ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR WINGS PROJECT

Preliminary Pilot Test Mining-Work Based on In Situ Leaching (ISL) Mining Method

Prepared for

HEADSPRINGS INVESTMENT PTY LTD

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The Project is issued for:

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Project Name	Wings Project ISL Pilot Test Mining
Project Manager	K.I. Egorov-Kirillov
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ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this document:

RK - Republic of Kazakhstan

EIA - Environmental impact assessment

ESIA - Environmental and Social Impact Assessment

ISL/ISR - In-situ leaching/In-situ Recovery

OECD - Organisation for Economic Co-operation and Development

GIP - Good International Industry Practice

SWAPO - South West Africa People's Organisation

WHO - World Health Organisation

Bq - Becquerel

L - Litre

mSv - Millisievert

SanPiN - Sanitary Rules and Regulations

SAB - Stampriet Artesian Basin

MAC - Maximum allowable concentration

PR - Pregnant solutions

LS - Leaching solutions

IDC - Individual dose criterion

pg - Picogram

1. INTRODUCTION

1.1 Overview of the Wings Project

The Wings Project is located within licences EPL 4654 to EPL 4657 and EPL 6780 to EPL 6783 of the Republic of Namibia in the northern part of Aranos Basin (Fig. 1.1).

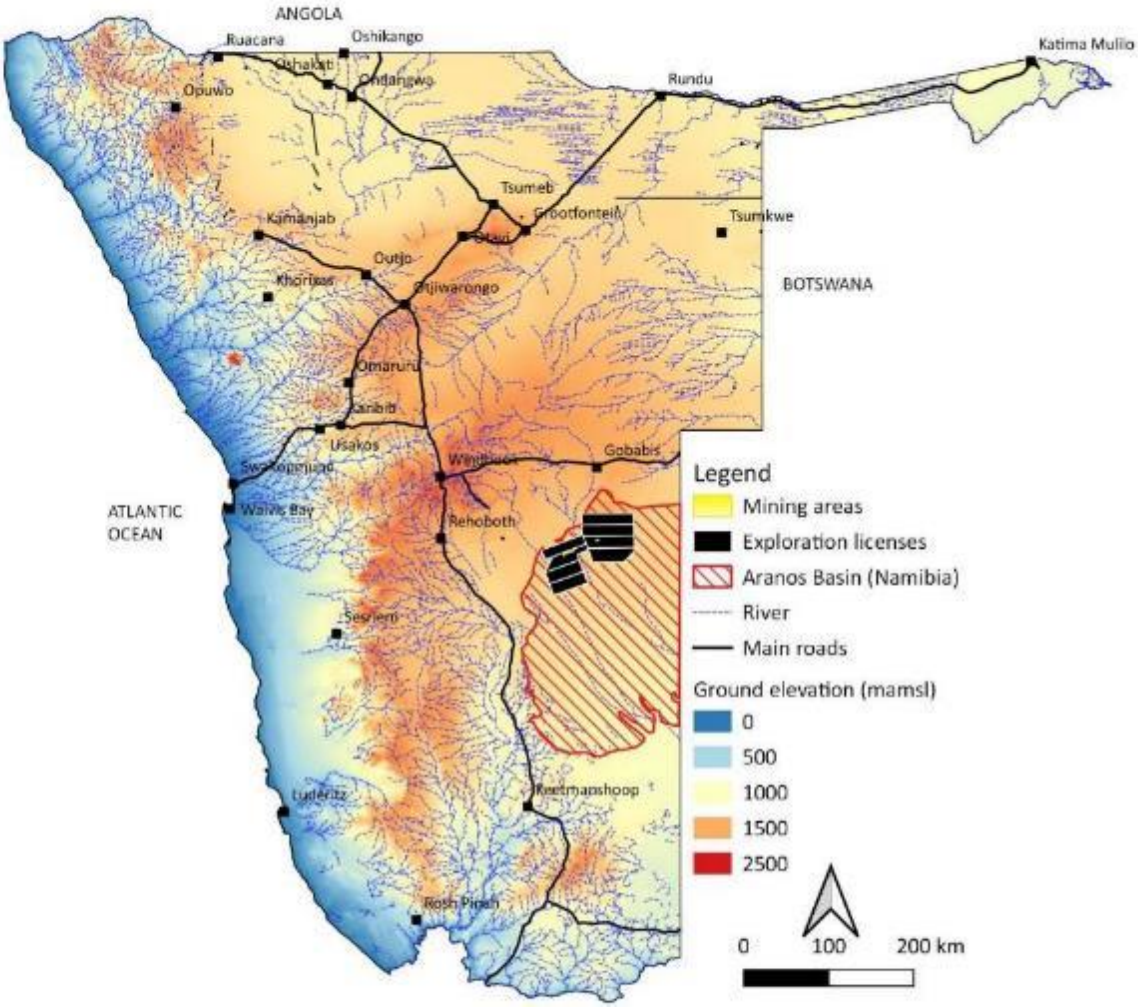

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Figure 1.1 Project area layout

1.1.1 Need for the Wings Project

Uranium is one of the six minerals that have been declared "strategic" by the Namibian government.

Uranium mining in Namibia is important to the country's economy. In 2011 Namibia was one of the world's largest uranium producers (ranked fourth after Kazakhstan, Canada and Australia). In 2022 Namibia was ranked third uranium procedure by producing 11% of the world uranium (ranked after Kazakhstan and Canada) (WNA, 2022)Headspring Investments is currently conducting a preliminary exploration activity, which is dominated by extensive drilling activities aimed at assessing the economic potential of the areas of interest for the development of in-situ uranium mining operations (ISL). Current exploration activities and potential future mining operations are focused on EPL Nos. 4654, 4655, 4656, 4657, 6780, 6781, 6782, and 6783. The target exploration potential for the Wings Project is 80-120 Mt at 300-500 ppm U_3O_8 (CSA Global, 2019).

If these preliminary and future feasibility studies prove positive, the proposed mining operations will include wells operations, a central processing plant, and auxiliary facilities. Residential facilities for the workers will be provided in Leonardville, the acid production plant and associated residential facilities will be located in Gobabis, 135 km from the mine.

The work planned for the project will also enable a more detailed study of the hydrogeological parameters of the region's groundwater as the only source of water, as well as the contours of the distribution of natural radionuclides.

1.1.2 Proponent of the Wings Project

Headspring Investments ("HSI" or the "Company"), a wholly owned subsidiary of Uranium One Group ("U1G"), has obtained mining rights under Exclusive Prospecting Licence ("EPL") Nos. 6780, 6781, 6782, 6783, 4654, 4655, 4656 and 4657 referred to in this report as the "Wings Project" (Fig. 1.1).

The Company is exploring the Aranos Basin in Namibia to discover new sandstone uranium deposits potentially suitable for in-situ leaching-based (ISL) mining method. The ISL method is an advanced and environmentally safe technology for uranium mining. Uranium One employs its ISL mining expertise in mining uranium from sandstone uranium deposits in Kazakhstan.

Uranium One has developed a rigorous internal system of health, safety and environmental standards. These standards form the basis of a tailored programme that is designed for each Uranium One’s operation. All Uranium One operations are certified to comply with the Occupational Health and Safety Management System (OHSAS 18001) [1] as part of the company's continuous improvement plan.

All of the company's mines comply with the standards and report on an ongoing basis, and measure performance based on key performance indicators (KPI). The information contained in those reports is closely monitored and controlled at the senior management level and reported to the company's Board of Directors.

As part of its continuous improvement efforts to manage health, safety and environmental performance, Uranium One regularly conducts specific audits at its operations, identify the required improvements, and monitor implementation thereof, and focus on critical hazards and risk mitigation aspects.

Strict radiation safety measures are applied to all Uranium One operations. All employees and contractors are regularly screened for alpha contamination and individual dosimeters are employed to monitor gamma radiation exposures. The use of hygiene techniques to avoid cross-contamination is mandatory. Routine monitoring for air, dust and surface contamination is carried out.

1.1.3 Wings Project Area

As noted above, the Wings Project is located within licences EPL 4654 to EPL 4657 and EPL 6780 to EPL 6783 of the Republic of Namibia in the northern part of Aranos Basin (Fig. 1.1). The Auob Formation aquifers have the greatest potential for uranium mining. The Aranos Basin (also called Stampriet Aquifer Basin or Stampriet Transboundary Aquifer System) is included in the Stampriet Groundwater Control Area, and bulk water abstraction (withdrawal for mass use) is regulated by the Government.

1.1.4 Environmental Features of ISL Projects

The in-situ leaching process involves a virtually waste-free technology using a closed cycle of extraction and injection of aquifer water with the addition of a leaching reagent (sulphuric acid). In-situ leaching (ISL) is efficient and environmentally the safest method of uranium mining.

Differences from the underground and open-pit mining method include the following:

- No open pits excavations.
- No rock dumps and tailings.
- No dewatering of aquifers during mining.
- No blasting/explosives work

As a result, the environmental impact of ISL projects is way less than conventional mining methods, provided that projects are properly designed, planned, operated, abandoned and closed using the best industry standards.

Monitoring wells installed around the ISL wellfield allow monitoring conditions within the aquifer.

In order to assess the likely migration of residual solutions in groundwater after the completion of the ISL works, it is necessary to determine in-situ permeability and rock adsorption/capacitive properties at the stage of exploration phase and design a hydrogeological model prior to starting the ISL works.

1.2 Hydrogeological Modelling and Monitoring

The most important area that may affect the Project is groundwater, especially in areas under special control, such as porous aquifers with high potential. However, a properly prepared Environmental Report(s) and interaction with international organisations/ government/local communities should ensure that permits are obtained for ISL work in the Stampriet Artesian Basin.

Therefore, mitigation measures may be necessary to protect or minimize impacts on the surface water system, groundwater horizons, as well as air quality, flora and fauna.

To further advance the HSI project, an Environmental and Social Impact Assessment (ESIA) based on equatorial principles must be carried out, which entails the collection of detailed baseline data and thorough analysis of selected aspects, including hydrogeological modelling and monitoring.

Particularly important is the conduct of a specific groundwater investigation programme, given that the project involves an ISL process.

Best practice for ISL works includes:

- Preparation of a regional hydrogeological model during the preliminary design phase.
- Preparation of hydrodynamic and geochemical models of the ISL process, including environmental issues at the preliminary design stage. This model can be used for the optimal design of the production wellfield, including the location of monitoring wells.
- Monitoring of the flow and composition of groundwater during the operation of the ISL wellfield, especially in the areas of faults and cracks, as well as in the directions of the natural flow of groundwater.
- If pregnant solutions are detected in a monitoring well, this well should be used as a production (extraction) well, and new monitoring wells should be constructed.

1.2.1 Overview of the Proposed Test Mining

Four ISL processes at Wings Project are going to be tried in order to determine the most optimum process for the Wings Project. The four processes proposed included the following:

1. **Oxygen Process:** This process involves the injection of a solution of oxygen into the water and uranium bearing sandstone. As the uranium comes into contact with oxygen it dissolves into the solution to become what is referred as the pregnant solution which is then pumped out of the ground to the surface plant where the uranium is recovered. This process is repeated several cycles until the uranium in the sandstone is fully recovered.
2. **Acid Process:** This process involves the injection of a complex agent solution of sulfuric acid into the water and uranium bearing sandstone. As the uranium and other minerals comes into contact with the sulfuric acid it dissolves into the solution to become what is referred as the pregnant solution. The solution with uranium and other minerals which is then pumped out of the ground to the surface plant where the uranium and other mineral are taken out is recovered to leave a barren solution. The barren solution is fortified again with the sulfuric acid to the concentration required and the process is repeated several cycles until the uranium in the sandstone is fully recovered.
3. **Oxygen/Sulfuric Acid:** The third process to be tested at Wings involves the combination of oxygen and acid into the solution used in the leaching of the uranium.

Chemical Process: Initially, the water is slightly carbonate with a total mineralization of 0.5 - 1 g / l, pH = 8-9. When oxygen is supplied, uranium is oxidized, uranium is tetravalent, insoluble, becomes hexavalent, soluble in the form of a carbonate complex, UO_2 CO_3. Up to 20% of uranium is leached in the laboratory. The salt composition practically does not change.

With weak acid leaching, the pH is reduced to 5.5. In solution, uranium is mainly in the form of bicarbonate complexes, $UO_2(HCO_3)_2$

The salt background increases to 1-3 g/ l, mainly due to sulfates, carbonates-bicarbonates, magnesium, aluminum, calcium.

50-70 % of uranium is leached when acid leaching pH = 1.5-2, the salt background grows to 10 g / l and half is a sulfate ion, the rest: chlorine from anions, cations - iron, magnesium, calcium, aluminium.

4. **Alkaline Process:** This process involves the injection of a complex alkaline solution (carbonate) into the orebody. As the uranium and other minerals comes into contact with the solution, it dissolves into the solution to become what is referred as the pregnant solution. The solution with uranium and other minerals which is then pumped out of the ground to the surface plant where the uranium is recovered to leave a barren solution. The barren solution is fortified again to the concentration required and the process is repeated several cycles until the uranium in the orebody is fully recovered. It is worth noting that, if there is significant calcium in the orebody (as limestone or gypsum, more than 2%), alkaline (carbonate) leaching must be used.

1.2.2 Area of the Pilot Test Mining

The pilot cell with the area of 202 m^2 in the Wings Project area (**see subsection 1.1.3**) is located south of the C23 road at a distance of 15 km west of Leonardville settlement (Fig. 1.2). A pilot cell was constructed to carry out pilot in-situ leaching activities. The pilot cell consists of four injection wells and one extraction well. The injection wells have filters length of each filter is 4 metres and the extraction well has a filter length of 6 metres and an effective thickness of 7.5 metres; the cell area is 202 m^2. The distance between the injection and extraction wells is 10 metres and the distance between the injection wells is 14.2 metres.

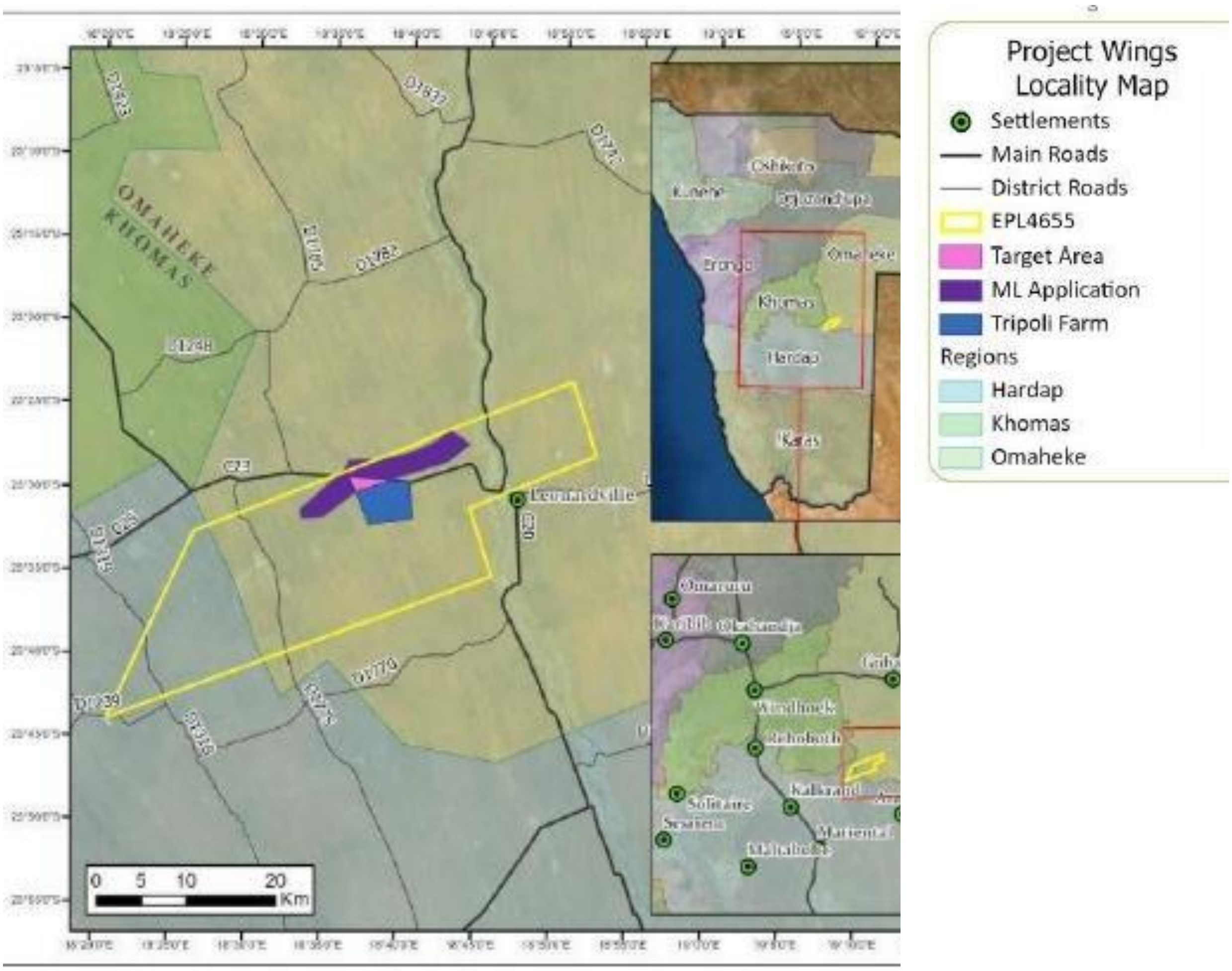

Figure 1.2 - Locality map of the pilot works area

1.2.3 Timeline for Pilot Test Mining of Sulphuric Acid ISL

The in-situ leaching pilot test mining works (pilot test of ISL) are based on a single pilot cell and cover the period from 2022 to 2025 (4 years).

1.3 Project EIA Requirements

The project is subject to environmental impact assessment developed in accordance with both national legal requirements and the requirements of international financial institutions. As this project is located in Namibia, the project must provide EIA documentation that meets the requirements of Namibian environmental assessment process. This EIA must also be carried out in accordance with equatorial principles, which entails the collection of detailed baseline data and a thorough analysis of groundwater impact aspects.

This EIA is in essence a local EIA, considering solely the hydrogeological model of the ISL in the context of the Wings Project, and the impact of the uranium ISL technology on the components of the environment, in order to further implement the full EIA process for the Wings Project.

1.4 EIA Objectives and Scope of Work

The purpose of this EIA is to determine the impact of ISL processes during test mining of uranium in the Wings Project environment on the condition and quality of groundwater and other environmental features affected by uranium in-situ leaching through hydrogeological modelling.

In accordance with the Equator Principles, OECD Common Approaches and JBIC Guidelines, the objectives of this EIA Report are based on the objectives defined by IFC Performance Standards PS1: Assessment and Management of Environmental and Social Risks and Impacts (para. 1.13) [2], i.e.:

- “To identify and evaluate environmental and social risks and impacts of the project implementation.
- To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimise, and, where residual impacts remain, compensate/offset for risks and impacts to workers, communities, and the environment.
- To promote environmental and social performance of clients through the effective use of management systems.
- To ensure that grievances from communities and external communications from other stakeholders are responded to and managed appropriately.
- To promote and provide means for adequate engagement with communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated."

According to the Terms of Reference issued by the proponent of the proposed activity the scope of work for the preparation of the Environmental Impact Assessment Design (EIA) of the uranium in-situ leaching mine in accordance with the current legislation of the Republic of Namibia, including the development of 3D hydrogeological and hydrodynamic models based on the example of the pilot block includes for the following:

- collection of hydrogeological data on existing wells (exploration, hydrogeological, agricultural water intakes).
- processing the results of the completed field work (groundwater level measurements, flow rates, results of chemical and analytical studies, etc.).
- classification of existing aquifers.
- characterisation of the natural groundwater regime.
- updating of the existing 'Regional' hydrogeological model (limited to the contour of the current contract area of the Wings Project deposit).
- development of a 'Local' hydrogeological model (pilot block).
- analysis of the planned operation regime of groundwater of Auob horizon on the basis of the built models, including a compilation of forecast changes of groundwater quality indicator.

- determination of the impact of the launched pilot block on agricultural water intakes.
- a compilation of groundwater monitoring programme.
- Preparation and execution of the Report on Environmental Impact Assessment (EIA) of the uranium in-situ leaching mine, in accordance with the current legislation of the Republic of Namibia, including the 3D hydrogeological and hydrodynamic modelling based on the example of the pilot block.

1.4.1 Project's Area of Influence

In preparing this EIA report, the following definition of the project's area of influence, as set out in IFC PS1 (para. 1.13) [2], has been used:

"Where a project involves specifically identified physical elements, exterior views or structures with a high probability of impact, the potential environmental and social risks and impacts should be identified, taking into account the project's intended area of influence. This area of influence encompasses, as appropriate:

The area likely to be affected by:

- the project and the client’s activities and facilities that are directly owned, operated or managed (including by contractors) and that are a component of the project.
- impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.
- indirect project impacts on biodiversity or on ecosystem services upon which communities’ livelihoods are dependent.
- Associated facilities, which are facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable; and
- Cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted."

As defined above, the project's area of influence includes areas that are likely to be affected by major project facilities (including the project area and associated facilities discussed above) and, in the case of cumulative impacts, areas adjacent to the project site where additional impacts from other non-project facilities under construction are likely to occur.

Potential environmental and social impacts on adjacent facilities have not been assessed in this EIA due to the absence of any information on such facilities.

2. POLITICAL, REGULATORY AND LEGAL FRAMEWORK AND ADMINISTRATIVE PRACTICES

Mining in Namibia is heavily influenced by the Environmental Management Act 7 of 2007 (EMA) and the Environmental Impact Assessment Regulations promulgated under this Act.

Pursuant to the said Act, no person may carry out exploration and mining activities without an environmental clearance certificate. The Namibian Minister of Mines and Energy may not issue a mining licence until the applicant has obtained an environmental clearance certificate (ECC).

This chapter provides an overview of the political, regulatory and legal framework and administrative practices in Namibia affecting the Project.

Headspring Investments ("HSI" or the "Company") follows Good International Industry Practice (GIP) principles in carrying out environmental and social activities at all stages of the Project.

2.1 General Information on Namibia

2.1.1 Territory and Population

The name Namibia derives from the Namib Desert, which is a unique geological site renowned for its pristine condition and landscape beauty. Geographically Namibia is located in Southern Africa and is bordered by the Atlantic Ocean (at its western end), Angola, Botswana, Zambia and South Africa. The country has a total area of 825,418 km^2, or 317,827 square miles, making Namibia the thirty-fourth largest country in the world in terms of land area (Figure 2.1).

Topographically, the country is divided into three main regions: The world's oldest desert, the Namib Desert, which stretches along the South Atlantic coast across the country from the border with Angola to the border with South Africa in the south and is crisscrossed by belts of dunes, dried-up riverbeds and deep canyons formed by soil erosion (the second largest canyon after the Grand Canyon); the central plateau, stretching from north to south and averaging 1,000 m to 2,000 m above sea level; and the Kalahari Desert, a relatively flat area covered by long vegetated dunes of fossil red sands, thick layers of continental sediment and limestone (Figure 2.2).

Figure 2.1 Physical map of Namibia

The climate in Namibia is dry and typical of semi-desert countries with regular droughts.

Namibia is one of the driest countries in the world. Rainfall is low and erratic. Namibia has five non-drying rivers, all flowing along its borders. These include the Orange River in the south, the Kunene, the Okavango, the Zambezi and the Kwando/Linyanti/Chobe in the north-east.

As an arid country, Namibia has some of the world's lowest population densities, averaging 2.1 persons per square kilometre. The arid climate results in scarcity of water resources, which is difficult and expensive to find and exploit and poses a high risk of irreversible environmental degradation.

According to the 2020 population and household census, the total population was about 2,746,745. According to the 2011 census, there were 1,091,165 females and 1,021,912 males. According to these censuses, 94 per cent of the people living in Namibia are citizens, and only 3 per cent are non-citizens.

Figure 2.2 Relief map of Namibia

Namibia is still a largely agrarian country. In 2011 it was estimated that 57% of the population lived in rural areas and only 43% in urban areas. 23% of the total population were under 14 years of age and 57% were between 15 and 59 years of age, while those over 60 years of age accounted for only 7%. About 89% of the population between the ages of 15 and 60 are considered literate, as they can read and write and understand any of the languages used in Namibia.

English is the official language, but Afrikaans is widely spoken in most towns and cities. Other indigenous languages are used for speech and in the lower primary school classes (such as the San languages Ju/Hoan). Along with other indigenous languages, it is used in some schools for teaching in the first three years. After third grade, subjects are taught in English, and the mother tongue is taught as a separate subject throughout the entire school years. Other languages include the Bantu languages spoken by the Ovambo (51.9 %), Kavango (11.8 %), Herero (8.1 %), Caprivi (4.9 %) and Tswana (0.3 %), and the Khoisan languages spoken by the Nama/Damara (10.5 %) and Bushmen (San) (1.5 %). Given the cosmopolitan nature of Namibian society, other world languages are also used in oral speech. European languages spoken in Namibia include Spanish, German, French and Portuguese.

The Constitution of Namibia establishes Namibia as a secular state and Article 3 of the Constitution provides for freedom of religion as a fundamental freedom. It is estimated that about 90 % of the population are Christian and 10 % practise other religions.

Despite the small size of its population, Namibia has a rich culture and tradition. Like many African countries, it has different ethnic groups such as the Ovambo, Kavango, Herero, Caprivians, Damara, Nama, Tswana, German, San, Afrikaans, Basters and Coloureds.

