reaction plans for unforeseen releases.

Potential human health and safety impacts during exploration and drilling includes exposure to drilling muds, geothermal fluids or steam, and hazardous materials such as petroleum, oils, and lubricants; and the increased risk of serious injury or accident, particularly to the drilling crew.

A primary concern during geothermal operations is the presence of hydrogen sulfide (H_2S) gas, which is commonly produced and released in development of geothermal resources. It is a colorless gas known for its pungent "rotten egg" odor at low concentrations. It is extremely flammable and highly toxic. Hydrogen sulfide can affect the body if it is inhaled or it comes in contact with the eyes, skin, nose or throat. It can also affect the body if it is swallowed. Inhalation of low concentrations may cause headache, dizziness and upset stomach. At higher concentrations hydrogen sulfide may cause loss of consciousness and rapid death. Hydrogen sulfide has a strong odor of rotten eggs at low concentrations, but a sweetish odor at higher concentrations. Odor must not be used as a warning of exposure since at concentrations of 20-30 parts per million hydrogen sulfide may deaden the sense of smell by paralyzing the respiratory center of the brain and olfactory nerve. H_2S gas is heavier than air, and therefore tends to collect and displace clean air in confined spaces. To the extent practical, confined spaces will be discouraged for this exploratory effort. If inclusion of one or more such spaces is necessary, the Contractor will monitor H_2S in these spaces. Workers will be trained in H_2S safety procedures and precautions.

H_2S monitoring equipment will be maintained in good working condition throughout the entire operation. At minimum, detectors will be placed at the rotating head, in the drill pad cellar, and at the end of the return flow area, and should set off an alarm if the H_2S concentration exceeds 10 ppm in air. Additional H_2S detectors must be placed in on-site living quarters, including kitchens, gathering areas, dining rooms, and sleeping quarters, and be set to sound a living-quarters evacuation alarm if the H_2S concentration in air exceeds 5 ppm. In addition, according to WHO European standards[17], 24hr average maximum concentration in living quarters will be 0.15 mg/m3, which may be reported as 0.116 ppm or 116 ppb. Workers must be trained in reaction protocols should the alarms sound.

Temporary noise levels may exceed 100 dBa during certain drilling activities. Noise abatement technology includes the use of rock mufflers, sound insulation, and barriers during drilling. Contractor(s) will be encouraged to include adequate noise control features into their equipment designs. If this is not practical, ear protection will be provided to workers and required to be used.

To ensure safe construction, lighting devices will be installed and used at active construction sites.

See also Section 5.1.17.

5.1.16 Worker Code of Conduct

[17] World Health Organisation Regional Office for Europe, Copenhagen. Air Quality Guidelines for Europe, 2nd Edition, 2000. WHO Regional Publications, European Serials, No. 91. http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

The Contractor will be required to adopt and enforce a worker code of conduct. The code of conduct will describe areas of prohibited and/or restricted access, set limits on interactions with local communities, prohibit alcohol consumption and restrict smoking to designated areas. The code of conduct will also include a worker grievance mechanism whereby workers can express concerns and complaints with assurance it will be addressed, and without fear of retribution.

5.1.17 Emergency Preparedness & Response

All contractors must have in place an effective Emergency Preparedness and Response Plan, which must include, at a minimum:

- Blowout prevention and response
- Escape procedures and plans
- Procedures for workers critically needed to remain on site for emergency reaction and management
- Procedures to account for employees following emergencies or evacuation
- Emergency alarm systems
- Portable fire extinguishers
- Training of assigned staff in medical first aid procedures or better
- Directory of local medical facilities and treatment centers, including maps, driving directions and telephone numbers
- Safety management of hazardous and toxic materials on site
- Employee training in all aspects of the Emergency Preparedness and Response Plan
- Specific employee training regarding H_2S exposure**.** Training topics must include, but not be limited to:
    - Characteristics, sources and health hazards of hydrogen sulfide
    - Symptoms of hydrogen sulfide exposure
    - Types of hydrogen sulfide detection methods and applicable exposure limits
    - Workplace practices and procedures to protect against hydrogen sulfide exposure
    - Emergency plans, locations of safety equipment, rescue techniques, first-aid
    - Confined space procedures
    - Respiratory protection equipment and its use

5.2 Seasonal Closures

Seasonal closure of the drilling sites will be required with the onset of cold and winter conditions and must be planned for. At minimum, Contractors will prepare closure checklists approved by R2E2. To effect closure, all fuel, hazardous, and spoilable materials must be removed from the site. All vehicles will be removed from the site. All facilities must be securely closed and locked to avoid occupancy by either wildlife or human intruders. Warning signs will be placed to inform possible visitors to not trespass and of hazardous conditions possible in abandoned industrial facilities.

R2E2 will inspect and approve winterization procedures before the site is abandoned for the winter. Sites will be visited and inspected at the first opportunity provided by warmer springtime temperatures, and immediate occupancy will be assured to avoid site entry by unauthorized persons.

5.3 Decommissioning

5.3.1 Site Clean-up and Remediation

Prior to construction, the Contractor will develop for R2E2 and Ministry of Nature Protection approval a reclamation and closure plan. This plan will define the condition in which the site will be left when the drillling program is completed, which will be in as natural a condition as feasible.

With the exception of drilling wastes, all wastes and leftover materials will be removed from the exploration site(s) and either recycled or properly disposed off-site in either the registered municipal landfill of Sisian City, or into the Sisian City sewage system. All abandoned production equipment, flow lines, power poles, transformers, power lines, fencing, gas meter runs, and all other material related to the exploratory program must be removed from the area.

After completion of drilling activity, the sump pit(s) must be surrounded by sturdy animal-proof fence and covered with sturdy netting to prevent birds from landing in them. After contents have evaporated, the contents will be landfilled in place. It is provisionally recommended that at least one meter of subsoil be packed on top of the dried contents, and a surface of topsoil applied. These recommendations and all procedures used for this disposal must be pre-approved by the State Environmental Inspectorate. The Inspectorate will also audit the disposal performance. After landfill procedures are completed, the fencing and netting will be removed from the site. Surface coverings of drill pads will be removed and disposed off-site. Reserved topsoil will be carefully replaced and planted or seeded with native plants recommended by a flora expert.

5.3.2 Well Plugging

Wells may be abandoned if geothermal resources found are inadequate for development of power. These wells must be adequately plugged before abandonment.