As with the coastal cities, Windhoek, the capital and centre of commercial activities, is attracting an increasing number of young people looking for work. Apart from the northern part of the country, the most populated area is Khomas.

Like many countries in Africa, Namibia faces threats to its social welfare and economy. One serious threat is HIV/AIDS, which remains one of the leading causes of death in the country. Alcohol and other substance abuse is a growing social problem, whose effects are compounded by other social ills that Namibia is combating. The first case of HIV/AIDS was diagnosed in Namibia in 1986. In recent decades the number of HIV/AIDS cases has increased, and the disease has spread to all parts of the country. The Ministry has developed a wide range of guidelines and instructions such as the Namibian HIV/AIDS Charter of Rights.

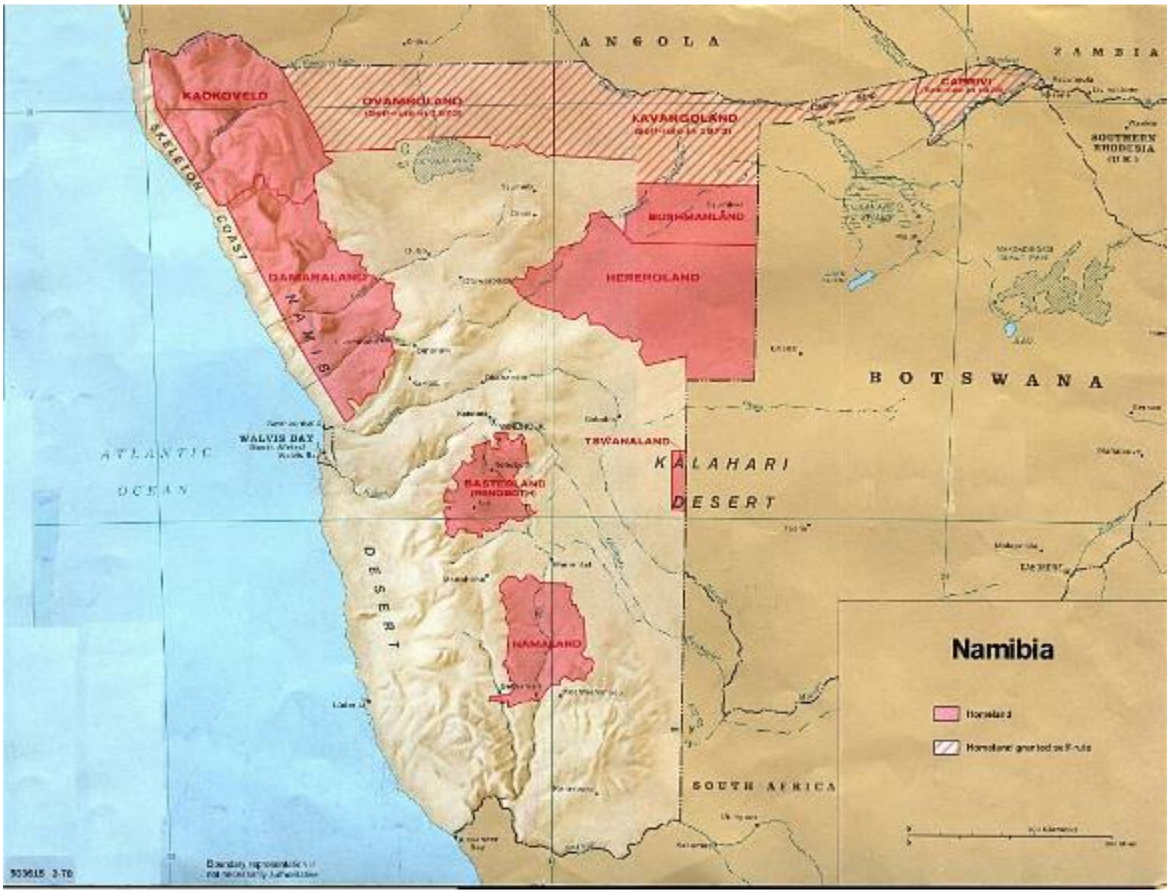

Figure 2.3 Ethnic map of Namibia

A Code of Practice on HIV/AIDS in the Workplace was drafted and approved by the National Assembly in 1998. The Code defines the legal and human rights of persons living with HIV/AIDS and provides for measures to raise awareness of HIV/AIDS and prevent the disease in all workplaces. The public and private sectors, civil society organisations and other initiatives have developed programmes to strengthen the national response to the HIV/AIDS pandemic.

Economic factors such as poverty, income inequality and migration play a significant role in the spread of the pandemic. Other contributing factors that are commonly perceived as contributing to the pandemic, although not supported by research, include certain cultural practices, cross-border movements, elements of gender inequality, stigmatisation, discrimination, exclusion and violence against women and children. Child and infant mortality rates reach 42 deaths per 1,000 live births and life expectancy at birth are 66 years for women and 64 years for men (source: WHO Global Health Observatory 2009).

2.1.1 A Brief Political History of Namibia

In pre-colonial times Namibia was inhabited by the San, Damara and Nama groups and subsequently by Bantu migrants from central Africa. These Bantu groups became the basis of the Caprivi, Herero, Kavango and Ovambo.

Since the 13th century, Germans and British missionaries, as well as foreign traders, began to infiltrate the interior of Namibia. The latter brought various products into the country, including weapons, which were exchanged for local Namibian goods. The number of European traders subsequently increased and they began acquiring land through unequal trade agreements and other dubious means. At the same time, missionaries began to interfere in local political life, as mission sites and churches were planned to be used as military strongholds.

As a result, the country was placed under German colonial rule in 1890 and remained so until the end of World War I. During the colonisation period, the people of Namibia were deprived of their rights and their traditional way of life was destroyed. In 1915 Namibia was occupied by South African troops and placed under military administration. At the end of the First World War, the Allied Powers decided to deprive Germany of all its colonies, including Namibia.

The Statute of the League of Nations placed Namibia under the League of Nations mandate system and the population was thereby prohibited from exercising their right to self-determination. Britain was designated as the Mandatory Power for Namibia, but in 1920 a special agreement appointed South Africa to administer Namibia on behalf of the British Crown.

Having accepted the League of Nations mandate, South Africa sought to annex Namibia as one of its provinces. It institutionalised political, social and economic discrimination, which was accompanied by massive human rights violations. Contrary to its mandate under the Statute of the League of Nations, South Africa supported increased white immigration from its territory into Namibia and encouraged racial segregation.

Following the demise of the League of Nations and the mandate system, the United Nations trusteeship system was established by the Charter of the United Nations. Mandatory countries entered into trusteeship agreements with the United Nations and therefore began to implement their mandates under the new system. However, South Africa rejected the notion of replacing the United Nations trusteeship system and challenged the right of the United Nations to intervene in Namibia. South Africa was advised and encouraged to abandon the Namibia mandate and to enter into a trusteeship agreement with the United Nations, but South Africa refused to do so. In 1971, the matter was referred to the International Court of Justice for an advisory opinion and the International Court of Justice affirmed that the provisions of the Charter applied to South Africa and that the former mandated territories should be placed under the United Nations trusteeship system. However, South Africa continued to reject the UN's authority over Namibia.

In 1960 the South West Africa People's Organisation (SWAPO) was formed in Namibia as opposition to the South African apartheid regime. During this period there were massive campaigns against the illegal occupation of Namibia and ongoing human rights violations. The SWAPO leadership faced severe persecution and was eventually forced to flee the country and go into exile to pursue alternative attempts to dismantle the South African domination of Namibia. In October 1966, the United Nations General Assembly decided in a resolution to abolish South Africa's mandate to govern Namibia. A similar decision was later taken by the International Court of Justice in 1971, but South Africa was again intransigent.

South Africa's stubborn refusal to comply with UN General Assembly resolutions and the International Court of Justice's opinion forced SWAPO and the people of Namibia to fight militarily to liberate the country. In 1966, SWAPO launched military operations in the struggle for freedom and continued until a ceasefire agreement was reached with the South African government in a process that culminated in UN-supervised elections in November 1989. During the struggle, Namibians continued to suffer the oppression of South Africa's apartheid system which continued to exploit the country's human and natural resources.

Negotiations continued on the international stage and eventually, an agreement was reached calling for free and fair elections in the country. In 1989, a ceasefire agreement was signed between SWAPO and South Africa under the mediation of the United Nations. Elections were held under the auspices of the United Nations, in which SWAPO won. The 1989 election resulted in the formation of a Constituent Assembly composed of elected officials who drafted a new Constitution for an independent Namibia. On 21 March 1990, Namibia became independent and on 9 February 1990, the Constitution was adopted as the supreme law of the country.

The main provisions and the centrepiece of the preamble to the Namibian Constitution were the principles of equality and the inherent dignity of all human beings and a total rejection of colonialism, racism and apartheid. It established that the country is "a sovereign, secular, democratic and unitary state based on the principles of democracy, the rule of law and justice for all" and provided for a multi-party system of government. The legal framework of the Namibian State and its institutional structures were shaped by decisions of the Constituent Assembly. The Constitution enshrines the principle of separation of powers, whereby the government is administered in a multi-party democracy based on a checks and balances system through the executive, legislative and judicial branches of government. General, presidential, regional and local government elections are held every five years.

2.1.2 Government Bodies

Executive power in Namibia is vested in the President and the Cabinet of Ministers, which initiate and enforce laws. According to the provisions of Article 35 of the Namibian Constitution, the Cabinet consists of the President, the Prime Minister and Ministers appointed by the President from amongst members of the National Assembly. The President is elected for a term of five years by direct universal suffrage.

Legislative power is vested in Parliament, which consists of the National Assembly and the National Council.

The National Assembly consists of 72 members elected directly by secret ballot by all Namibians on party lists on a proportional representation basis and up to six non-voting members appointed by the president on the basis of their special expertise, status, professional qualifications or experience. All laws are subject to presidential approval and review by the National Council, which comprises 26 members, two from each of the 13 regions.

Figure 2.4 Administrative map of Namibia

Under the Namibian Constitution, the Cabinet and Ministers have the power and duty to uphold the country's constitution and laws. Article 41 also provides that all ministers shall be personally responsible to the President and Parliament for the management of their ministries and collectively responsible for the management of the Cabinet.

Judicial power is vested in the Courts of Namibia–the Supreme Court, the High Court and the lower courts.

The independence of the Judiciary is constitutionally guaranteed. Article 32 of the Namibian Constitution vests in the President the power to appoint High Court judges, the Ombudsman and the Attorney General on the recommendation of the Judicial Service Commission. The Commission consists of the Chief Justice, a High Court judge, the Attorney General and two members in private practice representing the organised legal community. In Namibia, the President can only remove judges for mental incapacity or gross misconduct on the advice of the Judicial Service Commission.

The country is divided into thirteen administrative regions (Figure 2.4). Each region has an elected Regional Council. All members of the regional councils are elected by secret ballot.

2.1.3 Economic, Social and Cultural Characteristics of Namibia

Namibia is one of the higher middle-income countries, but also has some of the largest per capita income inequalities in the world. Per capita income inequalities among the main segments of the population are a result of the one-sided development that has characterised Namibia's economy in the past.

The livelihood and economic well-being of half the population depend on agriculture. More recently, the Central Bureau of Statistics introduced a new methodology for measuring poverty based on the value of basic needs, as opposed to measuring it by the proportionate share of food. Namibia is still lagging in terms of human development. According to the United Nations Human Development Index 2011, about 60% of Namibians live on two dollars a day or less.

Namibia's economy is based primarily on agriculture, mining, fishing and tourism. Namibia's main natural resources are diamonds, copper, uranium, gold, lead, tin, lithium, cadmium, zinc, salt, vanadium, natural gas and hydropower.

2.1.4 Legislative Framework for Mining in Namibia

Article 100 of the 1990 Constitution of the Republic of Namibia provides that all natural resources (including minerals) below and above the land surface and on the continental shelf and within the territorial waters and exclusive economic zone of Namibia belong to the State unless they are otherwise lawfully owned. This includes mineral resources as well. Mining in Namibia is regulated by the Minerals (Prospecting and Mining) Act 33 of 1992 (the "Minerals Act"), and Part 2 of this Act grants all rights in relation to minerals in the State. In addition, this Act provides for the administration of the mineral industry and access to mineral resources through various types of permits.

Under the Act, no person may carry on listed activities without an environmental clearance certificate. The listed activities include mining. The Minister of Mines and Energy may not issue a mining licence until the applicant has obtained an environmental clearance certificate.

Mining in Namibia is managed by the Ministry of Mines and Energy and its Minister. The Minister is assisted by a Mining Commissioner. The Minerals Act also provides for the establishment of the Minerals Council of Namibia. The Minerals Act prescribes the functions of the Commissioner of Mines and the Minerals Council.

Obtaining a Mineral Prospecting Licence in Namibia entitles the holder to carry out exploration operations, which are operations carried out in the prospecting of any mineral or group of minerals using airborne sensing techniques, including geophysical surveys, photogeological mapping or airborne images. This Namibia Mineral Prospecting Permit is valid for a maximum period of six months and may be renewed once for a period of six months.

Prospecting activities are carried out under non-exclusive and exclusive prospecting licences. Mineral prospecting in Namibia means the deliberate exploration, whether by excavation or otherwise, for any mineral or group of minerals to identify or estimate deposits or concentrations of any such mineral or group of minerals. A non-exclusive prospecting licence is valid for one year and may not be renewed. On the other hand, an exclusive prospecting licence is valid for 3 years and may be renewed twice for a period of 2 years per renewal. Further renewals are only possible if the Minister considers it desirable in the interests of developing Namibia's mineral resources.

Mining in Namibia may be carried out pursuant to a mining claim or a mining licence.

The holder of a non-exclusive prospecting licence may make a mining claim in Namibia, which may not exceed three hundred metres by six hundred metres in size. This claim is then registered with the Ministry, which gives the holder the right to mine in Namibia. The claim is valid for three years and can be renewed for two years. On the other hand, the holder of an exclusive prospecting licence may apply for a mining licence in Namibia. The mining licence is valid for 25 years and can be renewed for further periods of fifteen years.

2.1.5 Mining in Namibia

Mining is the backbone of the country's economy. It contributes 21.6% (1990) to the country's GDP, has substantial tax revenues and three-quarters of export earnings. Copper, tin, zinc, lead and other ores, cadmium, uranium, beryllium and gem diamonds are mined.

In 1990 Namibia's mining industry was dominated by three international corporations: Consolidated Diamond Mines (CDM), wholly owned by South Africa's De Beers, which controls the diamond trade; the UK's Rio Tinto Zink, which owns Rössing Uranium Limited; and South Africa's Gold Fields South Africa, which controls the Tsumeb Corporation Limited (mining of base metals). In the late 1990s, the Namibian government entered into negotiations to jointly own Rossing Corporation and to form a diamond mining joint venture with De Beers called Namdeb. Tsumeb Limited has declared bankruptcy. A new impetus for the diamond industry came from the discovery of diamond deposits on the ocean floor. Rising demand and global uranium prices have benefited Namibia's uranium production. The good prospects for the mining industry, the development of industrial zones that produce export products and the discovery of an offshore natural gas deposit near Walvis Bay make the future of Namibia's economy optimistic.

2.1.6 Uranium Mining Sector

Uranium mining in Namibia is important to the country's economy. In 2011 Namibia was one of the world's largest uranium producers (ranked fourth after Kazakhstan, Canada and Australia). In 2022 Namibia was ranked third uranium procedure by producing 11% of the world uranium (ranked after Kazakhstan and

Canada) (WNA, 2022). Uranium is one of the six minerals that have been declared "strategic" by the Namibian government. Since 2009 a new prospecting licence cannot be granted without the involvement of a government mining company.

The mineral was first discovered in 1928 in the Namib Desert by Peter Lu. The exploration went on for 30 years. Anglo American explored the deposit in the late 1950s, but development was soon abandoned in 1966. Ten years later, development resumed. In 1980, the UN held a meeting on the Namibian uranium deposit. In 1999 the International Atomic Energy Agency reported that the Rössing Mine is the largest uranium mine in the world. In 2008, uranium production throughout Africa increased by 16% over the previous year.

Namibia lifted a moratorium in December 2016 whereby granting new uranium exploration and mining licences were banned in the country. Following the lifting of the moratorium, Rosatom's uranium mining holding company Uranium One (Russian Federation) applied for 8 uranium exploration licences and received such 8 uranium exploration licences in the country.

Headspring Investments (part of Rosatom) has become one of Namibia's largest holders of prospecting licences for uranium deposits suitable for ISL mining, controlling an area of 8,000 km^2.

2.1.7 National Environmental Legislation and International Industry Practice

2.1.7.1 National Regulatory Requirements

The following is a summary of the applicable legalisation in relation to the proposed uranium exploration, mineral processing and local support infrastructure operations under the Wings Project:

Articles 91 (c) and 95 of the Namibian Constitution.

- Petroleum (Exploration and Production) Act of 1991 and related regulations.
- Environmental Management Act (7 of 2007) and Regulations (2012).
- Water Resources Management Act, 2013 (Act No. 11 of 2013), which commenced in August 2023 following the Gazetting of the Water Resources Management Regulations, 2023.
- Atomic Energy and Radiation protection Act, Act 5 of 2005.
- Hazardous Substances Ordinance (1974).
- Health Act (21 of 1988).
- Air Quality Act (39 of 2004).
- Atmospheric Pollution Prevention Act (45 of 1965).
- Communal Land Reform Amendment Act (13 of 2013).
- Forestry Act (12 of 2001) and the Forest Amendment Act (13 of 2005).
- Labour Act of 1992, Act 6 of 1992, as amended by Labour Act of 2007 (Act 11 of 2007).
- Labour Act (11 of 2004): Occupational Safety and Health Regulations (1997).

- National Heritage Act (27 of 2004).
- Nature Conservation Amendment Act (5 of 1996).
- Nature Conservation Ordinance (4 of 1975).
- Soil Conservation Act (70 of 1969), and
- Traditional Authorities Act (17 of 1995).

2.1.7.2 International and Regional Treaties and Protocols

Article 144 of the Namibian Constitution provides for a mechanism to ensure the ratification of all international treaties and protocols. All ratified treaties and protocols are subject to enforcement in the territory of Namibia by Namibian courts, including the following:

- The Paris agreement, 2016
- Convention on Biological Diversity, 1992.
- Vienna Convention for the Protection of the Ozone Layer, 1985.
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987.
- United Nations Framework Convention on Climate Change, 1992.
- Kyoto Protocol to the Framework Convention on Climate Change, 1998.
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989.
- World Heritage Convention, 1972.
- Convention to Combat Desertification, 1994 and
- Stockholm Convention on Persistent Organic Pollutants, 2001.
- Southern African Development Community (SADC) Protocol on Mining.
- Southern African Development Community (SADC) Protocol on Energy.

2.1.8 Ministry of Environment, Forestry and Tourism of Namibia

The Ministry of Environment, Forestry and Tourism (MEFT) was established in 1990 and is responsible for the protection of Namibia's natural resources. Since then, the MEFT has implemented far-reaching political and legislative reforms on the environment, attempting to mitigate the many constraints that the environment places on people and vice versa. These reforms have also sought to encourage various innovative partnerships between important environmental players, such as ministries with environmental interests within their jurisdictions, non-governmental organisations, civil society organisations and donor agencies from various countries. MEFT's mission is to maintain and restore essential ecological processes and life-support systems, conserve biodiversity and ensure the sustainable use of natural resources for the benefit of all Namibians, both present and future, as well as the international community as stipulated in the Constitution. The Ministry has three departments, each with its own subdivisions (known as directorates or divisions):

- Department of Tourism, Planning and Administration: the Directorate of Administration, Finance and Human Resources; the Directorate of Planning and Technical Services; and the Directorate of Tourism and Gaming.
- Department of Environmental Affairs (DEA): Division of Environmental Assessment, Waste Management and Pollution Control and Inspections; Division of Environmental Information and Natural Resource Economics; Division of Multilateral Environmental Agreements.
- Department of Natural Resource Management: Directorate of Wildlife and National Parks; Directorate of Scientific Services.

2.1.9 EIA Procedure in Namibia

The EIA procedure in Namibia was introduced in 2007 through the promulgation of the Environmental Management Act (EMA, No. 7, 2007) (GRN, 2007). This was later followed by the EIA Regulation in Notification No. 30 of 2012. (GRN, 2012).

EIAs are now conducted and reviewed by the Department of Environmental Affairs (DEA) in the MEFT. DEA has broad environmental responsibilities, including overseeing Namibia's compliance with various United Nations conventions and the implementation of various programmes related to these conventions. The DEA is also responsible for pollution control and waste management as well as the overall coordination of environmental issues within the Namibian Government. The Environment Management Act (EMA) No. 7 of 2007 of February 2012 established the Office of the Environment Commissioner and a broader committee known as the Sustainable Development Advisory Council, both of which were appointed at the same time after the publication of the EIA Rules. Their respective roles are summarised below.

The EMA defines EIA as the process of identifying, predicting and assessing the significant environmental effects of activities and the risks and impacts of activities and their alternatives and mitigation options, to minimise negative impacts, maximise benefits and promote compliance with the principles of environmental management. In addition, the Act emphasises the comprehensive nature of EIA. It defines the term "environment" as the totality of natural and anthropogenic factors and elements mutually interrelated and affecting the ecological balance and quality of life, including land, water and air; all organic and inorganic materials; all living organisms; and the various components of the human environment. These include the landscape and the natural, cultural, historical, aesthetic, economic and social heritage and values. Thus, the Act does not provide for a separate assessment of the environmental, social, health or cultural components.

The EMA is in line with current legislative trends, including:

- Adherence to the 'polluter pays' principle.

- The inherent need to include adequate provisions to achieve 'reduction at source' in the areas of pollution control and waste management.
- The need to consider alternatives and to avoid or minimise adverse impacts where possible.
- The costs of the EIA are incurred by the proponent, who is also responsible for ensuring that the EIA and the EIA report meet acceptable standards.
- The need for a binding agreement between the proponent and the government based on the recommendations contained in the EIA report, which specifies how environmental issues will be addressed when implementing of the project;
- The need for public participation in the EIA process. The list of activities requiring an EIA in Part VII of the EMA is a guideline, as the Minister may amend the list and the Environmental Commissioner may decide that activity requires an EIA on the basis of its expected environmental impact, even if the activity is not listed. (Part VIII, section 32(1)(b)). Types of activities requiring an EIA are listed in detail in Annex 18-1 under the following category headings:
- Energy generation, transmission and storage.
- Waste management, treatment, handling and disposal activities.
- Mining and quarrying.
- Forestry activities.
- Land use and development activities.
- Tourism development activities.
- Agriculture and aquaculture.
- Water resources development.
- Management, handling and storage of hazardous substances.
- Infrastructure.
- Other activities.

The EMA is in the process of revision. A consultation was held in 2016 to gather public views on the proposed changes. Amendments to the EMA are currently under review by the Ministry of Environment and Tourism.

The steps required to undertake an EIA are described below and shown schematically in Figure 2.5.

EIA Registration

The EIA regulations (GG No 4878 GN No 30) stipulate that before submitting an ECC application, the proponent must determine whether the activity for which the application is made is a listed activity (i.e. included in GN No 29 GG No 4878 - see Appendix 18-1). The proponent may seek the assistance of the Environment Commissioner to carry out this task. If this type of activity is listed, the proponent must apply for an EIA.

Screening and Scoping

Screening is the process of classifying a proposal to determine the level at which an environmental assessment will be conducted. Once an EIA application has been registered, the proponent should appoint an Environmental Assessment Specialist (EAS) and begin the scoping phase of the EIA. Scoping is defined as a consultative procedure that culminates in defining the scope and approach of the EIA. It is an early and open process of scoping the issues related to the planned activities. Public consultation forms a significant part of the scoping stage and there are specific requirements in this respect.

The main requirements in the EIA Regulations include notifying all potential interested and affected parties (I&APs) within a 21-day period by the following means:

- Providing a written notification to affected property owners, local, traditional and regional authorities and any public authority that may have jurisdiction over the proposed activity;
- Publication of the notice in two widely circulated newspapers for two consecutive weeks; and
- Display of an A2-format notice board near the affected site.

The proponent-appointed EAS should identify all impacts, their potential consequences and their significance. Based on this information, the proponent is responsible for determining whether further investigation is required or not. If further investigation is required, the proponent is responsible for developing a plan of study or terms of reference (ToR). The ToR should include, inter alia, the specialists to be appointed and the research methods to be used. This information should be recorded as part of the scoping report and submitted to the Environmental Commissioner. The Commissioner must decide, on the basis of his or her review of the scoping report, whether the report is adequate for decision-making and, if so, whether a detailed assessment is required or not. If a detailed assessment is required, the Commissioner "shall determine the scope, procedures and methods of assessment". Thus, the burden of investigation relating to the scoping decision rests with the proponent-appointed EAS and not with the Environmental Commissioner, but it is the Commissioner being responsible for deciding on the scoping. The Commissioner must respond to the question of whether further detailed investigations are required within 14 days of receiving the scoping report. Three answers are possible:

- The Scoping Report does not meet the scoping requirements and the deficiencies must be reviewed and resubmitted.
- The Scoping Report meets the relevant requirements, no further investigations are required and the ECC is issued (the Commissioner must notify the proponent within seven days of this decision date); and
- The Scoping Report complies with the relevant requirements, but detailed investigations are required as prescribed in the ToR (with or without amendments to the ToR). The Commissioner must notify the proponent within seven days of this decision date.

The EIA rules specify the content requirements both for scoping and detailed assessment reports. Both reports must contain the following information:

Biographical details of the EAP proponent/report;

- Description of the activity.
- Description of the environment affected.
- Statement of purpose and needs of the activity.
- Description of feasible and reasonable alternatives, their advantages and disadvantages, and an assessment of the impacts associated with the alternatives identified.
- Description of the extent to which the impacts can be addressed through mitigation measures.

Content requirements of the report relating to the review report include: identification of applicable legislation/permits, environmental management plan (EMP), details of the consultation process (evidence of how potential I&APs have been notified), including issues raised by I&APs and EAP responses. The EAS must include, among other requirements, information on proposed management and mitigation measures to address impacts identified during the scoping stage and must set objectives for environmental remediation and closure. A specific requirement also commits to the prevention and control of pollution. The definition of an EMP in the Regulations includes impact monitoring.

Preparing the EIA Report

Report content requirements specific to an assessment report include a methodology for determining impact significance, a comparative assessment of alternatives, a description of uncertainties and assumptions and a non-technical summary.

Working conditions, gender, climate change, resettlement, community health and safety, cultural heritage, biodiversity conservation, sustainable management of living natural resources and resource efficiency do not require specific inclusion in either overview reports or EIA reports. Pollution prevention and control is specifically required under the EMP.

Review of EIA Reports

The EIA Regulations require that both scoping and detailed assessment reports be circulated to I&APs before submission to the Commissioner as part of the public consultation process. *EIA Regulations*

All written I&AP comments (submitted during the public consultation or public review phase of the reports) must be recorded, including any EAP responses, but do not explicitly require the proponent or its EAP to respond to such comments. In some cases, an EIA report may be the subject of a public hearing (section 36 of the EMA), while section 45 of the EMA provides that the Environment Commissioner appoints an external reviewer in cases of potential controversy in which a high level of objectivity is required. In this case, EMA gives the government the right to recover the costs of the external review from the proponent.

The EIA report must be reviewed before the Environmental Commissioner can decide on the EIA application (Figure 18.2). Typically, the Commissioner consults with the national ministry with jurisdiction over the proposed project. The Commissioner is required to keep a record of the permit decision taken, including the reasons for the decisions. However, the regulations do not set out any criteria on the basis of which these decisions should be made and there are no guidelines on this. The Commissioner must notify the proponent of his or her decision in writing (including the reasons). In practice, reasons are stated only for negative decisions (i.e. rejections). In addition, the EMA requires that the decision report be made available to the public for review upon request.

- After consideration of the EIA report within seven days, the Environment Commissioner should:
- Satisfy the application and issue an ECC to the proponent; and
- Reject the application and provide the proponent with an explanation of the reasons for refusal.

Article 38 of the EMA requires that a record of the decision be kept in the prescribed form set out in Regulation 27 and made available for public inspection at the Office of the Environment Commissioner. The ECC is valid for a maximum period of three years.

Articles 50 and 51 of the Act provide for a simple appeals process. Under this process, any person may appeal a decision made by the Environment Commissioner to the Minister of the Environment and Tourism, and if this does not resolve the problem, the Minister's decision may be appealed to the High Court.

Audit

An environmental audit is not yet a common practice in Namibia, although several audits have been carried out. Most audits have been conducted because of property transfers (e.g., mines), where the new owners require specific information about the extent to which they are responsible for environmental impacts that have occurred or may occur in the future. Most of the audits were carried out by independent consultants. Neither the Act nor the EIA Regulations specify the need for audits.

Monitoring

The EIA Regulations do not specify the need for the proponent to carry out environmental monitoring. However, the need for monitoring can be derived from the requirement to draw up an EMP.

Section 17 of Part V of the EMA authorizes the Environmental Commissioner to carry out inspections to monitor compliance with the EMA and the conditions set out in the ECC. The Environmental Commissioner may be assisted in this task by Environmental Officers (who may be consultants appointed specifically for this role) and/or the police. This provision provides a way of overcoming the limitations opportunities in the context of the MET. Post-implementation monitoring following the promulgation of the EIA Regulations is more frequent than before that date, i.e. the pre-implementation monitoring. However, capacity constraints remain a concern and not all projects are monitored. Projects in dispute tend to receive more attention in this respect.

If monitoring and/or inspections show that a developer is not complying with the ECC or has violated the EMA, the Environmental Commissioner has the right to suspend or cancel the ECC for a period that he/she may determine. The ECC can be reinstated after the Environmental Commissioner verified and made sure that the appropriate person has rectified the deficiency that caused the suspension.

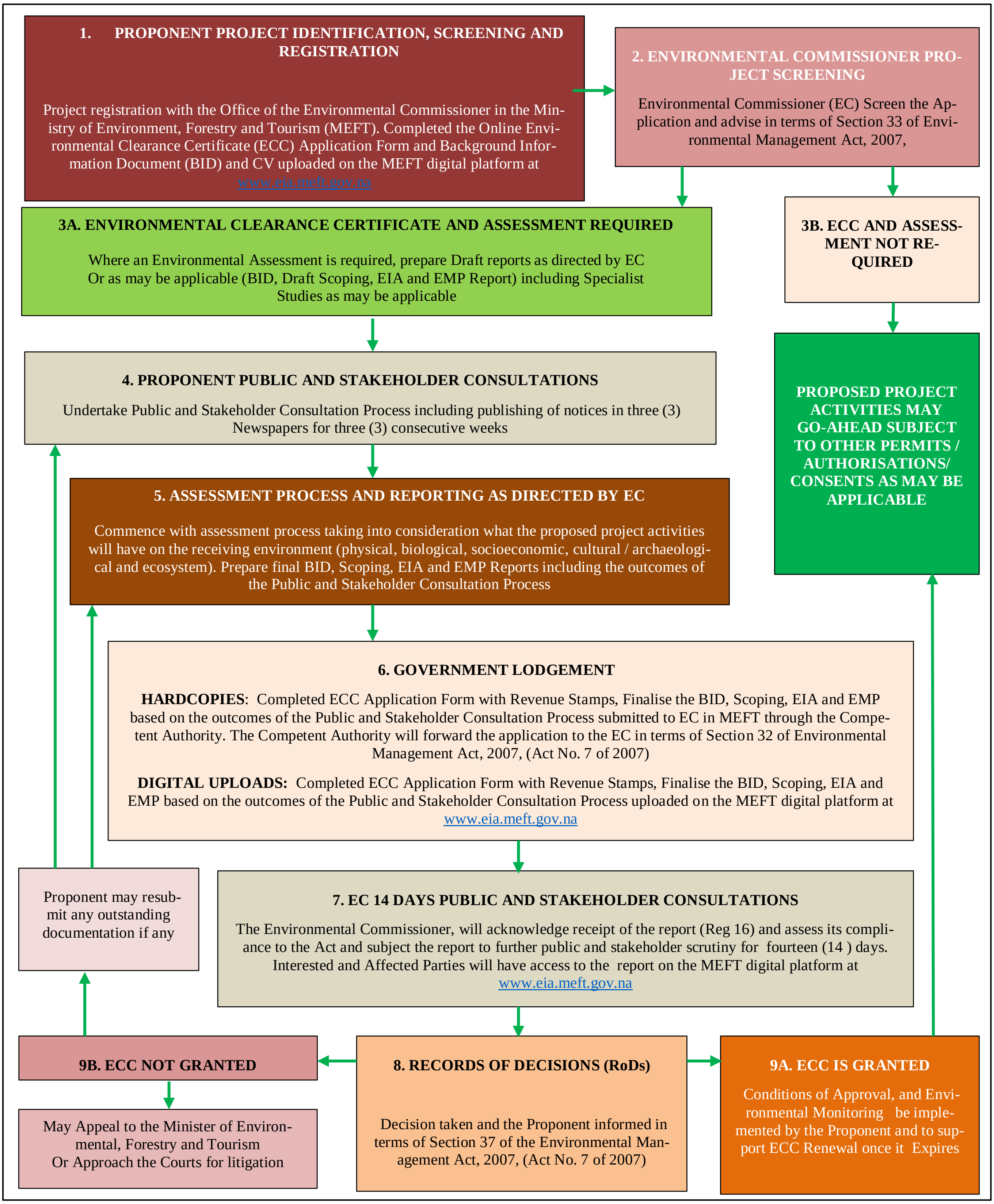

Figure 2.5 Block diagram of the EIA process for Namibia

3. IMPACT ASSESSMENT METHODOLOGY

The impact assessment methodology used in this report provides the basis for characterising the potential environmental and social impacts of proposed activities. The methodology is based on models commonly used in impact assessment and takes into account the requirements established by Namibian legislation and international organisations.

Potential impacts arising from the planned activities and the unplanned events are assessed. The planned ones include standard and non-standard Project activities and events required for uranium ISL technology. The unplanned events are those events that are not expected to occur in the normal course of Project activities.

The methodology for assessing the impact of planned activities takes into account the magnitude of the impact and the susceptibility of the facilities to impact. A matrix is also used to determine impacts under current conditions and after activities have taken place.

The concept of probability is part of the unplanned event methodology.

It considers the probability of an event and the likelihood of its consequences.

3.1 Environmental Impact Assessment Process

The EIA process is a systematic approach to identifying the environmental and social impacts of a proposed activity as well as describing the mitigation measures that will be implemented to address these impacts. Ultimately, it allows the relevant organisations to make justified decisions on proposals for the implementation of the proposed activity and allows the potentially involved stakeholders to participate in the process.

The environmental impact assessment includes the following stages:

Review of the application of the proposed activity in order to determine its compliance with the requirements of environmental legislation and, in some cases, screening of the impacts of the proposed activity.

Scoping the environmental impact assessment: The purpose of scoping of the environmental impact assessment is to determine the extent of detail and types of information to be collected and studied during the environmental impact assessment, the methods of investigation and procedure on how this information should be presented in the potential impact report.

Preparation of the potential impact report: in accordance with the opinion on the determination of the scope of the environmental impact assessment, the proponent shall ensure that the measures necessary to assess the environmental impact of the planned activity and the preparation of the potential impact report based on their results are carried out.

Public hearings with regard to the draft report on possible impacts: the draft report on possible impacts shall be subject to public hearings with the participation of representatives of interested state bodies and the public, which shall be held in accordance with this article and the rules of public hearings, approved by the authorised body in the field of environmental protection (hereinafter referred to as "the rules of public hearings").

Assessment of the quality of report on possible impacts: the authorised body in the field of environmental protection shall render a conclusion on the results of environmental impact assessment, which shall be based on the draft report on possible impacts, taking into account its possible revision in accordance with environmental legislation, the minutes of public hearings, which established the absence of comments and suggestions of the state authorities and public concerned, the protocol of expert commission meeting (if available), and, if necessary, the assessment of transboundary impacts on the results of such assessment.

Issuance of the environmental impact assessment conclusion and its consideration: The conclusions and conditions contained in the environmental impact assessment conclusion shall be taken into account by all state authorities when issuing permits, accepting notifications and other administrative procedures related to the implementation of the relevant planned activity.

3.2 Scope of Work on EIA

The process of assessing the potential impacts of the Project includes:

- **Forecast**: What will happen to the environment as a result of implementing this Project (i.e. identification of activities and impacts associated with the Project)?

- **Assessment**: Will it have favourable or unfavourable impacts? How big is the expected impact? How important will it be to the affected objects of impact?

- **Mitigation measures**: if the impact is a concern, can anything be done to prevent, minimise or compensate it? Are there opportunities to enhance the potential benefits?

- **Characterisation of residual impact**: is the impact a cause for concern after mitigation measures have been taken?

The severity of the impact with and without mitigation measures is therefore assessed. Impact severity in the absence of mitigation measures was assessed using the project's monitoring mechanism. Impacts without mitigation measures do not reflect the present extent of impact caused by the Project and are taken into account to facilitate understanding of how and why mitigation measures were identified.

The residual impact is what remains after mitigation and management measures have been applied, and is thus the final level of the impact associated with the Project implementation. Residual impacts are also used as a starting point for management and monitoring procedures during Project implementation and provide an opportunity to compare actual impacts against the forecast presented in this report.

For some types of impacts, there are empirical, objective and established criteria for determining the significance of potential impacts (e.g. if a standard is breached or a protected area is damaged). However, in other cases, the assessment criteria are more subjective and require more in-depth professional judgement. The criteria against which the significance of planned impacts for the purposes of this Project has been assessed have been described in terms of two components: magnitude of impact and receptivity of objects of impact.

3.2.1 Impacts from Various Activities

On the basis of the environmental impact assessment carried out during the scoping phase, the project activities and their potential impacts on physical, natural objects and the public have been further identified. Based on the ENVIID undertaken during the scoping phase, project activities and their potential impacts on physical, natural objects and the public have been further identified.

For this purpose, the following definition of the Project impacts from ISO 14001:2004 has been adopted:

- *Any change to the environment [or social impact object], whether adverse or beneficial, wholly or partially resulting from an organisation's environmental [or social] aspects.*

The definitions of "activity" and "impact target" are not included in ISO 14001:2004, but the following definitions are used for the purposes of this Project:

Activity under the Project is defined as:

- The physical action or object associated with the operation of the Project's plant, equipment, technology or vehicles, and the actions of Project personnel.

An object of impact under the Project is deemed to be:

- Someone or something that may be affected by the Project, including human health, water resources, atmospheric air, ecological habitats and species, cultural heritage sites, and the broader concept of the environment.

Impacts are therefore a process of interaction between Project activities and physical, natural objects and populations.

Project activities have been identified based on an analysis of the Project description (Chapter 4). Potential impacts have been identified based on the details of the Project activities and their potential interactions with the environment (physical, environmental and/or social objects of impact). This also requires an understanding of the potential sources of impacts and impact pathways, as well as compliance with the following conditions

- Having an understanding of the background state of the environment and potential objects of impact;

- The spatial and temporal extent of the Project's zone of influence;

- information from stakeholders, including authorities, experts and the public; and

- professional knowledge and experience in working on comparable projects or mines.

To some extent, the identification and understanding of Project activities and impacts have been an iterative procedure carried out throughout the EIA process as design, environmental and social baseline information became available.

As noted above, this EIA is actually of local nature, considering solely the hydrogeological model of the ISL in the context of the Wings Project, and the impacts of uranium ISL technology on environmental components in order to further implement the full EIA process for the Wings Project.

The environmental impact assessment for this EIA is structured within the following areas:

- water quality, hydrogeology.

- Soil, vegetation, fauna.

Impacts such as atmospheric air, public health and living conditions, ecological systems and ecosystem services cannot be considered in isolation with regard to the impacts of the ISL technology alone, without considering all aspects of the planned activities (without considering cumulative impacts) and therefore these areas have not been considered in this EIA.

3.2.2 Impact Characterisation

The structure of mitigation and prevention measures is established at the time of project development and is as follows:

- Prevention at source; Mitigation at source.
- mitigation in situ.
- mitigation at the receptor.
- restoration or correction.
- compensation.

Impacts after mitigation measures have been taken and which cannot be avoided due to a lack of technology in practice to eliminate or reduce the impact are referred to as residual impacts.

Initially, a qualitative assessment of the significance of possible impacts is carried out by experts. The most significant negative impacts to which mitigation measures should be applied are identified.

Then, taking into account the planned mitigation measures, the residual impacts will be assessed.

The type of impact, direct or indirect, is determined according to the following definitions:

- Direct impacts are impacts that are directly related to the project operation and result from the interaction between the operation and the host environment.

- Indirect impacts are environmental impacts that are not the direct (immediate) result of the project implementation, often occur at a distance from the project area or are the result of complex impacts.

The significance categories of residual impacts are then determined according to the semi-quantitative methodology outlined in the following sections and then compared with the original qualitative expert judgement. An example is presented in Table 3.1.

An assessment of the significance of residual impacts is important for the following reasons:

- to demonstrate to the project engineers the need for appropriate additional mitigation measures;

- To inform the relevant decision-making bodies and stakeholders of the most significant adverse impacts.

Table 3.1 - Example of a residual impact assessment

Initial description of impact, significance of impact (high, medium, low), type of impact (direct, indirect)	Mitigation measures	Residual impact	
		Impact description	Impact significance (high, medium, low),
Impacts during construction of the pipelines on the benthos. Benthos may be harmed or killed by dredging. Impact significance - high Type of impact - direct	No blasting will be used for trenching. Trenching will be done by bucket excavator or special trencher.	Suppression and partial mortality of benthos directly in trenching area	Impact intensity – moderate (3 scores) Time scale - Short-term (6 months) Area of impact - local (1 score) Significance – medium (18 scores)

3.2.3 Procedure for Determining the Significance of Impacts During Normal Operations

The impact study for the preparation of each specific EIA should include mitigation measures already envisaged by the design based on the work included in the preliminary design, together with those measures that are part of the relevant international practice.

Further detailing of the range of mitigation measures should be carried out at the detailed design stage. However, the characteristics of the environmental conditions should be carefully analysed at the earliest stages of design.

In assessing the significance of impacts, residual impacts are investigated.

The EIA reflects the impact analysis of the project (object), based on the design information available to the environmentalists. In turn, planners and designers should have information at the earliest stages of design on the natural conditions and features of the area (water area) where the project will be located.

For many impacts, the assessment of the significance of residual impacts is based on the design decisions and commitments provided by the proponent of the planned activity.

In turn, the developer of the EIA may propose to the client of the EIA a number of measures that will help to reduce the impact on individual components of the natural environment and will be included in the list of adopted environmental protection measures.

3.2.3.1 Significance Criteria

In most environmental impact assessments, it is difficult to quantify the significance of environmental changes. The proposed methodology is a semi-quantitative assessment based on scores.

The significance of an impact, which is the net measure of the assessed impact on a particular component of the natural environment, is assessed according to the following parameters:

- spatial scale.
- temporal scale.
- intensity.

Comparison of the impact significance values for each parameter is assessed by a score-based system according to the developed criteria.

In contrast to the social sphere, zero impact is not considered in case of the natural environment. This is due to the fact that, unlike the social sphere, any activity will have an impact on the natural environment. Zero impact will only occur in the absence of the planned activity.

A multiplicative calculation methodology is proposed to determine the significance of the impact on the natural environment.

3.2.3.2 Determination of the Spatial Scale of Impacts

The spatial scale of impacts is determined based on the analysis of technical solutions, mathematical modelling or the expert judgement of possible consequences of impacts using the following gradation:

- Site-wise impact - impacts that affect components of the natural environment, limited within the territory (water area) of the immediate location of the facility or insignificantly exceeding it in area. Impacts affecting areas up to 1 km^2. Impacts affecting elementary natural-territorial complexes on land at the level of facies or tracts.
- Limited impact - impacts that affect components of the natural environment in an area of up to 10 km^2. Impacts affecting terrestrial natural-territorial complexes at the level of groups of tracts or areas.
- Local impact - impacts having an effect on components of the environment within an area of up to 100 km^2 that affect terrestrial natural-territorial complexes at landscape level.

- Regional impact - impacts having an impact on the components of the natural environment on a regional scale within the territory (water area) of more than 100 km^2, affecting the natural-territorial complexes on land at the level of landscape districts or provinces.

Scale for assessment of spatial impacts is presented in Table 3.2.

Table 3.2 - Spatial scale (area) of impact

Scale	Spatial boundaries of impact* (km^2 or km)		Score
Site-wise impact	up to 1km^2 impact area	impact at a distance up to 100m from linear object	1
Limited impact	up to 10 km^2 impact area	impact at a distance up to 1 km from linear object	2
Local impact	impact area from 10 to 100 km^2	impact at a distance from 1km to 10 km from linear object	3
Regional impact	impact area of more than 100 km^2	impact at a distance of more than 10 km from a linear object	4

***Note**: Area boundaries are primarily used for linear objects; where the impact area cannot be estimated, the linear distance is used

3.2.3.3 Determination of the Temporal Scale of Impacts

The determination of the temporal scale of impacts on individual components of the natural environment is determined on the basis of analysis, analytical (modelling) assessments or expert judgement according to the following gradations:

- Short-term impact - an impact that is observed for a limited period of time (e.g. during construction, drilling or decommissioning), but usually ceases after completion of the operation, the duration does not exceed 6 months;
- Medium duration impact - an impact that occurs over a period of 6 months to 1 year.
- long-lasting impact - an impact occurring over a long period of time (more than 1 year, but less than 3 years) and typically covering the construction period of the project facility.
- Long-term (permanent) impacts - impacts occurring over 3 years or more (e.g. operational noise) and which may be periodic or frequently recurring. For example, impacts from regular burst emissions (BE) of air pollutants. Generally, relates to the period when the operation of the facility commences.

In the case of seasonal activities (which take place, for example, only during warm periods of the year over several years), the cumulative actual time of impact is taken into account.

The temporal impact assessment scale is presented in Table 3.3.

Table 3.3 - Temporal scale (duration) of impact

Scale	Temporal scale of impact*	Score
Short term impact	Impacts occurring up to 6 months	1
Medium duration impacts	Impacts occurring between 6 months and up to 1 year	2
Long-lasting impact	Impacts occurring within 1 to 3 years	3
Long-term (permanent) impact	Impacts occurring over a period of 3 years or more	4

The intensity scale is derived from a range of environmental assessments as well as expert judgement (estimates) and is shown in Table 3.4. The use of expert judgement is usually required in cases where criteria are not applicable to assess the intensity of impacts, for example, to assess individual emergencies/disasters.

Table 3.4 - Impact intensity scale

Scale	Description of impact intensity	Score
Insignificant impact	Changes in the natural environment not exceeding the existing natural variability	1
Minor impact	Changes in the natural environment exceeding the limits of natural variability, the natural environment is fully self-regenerating.	2
Moderate impact	Changes in the natural environment that exceed the limits of natural variability result in disturbance of individual components of the natural environment. The natural environment retains its ability to self-regenerate	3
Severe impact	Changes in the natural environment result in significant disturbance of components of the natural environment and/or the ecosystem. Individual components of the natural environment lose their ability to self-regenerate (this statement does not apply to atmospheric air)	4

3.2.3.4 Determining Impact Significance

Impact significance is actually a comprehensive (integral) assessment. Determination of impact significance is carried out in several stages.

Step 1: To determine the significance of impacts on individual components of the natural environment, it is necessary to use impact criteria tables. The impact significance score is determined using the formula.

$$O^{i}_{integr} = Q^{t}_{i} \times Q^{s}_{i} \times Q^{j}_{i}$$

where:

O^{i}_{integr} is integrated assessment score for the impact in question;

Q^{t}_{i} - is the temporal impact score on the *i-th* component of the natural environment.

Q^{s}_{i} - is the spatial impact score on the *i-th* component of the natural environment.

Q^{j}_{i} - is the intensity score of the impact on the *i-th* component of the natural environment.

Step 2: The significance category is defined by an interval of values depending on the calculated score, as shown in Table 3.5.

The significance categories are uniform across the different components of the natural environment and may already be comparable to identify the component of the natural environment that will be most heavily impacted.

Table 3.5 - Impact significance categories

Impact category, score			Significance categories	
Spatial scale	Temporal scale	Intensity of impact	scores	Significance
Site-wise 1	Short-term 1	Insignificant 1	1- 8	Impact of low significance
Limited 2	Medium duration 2	Minor 2	9- 27	Impact of medium significance
Local 3	Long-lasting 3	Moderate 3	28 - 64	Impact of high significance
Regional 4	Long-term 4	High 4		

Three categories of impact significance have been adopted to represent the results of the impact assessment:

- An impact of low significance occurs when effects are experienced, but the magnitude of the impact is quite low (with or without mitigation) and is within acceptable standards or receptors have low sensitivity/value.
- Impacts of medium significance can range from a threshold value below which the impact is low, to a level that almost breaches the legalized limit. Wherever possible, reductions in impact of medium significance should be demonstrated.

An impact of high significance occurs when the permissible limits for the intensity of pressure on a component of the natural environment are exceeded or when impacts of large magnitude are observed, particularly with respect to valuable/sensitive resources.

Categories of significance are determined for all components listed in the Environmental Code and EIA Guidelines.

In order to obtain the impact significance category, an average composite impact rating (as described above) is first determined for each component of the natural environment.

If the impact significance determined for a particular environmental component (air, wildlife, etc.) is the only one, it is used directly to assess the resulting impact significance.

In practice, a single component of the environment may be affected by different impacts from multiple sources and therefore a net impact significance assessment for a particular component of the environment is used to determine the impact significance. Based on the results of the identified levels of impact significance, the expert can provide an integral assessment of the impact on a particular component of the environment.

3.3 Mitigation Measures

Where the EIA had identified the potential for increased impacts, mitigation measures (including measures to avoid, manage or monitor impacts) were developed. Once an adverse impact was identified, the next step was to identify measures to avoid or mitigate it. Project controls and mitigation measures were developed based on their classification (Figure 3.1), which is considered best practice in risk management. The Project has adopted the following sequence of activities: identifying ways to avoid or eliminate negative impacts, then developing solutions to mitigate these through the use of project controls. In developing mitigation measures, activities related to prevention, minimisation, remediation and restoration were considered. Where there are significant residual impacts, offsetting measures were analysed. In order to exclude net loss of biological resources, a similar approach was applied to all phases of the assessment. The impact on the natural habitat of the most valuable biological species was analysed to ensure a "net gain" in their numbers. The classification of mitigation measures adopted by the project is shown in Figure 3.4.