A geothermal well will be plugged at or near ground level to prevent contaminants from entering and moving through the well bore. In order to confine subsurface fluids to the aquifers and reservoirs in which they were encountered, grout seals will also be placed at each confining layer penetrated by the borehole. A minimum of 15m (or other equivalent internationally accepted amount, as approved by R2E2) of cement will be placed at each confining layer separating aquifers. In addition, the innermost casing string reaching ground level will be cemented to a minimum depth of 15m measured from 2m below ground level. All cement plugs will have sufficient strength to withstand maximum reservoir pressures. Intervals of the hole not filled with cement will be filled with good quality heavy mud. All casing strings will be cut off at least 2m below ground level and capped by welding a steel plate on the casing stub. Cellars, pads, structures and other facilities will be removed.

6 Environmental Management Plan: Environmental Management Matrix

This chapter includes the requirements for managing and monitoring environmental and social issues. These requirements will be included in all contracts, including those for design, civil works, drilling, and decommissioning. The respective contractors will be required to prepare for R2E2 approval detailed plans for managing occupational health and safety, emergency preparedness and response, traffic, drilling fluids/mud/cuttings, and site restoration. Contractors and R2E2 will monitor implementation of these plans as specified in section 6.4.

6.1 Environmental Management Matrix – Design and Pre-Construction Phase

Table 6-1. EMP - Design and Pre-Construction Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
5.1.11	Waste Disposal	• Confirm permission with Sisian City Authorities to dispose of solid wastes in the registered municipal Landfill of Sisian City, and of liquid and sanitary wastes into the Sisian City sewage system. Agree on locations and procedures; • Secure advance approval from the State Environmental Inspectorate for specific mud sump pit drawings and designs prior to their construction, as well as approvals for landfilling procedures for the used drilling fluids in the mud sumps upon project completion.	Contractor & R2E2	Proposal & Construction Costs	Prior to Construction
5.1.1 5.1.6 5.1.12 5.1.14	Floral Diversity Protection	• Pre-construction Expert inspection of entire access road route, anticipated drill pad locations to identify local protected flora and clarify protection priorities; • Mark sites supporting protected flora; • Site inspections in company of Contractor's design engineers and fauna expert; • Specification of Access Road Route, including minor course changes to avoid protected flora impacts;	Contractor & R2E2	Construction Costs	Prior to Construction

Table 6-1. EMP - Design and Pre-Construction Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
		• Mark with stakes the proposed route for the vehicle track from the existing access road to the proposed drill pad locations; restrict vehicular traffic to these tracks; • Specification of drill pad locations, to avoid damaging protected flora; • Review of support facilities and specification of their locations to avoid damaging protected flora if any; • All vehicular traffic will be restricted to existing tracks to avoid unwarranted disturbance of flora; • Expert consultations with clients and MNP to determine appropriate offset of compensation measures if impacts are unavoidable.			
5.1.2 5.1.4 5.1.12	Faunal Biodiversity Protection	• Pre-construction Expert inspection of entire access road route and anticipated drill pad locations to identify local protected fauna, faunal habitat, and clarify resulting protection priorities in design factors; • Site inspections in company of Contractor's design engineers and flora expert; • Sensitive habitats and faunal resources will be plainly marked; • Specification of Access Road Route, including minor routing alterations, to avoid essential faunal habitats and food sources if any are identified; • Mark with stakes the proposed route for the vehicle track from the existing access road to the proposed drill pad locations; restrict vehicular traffic to these tracks pending future track paving; • Specification of drill pad locations, which may yet be changed; • Review of support facilities and specification of their locations; • Road tracks between drill pad locations and surface water	Contractor & R2E2	Construction Costs	Prior to Construction

Table 6-1. EMP - Design and Pre-Construction Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
		sources will be marked with stakes and tape to identify the route(s) selected to minimize floral and faunal impacts, and all future vehicular traffic between these points will be restricted to these unpaved tracks.			
5.1.3 5.1.9	Cultural Resource Protection & Chance Finds Procedure	• Receive response from the Ministry of Culture (MoC) in advance of final road and drilling facility location and design decisions; • Site inspection by MoC expert(s) in company of Contractor's design engineers to identify areas of potential cultural importance; • Specification of Access Road Route to avoid cultural sites if any; • Specification of drill pad locations to avoid cultural sites if any; • Evaluation of water storage locations for evidence of historically or culturally relevance; • Review of support facilities and specification of their locations; • Definition of Contractor responsibilities concerning care in identifying and protecting "chance find" artifacts during construction.	Contractor & R2E2	Construction Costs	Prior to Construction
5.1.1 5.1.2 5.1.9 5.1.4 5.1.13 5.1.19	Water Supply & Management	• Pre-construction evaluation of ground water source for Year 1 drilling; • During Year 1, evaluate ground water resource from perspective of increased fresh water needs for drilling in Year 2; • If reopening Soviet-era well proves not to be possible, the plan B is to drill another slim well (50 m deep) at the drilling site to use underground water; • All surface water will be marked with stakes and tape to prevent access by vehicles and people; • Consultation with local authorities must be held to	Contractor	Construction Costs	Prior to Construction

Table 6-1. EMP - Design and Pre-Construction Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
		confirm the specific location of springs that are used by local inhabitants as "medicinal" springs or spas, which will be protected from any project impacts.			
5.1.6 5.1.14	Erosion Control & Soil Conservation	• To the extent possible in the planning phase, areas planned for road or drill pad construction, or preparation of all other project facilities, will be examined to identify areas of probable need for erosion control measures; • Mark with stakes the proposed route for the vehicle track from the existing access road to the proposed drill pad locations; • Mark with stakes the drilling pad locations and restrict project activities to these areas; • Select locations for topsoil storage; • Design culverts and other drainage features on road to prevent erosion.	Contractor	Construction Costs	Prior to Construction
5.1.1 5.1.2 5.1.8	Mud Sump Construction & Management	• Determine locations of mud sumps, relying on Ecological Experts' advice to minimize impacts on flora and fauna; • Identify area for storage of reserved topsoil and a separate location for reserved subsoil; • Identify construction methods and sequences for the designs pre-approved by the State Environmental Inspectorate, to minimize traffic and ecological impacts.	Contractor	Construction Costs	Prior to Construction
5.1.3 5.1.9	Local Consultation	• Involve local village authorities of development plans and planning efforts; • Offer periodic public updates of project activities and progress; • Maintain open communications; • Respect and resolve questions and concerns; • Request information concerning identification of possible local cultural sites; • Explore opportunities for local employment (at Contractors' discretion);	Contractor R2E2	Construction Costs	Prior to Construction

Table 6-1. EMP - Design and Pre-Construction Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
5.1.1 5.1.2 5.1.10	Fuel & Hazardous Materials Management	• Identify area for storage of fuels and hazardous materials; • Design impermeable area for fuel and materials storage and use; • Identify construction methods and sequences to minimize traffic and ecological impacts, as well as to minimize exposure risk to site workers.	Contractor	Construction Costs	Prior to Construction
5.1.1 5.1.12	Materials Storage / Staging Area Management	• Design drill pad to include material storage and staging areas.	Contractor	Construction Costs	Prior to Construction
5.1.1 5.1.13	Living Facilities Management	• Design drill pad to include living facilities and associated facilities; • Accommodations to meet requirements of IFC/EBRD guidance note on worker accommodations.	Contractor	Construction Costs	Prior to Construction
5.1.7	Drilling fluids, mud, cuttings management	• Prepare plan for management and monitoring of drilling fluids, muds, cuttings to include site selection (see above), site preparation and liner, fences, and covers as needed, dewatering, closure.	Contractor	Construction costs	Prior to placement of material in mud sump
5.1.6 5.1.14	Vehicular Traffic Management	• Pre-construction traffic plan for construction and drilling materials to minimize disturbance of local villages; • Design interchange of access road with Highway M2; • Plan speed limit restrictions for service vehicles; • Determine driver training needs and develop training plan if needed, with special focus on drivers of trucks and construction machines; • Prepare operational vehicle rules, such as dust covers over truck loads.	Contractor	Construction Costs	Prior to Construction
5.1.15	Worker Health & Safety	• Require contractor to develop and implement H&S plan; • Avoid designing enclosed spaces that might concentrate H_2S into the drilling system; • Maximize ventilation potential of well cellar, design continuous monitoring system for H_2S; • Develop training program to familiarize all Contractor	Contractor	Construction Costs	Prior to Construction

Table 6-1. EMP - Design and Pre-Construction Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
		employees in H_2S safety procedures on-site in advance of operations; assure presence of adequate and appropriate safety equipment and demonstrate alarm sounds and other sensor indictors to all on-site workers.			
5.1.5 5.1.7 5.1.10 5.1.11 5.1.13 5.1.15 5.1.17	Emergency Preparedness & Response	• Review Contractors' Emergency Preparedness and Response Plans for deficiencies and specify plan upgrades; monitor Contractor response to this requirement; • Train all Contractor employees in H_2S safety procedures on-site in advance of operations; assure presence of adequate and appropriate safety equipment, as above; • Emergency response plans must be completed prior to construction; • Plan array of H_2S monitoring sensors in employee living facilities as per Section 5.1.15; • Employees involved in drilling activities must all be thoroughly trained in emergency response; • Adequate blowout preventers (BOP) must be designed into the drill string.	R2E2 Contractor	Construction Costs	Prior to Construction
5.1.1 5.1.2 5.1.3 5.1.6 5.1.9	Drill Pad Planning	• Select final locations for drill pads to avoid impacts on flora and fauna and nearby surface waters; • Site Year 1 drill pads, but include dimension of Year 2 pads in pad positioning determinations; • Identify areas for storage of scraped topsoil and sod reserved during construction.	Contractor	Construction Costs	Prior to Construction
5.1.1 5.1.2 5.1.3 5.1.6 5.1.9 5.1.14 5.1.15	Road Planning	• Pre-construction survey by Contractor engineers to identify all road crossings with potential to interfere with free flow of seasonal watercourses, for guiding design efforts; • Pre-construction survey by biodiversity experts to identify areas that cannot be disturbed in order to protect flora and fauna;	Contractor	Construction Costs	Prior to Construction

Table 6-1. EMP - Design and Pre-Construction Phase					
Reference / Corresponding ESIA Sections	**Issue / Potential Impact**	**Action**	**Action Party**	**Costs**	**Implementation Period**
5.1.16		• Design of most environmentally appropriate design solution for each individual crossing; • Final designs to include over-estimates of peak water flow to assure excess free flow capacity to account for seasonal flow estimation inaccuracies; • Develop plans for restoration of vegetation on disturbed land.			

6.2 Environmental Management Matrix –Construction and Drilling Phase

Table 6-2. EMP – Construction and Drilling Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
5.1.1 5.1.6 5.1.12 5.1.14 5.1.16	Floral Biodiversity Protection	• All vehicular traffic will be restricted to existing tracks to avoid unwarranted disturbance of flora; • Access road improvements will be completed before construction of other project facility construction will commence; all subsequent vehicle traffic will be restricted to the road; • All project areas, including storage and staging areas, living quarter facilities, waste handling areas, and vehicle parking areas will be prepared according to options discussed in Section 5.1. • All scraped and dug topsoil and subsoil will be reserved separately in only previously designated locations for use in site restoration; • In each Autumn season collect seeds to use in the next year's restoration activities; • No other collecting of seeds or plants by workers will be permitted; • Seeds will be applied to all disturbed land as soon as disturbance ends; • Construction machinery restricted to work sites while on location, and to roadways when relocating; • All activities will be restricted to previously appointed locations; • Workers will be trained to recognize and honor the ecological warning markers utilized to identify protected species and other off-limits areas; • Workers will be instructed regarding the Contractor's Code of Conduct accepted by R2E2.	Contractor	Construction Costs	During Construction and Drilling
5.1.2 5.1.4	Faunal Biodiversity Protection	• All vehicular traffic will be restricted to existing tracks; • No hunting of animals or collections of any animal species	Contractor	Construction Costs	During Construction and

Table 6-2. EMP – Construction and Drilling Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
5.1.16		by workers will be permitted; • Workers will be trained to recognize and honor the ecological warning markers utilized to identify protected species and other off-limit areas; • Workers will be instructed regarding the Contractor's Code of Conduct accepted by R2E2.			Drilling
5.1.3 5.1.16	Cultural Resource Protection & Chance Finds Procedure	• Construction crews educated to recognize potential historical artifacts that might be found, and their responsibilities in such event as per established Chance Finds Protocol; • Immediate reporting of artifacts to MoC; • Cessation of activity until resumption is approved by MoC; • No further land disturbance during drilling; • All cultural sites will be avoided by workers, other employees, staff, and visitors unless accompanied by MoC staff.	Contractor and R2E2	Construction Costs	During Construction and Drilling
5.1.1 5.1.6 5.1.8 5.1.12 5.1.13 5.1.14	Erosion Control & Soil Conservation	• Road construction scars occurring around or off the road will be protected against erosion grading and revegetation with native flora or sod; • All stored topsoil and sod from all excavations will be protected from erosion; • Earth or gravel borrowing will not be permitted from the Karkar site. All fill materials must be purchased at established off-site sources and transported for use on the site; • Vehicles will be driven only on paved surfaces or specified and marked tracks to avoid ecological damage; • The complete length of the paved roadway will be inspected monthly to determine if runoff diversion structures are working properly, and whether revegetation plantings are growing satisfactorily;	Contractor	Construction Costs	During Construction