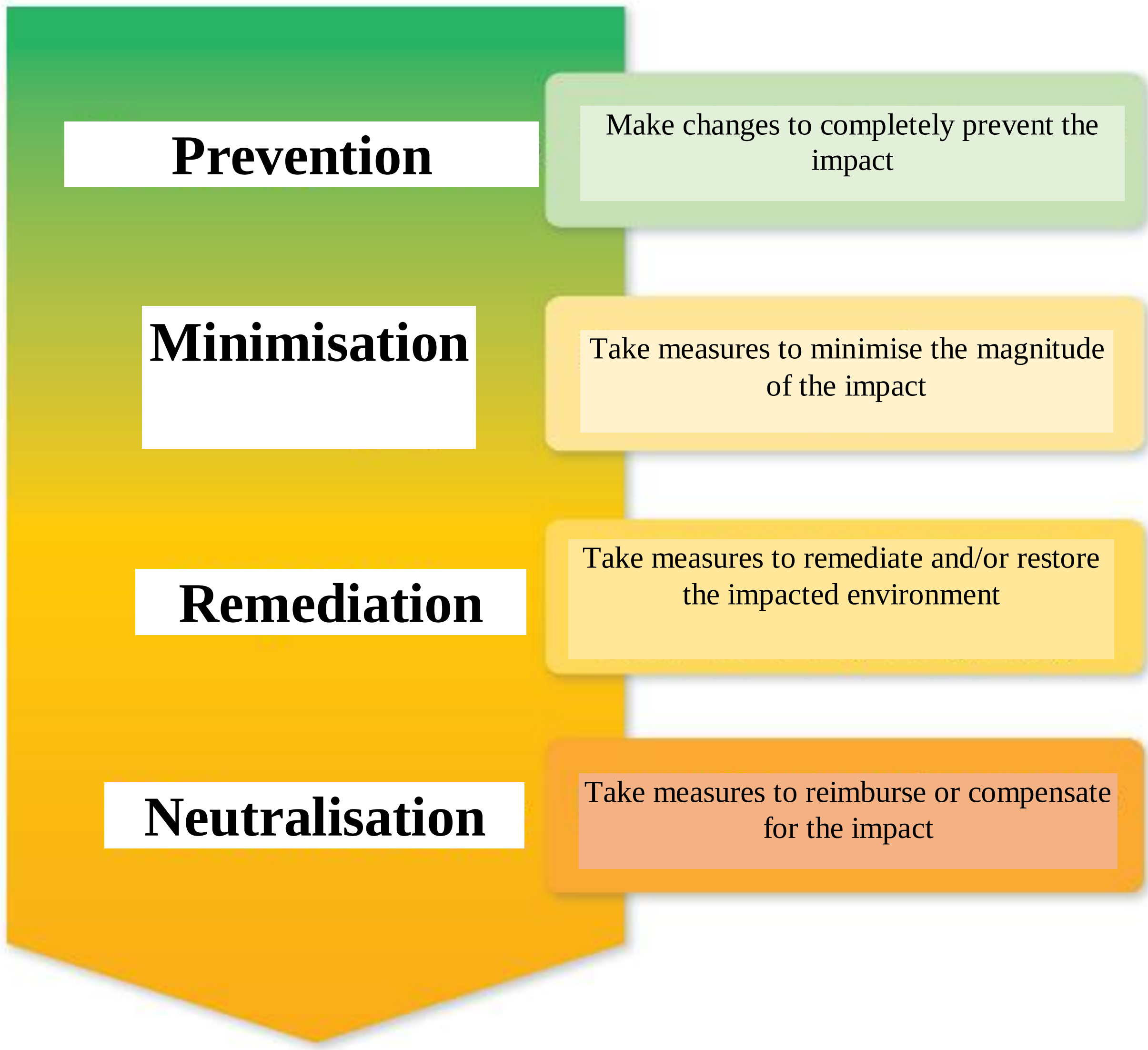

Figure 3.1 - Classification of impact mitigation measures

3.1 Residual Impact Assessment

EIA specialists were engaged to work in close cooperation with the project's technical specialists to address the challenges of developing feasible and economically viable mitigation measures. These measures have been agreed upon and incorporated into the project implementation plan.

Once cost-effective mitigation measures had been identified and agreed upon, the EIA team re-assessed the EIA for the conditions under which these measures would be successfully implemented in accordance with the plan.

In general, impacts with "negligible" or "low" significance of residual impacts were not considered to be of interest for the development of the Project. For adverse impacts of "moderate" and "high" significance, an iterative procedure is undertaken to further explore opportunities to reduce impacts in line with the classification above. In cases where significance cannot be reduced, an explanation is provided as to why further reduction is not feasible. Monitoring is required to confirm that mitigation measures are working properly and that impacts do not exceed predicted ones.

4. DESCRIPTION OF THE PLANNED ACTIVITY

4.1 Description of the Location of the Planned Activity

As noted above, the Wings Project is located within licences EPL 4654 to EPL 4657 and EPL 6780 to EPL 6783 of the State of Namibia in the northern part of Aranos Basin. The Auob Formation aquifers are estimated to contain 180 billion m^3 (JICA, 2002) of freshwater that is used for water supply, human consumption, livestock production and irrigation. In addition, the Auob Formation aquifers have the greatest potential for uranium mining. The Aranos Basin (also called Stampriet Aquifer Basin or Stampriet Transboundary Aquifer System) is included in the Stampriet Groundwater Control Area, and water abstraction for mass use is regulated by the government.

The Wings Project Deposit is located in the southwestern part of the Kalahari Desert (Figure 4.1).

The western boundaries of the Wings Project are located 153 km south-east of the Namibian capital city of Windhoek. The project predominantly occupies the Omaheke Region, partially Hardap Region and Khomas Region. The only dry river, Nossob, runs through the project area.

There are no national parks and nature reserves or other protected areas or recreational areas in the project area.

The pilot test mining cell with an area of 202 m^2 is located south of the C23 motor-road at a distance of 15 km west of Leonardville settlement. Leonardville is a village in the Omaheke region of eastern Namibia. Founded by about 500 community members, by 2010 the depopulation of villagers had reduced the number to 176.

Leonardville is governed by a five-seat village council. In the 2010 local elections in the village, the ruling SWAPO party won three of the five seats on the village local council. The Rally for Democracy and Progress (RDP) and the National Unity Democratic Organisation (NUDO) won one seat each. Local government elections in 2015 ended with the same result: three seats for SWAPO and one each for NUDO and RDP.

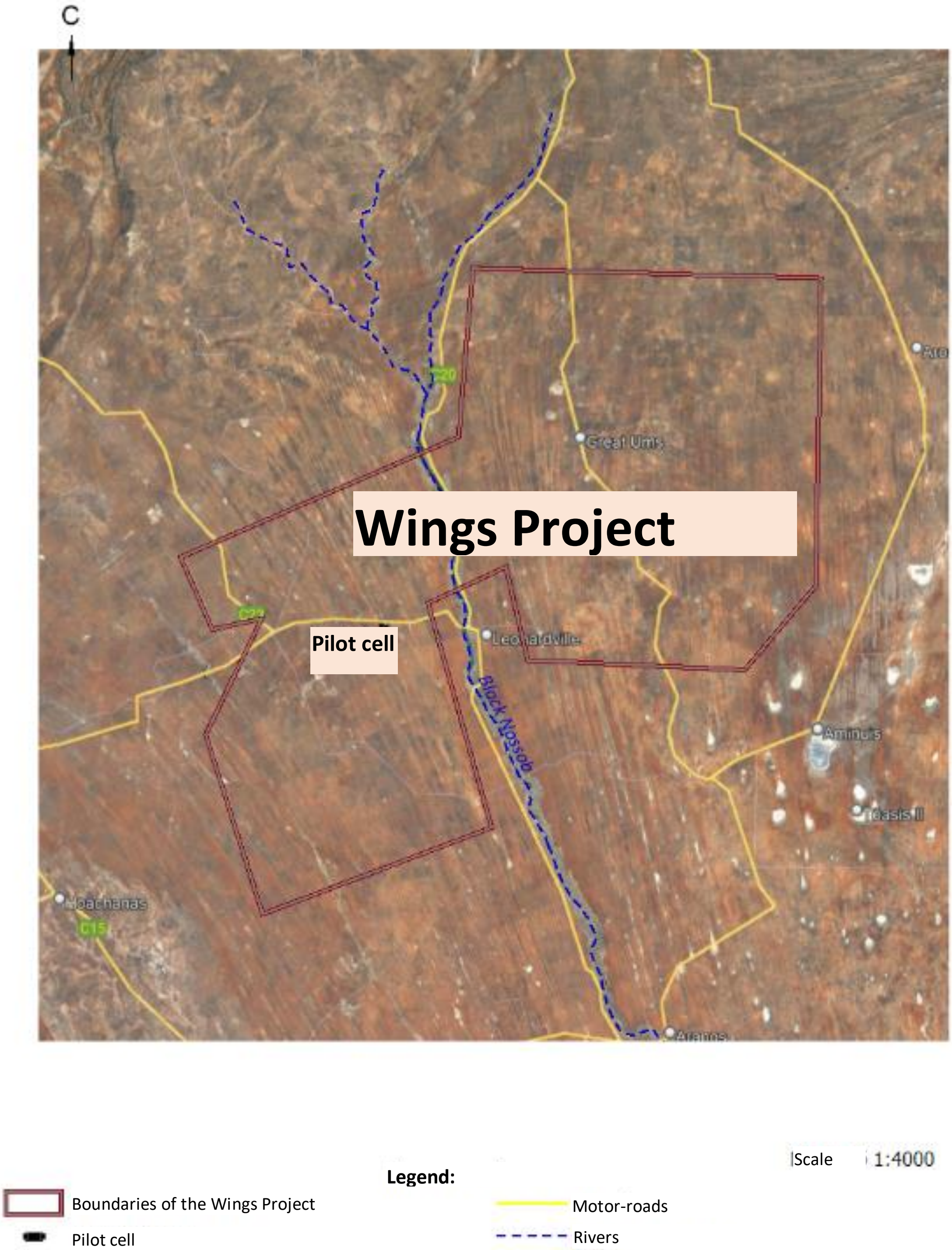

Figure 4.1 Overview map of the Wings Project boundary location

4.1 Brief Description of the Environment of the Wings Project Area

4.1.1 Climate and Physical and Geographical Conditions

The Kalahari Desert is a large semi-arid sandy savannah in Southern Africa extending for 900,000 km^2, covering much of Botswana, northern South Africa, and eastern Namibia. The entire territory of the Kalahari is occupied by sand dunes, usually in chains.

The project area is represented by a smoothed terrain with long narrow dunes in the western part and rounded lowlands in the eastern part. The absolute altitude varies between 1,200 and 1,500 m.

Desert drainage is carried out through dry, sub-meridional, seasonally flooded valleys Nossob, Olifants and Auob, as well as large salt marshes in the eastern part of the project area.

The Kalahari Desert is a harsh place with two seasons: the dry season and the rainfall season. The dry winter season (March to November) lasts eight months or more, and the wet summer season (December to February) usually lasts from one to four months, depending on the area.

The mean annual rainfall ranges from 50-200 mm (on the verge of aridity) to 700 mm in rare wet years. In the summer, rainfall can be associated with heavy thunderstorms. On average, more than 4,000 hours of sunshine are recorded annually.

The evaporation volume is 3,000 mm, much higher than the amount of rainfall.

The main watercourses of the Nossob and Oliphants Rivers have a south-easterly direction. Huge reserves of subsurface water lie under some parts of the Kalahari.

The flora is represented by tree species (various types of acacias), and numerous grass plants. When moving to the south and southwest, the vegetation becomes more and more desert-like. Pit-and-mound sandy plains are replaced by high sand dunes with a sparse cover of grass plants, namely Aristida, Eragrostis. Separate xerophytic shrubs grow in the inter-saline depressions.

The Kalahari is home to many migratory birds and animals. Previously it used to be a haven for wild animals from elephants to giraffes, and for predators such as lions and cheetahs. The riverbeds are now mostly grazing spots, though leopards and cheetahs can still be found. The area is now heavily grazed and cattle fences restrict the movement of wildlife.

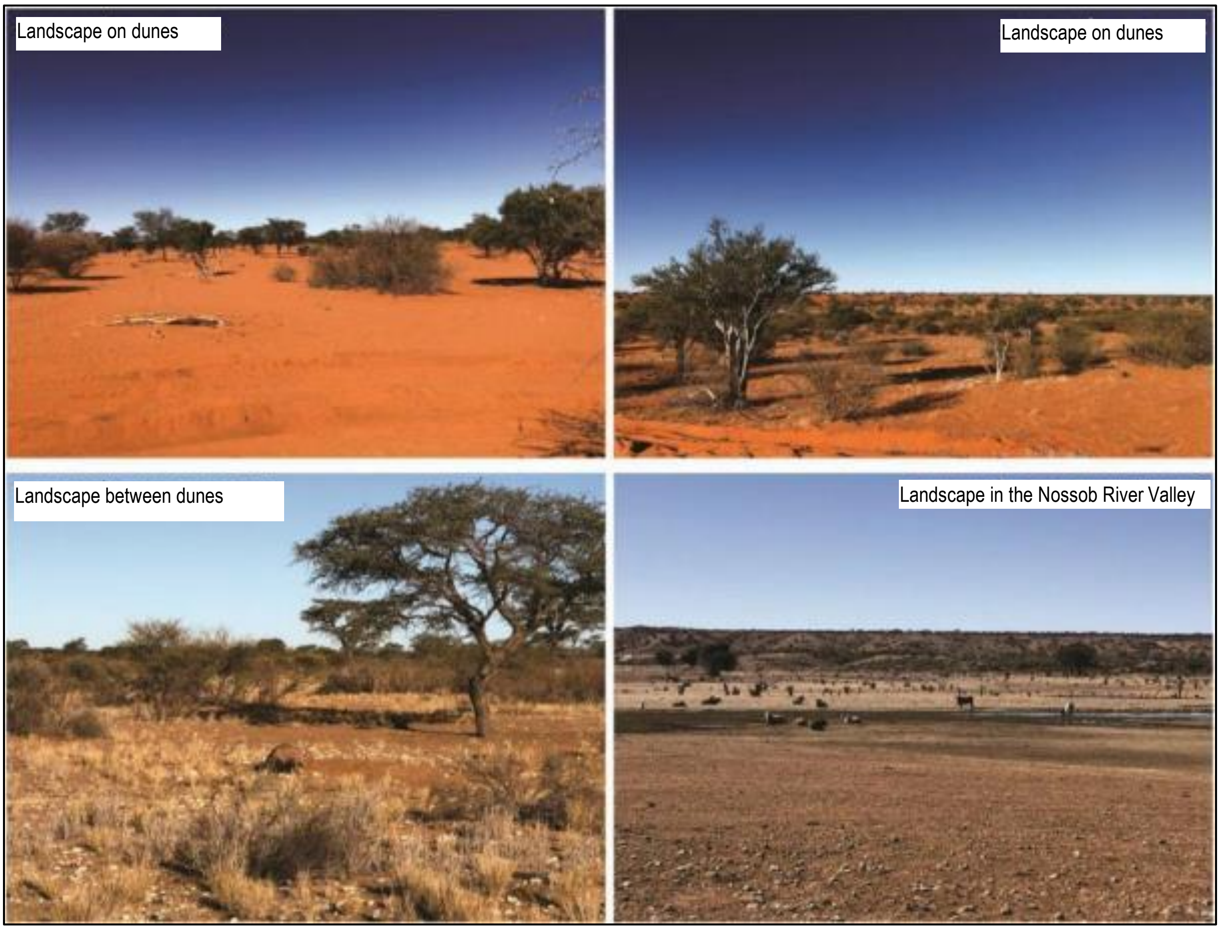

Figure 4.2 Landscapes of the Project Wings

Although there are few endemic species, a wide variety of species are found in the region, including large predators such as the lion, cheetah, leopard, spotted hyena, brown hyena, and Cape wild dog. Birds of prey include the secretary bird, martial eagle and other eagles, the giant eagle owl and other owls, falcons, goshawks, kestrels, and kites. Other animals include wildebeest, springbok and other antelopes, porcupines and ostriches.

4.1.2 Geology

The Aranos Basin of the Karoo period is extensive and covers eastern Namibia, western Botswana and northwestern South Africa.

The Damara complex and the Nama group are considered as the basement rocks of the Aranos basin since from the hydrogeological point of view they serve as an impenetrable regional water barrier (JICA, 2002).

The Karoo Sequence in the Aranos artesian Basin consists of a basal Dwyka group consistently overlapped by the Prince Albert formation, which is represented by Nossob, Mukorob, Auob and Rietmond horizons.

The Dwyka Group is located at the base of the Aranos Basin and consists of glacial sediments that were deposited in the Late Carboniferous to the Early Permian Period. Specialists of JICA (2002) considered the group as the basement rocks of the study area because they serve as an impermeable layer from a hydrogeological point of view.

The base of the Nossob Horizon sandstones is the base of the Prince Albert Formation. The transition from the sedimentation conditions of Dwyka Group to the Nossob horizon was abrupt.

At the base of the Nossob horizon lies a thin pebbly sandstone up to 54 cm thick with pebbles formed from the underlying rocks of the Dwyka Group, which indicates the erosion of the underlying sediments (JICA, 2002).

The Nossob horizon is composed of fine-grained limestone and clay-limestone sandstones with fragments of silty clay, sandy siltstones. Layers of siltstones and mudstones occur in the upper and middle parts of the horizon. The thickness of the Nossob horizon exceeds 25 metres.

The Mukorob horizon is considered to be a shale-siltstone-sandstone sequence between the upper sandstone of the Nossob horizon and the eroded base of the Auob horizon.

The Auob horizon of alluvial-lacustrine and coastal-marine sediments, in which roll front uranium bodies were formed, is an ore-hosting horizon. The Auob horizon is divided by regional aquicludes into three well permeable packages: Lower (A1), Middle (A2) and Upper (A3) (Pechenkin I.G. et al., 2012). However, they are considered as one hydrogeological unit due to their horizontally volatile lithofacies (Figure 4).

To distinguish the three components of the Auob horizon, the principle of rhythmic stratigraphy was employed (the beginning of the rhythm is coarse-grained or sandy deposits, the end of the rhythm is clay or siltstone).

According to Miller (2008), the Auob Formation is divided into 5 units (Table 1). On the outskirts of the depression, to the north and west, clayey strata are absent and one Auob sandstone package, called the Platneus package, is present. The existence of another single sandstone stratum, called Stampriet, between Stampriet and Gochas, is known from the logs.

From a hydrogeological point of view, the extensive aquifer sections in the centre and south have two aquifers and may function as independent aquifers.

The Rietmond Horizon consists of two units, a Lower Rietmond Horizon consisting of shale and an Upper Rietmond Horizon consisting mainly of sandstone with some shale layers and oxidized fine-grained sands. The Upper Rietmond rests unconformably on the Lower Rietmond (Figure 3, Figure 4) (JICA, 2002). The Lower Rietmond appears to rest conformably on the Auob Formation sediments. The thickness of the horizon is from 65 to 140 metres.

The Kalahari sediments overlie all the underlying rocks with erosion. The thickness of the Kalahari Group varies between 10 to 50 metres within the study area.

The upper part of the suite, widely developed on the surface of the basin, is called the "Kalahari Sands". These are unconformable red and grey sands of Pleistocene, mostly poorly graded sands of fluvial origin and fairly graded aeolian sands. Areas of coarse-grained sands can be both aeolian residual sediments and fluvial in origin. The prevalence of calcareous cement in these sands varies. (JICA, 2002).

Uranium mineralisation in the Aranos Basin is confined to the boundary of the wedging zone of the formation oxidation zone, where a contrasting redox barrier is created during epigenetic ore formation. Uranium mineralisation is a hydrogenous deposit with a roll front.

Secondary oxidation with the formation of redox fronts has been established in five horizons of the Karoo Sequence (Figure 4):

- The upper Auob horizon (A3),
- The middle Auob horizon (A2),
- The lower Auob horizon (A1),
- The Nossob horizon (N),
- The Dwyka Group (D).

4.1.3 Hydrogeology

The Aranos Basin contains groundwater in porous aquifers with moderate to high potential. Groundwater in porous aquifers with high potential may be under special control.

The Kalahari artesian basin is developed within the Aranos sedimentary basin. The Auob and Nossob horizons are major artesian (pressurised) aquifers, while the Kalahari groundwater aquifer is an unconfined (free-flow) aquifer. The hydrogeological regime within the Dwyka horizon is unknown and needs to be studied.

The Aranos Basin has undergone erosion in pre-Kalahari times, leading to the removal of some Karoo sediments from the central-southern parts of the basin in Namibia.

The eroded valley up to the Kalahari was filled with sediments of the Tertiary and Quaternary age. It is assumed that groundwater from the Auob aquifer flows into the Kalahari sediments. As this process continued over time and the valley filled with sediments, the escaping groundwater evaporated and the salinity of the remaining water increased (Miller, 2008). The southern part of the Aranos Basin has saline groundwater and is known as the Salt Block.

The Kalahari artesian basin receives groundwater recharge from the uplands in the northwest, north and west of the Aranos Basin, a groundwater discharge area in the south. The regional groundwater flow direction is south-eastern.

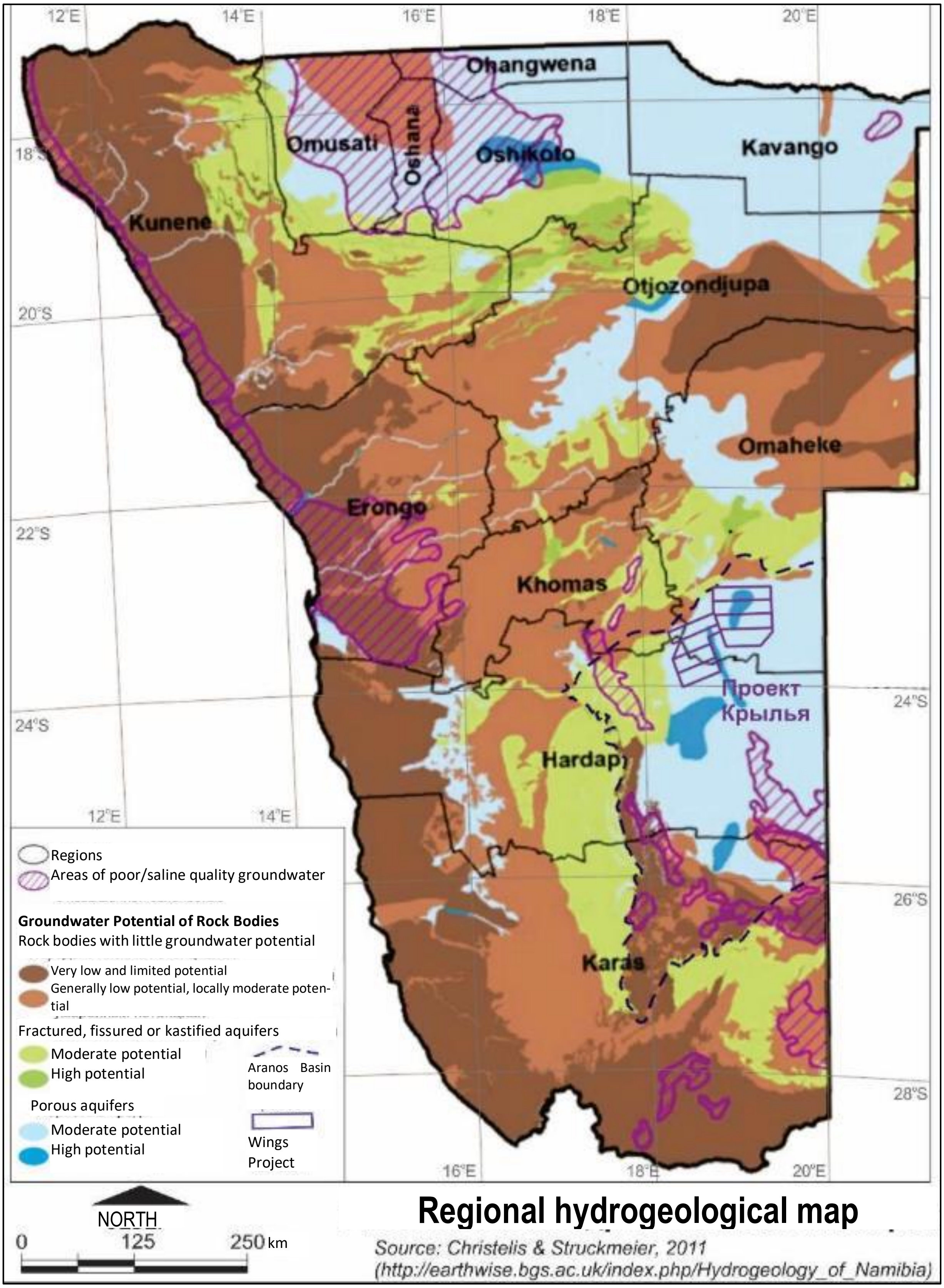

Figure 4.3 Regional hydrogeological map

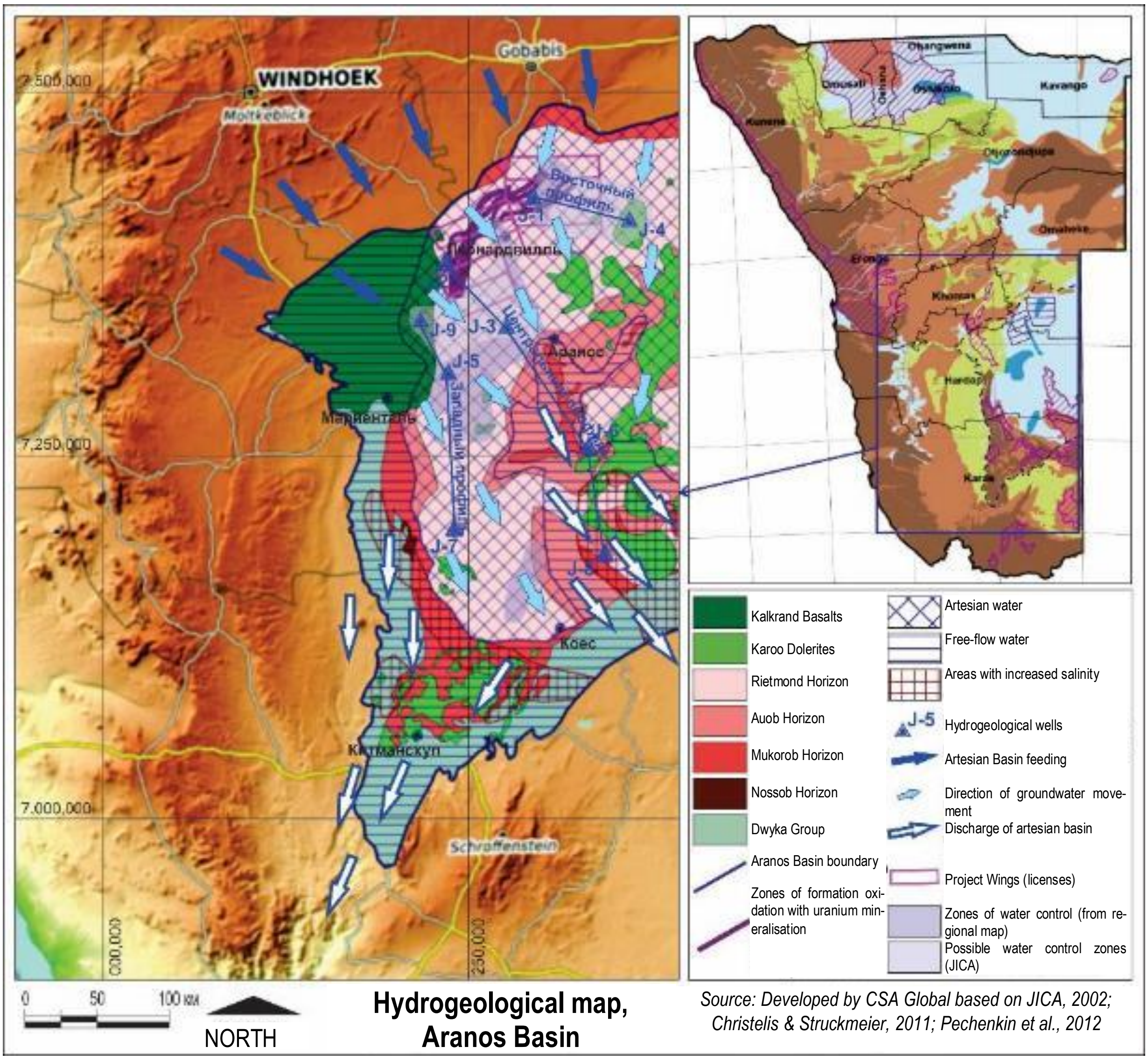

Figure 4.4 Hydrogeological map of the Aranos Basin

4.2 Project Status, Activity, Influence, Impact and Control

Headspring Investments (Pty) Ltd (proponent) holds the mining rights under the Exclusive Prospecting License (EPL) Nos. 6780, 6781, 6782, 6783, 4654, 4655, 4656 and 4657, referred herein as "Wings Project".