Table 6-2. EMP – Construction and Drilling Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
		• Problems identified will be corrected immediately.			
5.1.1 5.1.5 5.1.8	Mud Sump Construction & Management	• Sump pit constructed of at least 1,500m^3 capacity at each drill pad; • Topsoil and subsoil will be reserved separately for later remediation and revegetation to preserve flora and prevent erosion; • Construction will conform to designs and materials pre-approved by the state Environmental Inspectorate; • Liner seams will be tested on site; • The foundation for liner installation will be carefully prepared, devoid of sharp rocks or other potentially cutting materials, and compacted; • Sump pit will be surrounded by sturdy animal-proof fence and covered with sturdy netting to prevent birds from landing in them.	Contractor	Construction Costs	During Construction
5.1.7	Drilling Fluids Management	• Used drilling muds and excess materials will be collected in the mud sump pit; • Reject water, produced water, excess sample water, and other spent geothermal fluids will be re-injected into the geothermal formation or collected in the mud sump pit; • Other waste fluids and drill cuttings will be collected in the mud sump pits; • No geothermal fluids will be released into the environment.	Contractor	Drilling Costs	During Drilling
5.1.9	Local Consultation	• Offer periodic public updates of project activities and progress; • Maintain open communications; • Respect and resolve questions and concerns; • Explore opportunities for local employment.	Contractor & R2E2	Construction Costs	During Construction and Drilling
5.1.10	Fuel and Hazardous Materials Management	• Cover vehicle fueling area with impermeable surface material; • Grade the area to drain to a spilled fuel collection vessel;	Contractor	Construction Costs	During Construction and Drilling

Table 6-2. EMP – Construction and Drilling Phase					
Reference / Corresponding ESIA Sections	**Issue / Potential Impact**	**Action**	**Action Party**	**Costs**	**Implementation Period**
		• Construct hazardous materials storage area by constructing a soil- or concrete-bermed area covered with impervious synthetic liner material similar to or the same as that used for the mud pit. The area should be graded to collect spills fluids in a collection vessel; • Log all takings and uses of hazardous materials with initials of taker; • Inventory quantities of hazardous materials on hand and balance with known initial volumes and volumes taken for use. Resolve discrepancies; • If spills are identified, invoke the emergency preparedness plan to clean up the spill and protect all personnel; • Prepare spill report for R2E2 discussing the volume of spill, cause, response and cleanup, damage assessment including medical injuries, and steps taken to avoid future occurrences.			
5.1.11	Solid and Liquid Waste Management	• Establish a solid waste receptacle for collecting all construction-generated and operational solid waste; this receptacle may be the bed of a truck or a container that may be readily loaded onto a truck for removal and off-site disposal; • Construction-related non-hazardous liquid wastes will be collected in a leak-proof receptacle for later disposal in mud sump pits; • The drain will include a container suitable for removing collected wastes and disposing them at an off-site, approved waste disposal facility; • No wastes will be disposed on site; • All wastes will be regularly collected and safely transported for disposal in the Sisian City sewage system or the Sisian City registered municipal landfill;	Contractor	Construction Costs	During Construction and Drilling

Table 6-2. EMP – Construction and Drilling Phase					
Reference / Corresponding ESIA Sections	**Issue / Potential Impact**	**Action**	**Action Party**	**Costs**	**Implementation Period**
		• Solid waste receptacles will be monitored for volume and disposed off-site when full; • Non-hazardous small volume liquid wastes will be collected in a leak-proof receptacle for later disposal in mud sump pits; • See also Living Facilities Management, below.			
5.1.1 5.1.13	Living Facilities Management	• Install only mobile or portable living units without permanent or constructed foundations; • Install self-contained grey water system in each living unit or in a central tank(s); • Install self-contained sanitary waste system in each living unit or in a central tank(s); • Establish a container receptacle for all living quarters solid and food wastes; container must be loadable onto a truck for frequent off-site disposal transport, and it must have a cover to keep wildlife from accessing food wastes; • Monitor water levels self-contained grey water system(s) in each living unit or in a central tank common to all living units; transfer collected grey water for off-site disposal as containers approach full; • Monitor self-contained sanitary waste system(s) in each living unit or in a central tank common to all living units; pump out and dispose of sanitary wastes into the Sisian City Sewage System at least once per two weeks, and more frequently if needed; • Monitor solid waste living quarters receptacles, and transport content to the Sisian City registered municipal landfill at last once per week.	Contractor	Construction Costs	During Construction and Drilling
5.1.15	Worker Health & Safety	• Workers will be trained concerning Contractors' worker safety plans; • Workers will be issued and compelled to wear/use personal protective equipment as appropriate to their job	Contractor	Construction Costs	During Construction and Drilling

Table 6-2. EMP – Construction and Drilling Phase					
Reference / Corresponding ESIA Sections	**Issue / Potential Impact**	**Action**	**Action Party**	**Costs**	**Implementation Period**
		activities; • All drilling structures will be well maintained to minimize air emissions; • H_2S gas sensors will monitor living quarters as per Section 5.1.15 and will set an alarm off at 10ppm; • H_2S sensors will monitor well areas as per Section 5.1.15, and will set an alarm off at 15 ppm; • Protective gas masks will be made available to all on-site workers; • Contractor will maintain first aid supplies on-site; • At least one on-site employee will be pre-trained in first aid treatment; • Contractor will provide a directory of local / regional health and medical treatment facilities to guide emergency evacuation of injured or ill employees; • Noise abatement technology will be employed to the extent practical; • Adequate and safe drinking water will be supplied from off-site sources for use by employees.			
5.1.5 5.1.7 5.1.8	Well Construction – Groundwater Protection	• For acid treatment of wells, leak-proof well casings to a depth appropriate to the geological formation will be used to avoid leakage of acidic fluids to groundwater; • All string casings will be cemented back to the surface using procedures designed by the on-site Drilling Supervisor; • Casing pressure tests will be conducted after cementing; • BOPs will be installed, each to include double ram preventers, an annular BOP, and a rotating head BOP, with gate valve on the flow line; • Each BOP unit will be pressure tested immediately after nippling up is completed;	Contractor	Drilling Costs	During Drilling