The proponent is currently conducting a preliminary exploration activity, which is dominated by extensive drilling activities aimed at assessing the economic potential of the areas of interest for the development of on-site uranium mining operations. Current exploration activities and potential future mining operations are focused on EPL Nos. 4654, 4655, 4656, 4657, 6780, 6781, 6782, and 6783. The target exploration potential for the Wings Project is 80-120 Mt at 300-500 ppm U3O8 (CSA Global, 2019).

If these preliminary and future feasibility studies prove positive, the proposed mining operations will include wellfield operations, a central processing plant, and auxiliary facilities. Residential facilities for the workers will be provided in Leonardville, and the acid production plant and associated residential facilities will be located in Gobabis, 135 km from the mine site.

The proposed solutions of the Uranium Project will be implemented once all the necessary regulatory approvals, such as Mining License (ML), Environmental Clearance Certificate (ECC), water intake and discharge permits, are granted by the Government and all lease/access rights to the land, contracts are agreed and signed with the landowners.

The environmental assessment steps that have been taken or are yet to be taken are summarised as follows:

1) Project selection process (conducted in August 2020).

2) Preparation of R&D Report for consultation with stakeholders and registration of projects (implemented in August / September 2020 and updated in 2021).

3) Preparation of a draft report on the assessment of the scope of work with the terms of reference (ToR) for consideration by the proponent (held in September / October 2020 and updated in 2021).

4) Preparation of a public notice for publication in local newspapers as part of the necessary public consultation process (held in September / October 2020 and updated in 2021).

5) Registration/notification of projects by filling out a formal online registration/notification form on the MEFT online portal (www.eia.met.gov.na) together with hard copies of the BID submitted to the Environment Commissioner at MEFT through the Director of Energy of the Ministry of Mining and Energy (MME) (Competent Authority) for review (to be completed during the feasibility study in 2021).

6) A register of stakeholders has been opened, which will be maintained throughout the consultation process (held in 2021).

7) Invitation/notification for stakeholders and the general public to participate in the environmental assessment process, distributed through advertisements in local newspapers, as well as through direct emails with key stakeholders, such as sectoral ministries, regional and local authorities, as appropriate (in 2021).

8) Preparation of the final scoping, draft reports of the EIA and the EMP for consideration by the client (in 2021).

9) Comments and input from clients and stakeholder consultations used to finalise the EIA and EMP reports (to be adopted in 2021).

10) The final EIA and EMP reports must be submitted to the Environmental Commissioner at MEFT through the MME (Competent Authority) in accordance with all the requirements of the Environmental Impact Assessment Regulation (EIA) No. 30 of 2012 and the Environmental Management Act (EMA) of 2007 (Act 7 of 2007) on the application of the ECC for the proposed projects (in 2021).

11) After submitting an ECC application to the Environment Commissioner, the public and stakeholders who are interested in or affected by the proposed projects will have an additional fourteen (14) days to submit comments/materials on the proposed projects directly to the Authorised Environmental Department. When the application is available for additional comments/materials by the Environmental Commissioner, it will be published on the MEFT digital portal www.eia.met.gov.na.

This EIA considers in-situ leaching, including 3D hydrogeological and hydrodynamic modelling based on the pilot block example.

4.3 Brief Description of the In-Situ Leaching Technology

The ISL process is carried out by pumping a reagent solution (2% acidic or carbonate) into an aquifer in situ in the subsoil without extracting the ore to the surface but extracting the dissolved uranium.

The ISL method is employed to mine uranium from deposits where the ore body is located in a well-permeable geological environment, in an underground aquifer.

Uranium is extracted from the ore-bearing horizon by means of a system of technological wells. A leaching solution containing a reagent that dissolves uranium minerals is pumped into the pay zone through injection wells. The leaching solution moves through the pores of the ore-bearing sand horizon. The leaching solutions do not destroy the rock, but only leach and dissolve the uranium and some minerals, resulting in a pregnant solution containing natural uranium.

The pregnant solution is extracted to the surface by means of a system of extraction wells with the help of submersible pumps. Further, via the system of intra-block and main pipelines, the pregnant solution flows to the container tank (collection tank) of the pregnant solutions processing plant.

During processing of the pregnant solution, uranium is extracted from therefrom through the ion exchange resin columns, and the solutions remaining after processing, referred to as barren solutions, are pumped through the system of main and intra-block pipelines from the processing plant to acidification units wherein they are additionally stabilised with a reagent to the required concentration and then pumped back to the injection wells.

Several volumes of leaching solutions have to be pumped through the pore space of the ore mass in order to achieve the required uranium recovery rate.

The ISL process is closed-circuit with the amount of solution injected into the ore bearing aquifer equal to the amount of solution extracted to the surface. There are no waste solutions that are withdrawn from the process. That is why there can be no lowering of the aquifer water level as in case with the groundwater extraction.

In case with in-situ leaching of uranium, ore extraction and lifting it to the surface, ore crushing, and ore grinding are completely excluded, as there is no need for the ore processing plants, there are no dumps and tailing storage facilities.

4.4 Full-Scale Test Mining of Sulphuric Acid ISL

A pilot cell has been constructed to carry out pilot test mining of in-situ leaching activities.

The pilot cell consists of four injection wells and one extraction well. The injection wells have filters, length of each filter is 4 metres and the extraction well has a filter length of 6 metres and an effective capacity of 7.5 metres; the cell area is 202 m^2.

The distance between the injection and extraction wells is 10 metres and the distance between the injection wells is 14.2 metres.

5. WATER QUALITY, HYDROGEOLOGY

This chapter discusses the potential impacts on water quality and hydrogeology associated with uranium in-situ leaching in accordance with the Namibian EIA guidelines and other relevant standards. It details the baseline hydrogeology of the contract area, describes the identification and assessment of impacts on each receptor and, where appropriate, identifies proposed measures to minimise potentially significant impacts. The forecast of the impacts of the ISL on groundwater is based on the developed "Local" hydrogeological model (pilot block) and the analysis of the planned operation regime of groundwater of the Auob horizon based on the completed models, including predicted changes of the groundwater quality indicator. Detailed necessary justifications, baseline data, calculations and analysis of the planned Auob groundwater operation regime on the basis of the completed models, indicating predicted changes of groundwater quality, are specified in **Book 1**.

The impacts on surface water quality are not considered in this EIA due to no direct impact of the ISL technology on surface water. Impacts on surface water by all of the Wings Project facilities and activities will be considered in a separate, full ESIA.

5.1 Spatial and Temporal Boundaries

5.1.1 Project Area

The proposed Wings Project ISL uranium mining operations are located within the Stampriet Artesian Basin. The most promising aquifers for detecting uranium mineralisation are the Auob and Nossob aquifers.

5.1.2 Study Area

The study area includes three major aquifers in the Kalahari Formation, the sandstones of the Auob and the Nossob.

5.1.3 Zone of Influence

The zone of influence has been defined using a pilot test cell located south of motor-road C23 at a distance of 15 km west of the village of Leonardville and corresponds tentatively to the area of the technological wells. The boundary of the pollution halo reaches a distance of 50-100 m from the outermost wells provided that the ISL sites operate in a balanced mode. The specific area of impact of the ISL sites will be determined during the preparation of a full EIA for the Wings Project as a whole.

5.2 Methodology

5.2.1 Applicable Guidelines and Standards

A description of the legal and regulatory framework relevant to the Project is in **Chapter 2 Policy, Regulatory and Administrative Framework**. The following sections present the guidelines, regulations and standards that specifically relate to water quality and hydrogeology for the Project implementation purpose.

The following documents, relevant to groundwater, have been adopted as guidelines or reference guidelines and standards, including:

- Namibia Drinking Water Guidelines.
- National Primary Drinking Water Regulations. EPA.
- Guidelines for drinking-water quality - 4th ed. © World Health Organisation, 2017.
- Russian standard SanPiN 2.1.4.1175-02 on hygienic requirements for the quality of non-centralised water supply. Sanitary protection of water supply sources.
- Russian standard GN 2.1.5.1315-03 on maximum allowable concentrations of chemical substances in water bodies for domestic, drinking and social needs.
- Russian standard SanPiN 2.1.4.1110-022.1.4 for drinking water and water supply of settlements, zones of sanitary protection of water supply sources.
- Sanitary Rules "Sanitary and Epidemiological Requirements for Water Sources, Places of Intake for Domestic and Drinking Purposes, and Domestic Water Supply and Places of Culture and Household Water Use and the Safety of Water Bodies", approved by Order No. 209 of the Minister of National Economy of the Republic of Kazakhstan, dated 16 March 2015.
- Hygienic Standards Sanitary and Epidemiological Requirements for Radiation Safety, approved by Order No. 155 of the Minister of National Economy of the Republic of Kazakhstan, dated 27 February 2015.

5.2.1.1 Namibia National Requirements

The Drinking Water Guidelines are not standards as there are no publications in the Namibian Government Gazette on this subject. However, the Cabinet of the Transitional Government of National Unity has adopted the existing South African guidelines (461/85). They came into force on April 1, 1988, signed by the then Minister of Water Resources. After the declaration of independence, the Government of the Republic of Namibia decided that the provisionally existing Guidelines would remain in force and would be used until a proper study was carried out and new standards were formulated (Section 140 of Act No. 1, 1990).

The standards used are shown in Tables 5.1 to 5.4.

Table 5.1 Determinants with aesthetic or physical effects on drinking water

Determinant	Units	Maximum allowable limits for groups			
		A	B	C	D[2]
Colour	mg/l Pt	20			
Conductivity	mS/m at 25°C	150	300	400	400
Total hardness	mg/l CaCO3	300	650	1.300	1.300
Turbidity	NTU4	1	5	10	10
Chloride	mg/l Cl	250	600	1.200	1.200
Chlorine (free)	mg/l Cl	0.1 - 5.0	0.1 - 5.0	0.1 - 5.0	0.1 - 5.0
Fluoride	mg/l F	1.5	2.0	3.0	3.0

Determinant	Units	Maximum allowable limits for groups			
		A	B	C	D[2]
Sulphate	mg/l SO4	200	600	1.200	1.200
Copper	mg/l Cu	500	1.000	2.000	2.000
Nitrate	mg/l N	10	20	40	40
Hydrogen sulphide	pg/l H2S	100	300	600	600
Iron	Mg/l Fe	100	1.000	2.000	2.000
Manganese	pg/l Mn	50	1.000	2.000	2.000
Zinc	mg/l Zn	1	5	10	10
pH[5]	unit	6.0 - 9.0	5.5 - 9.5	4.0 - 11.0	4.0 - 11.0

Table 5.2 - Inorganic determinants for drinking water

Determinant	Units	Limits for groups			
		A	B	C	D
Aluminium	pg/l Al	150	500	1.000	1.000
Ammonia	mg/l N	1	2	4	4
Antimony	pg/l Sb	50	100	200	200
Arsenic	pg/l As	100	300	600	600
Barium	pg/l Ba	500	1.000	2.000	2.000
Beryllium	pg/l Be	2	5	10	10
Bismuth	pg/l Bi	250	500	1.000	1.000
Boron	pg/l B	500	2.000	4.000	4.000
Bromine	pg/l Br	1.000	3.000	6.000	6.000
Cadmium	pg/l Cd	10	20	40	40
Calcium	mg/l Ca	150	200	400	400
Calcium	mg/l CaCO3	375	500	1.000	1.000
Cerium	pg/l Ce	1.000	2.000	4.000	4.000
Chromium	pg/l Cr	100	200	400	400
Cobalt	pg/l Co	250	500	1.000	1.000
Cyanide (free)	pg/l CN	200	300	600	600
Gold	pg/l Au	2	5	10	10
Iodine	pg/l I	500	1.000	2.000	2.000
Lead	pg/l Pb	50	100	200	200
Lithium	pg/l Li	2.500	5.000	10.000	10.000
Magnesium	mg/l Mg	70	100	200	200
Magnesium	mg/l CaCO3	290	420	840	840
Mercury	pg/l Hg	5	10	20	20
Molybdenum	pg/l Mo	50	100	200	200
Nickel	pg/l Ni	250	500	1.000	1.000
Phosphate	mg/l P	1	See note below		
Potassium	mg/l K	200	400	800	800
Selenium	pg/l Se	20	50	100	100
Silver	pg/l Ag	20	50	100	100
Sodium	mg/l Na	100	400	800	800
Thallium	pg/l ti	5	10	20	20
Tin	pg/l Sn	100	200	400	400
Titanium	Mg/I Ti	100	500	1.000	1.000
Tungsten	pg/l W	100	500	1.000	1.000
Uranium	**pg/l U**	**1.000**	**4.000**	**8.000**	**8.000**
Vanadium	pg/l V	250	500	1.000	1.000

Table 5.3- Bacteriological determinants for drinking water

Determinant	Limits for groups[1]			
	A[2]	B[2]	C	D
Standard plate counts per 1 ml	100	1,000	10,000	10,000
Total coliform counts per 100 ml	0	10	100	100
Faecal coliform counts per 100 ml	0	5	50	50

Determinant	Limits for groups[1]			
	A[2]	B[2]	C	D
Escherichia coli counts per 100 ml	0	0	10	10

Table 5.4- General standards for the discharge of waste or wastewater into the environment

Determinants	Units	Maximum allowable levels
Arsenic	mg/l As	0.5
Biological oxygen demand	—	—
Boron	mg/l B	1.0
Chemical oxygen demand	mg/l O	75
Chlorine (residual)	mg/l Cl2	0.1
Chromium, hexavalent	pg/l Cr(VI)	50
Chromium, total	pg/l Cr	500
Copper	mg/l Cu	1.0
Cyanide	pg/l CN	500
Dissolved oxygen	%	At least 75% saturation[1]
Detergents, surfactants, tensides	mg/l as MBAS[2]	0.5
Fats, oil and grease	mg/l	2.5 (gravimetric method)
Fluoride	mg/l F	1.0
Free and saline ammonia	mg/l N	10
Lead	mg/l Pb	1.0
Absorbed oxygen	mg/l O	10
pH	units	5.5 - 9.5
Phenolic compounds	pg/l as phenol	100
Phosphate	mg/l P	1.03
Sodium	mg/l Na	Not more than 90 mg/l > influent
Sulphide	mg/l S	1.0
Temperature	°C	35
Total dissolved solids	mg/l	Not more than 500 mg/l > influent
Total suspended solids	mg/l	25
Typical faecal coliforms	Per 100ml	0
Zinc	mg/l	5.0

5.2.1.2 Standards for Uranium Content in Water

As shown in Table 5.2 above, the Namibian Drinking Water Guidelines allow for a maximum of 1.0 pg/L (0.0000007 µg/L) in water for Group A quality class (water of excellent quality). Uranium is a naturally occurring substance, found in granite rocks and various other mineral deposits.

The level of intake of uranium in the body with air is low, the level of intake of uranium with food is from 1 to 4 µg/day. Intake of uranium in drinking water is usually extremely low, but if uranium is present in the source of drinking water, the latter may be the main source of uranium intake.

The guideline value recommended in the WHO Guidelines for Drinking-Water Quality is 0.03 mg/L (30 µg/L). The guideline value is calculated as a conditional value because of the uncertainty of scientific data regarding the toxicity of uranium. Levels of uranium concentration in drinking water are generally below 1 µg/L, although concentrations of up to 700 µg/L have been detected in some private water supplies. A level of 1 µg/L can be achieved by conventional treatment (e.g., coagulation or ion exchange). If concentration levels exceed 30 µg/L, it is very important to avoid hasty action. Consideration should first be given to exposure from all sources and the availability of alternative safe sources. Only the chemical aspects of uranium toxicity are discussed here; for radiological aspects of uranium toxicity, see the next section.

There is insufficient data on the carcinogenicity of uranium to humans and experimental animals. The main consequence of chemical exposure of uranium to humans is nephritis. There is very little data on the chronic health effects of natural uranium exposure in humans. Several epidemiological studies of populations exposed to uranium in drinking water have found a correlation between the presence of alkaline phosphatase and β-microglobulin in urine and small changes in proximal renal tubular function. However, these measurements were not above the physiological norm, and the results of different studies did not give unambiguous results. So far, studies in humans have not been able to clearly determine at what concentration uranium has no harmful effects. This is not surprising, as the populations included in the studies are most often relatively small, and there is considerable normal variation in the measured parameters of the human population. Nevertheless, it can generally be stated that clear data on the effects of uranium exposure below 30 µg/L are not available. Evidence for effects on the kidneys, which appear to be the most susceptible organ, only becomes unequivocal with uranium exposure at much higher concentrations. The conditional guideline value of 30 µg/L, derived from new epidemiological studies of populations exposed to high concentrations of uranium, has replaced the conditional guideline value of 15 µg/L derived from studies on experimental animals, which was considered conditional because of uncertainty about uranium toxicology and epidemiology and because of technical difficulties in conducting such studies in small-scale water systems. As noted, human population studies, if available and of good quality, are the preferred source of health information that should be used to calculate guideline values.

5.2.1.3 Radiation Exposure When Consuming Drinking Water

Protection against radiation is based on the assumption that any radiation exposure involves a certain level of risk. There is evidence that long-term radiation exposure, e.g. consumption of drinking water containing radionuclides for a long time, increases a person's risk of cancer when doses exceed 100 mSv (Brenner et al., 2003). At lower doses of exposure, epidemiological studies have not found an increased risk. It is assumed that there is a linear relationship between exposure and risk and that there is no threshold below which there is no risk. The individual dose criterion (IDC) of 0.1 mSv/year implies a very low risk that is not considered to result in any detectable adverse health effects.

Indicators of radiation safety of drinking water in Kazakhstan:

- Total α-radioactivity is 0.1 Bq/L;
- Total β -radioactivity is 1.0 Bq/L.

Requirements for radiation safety of drinking water of the Russian Federation (SanPin 2.1.4.1074-01):

- Specific activity of radon is 60 Bq/L.
- Total α-radioactivity is 0.2 Bq/L.

- Total β -radioactivity is 1.0 Bq/L.

The recommended assessment methodology for the control of health risks associated with the presence of radionuclides in drinking water includes four steps.

1. A IDC equal to 0.1 mSv for 1 year of drinking water consumption is assumed.

2. An initial assessment of total alpha radioactivity and total beta radioactivity is carried out. If the measured radiation levels are below the reference levels of 0.5 Bq/L for total alpha radioactivity and 1 Bq/L for total beta radioactivity, no further action is taken.

3. If any of the reference levels are exceeded, the concentration of the individual radionuclides should be determined and compared with the guideline levels.

4. The result of further assessment may indicate both that no further action is necessary and that further assessment is necessary to then decide on the necessary dose reduction measures.

Standards of the Republic of Kazakhstan determine that acceptable values of radionuclide content in food, drinking water and atmospheric air, corresponding to the limit of man-made dose to the population of 1 mSv/year and quotas from this limit, are calculated on the basis of values of dose coefficients for radionuclide intake through digestive organs taking into account their distribution on dietary components and drinking water, as well as taking into account radionuclide intake through the respiratory organs and external irradiation of people.

A preliminary assessment of the permissibility of using water for drinking purposes according to radiation safety indicators is given by specific total alpha- (Aa) and beta-activity (Ab). When the values of Aa and Ab are below 0.2 and 1.0 Bq/kg respectively (SanPiN RF 2.1.4.1074-01) further investigation is not obligatory. In case these levels are exceeded, the radionuclide content in water is analysed.

5.2.2 Methodology for Baseline Studies

A desk review of available information from national and international sources was undertaken. These included:

- JICA, The study on the groundwater potential evaluation and management plan in the Southeast Kalahari (Stampriet) Artesian Basin in the Republic of Namibia. Japan International Cooperation Agency (JICA), Department of Water Resources, Ministry of Agriculture, Water Resources and Rural Development, Republic of Namibia. March 2002, with updates by CSA Global (2019).
- Interim Mineral Resource Assessment Report for the Wings Project uranium deposit as of December 10, 2021, Almaty, Republic of Kazakhstan, 2021.
- Pechenkin I., Avvakumov V., Vorgacheva Y., Zublyuk Y., Ivlev I., Kaldyshkin Y., 1:250 000 scale prospecting and geological studies in the northern Aranos Basin, Namibia. All-Russian Institute of Mineral Raw Materials (VIMS). Moscow, 2012 (in Russian).

- Specialist input to the environmental scoping study. Regional-scale numerical groundwater flow model of the Auob Aquifer, Aranos Basin, Namibia. URANIUM PROJECT WINGS, U1GSST01 HEADSPRING INVESTMENTS, PO BOX 318, WINDHOEK, NAMIBIA, 2021.
- PRELIMINARY REPORT ON THE HYDROGEOLOGICAL WORK PROGRAMME: testing for groundwater inflow and engineering hydrogeological survey at the stage of geological exploration at a hydrogenic type facility for the in-situ leaching method-based mining designed for Auob horizon (upper sub horizon), Windhoek, Namibia, 2021.
- Stampriet Transboundary Aquifer System Assessment. Governance of Groundwater Resources in Transboundary Aquifers (GGRETA) - Phase 1. Technical Report, UNESCO 2016.

5.3 Overview of Existing Baseline Data

The ISL uranium mining operations proposed under the Wings Project are located within the Stampriet Artesian Basin, a groundwater protection area administered by the Department of Water Affairs of the Ministry of Agriculture, Water and Forestry. The Stampriet Artesian Basin (SAB) is part of the Greater Kalahari Basin and covers Namibia, Botswana, South Africa, Angola, and Zambia. The Stampriet Artesian Basin (SAB) is a transboundary groundwater resource that Namibia shares with Botswana and South Africa. Groundwater recharge in the Stampriet Artesian Basin is very limited. Potential sources of water supply for the proposed exploration activities can be obtained from local groundwater resources. The Stampriet Artesian Basin is recharged by several river channels, such as the sporadically flowing Nossob and Olifants rivers.

The presence of groundwater in the Stampriet Artesian Basin (SAB), including the proposed uranium mining operations under the Wings Project, is associated with the upper Kalahari group and the underlying Karoo sequences.

The three main aquifers in the SAB in Namibia are the Kalahari beds, the Auob sandstones and the Nossob sandstones. The average thickness of the Kalahari aquifer is 100 m, Auob is 80 m, and Nossob is 25 m (JICA 2002). In the south-eastern part of the Namibian SAB, the Kalahari deposits are much thicker, reaching about 250 m in the "Pre-Kalahari Valley".