Table 6-2. EMP – Construction and Drilling Phase

Reference / Corresponding ESIA Sections	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
5.1.16	Worker Code of Conduct	• Workers will be instructed and compelled to protect natural and historical resources; • Hunting by Contractor personnel will be prohibited; • Seed and plant gathering by Contractor personnel will be prohibited; • Wildlife collecting of any kind by Contractor personnel will be prohibited.	Contractor & R2E2	Construction Costs	During Construction
5.1.17	Emergency Preparedness & Response	• Contractors will have in place those components of their Emergency Preparedness and Response plans as are appropriate to construction activities, including: fire extinguishers, staff training, medical directories, and first aid training at a minimum; • BOPs with double ram preventers, and annular BOP, and a rotating head BOP with gate valve on the flow line will be installed; • The BOP will be tested prior to drilling; • H_2S monitoring sensors will be installed as per Section 5.1.15; • Emergency warning alarms will be in place and tested, and on-site employees will be trained in advance to recognize the sound and what their responsive and safety responsibilities are.	Contractor & R2E2	Construction Costs	During Construction and Drilling
5.2	Winterization & temporary abandonment	• Remove excess water from mud pits before leaving for the winter season; • All sanitary, solid, and fluid wastes will be collected and properly removed from the site; • All fuels and hazardous wastes will be removed from the site; • All drilling equipment will be removed from the sites, as Year 1 and Year 2 programs will use different equipment; • All vehicles will be removed from the site; • All power supplies and equipment will be secured and	Contractor With R2E2 Oversight	Contract Costs	During Project Operations

Table 6-2. EMP – Construction and Drilling Phase					
Reference / Corresponding ESIA Sections	**Issue / Potential Impact**	**Action**	**Action Party**	**Costs**	**Implementation Period**
		prepared for winter; • All facilities remaining over winter on site will be locked to prevent entry by human or wildlife visitors; • After Year 1properly plug slim wells; • After Year 2 production size wells will be temporarily abandoned according to current international safety standards.			
	Community Health & Safety	• Warning signs will be posted on all sites of the facility to discourage access.	N/A	N/A	N/A

6.3 Environmental Management Matrix – Decommissioning Phase (if no further development is planned)

Table 6-3. EMP - Decommissioning Phase

Reference / Corresponding ESIA Section	Issue / Potential Impact	Action	Action Party	Costs	Implementation Period
	Monitoring	• A Qualified Environmental Observer approved by and reporting to R2E2 will be contracted to monitor all on-site decommissioning activities; • Completed Decommissioning preparations will be audited by R2E2, MNP.	Expert Observer R2E2 MNP	Contract Costs	Post-Operational Decommissioning
5.1.1 5.1.6 5.1.12 5.1.14 5.1.16	Land restoration	• Develop decommissioning/site restoration plan for R2E2 approval; • Remove or cover drill pad with soil; • Remove all structures and dispose all debris from site; • Remove and evaporate all water from mud pits; • Cover dry mud with reserved topsoil and sod; • Regrade surface to minimize run-on and infiltration; • Seed and/or replant all disturbed areas with local vegetation.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.2 5.1.4	Water Supply & Management	• Remove all water gathering and piping structures; • Remove pump from water supply well as directed by MNP.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.5	Well Construction – Groundwater Protection	• All wells will be carefully plugged as per Section 5.1.5.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.6	Erosion Control & Soil Conservation	• Remove drill pad paving and structures; • Remove mud pit liners and soil protection layers; • Refill mud pits with reserved subsoil; • Regrade mud pit and pad areas, storage and staging areas, living facility areas, and cover with reserved topsoil; • Seed and/or replant local vegetation; • Make a final audit of erosion control structures incorporated into road design to assure proper function.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.9	Local Consultation	• Seek approval of local authorities by allowing inspections	Contractor	Contract	Post-Operational

Table 6-3. EMP - Decommissioning Phase					
Reference / Corresponding ESIA Section	**Issue / Potential Impact**	**Action**	**Action Party**	**Costs**	**Implementation Period**
		of land restoration activities.	& R2E2	Costs	Decommissioning
5.1.10	Fuel and Hazardous Materials Management	• All fuels and hazardous wastes will be removed from the site before abandonment.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.11	Solid and Liquid Waste Management	• All non-hazardous solid and liquid waste will be removed from the site and disposed in approved off-site disposal facilities.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.12	Materials Storage / Staging Area Management	• All tools and equipment will be removed from the site; • All wastes and left-over materials will be removed from the site and either recycled or properly disposed off-site.	Contractor	Contract Costs	Post-Operational Decommissioning
5.1.15	Worker Health & Safety	• All worker health and safety provisions will remain in force until all cleanup and site preparation activities are completed.		Contract Costs	Post-Operational Decommissioning

6.4 Environmental Monitoring Plan

Table 6-4. Environmental Monitoring Plan

Phase	What	Where	How	When	Why	Cost	Who
Pre-Construction Preparation							
	Flora and fauna	Road route and all construction areas	Expert inspection of route and recommendation of rerouting and location alternatives	By biodiversity expert before final design, in company of Contractor Design Engineers	Avoid impact on protected species	Contractor Cost	Expert hired and supervised by R2E2
	Flora and Fauna	Surface water features near drill pads	Expert inspection and marking with stakes, fences, or colorful tapes	By biodiversity expert before final design, in company of Contractor Design Engineers	Inform workers and enable work crews to avoid these areas	Contractor Cost	Expert hired and supervised by R2E2
	Historical and Cultural Sites	All areas to be disturbed	Mark areas that may be identified by the Ministry of Culture (MoC)	As directed by the MoC	Inform workers and enable work crews to avoid these areas	Contractor Cost	Ministry of Culture Verified by R2E2
		All construction sites	Monitor all excavations for "Chance finds"	Throughout construction by trained foreman and workers	To protect cultural heritage	Contractor Cost	Ministry of Culture Verified by R2E2
	Drainage and Erosion control	Road Route and other areas of disturbance	Inspection of proposed route and drill pad areas	By environmental expert before final design, in company of Contractor Design Engineers	Identify drainageways and potential erosion hazards to allow proper design	Contractor Cost	Contractor
	Traffic Management	M2 in village(s)	Traffic Plan	Pre-construction	Minimize Village disturbance	Contractor Cost	Contractor; Review by R2E2
		Access road and project site	Traffic Plan	Pre-construction	Worker Safety & Accident Prevention	Contractor Cost	Contractor; Review by R2E2
	Water Supply	Project site	Testing and evaluation	Preconstruction well	Assure adequate	Contractor	Contractor;