The Auob sandstone aquifer and the Nossob sandstone aquifer lie in the Ecca group of the lower Karoo stratum and are separated by layers of the Mukorob element shale, which is overlain by the Rietmond shale and sandstones. The Auob and Nossob aquifers are restricted and flow freely in the Auob Valley from Stampriet and further downstream, as well as in the Nossob Valley around Leonardville. Water levels in other wells in artesian aquifers are sub-artesian. Several springs are located in the eastern Kalkrand basalt outcrop to the northwest. Groundwater is also found in the Kalahari layers throughout the basin.

According to the Department of Water Affairs and Forestry (2001) and the International Hydrological Programme of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) (2016), water in the area is used for human consumption, livestock watering, and increasingly for irrigation and tourism/hotel businesses. While agriculture and tourism/hotel facilities have economic advantages in terms of opening more jobs in rural areas, these economic activities, if poorly managed, can be a major source of groundwater pollution due to the use of fertilisers and poor choice of locations due to well faults in the agricultural sector, poor wastewater management and solid waste disposal in the tourism/hotel facilities sectors.

The Stampriet Artesian Basin (SAB) shows an increase in the level of residual water with good pressure to which the Nossob aquifer is exposed within the basin. This observation is very important from an environmental point of view since the penetration of the wellbore into the Nossob aquifer is likely to lead to the seepage of relatively low-quality groundwater from the aquifer up into the overlying Auob aquifer (with higher-quality groundwater) and even into and past the Kalahari aquifer.

5.3.1 Hydrogeological Regime of the Project Area

The most promising aquifers for detecting uranium mineralisation are the Auob and Nossob aquifers. Both aquifers are artesian, but the Nossob aquifer is free-flow / unrestricted. Auob aquifer is hydraulically connected to the Kalahari aquifer in the central and southern part of the basin, where the Rietmond horizon is eroded. The Auob aquifer is probably also locally hydraulically connected to the Kalahari aquifer in other parts of the basin, along faults, or in areas with a predominantly sandy composition within the Rietmond horizon. The Nossob aquifer is everywhere artesian because of the Mukorob horizon, which is not eroded inside the Aranos Basin.

The Artesian Kalahari Basin in the Aranos Basin most likely has a flow in a southeasterly direction into the Nossob and Auob river valleys. It also probably flows in a westerly and south-westerly direction into the valleys of the Nauchab and Asab rivers due to the outcrops of the Auob and Nossob elements in the rocks.

Groundwater recharge to the Kalahari Artesian Basin occurs from the newest orogenic upland along the Damara Sequence, located to the north and northwest of the Aranos Basin. Groundwater recharge to the north-western part of the Basin is carried out through the Kalkrand basalt plateau. Groundwater recharge from the northeast direction may be less due to the Okwa River.

The flow of groundwater in the Kalahari Artesian Basin (Aranos basin), as a rule, from northwest to southeast corresponds to the location of the recharge and discharge zones of groundwater, as well as the dip of the Karoo Sequence horizons. The formation of the uranium mineralization in the Karoo Sequence corresponds to this direction of the groundwater flow.

5.3.2 Kalahari Aquifer

Most of the Aranos Basin is covered by Kalahari deposits, with the exception of the western flank, where the Kalkrand basalts and the Karoo complex sediments (Dwyka Group, Mukorob and Nossob horizons) are distributed. Calcrete deposits, consolidated by salt and calcium, occupy the upper part of the aquifer. Except for the western part of the Aranos Basin, where the Kalahari aquifer is blocked by stabilized sand dunes. In the area covered with sand dunes, rare watercourses are developed: the Auob, Olifants and Nossob rivers flow here. In the western part of the Aranos Basin, the Kalahari aquifer is exposed on a plateau.

The Kalahari aquifer is located at the top of the aquifers and is composed of Kalahari sediments. Groundwater in the Kalahari aquifer is non-pressurised (unconfined). The bottom of the aquifer is bounded by the Rietmond horizon or its lower part of the upper part of the Rietmond horizon is composed of sandy rocks. The Rietmond horizon is sometimes absent, especially in the central and southern parts of the Aranos Basin, due to erosion, so in such areas, the Kalahari aquifer is hydraulically connected to the Auob aquifer.

The upper level of the Kalahari horizon is not bounded. The depth of the static level is from 0.5 to 46.0 metres. Well flow rates vary from 1.8 to 7.5 m^3/h (Figure 5.1). The waters are neutral. Total dissolved solids (TDS) according to regional data varies very widely from 670 mg/L to 14,874 mg/L (Figure 5.2).

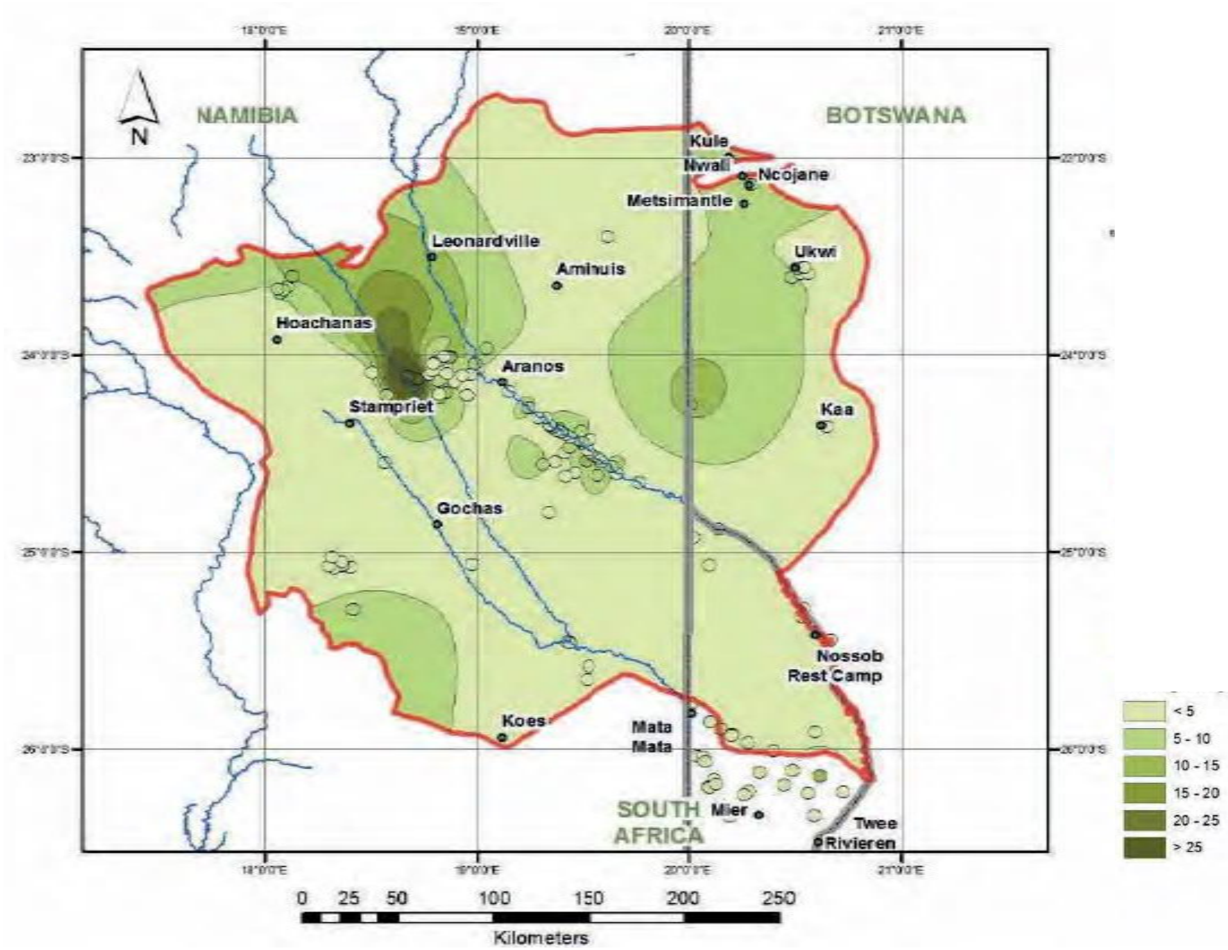

Figure 5.1 - Well flow rate (m^3/h) in the Kalahari aquifer (Source: GGRETA, 2015)

Designation: dark green: <500 mg/L; green: 500 - 1000 mg/L; yellow: 1000 - 2000 mg/L; orange: 2000 - 5000 mg/L; red: > 5000 mg/L; grey: no information.

The highest dissolved solids concentrations are observed in the south-eastern part of the Aranos Basin, especially within the J-6 well. This area mostly coincides with the Pre-Kalahari Valley or "salt block". The maximum concentration of dissolved solids, mg/L was observed at well J-6. According to the WHO drinking water standards, TDS should be less than 1 g/L.

There is local nitrate contamination in the Leonardville area. The transmissibility of the horizon varies from 0.1 to 30.0 m^2/day. In terms of radiation, the waters are safe. No areas of increased gamma-ray activity were observed by regional and geochemical studies. The groundwater level and the direction of movement of the Kalahari horizon is shown in Figure 5.3.

In the study area, the Kalahari aquifer is used most intensively. Approximately 4,500 wells, more than 80% of the total number, have been drilled into the Kalahari aquifer. A total of 9.8×10^6 m^3 of groundwater per year is extracted from the Kalahari aquifer, which is 65% of the total groundwater withdrawal in the study area.

The Auob horizon is locally outcropped east of Mariental and along a slope that extends south of Mariental.

Geologically, this horizon can be divided into three strata: lower Auob - A1, middle Auob - A2 and upper Auob - A3. These may correspond to three separate hydrogeological horizons, often hydraulically connected. They can also be considered as one hydrogeological unit due to their horizontally variable lithofacies.

The Auob horizon is the only sand layer in the western part of the Aranos Basin, with each of its strata having a more complex structure in the eastern part of the Aranos Basin. For example, in the upper horizon (A3) in the middle part, there are layers of impermeable sediments.

In general, the surface of the Auob horizon decreases from the northwest to the southeast. Its altitude at the north-western border of the basin and the south-eastern corner is 1,350 m and 800 m above sea level, respectively.

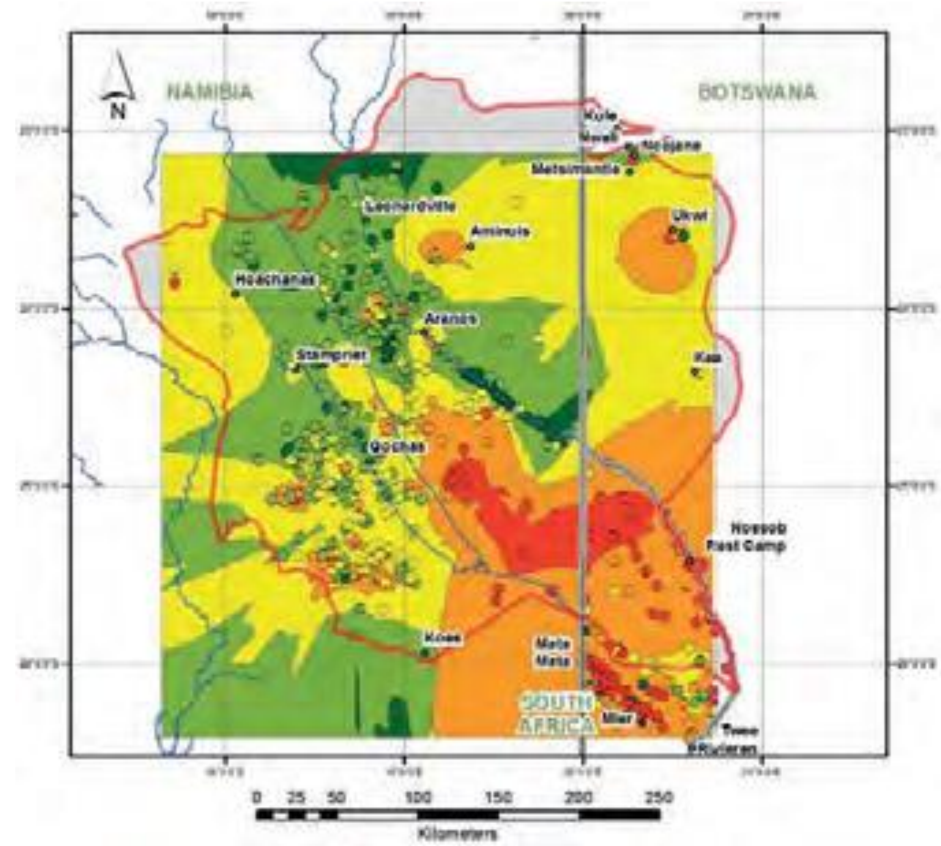

Figure 5.2 - Total dissolved solids (TDS) [mg/L] of the Kalahari aquifer (Source: GGRETA, 2015)

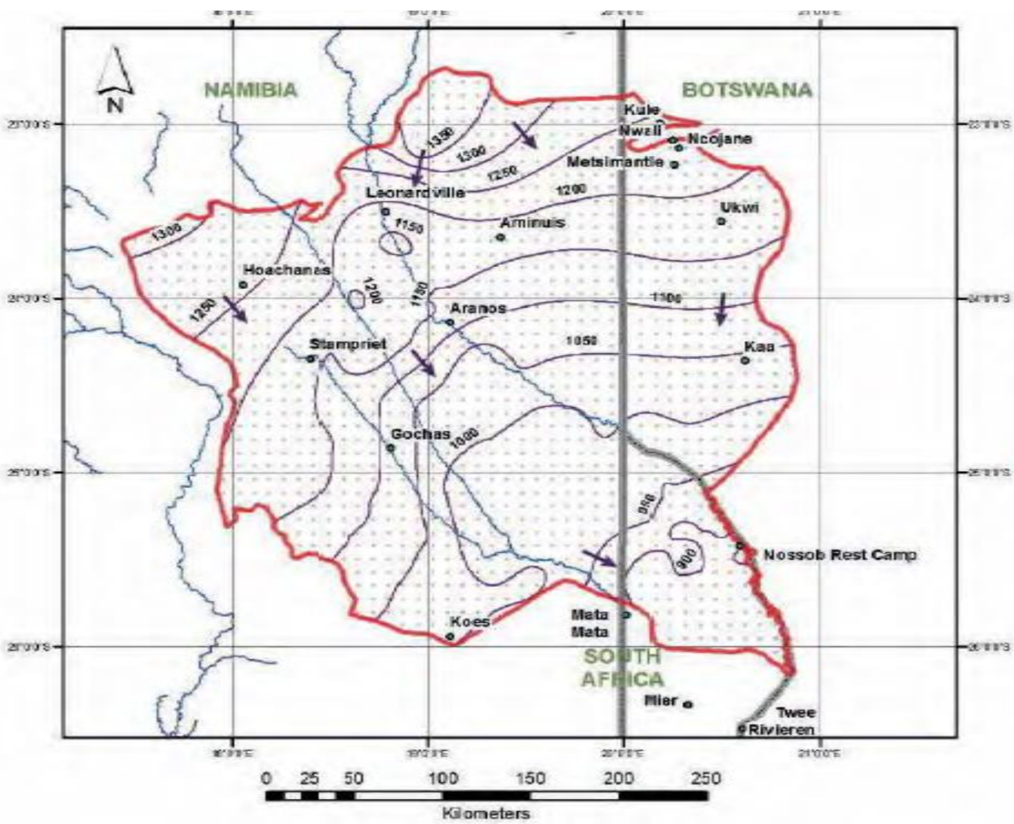

Figure 5.3 - Simplified conceptual model of the Kalahari aquifer

5.3.3 Auob Aquifer

The Auob horizon mainly extends from the south of Aminius to the east of Aranos. Within this area, the thickness of the aquifer as a whole is between 100 and 150 m, although in some places it exceeds 150 m. The Auob horizon is thinned at the edges of the basin with a decrease in thickness to 0-50 m, as well as in the centre of the basin and the southern direction as a result of deep erosion in the Pre-Kalahari Valley.

The Auob Aquifer is hydro geologically bounded by the Rietmond horizon at the top and the Mukorob Horizon at the bottom. Therefore, in general, the Auob groundwater horizon is artesian. However, sometimes, especially in the southern part of the basin, the aquifer is free and hydraulically connected to the Kalahari aquifer due to the absence of the Rietmond horizon in this area.

The depth of the static level is from 60 to 80 meters. Well flow rates vary from 9.5 to 13.6 m^3/h. The waters are neutral. The aquifer transmissibility varies very widely, from 3.4 to 1,280 m^2/day.

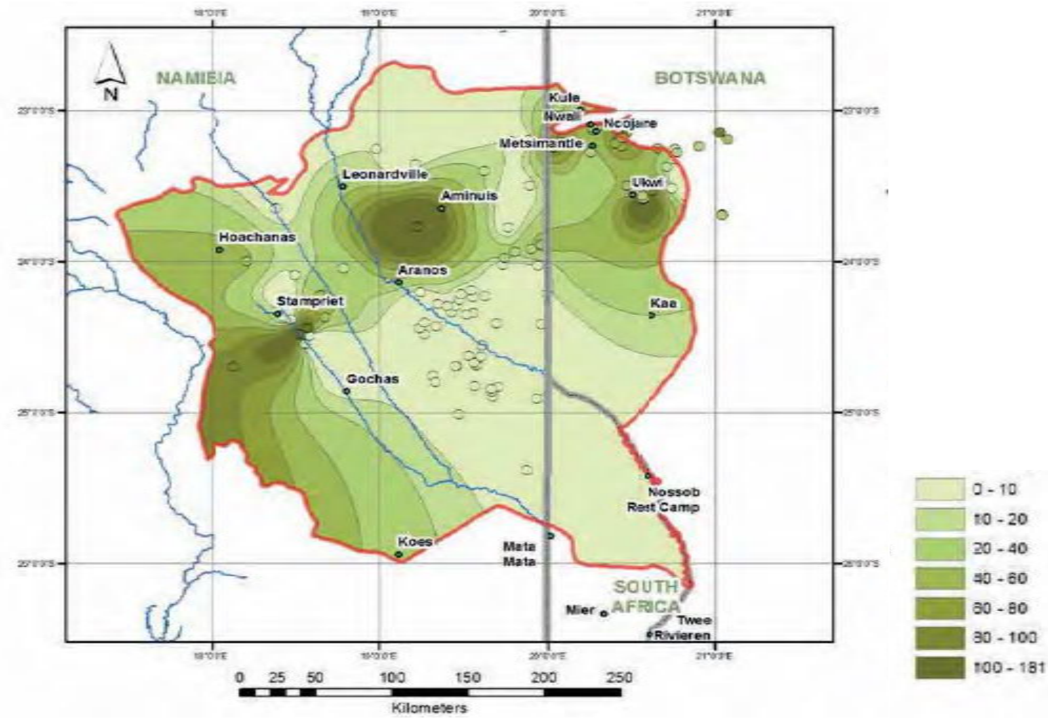

Figure 5.4 - Well flow rate (m^3/h) in the Auob aquifer (Source: GGRETA, 2015)

The total dissolved solids (TDS) according to regional data varies from 656 mg/L to 6,754 mg/L (Figure 5.5). High dissolved solids concentration is observed in the Auob aquifer near the J-8 well. The presence of a salt block in this area is not so obvious. The maximum recorded value of total dissolved solids is 6,754 mg/L at well J-8.

The water quality in the north-eastern half of the study area is generally better than elsewhere, including the Kalahari aquifer.

A hydro chemical sampling of the area of work in 2012 showed a high content of uranium in the upper parts of the section of the aquifer.

Uranium was detected in 60 out of 197 samples (31%). The maximum value of 0.07 mg/L corresponds to well 4700. Three kilometres west of this well, the waters of well 9099 had uranium contents of 0.04 mg/L. The average content for all sampled wells was 0.012 mL/L.

The allowable uranium content in water for the Group water quality class according to Namibian standards (water of excellent quality) is 1.0 mg/L. The distribution of uranium content is shown in Figure 5.6.

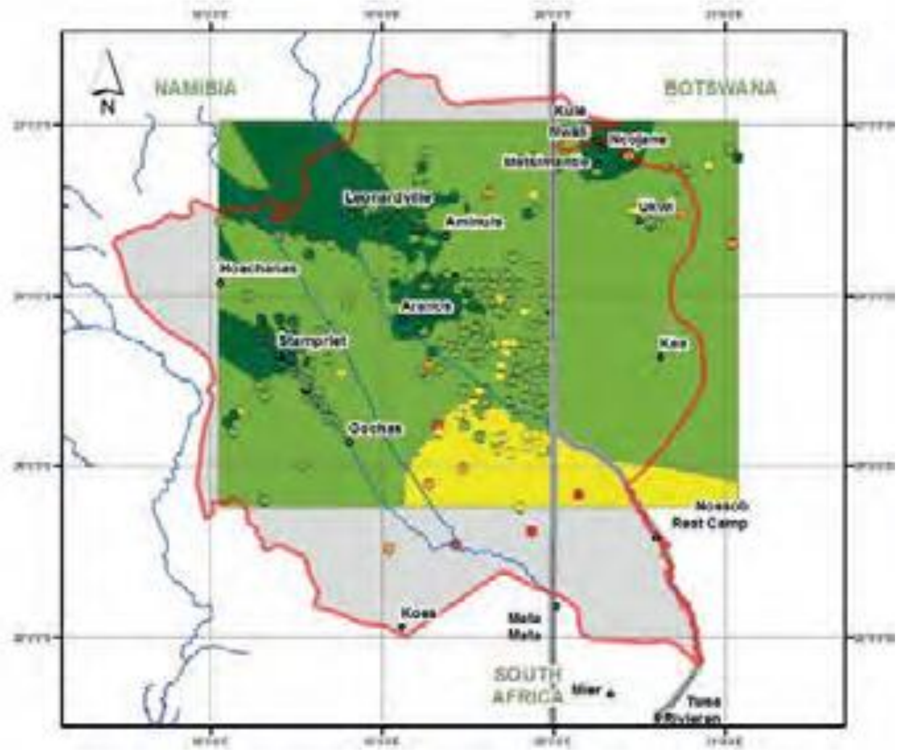

Figure 5.5 - Total dissolved solids (TDS) [mg/L] of the Auob aquifer (Source: GGRETA, 2015)

Designation: dark green: <500 mg/L; green: 500 - 1000 mg/L; yellow: 1000 - 2000 mg/L; orange: 2000 - 5000 mg/L; red: > 5000 mg/L; grey: no information.

Auob Horizon. The Auob aquifer is under confined conditions and recharge occurs along the edges of the aquifer. Groundwater outflow occurs into an eroded valley filled with Kalahari sediments. The regional direction of groundwater flow in the Wings Project area is from north and north-west to south-east of Namibia to neighbouring Botswana and South Africa.

The recharge areas, although confined to the western edge of the basin, cannot be clearly delineated according to the available data. Recharge is identified at the basin margins where the Auob is shallow or partially exposed. This includes monitoring points WW39873, WW39874, WW8399, WW93562, and WW40007 (Figure 5.6). Uncertainty in the inputs, especially in the withdrawal rates, introduces ambiguity in the estimates of recharge.

The Aranos Basin has been exposed to regional-scale faulting and intrusion of dolerite sills and dykes associated with the break-up of the Gondwana continent. The impact of faults and intrusive on groundwater flow is not discussed in the literature. Contour piezometric levels show no relationship to mapped faults that would indicate preferential flow along fault zones or aquifer divisions. However, recharge areas along the western boundary of the basin may be associated with increased secondary permeability associated with faults.

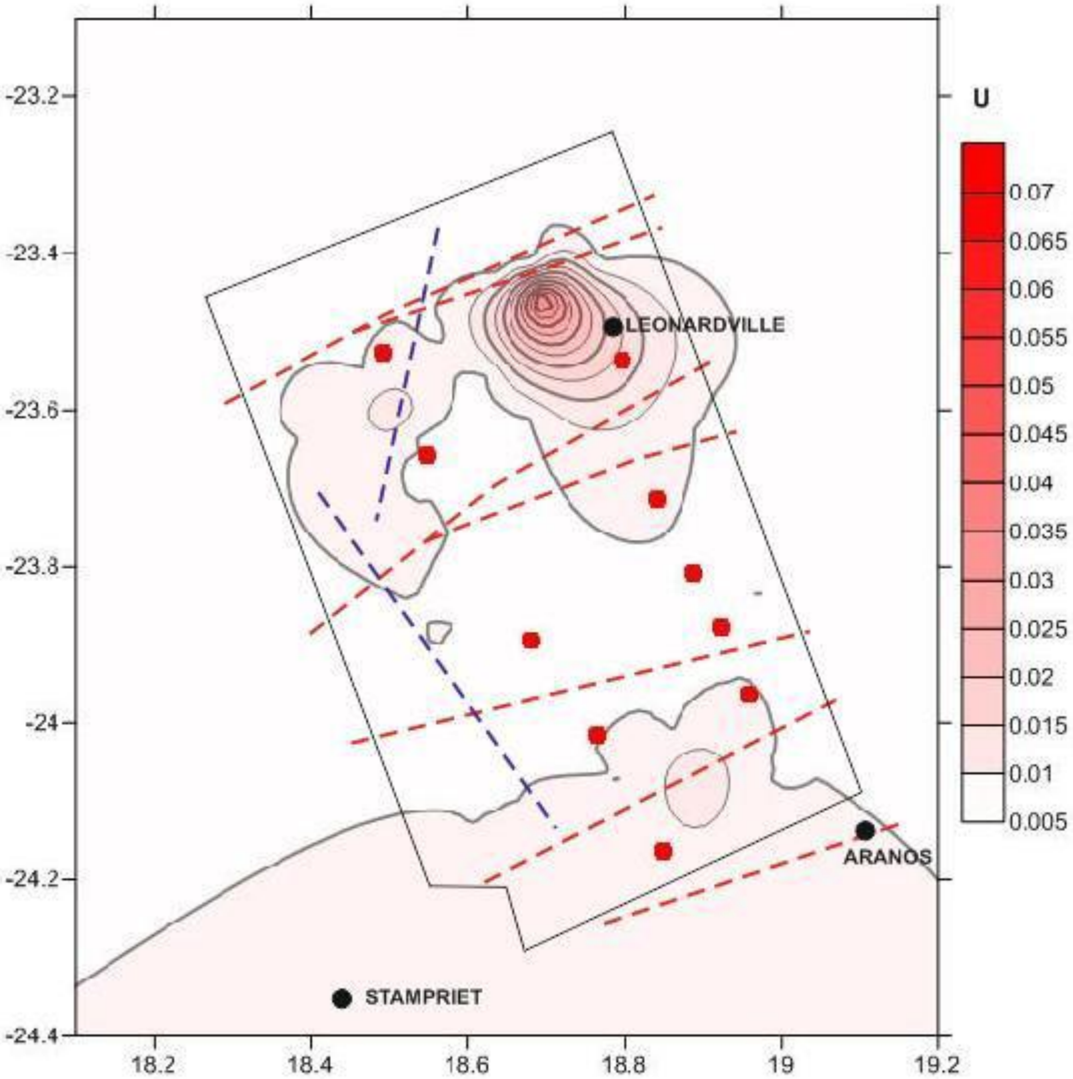

Figure 5.6 Distribution of uranium (mg/L)

The Auob aquifer drains into a sediment-filled trough up to the Kalahari in the south-central part of the basin in Namibia and further southward along the southern part of the Auob aquifer. The trough to the Kalahari eroded and exposed the entire Auob Formation strata in the central part of the basin (Miller, 2008). The flow rate of the Auob aquifer into the Kalahari sediments and the outflow rate were calculated using the Darcy equation (JICA, 2002) to be 6,790 m^3/day.

The flow rate estimated in the two areas from Stampriet to Gochas and north of Aranos was 2 m/year, which is a slow rate of groundwater movement.

Local residents have long used groundwater from this aquifer. The total volume is 4.97 x 10^6 m^3/year, which is about 33% of the total groundwater intake in the study area. Water intake is mainly carried out in the western part of the basin within Stampriet and Aranos, where the depth of the aquifer is relatively less than in the eastern region. The total number of wells in the Auob horizon is estimated at about 700 wells. One should understand that the groundwater potential of the Auob aquifer is on average more than three times higher than that of the Kalahari aquifer.

The Auob aquifer extends beyond political boundaries into Botswana and South Africa. In the north-eastern part of the Auob aquifer, the flow is to the east (Botswana) as shown by the piezometric levels (Figure 5.7), while in the east and southeast the flow is predominantly to the south.

Farm irrigation and livestock watering wells draw water at a low rate but they are numerous and the collective intake is significant. The irrigation reserve capacity was taken from records of ORASECOM website (*wis.orasecom.org/stas*). Namwater systems are used to supply cities in the Aranos Basin area throughout the year at moderate to high intake levels.

Irrigation pumps make up the bulk of water intake from the Auob aquifer. However, there is ambiguity in the records provided by the permit holders regarding the rate and duration of pumping. The available records show that the pumping rate and the annual permitted pumping rate vary, with most annual pumping rates being less than the permitted rate. On the other hand, missing records or unrecorded pumping often lead to an underestimation of the total abstraction for many farms.

The hydro-census carried out by the JICA project in 2001 (JICA, 2002) estimated a withdrawal rate of 5.82 million m^3/year from the Auob aquifer.

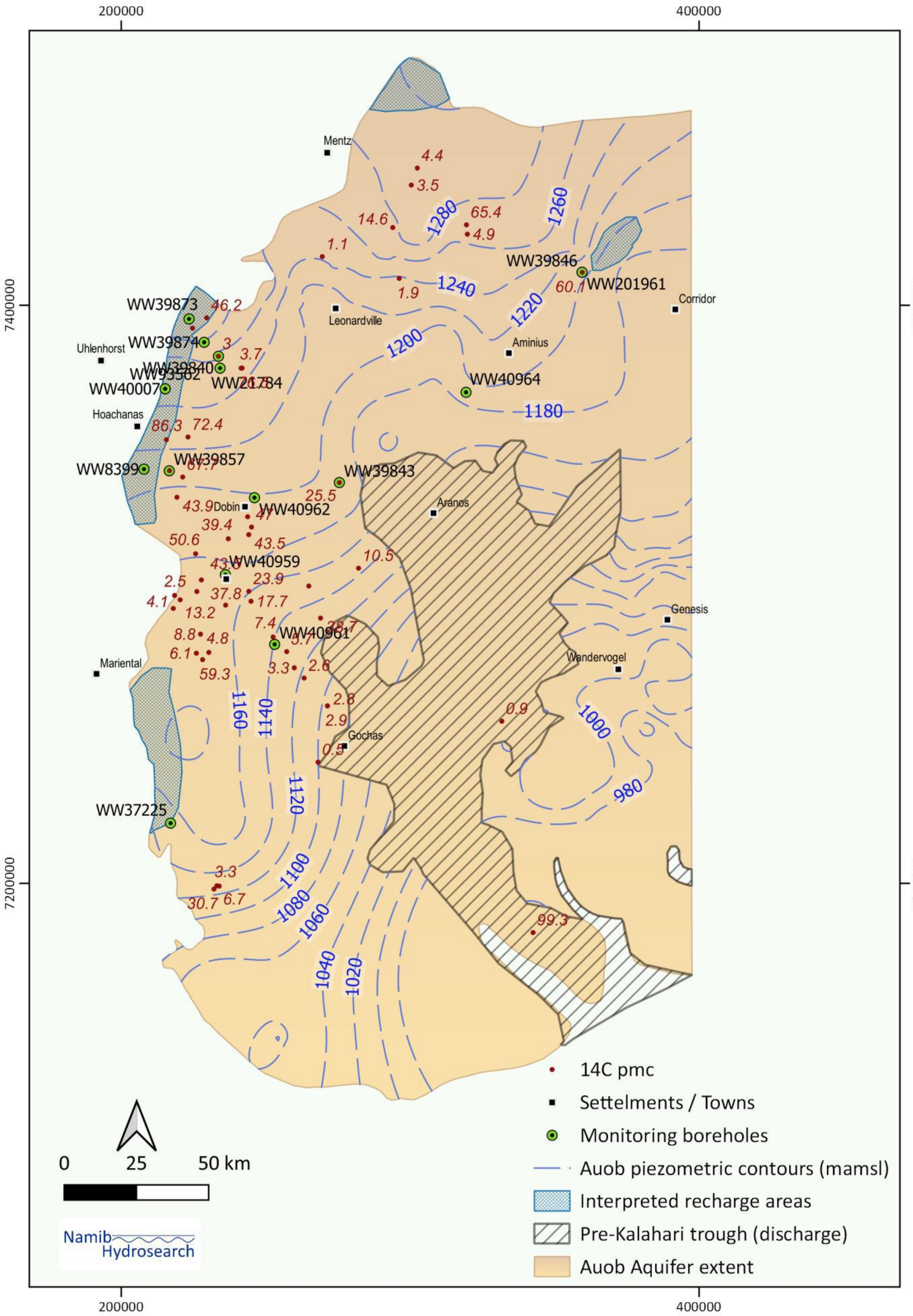

Figure 5.7 - Possible recharge areas of the Auob aquifer

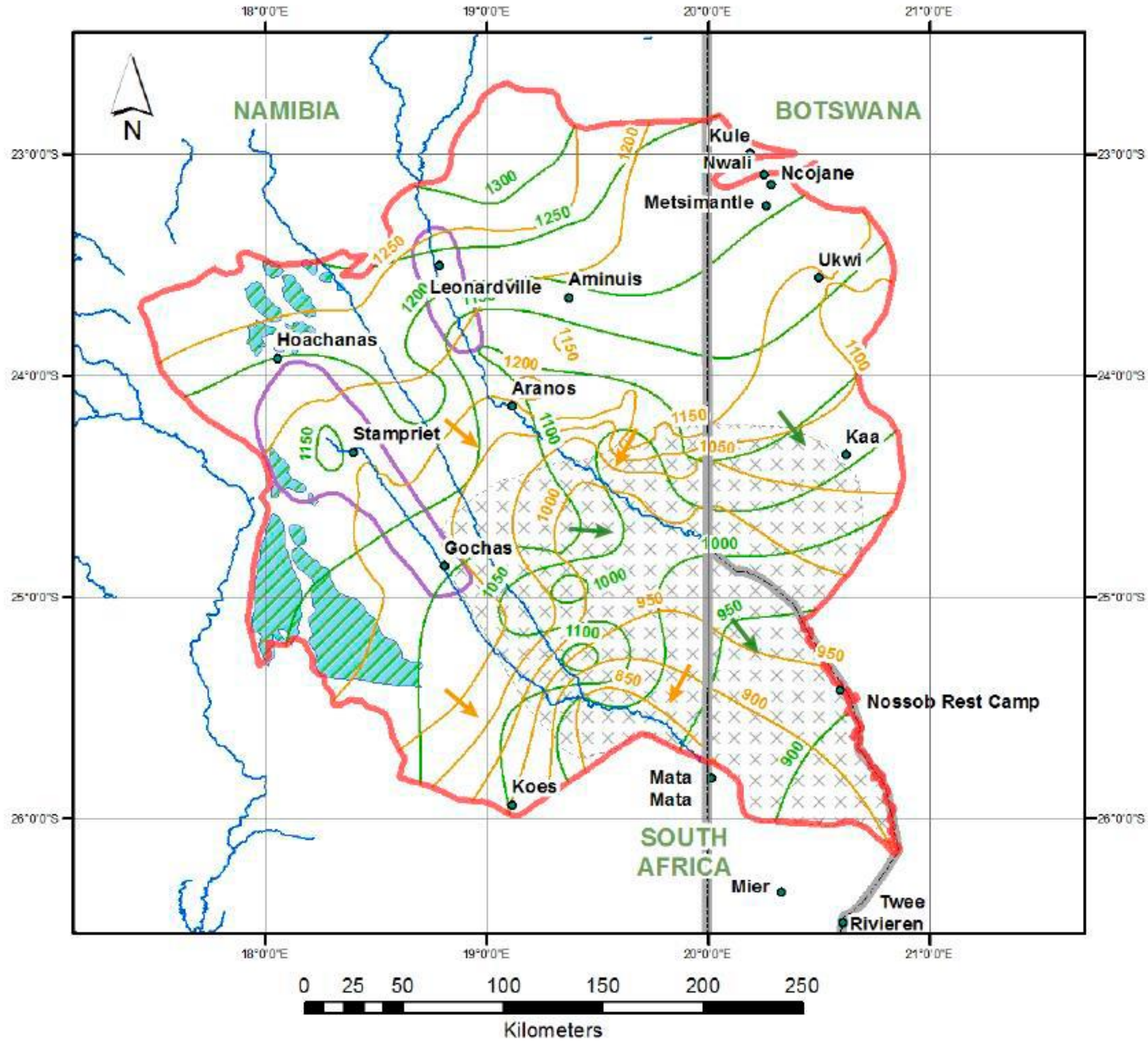

Figure 5.8 - Conceptual regional groundwater flow in the Auob transboundary aquifer (Aranos basin/Stampriet transboundary aquifer system)

Indications: green shaded polygon areas - recharge areas; purple polygon areas - free area; grey crossed polygon area - Kalahari discharge; brown outline - Auob groundwater level; brown arrow - Auob groundwater flow direction; green outline - Nossob groundwater level; green arrow - Nossob groundwater flow direction. Source: http://wis.orasecom.org/; GGRETA project.

Table 5.5 - Estimated water use from the Auob aquifer

Consumers	Volume
Irrigation	5,708,637 m3/year
Domestic water supply	470,000 m3/year
Domestic livestock	275,242 m³/year
Total	6,453,879 m³/year

5.3.4 Nossob Aquifer

The thickness of the Nossob aquifer tends to increase towards the centre of the basin, although it is absent at the edges of the basin. The average thickness of the aquifer is estimated at about 25 metres. However, in some places, the aquifer is much thicker with a maximum value of 94 m according to wells drilled at the Vreda farm in 1963 and 1994.

The Nossob horizon has a north-west to south-east declination similar to the Auob aquifer. Its altitude is approximately 1,000 m above sea level at the north-eastern edge of the basin and 650 m at the south-eastern corner. The Nossob aquifer is an Artesian (confined) aquifer that lies between two impermeable strata: the Mukorob horizon and the Dwyka group.

The Nossob aquifer has the highest piezometric head among the three aquifers, reaching more than 20 m above the earth's surface (*Figure 14*).

The depth of the static level in the Wings Project area ranges from 16 to 43 metres. The waters are predominantly neutral. The aquifer transmissibility varies in the range of 0.02-7.01 m^2/day (Figure 5.8).

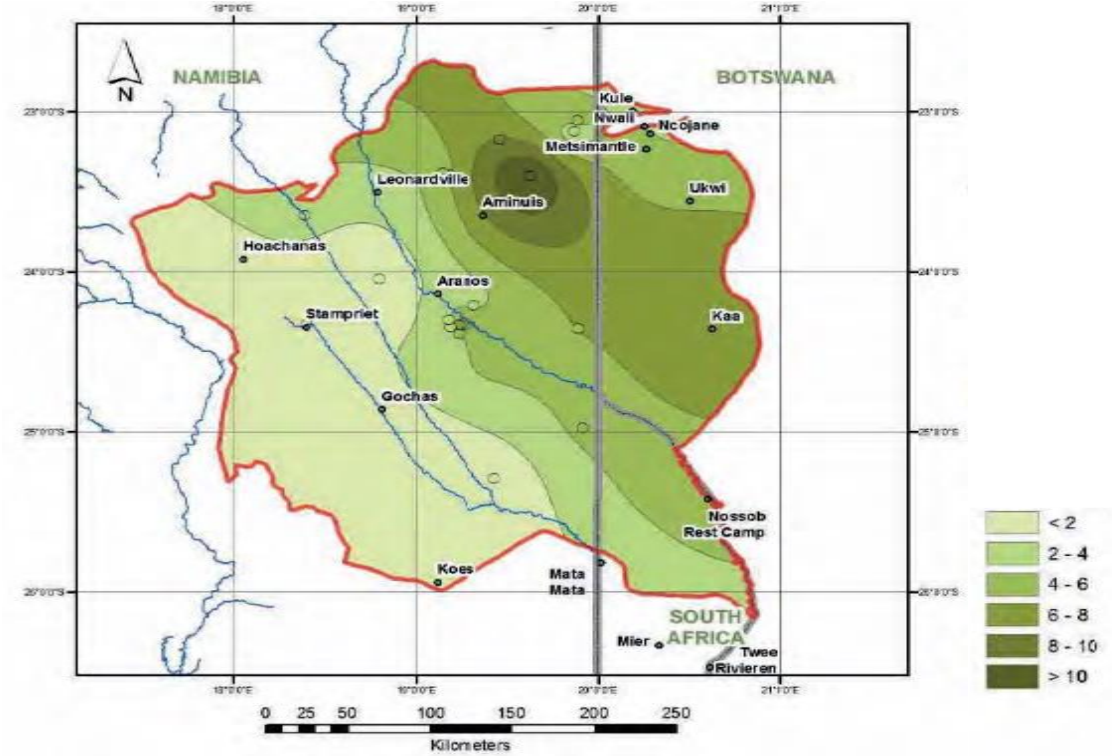

Figure 5.9 - Well flow rate (m3/h) in the Nossob aquifer (Source: GGRETA, 2015)

High dissolved solids concentration is observed in the Nossob aquifer within the J-8 well. The available data indicate that the water quality in the Nossob aquifer is the worst of the three aquifers.

The total dissolved solids (TDS) is high in most of the Nossob aquifer and does not meet water quality standards (Figure 5.9).

Regional operations in individual wells show an increased content of uranium.

Less than 30 wells have been drilled into the Nossob horizon. The total groundwater intake from this aquifer is only 0.2 million m^3 per year, which is about 1.3% of the total groundwater intake in the study area, mainly due to the fact that this aquifer is thin, deep and contains low-quality groundwater.

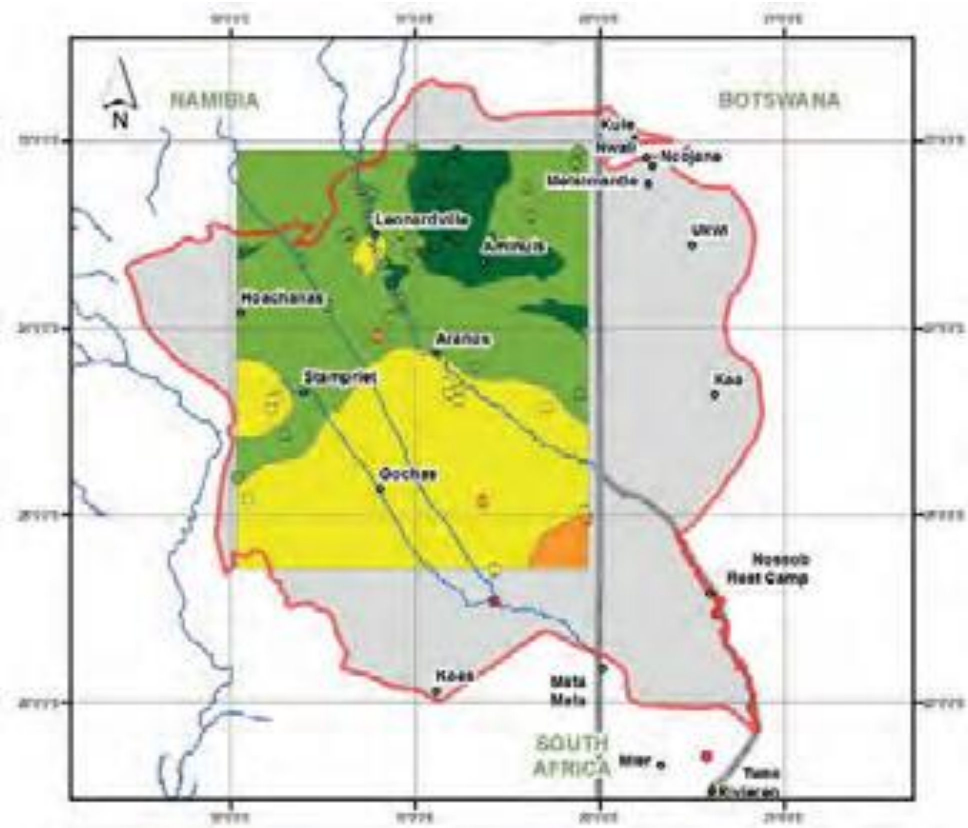

Figure 5.10 - Total dissolved solids (TDS) [mg/L] of the aquifer

Designation: dark green: <500 mg/L; green: 500 - 1000 mg/L; yellow: 1000 - 2000 mg/L; orange: 2000 - 5000 mg/L; red: > 5000 mg/L; grey: no information.

5.3.5 Radiation background

Based on the geology of the proposed area, as well as the estimated uranium deposits to a depth of ~120 m, the total project area has a very low radiation background. Naturally occurring within the local Kalahari sands, calcrete, and rocks, uranium is a material with low specific activity and weak background radioactive activity. Uranium-238, which is 99.3% natural uranium, has a half-life period of 4.5 billion years. The remaining 0.7 per cent is made up of other uranium isotopes: mostly uranium-235 (with a half-life period of 703 million years) and a very small percentage of uranium-234 (with a half-life period of 244 thousand years).

The results of groundwater analysis of all hydrogeological wells of the Wings Project exceeded the WHO (2011) radiation safety requirements for drinking water in terms of radionuclide content.

A hydrochemical sampling of the work area carried out in 2012 at farmer wells (prior to exploration activities) showed high uranium content in the upper parts of the aquifer section. Uranium was detected in 60 out of 197 samples (31%). The maximum value of 0.07 mg/L corresponds to well 4700. Three kilometres west of this well, the waters of well 9099 had uranium contents of 0.04 mg/L. The average content for all sampled wells was 0.012 mL/L.

The value of integral specific alpha activity > 0.5 Bq/l, which, according to the revealed dependence, corresponds to the approximate effective dose of 0.1 mSv/year, or the reference level, may be used for preliminary assessment of groundwater by the principle "background - anomaly", followed by the measurement of individual NRN activities in it.

This value of specific total alpha-activity is close to the standard established by the US Safe Drinking Water Act according to which its values, excluding uranium, must not exceed 0.5 Bq/l.

The boundary conditions for classifying groundwater as abnormally contaminated with radionuclides are its concentrations ensuring the total dose-effect ≥ 0.2 mSv/year and specific integral alpha-activity of 1 Bq/l. The results of groundwater analysis of all hydrogeological wells of the Wings Project showed exceeding the radiation safety requirements for drinking water in terms of radionuclide content.

The maximum total α-radioactivity (172.9 ± 2.7 Bq/kg) and β-radioactivity (21.34 ± 0.58 Bq/kg) were observed in well 94-AB3.

It is recommended that the groundwater quality of all farmer wells in the Wings Project area, including radionuclide content, be analysed prior to conducting the in-situ leaching activities and recorded in documents agreed with the local executive state authorities, or local governments.

5.3.6 Hydrogeology of the Wings Project Work Area

The permeability of the Auob horizon is favourable for in-situ leaching (ISL). The permeability acceptable for in-situ leaching is confirmed by cluster extractions from Auob horizon in 2020-2021 (sub horizons: Upper Auob, Middle Auob, Lower Auob):

- the filtration coefficient was 0.29 - 1.76 m/day.
- Static level is 50-80 m.
- Groundwater pH is 7.2-8.1.
- Persistent aquicludes.
- Groundwater flow direction is south-east.
- Average groundwater temperature was 27.71°C.

During the experimental filtration works the necessary data were obtained to calculate the main hydrogeological parameters.

Concurrent analytical works for the determination of the granulometric composition of ores and rocks enabled a more detailed partitioning of the lithological section.

The ore zone in all observed wells is represented mainly by fine-grained sands. At contact with the host rocks (aquicludes), the fractional size decreases, both at the top and the bottom of the formation. The near-contact zone is composed of fine-grained sands, often interbedded with siltstone varieties at the transition to the aquiclude. The impermeable clayey rocks comprise the impermeable aquicludes.

The filtration coefficient in the hydrogeological wells ranges from 0.29 to 1.76.

The most favourable conditions for further field tests are in the area of the main exploration works. The data from the pilot filtration works can be called preliminary, in order to assess the prospectivity for setting up pilot uranium leaching works.

More detailed aquifer studies are required with narrowing the hydrogeological research well pattern.

In order to construct the piezometric surface of the Auob horizon, groundwater levels were measured in all hydrogeological wells. However, the measurements were made at different times and the results were probably affected by the seasonal lowering of the level due to intensive water abstraction by the farms during the dry period.

The seasonal changes in the head are reproduced by modelling and support the assumption that the head response is caused by pumping during the summer months.

In order to plot the piezometric surface of the Auob horizon, static level measurements were also taken for the farm abstractions, which are used for irrigation, domestic supply and livestock production/farming, from the Kalahari, Auob and Nossob aquifers of the Wings Project area based on 2022 data.

The direction of groundwater movement in the Wings Project area is from north, north-west, north-east to south, south-east and south-west. The natural flow rates calculated based on filtration coefficients and piezometric contour location were 1-2 m/year, which is a slow groundwater movement rate.

The piezometric surface map shows the influence of the farmer wells on the groundwater flow directions and allows the construction of monitoring wells to control the spread of process solutions and to observe the spread of groundwater pollution halos.

The Auob aquifer is isolated by the aquiclude from the Kalahari groundwater horizon, so farmer wells drilled into the Kalahari aquifer will not affect the groundwater movement of the Auob horizon if there is no hydraulic connection between the horizons.

5.3.7 Surface Waters

The only drying river, Nossob, runs through the project area.

The Nossob River, which has a channel 12 km east of the worksite, originates from two main tributaries, Swart-Nossob and Wit-Nossob, meaning black and white respectively. Both tributaries originate on the eastern slopes of the Otjihavera mountain range, east of Windhoek. Their springs are located at an altitude of 1800 m and over 2000 m above sea level respectively. The channels of the two rivers have a confluence about 80 km south of Gobabis, situated on the banks of the Swart-Nossob River.

From this confluence, the river course passes the settlements of Leonardville and Aranos to arrive at Union's End, South Africa. From Union's End the riverbed, forming the Botswana border, meanders through the

Kgalagadi Transfrontier Park for a distance of over 200 km. It reaches the southern boundary of the game reserve just north of Twee Rivieren Camp, near its confluence with the Auob river.

In the Kalahari, the Nossob is said to flow about once a century. However, water does flow underground to provide life for grass and camelthorn trees growing in the riverbed. The Nossob may flow briefly after large thunderstorms, causing wildlife to flock to the river.

5.4 Impact Assessment

5.4.1 Impact Assessment Methodology

The impact assessment methodology is based on the principles of 'source - pathway - the object of impact perception'. The source in this context is defined according to the in-situ leaching technology. Groundwater is considered the receptor of impact. Indirect impact receptors that are associated with groundwater, in this case, groundwater abstractions, have also been considered. Pathways connecting the sources to the impact receptors have been identified. Potential impacts can only occur where there is a 'source-pathway-impact-sensitive receptor' link.