Table 6-4. Environmental Monitoring Plan

Phase	What	Where	How	When	Why	Cost	Who
			of Soviet-era well, selection of pipeline route	testing and evaluation by design contractor, pipeline route by environmental expert accompanied by design contractor	supply and select least-impact route along road	Cost	Review by R2E2 and MNP
		Development Site	Identify least-impact reservoir construction locations	Pre-construction by design contractor accompanied by environmental expert	Minimize cut and fill needs; maximize use of natural land contours	Contractor Cost	Contractor; Review by R2E2 and MNP
	Occupational Health and Safety	Office Review	Review of Contractor's H&S plan and Emergency Response Plan, including H_2S Safety and Response Procedures	Prior to mobilization by H&S expert	Assure emergency planning and training	Contractor Cost	R2E2 and MNEP
		Office Review	Well Design Review for BOP Design	Pre-construction by qualified expert	Assure adequate blowout protection	Contractor Cost	R2E2 and MNEP
		Office Activity	Design checklists and reporting forms for each of the monitoring activities listed below	Pre-Construction by environmental expert	Assure adequate inspections and prompt reporting of results. Reports will be completed daily and transmitted to R2E2 and MNP weekly unless urgent needs require immediate reporting.	Contractor Cost	Environmental Expert in Consultation with R2E2 and MNP
Construction and Drilling							
	Footprint control	All construction areas	Visual monitoring of construction areas and off-limits areas	Daily by foreman; Weekly by environmental expert	Verify minimal project footprint, identify areas to be	Contractor cost	Expert hired and supervised by

Table 6-4. Environmental Monitoring Plan							
Phase	**What**	**Where**	**How**	**When**	**Why**	**Cost**	**Who**
					repaired		R2E2
	Flora and Fauna	Road and Development site	Visual monitoring of all construction and off-limits areas	Daily by foreman and weekly by Environmental Expert	To ensure construction stays in approved footprint, verify no impacts on protective species	Contractor Cost	Expert hired and supervised by R2E2
	Historical and Cultural Sites and Artifacts	All construction Sites	Monitoring and interviews of work crews trained to recognize artifacts and in reporting responsibilities	Continuously by foreman; Weekly by environmental expert	Identify and preserve artifacts and their sites as appropriate	Contractor Cost	Contractor, who promptly reports all artifact findings to R2E2 and MoC
	Erosion control	Road and all disturbed areas	Visual observations to confirm proper drainage and identify problem areas	Daily by foreman, Weekly by Environmental Expert	Detect signs of erosion and consult with engineers to design appropriate corrective actions	Contractor Cost	Expert hired and supervised by R2E2
	Topsoil and sod preservation	All construction areas	Visual observations of excavation areas and storage piles	Weekly by Environmental Expert	Avoid topsoil and seed loss and to assure sufficient supply of local fill material verify the stability of storage piles	Contractor Cost	Expert hired and supervised by R2E2
	Conservation and Hunting	Development Site	Enforcement of Code of Conduct	Continuously by foreman	Wildlife protection	Contractor Cost	Expert hired and supervised by R2E2
	Traffic	Roads and project site	Visual observations of driving practices, reviews of accident reports, consultations with local authorities	Weekly records check by Environmental Expert	Compliance with Traffic plan	Contractor Cost	Expert hired and supervised by R2E2

Table 6-4. Environmental Monitoring Plan							
Phase	**What**	**Where**	**How**	**When**	**Why**	**Cost**	**Who**
	Occupational Health and Safety	Development Site	Visual observations of worker behavior, including PPE use and safety equipment and worksite conditions, review of records, interviews of foremen and workers	Daily by designated H&S supervisor, weekly observations and inspections by Environmental Expert	Compliance with H&S plan and protection of workers	Contractor Cost	Expert hired and supervised by R2E2
	Hydrogen sulfide (H_2S) air quality monitoring sensors	Drill Pad Sites	Examination of operating sensors and audit of calibration procedures	Daily by foreman; Weekly by Environmental Expert	To protect workers from dangerous concentrations of H2S	Contractor Cost	Contractor
	Hydrogen sulfide (H_2S) Air Quality Monitoring Sensors	Worker Living Quarters	Examination of operating sensors and audit of calibration procedures	Daily by foreman; Weekly by Environmental Expert	To protect workers from dangerous concentrations of H_2S	Contractor Cost	Contractor
	Drilling Fluids Control	Drill Pads and mud sumps	Observations; worker interviews, review of well logs	Daily by foreman; Weekly by Environmental Expert	Detect leakage or escape of fluids that could contaminate soil or water	Contractor Cost	Expert hired and supervised by R2E2
	Hazardous Materials Management and Handling	Drill Pad & Storage Areas	Observations, material inventory record examination	Weekly by Environmental Expert	Avoid accidental discharges and spills, as well as misuse	Contractor Cost	Expert hired and supervised by R2E2
	Acid Treatment of Wells	Development Site	Observations; audit of well logs and hazardous material logs	Weekly by Environmental Expert	Avoid groundwater contamination and assure compliance with government permit conditions	Contractor Cost	Expert hired and supervised by R2E2
	Waste Management	Development Site	Observations and inspection of records	Weekly by Environmental Expert	Maintain site cleanliness and protect wildlife; avoid attracting wildlife	Contractor Cost	Expert hired and supervised by R2E2

Table 6-4. Environmental Monitoring Plan							
Phase	**What**	**Where**	**How**	**When**	**Why**	**Cost**	**Who**
	Sanitary Facilities	Development Site	Observations of facilities	Weekly by Environmental Expert	Maintain site cleanliness and assure public health	Contractor Cost	Expert hired and supervised by R2E2
	Temporary/winter closure	Drilling pads	Observations of all facilities and areas	Prior to winter site abandonment, by foreman and Environmental Expert	To verify site is secured and stable	Contractor Cost	Expert hired and supervised by R2E2
Decommissioning							
	Site Cleanup	Development Site	Observation and inspection	Weekly during decommissioning activities by Environmental Expert	Confirm removal of all equipment, vehicles, and facilities.	Contractor Cost	Expert hired and supervised by R2E2
	Site grading and covering with topsoil	Development Sites	Observation and records review:	Prior to final site abandonment by Environmental Expert	To prepare the site for revegetation	Contractor Cost	Expert hired and supervised by R2E2
	Revegetation, including repairs if necessary	All disturbed areas	Observation of planting success (vegetative cover)	Prior to site abandonment and then (in future years) monthly until vegetative cover is self sustaining by Environmental Expert	To ensure effective Reclamation & Habitat Restoration	Contractor Cost	Expert hired and supervised by R2E2
	Well plugging and abandonment procedures	Well sites	Observation of Abandonment Plans, observation of actual procedures, and audit of abandonment reports	Before and during abandonment tasks by qualified expert	Assure long-term prevention of ecological and groundwater contamination by the abandoned well(s)	Contractor Cost	Geothermal or oil well drilling expert hired and supervised by R2E2; paid by Drilling Contractor

7 Development of an Operating Geothermal Power Plant

This ESIA addresses potential impacts and mitigation of a geothermal exploration program. If the program finds there are exploitable geothermal resources, however, the Government will have to decide whether to develop the power resources found, and what kind of development to foster. If the Government decides to develop the geothermal resources, a new ESIA will be required, and as noted in Chapter 2, it would be considered to be Category B under Armenian law[18].

Because the results of that program could lead to development of a geothermal power plant, it is appropriate to examine the type of plant that could be developed, and its own potential impacts, even at this early stage of exploration. The purpose of such an examination would be to provide a high-level identification of potential impacts and the extent to which it is likely they could, or could not, be avoided or reduced to acceptable levels. This in turn can inform the decision whether to proceed with the exploration program, particularly if it is considered likely that potential impacts of full development cannot be reduced to acceptable levels.

A consultant study[19] has estimated that the geothermal potential at Karkar could be sufficient to support development of a 25-30MW flash cycle power plant or a 6-8MW binary plant. The environmental and social impacts would not be significantly different for the two plant types. The construction impacts would be similar to any construction project and impacts would be confined to the transport routes and the project footprint. This chapter describes the typical power plant conceptualized in the World Bank study, summarizes the potential impacts at the plant site, along with the likely extent to which they can be reduced to acceptable levels.

Single or Double Flash Plants

Commonly built in sizes from 25 to 60 MWe, a "condensing unit" (also called a conventional steam cycle) is the standard technology used to generate power from fluid or steam with temperatures above 200°C.

The most common version of the condensing unit is the single flash steam plant, usually the most economical choice for high-enthalpy liquid dominated resources. The hot water or liquid vapor mixture coming from the wellhead is directed into a separator, where the steam is separated from the liquid.

The steam is expanded through a turbine and then usually re-injected, together with the separated brine, back into the reservoir. The brine could, however, be used by a "bottoming unit"(Bottoming units use the residual heat from the main power plant to generate additional power) or in another application, such as heating, cooling, or multiple use.

A double flash steam cycle differs from a single flash cycle in that the hot brine is passed through successive separators, each at a subsequently lower pressure. The steam is directed to a dual-entry turbine in which steam at different pressures flow to different parts of the turbine. This increases overall cycle efficiency and better utilizes the geothermal resources, but at an overall increase in capital cost.

In the typical direct contact cooling in flashing plants the majority of the cooling water is condensate that is circulated through cooling towers and back into the condensers. Some cooling water is lost in this process and it is also necessary to inject fresh water into the loop

[18] Law of the Republic of Armenia on Environmental Impact Assessment and Expert Examination, adopted June 21, 2014.

[19] *Economic and Financial Appraisal of the Potential Geothermal Power Plant at Karkar*, Tasks 1 and 2 reports prepared by Denzel Hankinson for the Armenia Renewable Resources and Energy Efficiency Fund, which is partly financed by the World Bank.

to prevent buildup of all sorts of crap in the cooling system. In Armenia, the experts estimate that less than 15 l/s of water will be required because of the relatively cold climate for much of the year.

Binary Plants

Generating electricity from low or medium temperature geothermal fluids and from the waste hot fluids coming from separators in liquid-dominated geothermal fields has made considerable progress since improvements were made in binary fluid technology. Binary plants utilize a secondary working fluid, usually an organic fluid (typically n-pentane) with a low boiling point and high vapor pressure at low temperatures as compared to steam. The secondary fluid is operated through a conventional Rankine cycle: the geothermal fluid yields heat to the secondary fluid through heat exchangers, where the secondary fluid is heated and vaporizes. The vapor produced drives a turbine, then is cooled and condensed, and the cycle begins again. In the binary plants the most common thing to do is to use air cooling. This requires no water.

The plant would occupy an area of about 1.5 hectare, and would likely be near or even an extension of one of the two exploratory drill pads. A total of 4 to 10 production and injection wells (with casing diameters of 18 $^{5}/_{8}$ inch-diameter at the surface progressively reducing to 7 inches at 1250m) would be drilled and installed. Production wells would produce the hot geothermal fluids needed for power production and injection wells would be used to re-inject geothermal fluids back into the formation. Production wells would be placed within the overall plant footprint, which would also contain piping, parking, warehouse and maintenance facilities, fluid storage, worker quarters, and associated facilities. Injection wells would be at a distance up to a kilometer away, ultimately to be connected to the plant by an elevated pipeline or buried pipe.

Up to 2 drill rigs would be employed at a time, and it would take up to 50 days to drill, case, and complete each well. Multiple mud pits would be needed to store and then dispose drilling cuttings in place. These would be constructed in the same manner as described above for the single production-size well, fitted with an impermeable liner and placed so as to minimize excavation and also prevent run-on. After well completion, free water in the pit would be pumped away and all remaining water would be allowed to evaporate, then the dry mud would be covered with a meter or more of soil or other growth medium, graded to drain away from the unit, and seeded with native species. Monitoring would continue until the vegetation was considered to be self-sustaining.

The plant area would be paved with a combination of gravel and asphalt or concrete. The power plant buildings would be concrete and steel and would contain turbines, heat exchangers, pumps, condensers, piping, etc. A small substation with transformers to step power up to 110kV would also be constructed on the plant site in the plant footprint.

The entire area of the plant footprint would need to be cleared of its low vegetation cover, with topsoil salvaged and stored. As part of the ESIA, the area and its surroundings would be surveyed by biodiversity experts to allow its precise location to be adjusted so as to avoid destruction of any populations of protected species. The location would also be sufficiently far away from any of the nearby seasonal surface waters sources to allow those sources to be fully isolated and protected from construction impacts due to run-off and erosion from disturbed areas. Signs and other barriers would be placed to discourage worker access as well.

The current access road, which will have been improved for the exploration program, would be further improved by covering with gravel or paving its entire length. This in turn would require transport of large quantities of rock and/or paving materials. Impacts due to noise, air emissions, dust, etc., could be readily controlled. If the road needed to be slightly re-routed to accommodate heavier vehicles, there would be biosurveys before construction to allow areas of

conservation value or protected species to be avoided. Road construction would take place within a single summer season.

Plant construction activities would last about 4 years. If night work were required, lighting would be the minimum needed for worker safety and efficiency, and would be shielded to minimize visibility away from the site. Good international industry practices would be implemented to control air emissions of dust and engine exhaust gases, to control run-off and erosion from the project area, to manage materials and wastes, and to ensure worker safety. The construction workforce could reach 200 or more at its peak and would likely include some workers from local communities. Other than locals, workers would be housed at the site, in accommodations that met Armenian and international standards (such as the IFC-EBRD guidance note on worker accommodations). An environmental manager would remain on site at all times to oversee implementation of appropriate management plans and good practices, and a full-time safety manager would oversee occupational health and safety conditions and performance. It is possible that the initial plant will be smaller than the nominal size and then be expanded as more is learned about the resource over time.

During operation, about 30-40 workers would be employed the plant, in three shifts covering 24 hours per day, seven days per week. Some may be housed locally, but most or all would be in permanent quarters at the plant site.

Power would be evacuated through a new 110kV transmission line constructed immediately adjacent to the 18km access road and then alongside M2 for another 12km to the nearest substation. Double-circuit conductors would be mounted on about 150 two-footed towers spaced about 200m apart. An area about 10m x 10m would be disturbed during erection of each pole, which would damage or destroy the vegetation. This could be readily restored following construction by replacing topsoil and planting with native seeds (this in turn would likely require stockpiling seeds or sod in a preceding autumn season). Poles will not be placed in locations that would require damage to boggy areas or dry waterways. Stringing of conductors would take place in the dry season, and would be carefully managed to minimize off-road impacts between the poles. Any damage to surface soil or vegetation would be promptly repaired.

Water-cooled flash cycle geothermal plant would use about 20 liters of freshwater per megawatt hour generated, which could come from the same source as water needed for drilling the production and injection wells, while binary air-cooled plants use no freshwater.

No geothermal fluids or produced waters would be discharged or otherwise disposed at the surface. Rather, all downhole fluids would be returned to the subsurface. With proper well construction and casing, intermediate freshwater aquifers would not be contaminated by geothermal fluids or cross-contaminated by brine aquifers, either during drilling or production. It is not considered likely that exploitation of a geothermal resource at 1000m or more below the surface would have any effect on the hot springs found over a kilometer from the site. This will be confirmed before development is initiated.

At the Karkar site, earthquakes in the magnitude range of 7.4-7.6 can occur, but the recurrence interval for such events is estimated to be at least a few thousand years. Accumulations of weak earthquakes have not been recorded in the region over the entire period of seismological observations in Armenia, as is frequently the case at other geothermal fields. Thus, the Geological Institute of the Armenia Academy of Sciences considers that induced seismicity as a result of operation of geothermal resources at Karkar is unlikely.

Development of a small power plant in such a rural location would not be expected to lead to significant induced development, either in the immediate vicinity, regionally, or nationally. Some small local suppliers in perishable and nonperishable supplies would see an increase in demand, but not enough to lead to important economic development.

In summary, it is considered that there should be no unacceptable impacts resulting from full-scale development and operation of a small geothermal power plant, if the project is properly designed, planned, and implemented. No protected areas would be affected, and any potential adverse effect on protected species could be avoided. Site visits, literature reviews, and interviews with local authorities and experts have not identified any areas of high conservation value or critical habitat in the vicinity, and this would be further confirmed prior to construction, with plans adjusted to avoid significant conversion if necessary. There would be the normal disturbances and hazards associated with major construction activities, but these could be reduced to acceptable levels by the application of good international industry practice as noted above.

Prior to any final decision to proceed with full development, a number of studies would be required to verify that resources at risk are properly characterized and that impacts can indeed be reduced to acceptable levels.

- Hydrologic studies of ground water, including their categories, flow patterns qualitative and quantitative indicators, water use, water discharge/disposal, water system or its separate parts and other characteristic features, including an assessment of potential effects of development on the hot springs.
- Detailed surveys of flora and fauna within a kilometer of the plant site and at transmission line tower sites, including specific flora composition and habitat conditions.
- Detailed survey of the plant site and the transmission line route for physical artifacts and features of historic or prehistoric value.
- Detailed evaluation of potential induced development in the region or elsewhere in Armenia.
- Evaluation of emissions of carbon dioxide or other greenhouse gases, as levels of CO_2 from geothermal development may be an appreciable fraction of that generated by an equivalent fossil fuel plant.

These studies and others would inform the full feasibility study and ESIA and inform the final decision of the Government whether to proceed.

8 Proposed Approach for Public Consultations

Three villages Tsghuk, Sarnakunk and Spandarian are considered to be the affected parties during the construction and drilling phases—all are over 20km distant. The draft ESIA report and EMP will be disclosed on the website of the R2E2 Fund and the Ministry of Energy and Natural Resources. Hard copies of draft ESIA report and EMP will be submitted to Tsghuk village municipality. The residents of Tsghuk, Sarnakunk and Spandarian communities and representatives of non-governmental organizations will be invited to public consultations and will be provided with the opportunity to get acquainted with the basic provisions of the planned project and draft ESIA report and EMP during meeting to be held at Tsghuk village. ESIA report and EMP will be finalized by reflecting the comments from all interested parties.

Annex 1: List of persons met

Table A1-1. Persons Met and Consulted

Name	Organization	Position
Tamara Babayan	R2E2	Director
Hmayak Avagyan	R2E2	Coordinator
Arthur Kochnakyan	World Bank	Team Leader
Arkady Karakhanyan	National Academy of Sciences Institute of Geological Sciences	Director
Anush Nersesyan	National Academy of Sciences Institute of Botany	Senior Researcher
Boris Gabrielyan	National Academy of Sciences Institute of Fisheries	Director
Vardan Tserunyan	EU Twinning Project on IPPC	Coordinator
Arev Samuelyan	Ministry of Culture	Deputy -Minister
Martiros Tsarukyan	Ministry of Nature Protection Atmospheric Air Policy Division	Division Head
Vigen Avetisyan	Ministry of Nature Protection Dept. of Underground Resources And Land Protection Policy	Department Head
Karen Manvelyan	WWF-Armenia	Director
Vasil Ananyan	WWF-Armenia	Project Coordinator
Zaruhi Hayrapetyan	Social Development and Resettlement	Consultant
Mesrop Amirjanyan	Village of Tsghuk	Mayor
Hakob Khachatryan	Village of Tsghuk	Accountant
Manuchar Mkrtchyan	Village of Sarnakunk	Mayor
Varuzhan Vardanyan	Village of Spandaryan	Head Administrator & Chief Accountant

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Annex 3: Figures and Tables

List of Figures (Photographs and Maps)

List of Tables