A general description of the process used in the EIA and the general methodology adopted for the assessment of impact magnitude is described in **Chapter 3 Environmental Impact Assessment Methodology**.

While there are a number of water quality standards that apply to the Project, there are relatively few guidelines describing how water impacts are to be assessed. Building on the general principles of the methodology described in **Chapter 3**, the assessment of impacts on groundwater is based on the results of the hydrogeological modelling described in **Book 1**. A brief report of the significance of the impacts and the impact parameters that have been used to assess them is presented herein.

5.4.2 Project Activities to be Assessed in this EIA

In-situ uranium leaching may have an impact on the environment. A detailed description of the ISL technology is provided in **Section 4.1** of this report. Other activities envisaged by the Wings Project that has the potential to impact on groundwater will be considered during the preparation of the full ESIA and are not addressed in this EIA.

5.4.3 Identification of Sources and Types of Impacts

A brief description of the in-situ leaching technology is given in **Section 4.1**. The closed-circuit cycle of technological solutions in the scheme: wells ⇒ PS ⇒ sorption ⇒ LS ⇒ wells does not imply the generation of wastewater and its discharge into groundwater aquifers.

The development of uranium deposits by the ISL method is the most economical and profitable method to extract the useful component without mechanically disturbing the orebody, but the use of LS and the transportation of uranium in solutions may lead to radionuclide and acid pollution of the environment, mainly of the ore-bearing aquifers.

In order to determine the sources, types and significance of impacts resulting from aquifer contamination and subsequent remediation, in-situ experiments and modelling of demineralisation and neutralisation solutions in groundwater have been carried out.

The demineralisation modelling data and associated calculations are set forth in **Book 1**. The following subsections summarise the main conclusions of the modelling performed. Impact significance has been determined using the criteria described above in **Chapter 3 Impact Assessment Methodology**.

5.4.4 Impact Receptors

The receptors considered in this EIA are the Kalahari and Auob aquifers. The Kalahari Aquifer will not be involved in the ISL and therefore is not a receptor.

Spreading Pathways.

Spreading pathways are the ways whereby a particular activity can affect an object of impact reception. The impact may occur provided that there is an activity, a pathway and a receptor. In the case of ISL technology, the pathway is the physical migration (movement) of contaminants associated with pumping of weak chemical reagents into the orebearing aquifer. When sulphuric acid is used, almost all elements available in rocks in quantities exceeding maximum permissible concentrations for drinking water supply are transferred to the solution to a greater or lesser extent. Thus, the next pathway of spreading is the movement of contaminants in groundwater. An unplanned pathway of contaminant spreading can be the infiltration of contaminants from the productive aquifer into the overlying aquifer through boreholes of poor or improperly constructed wells. It is worth noting that after wells construction, wells are tested for leakage using geophysical survey probes, before they are put in production. Such impacts can occur both during and after production. Unplanned contamination pathways also include accidental spills of production and leaching fluids at the surface and their subsequent seepage into the upper aquifer.

Sensitivity of Impact Receptors.

In order to assess potential impacts on groundwater, a number of impact rating criteria have been developed, based on the general methodology described in **Chapter 3 Impact Assessment Methodology**, professional judgement and experience, international relevant standards and codes governing implementation of the project.

The sensitivity of receptors such as groundwater is a reflection of how vulnerable the receptor is to changes in chemical or physical properties. Less sensitive objects are those that are most resistant to changes (less vulnerable to them). The notion of sensitivity also takes into account the importance of a receptor by defining the extent to which it is important to users of the environment (i.e. sustaining ecosystems and society through ecosystem services). Sensitivity assessing criteria have been developed using four categories: high, moderate, low and insignificant. If the allowable value and vulnerability differ significantly for a particular receptor, the more conservative category is preferred.

The sensitivity of groundwater bodies is generally based on three aspects: dissolved chemical content, quantity and groundwater use. For example, a groundwater body can be useful as a source of drinking water or as an integral part of an ecosystem dependent on groundwater.

The Kalahari aquifer is characterised by **moderate sensitivity**, as it is not ore-bearing and will not be used as a productive aquifer but is the most intensively used for water supply.

The Auob Aquifer is **highly sensitive** as it is ore-bearing and local residents use groundwater from this aquifer.

5.4.5 Sources and Types of Impacts on the Kalahari Aquifer

The Auob productive aquifer is isolated by aquicludes from the Kalahari groundwater horizon and will not affect its water quality under normal operation.

As noted above, the Kalahari aquifer is at the top of the aquifers and is most susceptible to accidental inputs of contaminants from accidental leaks or spills of production/pregnant and leaching solutions.

Most leaks and spills are likely to occur in relatively small amounts, as much of the contamination remains in the soil or groundwater. The water quality of the aquifer may be locally reduced but is expected to recover gradually over a short period. The spatial scale of the impact on groundwater quality due to accidental leakages is assessed as site-wise (less than 1 km^2 in the area affected). The temporal scale is assessed as **short-term impact** (recovery within a short period). Impact intensity is assessed as **insignificant** (changes not exceeding the existing limits of natural variability). Impact significance is **low**.

Impacts on operating water intakes are also assessed as an **impact of low significance**.

Spreading of contaminants due to seepage of pollutants through wells of poor quality or improperly designed wells will occur in small amounts, over a medium-term period. Water quality may be **site-wise** reduced. Potential impact on groundwater quality related to the flow of contaminants along the borehole is assessed as **site-wise** impact (less than 1 km^2), **long-term** (well operational period), **moderate** in intensity (changes exceed the limits of natural variability, groundwater retains its capacity for self-regeneration). Impact significance is **medium**.

Impacts on existing intakes depend on their location in relation to extraction sites and are assessed as the impact of **medium significance** in the worst-case scenario.

5.4.6 Sources and Types of Impacts on the Auob Aquifer

According to CSA Global, (2019) and the initial results of the regional hydrogeological model of the project area, the permeability of the Auob element is favourable for the application of the ISL method, with a permeability of 0.14 m / day to 5.7 m/day (average 1.64 m / day).

However, the permeability values determined during the JICA tests from 1999 to 2002 are too general, and additional hydrogeological modelling was carried out to verify the permeability measurements in the Auob aquifer, as well as to predict possible aquifer water contamination, which is briefly described, and the results are set forth below. The results of the modelling are presented in more detail in **Book 1**.

5.4.6.1 Aquifer Pollution by ISL

In-situ leaching is associated with the pumping of weak chemical reagents into the ore bearing aquifer and is therefore inevitably accompanied by groundwater pollution in the area of the technological wells.

When sulphuric acid is used, almost all elements available in rocks in quantities exceeding maximum permissible concentrations for drinking water supply are transferred to the solution to a greater or lesser extent. The total mineralisation of groundwater increases to 10 - 25 g/L.

When the ISL sites operate in a balanced regime, there is usually not much pollution, the pollution halo boundary reaches a distance of 50 - 100 m from the outermost wells and then the self-cleaning process takes place, as described below **in Subsection 5.4.2.4**.

Concentrations of all contaminating components during sulphuric acid in-situ leaching decrease rapidly with distances from the outermost technological wells. A definite geochemical zoning is observed:

$U \rightarrow Fe^{3+} \rightarrow Al^{3+} \rightarrow Fe^{2+} \rightarrow Ca^{2+} \rightarrow NO_3^{-} \rightarrow SO_4^{2-}$.

The content of uranium, iron, and aluminium in the peripheral solutions is mainly determined by the pH value. Approximately the following pH values can be named, at which the concentration of macro components and uranium sharply decreases:

U^{+4} (pH≈2 - 2.5), U^{+6} (pH≈4 - 6), Fe^{3+} (pH≈3), Al^{3+} (pH≈4 - 5), Fe^{2+} (pH≈6).

The calcium content in the solutions of the production blocks during sulphuric acid leaching reaches 0.5-0.6 g/L and is determined by the solubility of gypsum. As one moves away from the operating site, the calcium content decreases rapidly to background values.

Alkali metal cations (Na^{+}, K^{+}, Mg^{2+}, etc.) in neutral groundwater environment are rather actively absorbed by rocks, especially by clay fraction. NO_3^{-} and SO_4^{2-} anions have a great migration ability. Sulphate-ion often forms insoluble salts of some metals and gypsum, as a result of which its quantity gradually decreases. The NO_3^{-} anion does not form insoluble compounds, but its concentration decreases as it moves away from the leached area due to dilution.

The concentration of associated radioactive elements in sulphuric acid uranium leaching is low. For example, radium is transferred to the solution in an amount of not more than 2 % of its total content in ores. It migrates on small distances (some tens of meters), as the presence of SO_4^{2-} ion in water leads to the formation of poorly soluble gypsum and also almost insoluble sulphates of barium, lead, strontium, which causes co-precipitation of radioactive elements.

The concentration of contaminants in the subsurface is reduced by chemical interaction with rock minerals, neutralisation of the medium, ion-exchange processes, sorption, and diffusion.

When using a bicarbonate reagent that has a selective effect on uranium ores, the amount of pollution components entering the groundwater is drastically reduced. There are increased amounts of carbonate and bicarbonate ions, Ca^{2+}, Mg^{2+}, NH^{+}, K^{+}, Na^{+} appear in the solution (except for uranium compounds). The reaction of the environment is slightly alkaline. In spite of the limited complex of harmful impurities, the composition of contaminants in bicarbonate leaching cannot be ecologically less harmful, because in this case radium and often selenium compounds, having greater migration ability in an alkaline environment, pass into the solution. Uranium carbonate complexes are stable in neutral and alkaline media and can also migrate.

5.4.6.2 Full-Scale Test Mining of Sulphuric Acid ISL

A pilot test cell was constructed to carry out pilot test of in-situ leaching activities. The pilot cell consists of four injection wells and one extraction well. The injection wells have filters, the length of each filter is 4 metres and the extraction well has a filter length of 6 metres and an effective capacity of 7.5 metres; the cell area is 202 m^2. The distance between the injection and extraction wells is 10 metres and the distance between the injection wells is 14.2 metres. The cluster (envelope) hydrogeological pumping from well 132-1reG was carried out from November 15 to November 22, 2021. Wells 132-2inbisG, 132-3inbisG, 132-4inbisG, 132-5inbisG were used as monitoring wells. Well pattern is envelope, in this pattern monitoring wells are placed at the apexes of the square and the central well is at the intersection of its diagonals.

The flow rate of the central well decreased slightly (less than 5%) during extraction. In the first 5 minutes, there was a sharp (up to 50%) jump in the water level. Thereafter, the drawdown developed slowly and smoothly. In the monitoring wells, smooth and slow development of the drawdown was observed from the first minutes. No level stabilisation was recorded in all wells of the cluster.

Level recovery is also characterised by a jump to 50% in the central well with a further smooth recovery and slow recovery in the monitoring wells. Flow rate is 6.9 m^3/h, static level in well 132-1reG is 58.5 m, drawdown is 31.35 m.

A 1-2% weak sulphuric acid solution (concentration of 15 - 5 g/L) is used. It is pumped into injection wells 132-2in, 132-3in, 132-4in and 132-5in. The solution passes through the pore space of the ore-bearing rocks, dissolving the uranium.

In addition to uranium, the sulphuric acid leaching method extracts rock-forming elements, such as aluminium, magnesium, calcium, iron and other elements from the subsoil.

At the stage of oxidation of ore-bearing rocks for in-situ leaching of uranium with process solutions of sulphuric acid (concentration of 15 - 10 g/L). In pregnant solutions with pH lower than 5-4 a significant increase in concentrations of aluminium, iron, calcium, magnesium and other metals compared to their background concentrations in natural waters is observed.

The mechanism of movement of these metals in the liquid phase along the way of filtration from injection wells to extraction wells is similar to the mechanism of migration and movement of uranium on the mobile neutralisation (alkali) geochemical barrier.

Thus, acidic technological solutions, while leaching uranium from ores, simultaneously extract rock-forming elements from them.

The pregnant solution is extracted to the surface through extraction well 132-1reG. After the sorption extraction of uranium, the sorption barren solutions are acidified with sulphuric acid and pumped to the injection wells.

By macro component composition, the sulfuric acid solutions are acidic sulphate ferro-aluminium-magnesium brines with common mineralisation of 10-15 g/L, pH 1.5 - 2. Their macro- and micro-component composition is formed in the process of predominantly dissolution of rock-forming minerals. By the end of the ISL, the zone of sulphuric acid solutions with pH = 2 will take up 65-80 % of the total volume of the ore-bearing horizon in the contour of the pilot cell.

Comparison of the chemical composition of natural water and process solutions allows assessing the degree of change in the natural hydrogeochemical environment. Technological solutions are taken with maximum possible mineralisation according to in-situ leaching mines. Particularly high contamination contrasts are noted for sulphates (20 times or more), aluminium and uranium (hundreds of times), iron, etc.

Natural/Baseline water composition data for pilot test cell 132 are from the analytical laboratory of Namibia (Analytical Laboratory Services, Windhoek, Namibia, info@analab.com.na) for chemical and organic analyses and for radionuclides analysis from Hydro-isotope accredited laboratory in Germany.

According to the content of Na and Br- (in all wells), U, Mn, I-, Se, Fetot (by individual wells) in groundwater, the groundwater belongs to the Group B "Water of acceptable quality", according to the Namibian classification. Turbidity for individual wells is classified as Group C and Group D.

Ideally, the water should be of excellent quality (Group A) or acceptable quality (Group B), but in practice, many indicators may fall outside these groups. If water is classified as low health risk (Group C), attention should be paid to this problem, although often the situation is not yet critical. If the water is classified as high risk to health (Group D), urgent and immediate attention should be paid to this issue.

5.4.6.3 Spontaneous Recovery of Groundwater Quality

After completion of mining ore deposits, the lenses of technogenic residual brines formed in the subsoil move in aquifers under the influence of the following factors: pressure differential in the natural groundwater flow and the density gradient arising at the interface of "light" natural water and "heavy" technogenic solutions (solution density is 1.02 g/cm^3).

Technological solutions in the absence of artificially created head gradient will move with the speed of natural groundwater flow in the direction from north-west to south-east.

In the system of residual sulfuric acid solution and unaltered rock after ISL completion occurs under conditions of the natural hydrodynamic regime at a flow rate of about 1-2 m/year (0.0027 - 0.0055 m/day).

Along the way of filtration acidic solutions enriched with metals are neutralised by interaction with new volumes of fresh rocks, and due to hydrolysis metal hydroxides or carbonates precipitate out. To some extent this impairs the permeability of the ore-bearing rock, creating 'reversible' (temporary) clogging of the formation. A geochemical (acid-alkaline and sorption) barrier is formed as the sulphuric acid solutions are neutralised by carbonates, phosphates and dissolved aluminosilicates.

Residual sulphuric acid solutions, when displaced by groundwater flow into the area of original, technogenically unaltered rocks, first of all, start to be neutralised by calcite. After its complete destruction or screening by gypsum films, the main neutralisers are aluminosilicates with particle size <0.05 mm, having high specific surface area.

As the residual solution front advances into unaltered rocks and the degree of neutralisation of sulfuric acid solutions increases, the technogenic mineral zoning is formed: amorphous silica (pH of the beginning of deposition 2.2-2.9), gypsum, hydrogetite and hematite - simultaneously (pH 2.3-2.6); alunite, amorphous Fe(lll) hydroxide, jarosite, gibbsite, minerals of halotrichite and pickeringite groups - almost simultaneously (pH 2.8-3.8), rhodochrosite, siderite, calcite and newberyte - simultaneously (pH 6- 7).

Concentrations of all contaminating components during sulphuric acid in-situ leaching decrease rapidly along with distancing from the outermost production wells.

The neutralising geochemical barrier is mobile in space. As the lens is displaced by groundwater flow, it will move, but at a slower rate than the velocity of the fluid flow front. The sulphuric acid brine lens will gradually shrink under the influence of neutralisation processes until it disappears completely. At the same time, the amount of accumulated substance in the area of the geochemical barrier will increase, and consequently, the filtration resistance of rocks in the barrier zone will increase.

Besides clogging phenomena, the structure of the front of technogenic solutions flow is influenced by density differentiation of solutions, arising under the influence of density difference (maximum value Δp = 0.02 g/cm^3) at the border of technogenic brines and natural waters.

Main patterns of spontaneous neutralisation and demineralisation of residual sulfuric acid solutions after completion of ISL, identified at South and North Bukinai deposits of Central Kyzylkum uranium-deposit province, are in full agreement with the results of studies of these processes at the deposits of Syrdarya (Karamurun, Irkol), Chu-Saryssu (Uvanas) and at Dalmatov deposit from Trans-Ural group of deposits of paleovalley type. At all pilot sites of the listed deposits, it is established that after the termination of sulfuric-acid ISL in aquifers, hosting halos of residual solutions, there is damped irreversible neutralisation and demineralisation of residual solutions, accompanied by slow transition of harmful substances into a solid phase.

5.4.6.4 Simulation of Pilot Cell Demineralisation.

The pilot test cell is assumed to operate in a balance of injected and pumped solutions and there is no decrease or rise in the groundwater level outside the pilot cell. The leaching rate is determined by the head gradient.

Taking into account the technological spreading of solutions within the area of a pilot test cell is enlarged from 202 m^2 to 450 m^2 (based on half of the distance between injection and extraction wells as a result of pressure gradient created in course of cell operation).

The bulk mass of rocks is 2.10 g/cm^3 (2,100 kg/m^3 or 2.10 t/m^3), according to the research of hydrogeological wells 131-3M-AB3 and 131-5M-AB3 monoliths in Volkovgeology JSC branch Central Experimental and Methodical Expedition of Chemical-Analytical Party (laboratory) of Kazakhstan.

The width of the pilot test cell as a result of technological spreading will increase from 14.2 meters to 21 meters, which is the width of the pollution halo.

The most negative demineralisation option at the pilot cell in which maximum contamination is possible is considered. The case considered is that work on the pilot cell, for some reason, is stopped at maximum mineralisation of process solutions, with a sulphuric acid concentration of 10 g/dm^3 and uranium concentration of 100 mg/dm^3. No further ISL work on the cell is planned. This option is considered to be theoretically as negative as possible. In practice, this does not usually happen, and the cell/block is fully mined. This option is considered only to simulate and estimate the demineralisation of the "contaminated" horizon under the most negative conditions.

The acid capacity of rocks for calculations is taken according to laboratory research as 8 kg/t of ore material.

5.4.6.5 Calculation of Groundwater Neutralisation Time

The manual calculation is based on the neutralisation of sulphuric acid in rocks unaffected by leaching (mainly carbonates). It is assumed that when sulphuric acid is neutralised and the pH of the solution is increased, all contaminating components will begin to precipitate and be sorbed by rocks (mainly clay) on the acid-alkali and sorption barriers, in the manner of the roll front type uranium deposits formation.

The calculation was made for the worst-case contamination of the pilot test cell area by sulphuric acid:

Complete neutralisation of the pollution halo would require 706 tons (336 m^3) of fresh rock. The pollution halo for complete neutralisation would advance up to 16 metres into the rocks unaffected by acidification. With the width of the pollution halo at 21 m, the outermost distant boundary will extend to 37 metres.

The movement of the pollution halo will be at a natural groundwater flow rate of 2 m/year in the east-south-east direction of the natural flow. The time for neutralisation of sulphuric acid and complete demineralisation would be 18.5 years, with the pollution spot advancing only 37 metres from the active cell and then self-recultivating.

In determining the time of demineralisation and the maximum distance that the contaminated front will advance under the influence of natural flow, no account is taken of the influence of geochemical barriers (reducing and sorption), changes in rock permeability and no account is taken of the neutralisation of solutions by newly formed minerals. The vertical subsidence of heavier sulphuric acid solutions and deposition of some of the contaminants on the aquiclude is also not taken into account. All of the above factors accelerate the conversion of dissolved metals into insoluble compounds, but are not considered in this report, as the mechanism of their influence is much more complex than the calculation above, and their share in accelerating the neutralisation of solutions and deposition of contaminants is negligible.

5.4.6.6 Modelling of Natural Demineralisation

Information on the Wings Project deposit was collected in Leapfrog Geo. The hydrodynamic modelling was performed in Visual Modflow Flex.

Modelling was carried out according to the following sequence:

- Building of the wireframe model in the Leapfrog program and assigning the wireframes to the horizon parameters specified in the previous sections.
- Importing the model into Visual Modflow.
- Defining model calculation conditions.
- Calculation of the steady-state model for convergence estimation.
- Hydrodynamic and hydrogeochemical calculation of the model.

Analysis of obtained results.

Initially upper and lower limits of the analysed Auob horizon were determined with due consideration of topographical survey data and cross-sections by historical and exploration wells. The conceptual model of the horizon is shown in Figure 26. The original model was built in Leapfrog software and then exported to Modflow Flex. The initial condition of the horizon is assumed to be a steady-state water drive resulting from the operation (Figures 27 and 28). For a more thorough analysis of the effects of pilot test extraction, the model boundaries were reduced and a pattern spacing of 5 m was assumed to translate into the power model.

The Initial heads and Conductivity parameters were taken according to the hydrogeological sections and hydrogeological surveys, the Initial concentration for SO_4^{2-} ion was taken according to the geochemical analyses of the samples, and the average value of the considered area, 80 mg/L, was taken as the initial mg/value.

The hydrodynamic modelling of the demineralisation process was carried out under the condition that the pilot cell operates in the balance of injected and pumped solutions, with no decrease or rise in the groundwater level outside the pilot cell. Taking into account understudied hydrogeochemical parameters, the experience of works at similar mines in the Republic of Kazakhstan was taken as a basis for modelling acid-containing solutions distribution. It should be noted that uranium deposits developed by the ISL method in the Republic of Kazakhstan have more favourable parameters: higher filtration coefficient, lower carbonate index, the lower acid capacity of rocks, which is a prerequisite for more aggressive distribution of acid-bearing solutions.

The option of the beginning of demineralisation was considered in the case when the operation of the pilot test cell was stopped at maximum mineralisation of process solutions, with a concentration of sulphuric acid in pumped solutions of 10 g/dm^3.

In the groundwater of the ore-bearing horizon, in and around the field of the deposit there is an unfavourable ecological-hydrochemical situation caused by natural reasons. The waters of the ore-bearing aquifers, within the site, **naturally contain elevated concentrations of uranium radionuclides.**

5.4.6.7 Radiation Impact on the Aquifer

During the in-situ leaching process, radionuclides will be redistributed within the orebody (exploitable block). It should be borne in mind that the volumes of pregnant and residual solutions at this time are in aquifers initially contaminated by natural processes, unsuitable for all types of water consumption. ISL processes of mining uranium within a given areas of wellfields, during continuous production/mining there are little or no effect on groundwater outside the mining blocks. The spread of radionuclides with groundwater flow beyond the contour of the pilot test cell is not expected.

The concentration of associated radioactive elements in sulphuric acid uranium leaching is low. For example, radium is transferred to the solution in an amount of not more than 2 % of its total content in ores. It migrates on small distances (some tens of meters), as the presence of SO_4^{2-} ion in water leads to the formation of poorly soluble gypsum and also almost insoluble sulphates of barium, lead, strontium, which causes co-precipitation of radioactive elements.

At the end of pilot test mining, when the pH =5.5 is reached, uranium is precipitated from solutions, which contributes to the improvement of the radiological situation. The estimated time of reaching background uranium content in formation water according to the experience of uranium deposits in the Republic of Kazakhstan is not more than 0.5 years after completion of works.

5.4.6.8 Conclusions on the Results of Hydrogeological Modelling

As noted above, when using sulphuric acid almost all elements available in rocks in amounts exceeding maximum permissible concentrations for drinking water supply are transferred to a solution to a greater or lesser degree. At that boundary of pollution halo reaches 50-100m distance from production wells and the further self-cleaning process occurs.

The potential impact on the water quality of the Auob aquifer as a result of the ISL is assessed as **limited** (depending on the size of the exploited deposit, usually not more than 10 km^2), **long-term, moderate** impact. Impact significance is **medium**.

Impacts on existing water intakes are also assessed to be of **medium** significance.

5.4.7 Mitigating Adverse Impacts and Monitoring

Potential impacts from the ISL on groundwater have been identified. The significance of these impacts has been assessed taking into account the sensitivity of each receptor and the expected significance of potential impacts. Where impacts have been identified as significant, mitigation measures will be required to minimise the impact or reduce the likelihood of an impact occurring. This section considers the appropriate mitigation measures that have been recommended for application. It should be noted that many of the proposed mitigation measures aim to reduce the likelihood of accidents occurring, e.g. those associated with accidental leaks and spills. Spill pathways may still be present, and the magnitude and duration of the consequences may not necessarily be reduced. Nevertheless, the likely frequency of potential impacts will be reduced.

5.4.7.1 Mitigating Adverse Impacts on the Kalahari Aquifer

The main measure to prevent accidental leaks or spills of pregnant and leaching solutions is to ensure that the pipelines are leak-tight and that the pumping and transport of the pregnant solutions work smoothly. This measure is implemented by proper control of the design and construction process, including the establishment and observance of the regulations for the repair and maintenance of wells and surface facilities of the wellfield.

To minimise the consequences of accidental spills of pregnant and leaching solutions, the accident should be eliminated within 1 hour by pumping the spilt solutions into a stored tank and neutralising with caustic lime or soda ash.

In order to prevent the infiltration of pollutants into the upper aquifer along the well, it is necessary to implement measures to ensure the reliability of well structures, implemented by controlling the design and construction process of wells. The technical design for drilling and well construction must include measures for sealing of threaded joints, quality control of clay mud, an inspection of well casing leakage by well-logging methods before putting the well into operation, and in case of casing defects by repair, then pressure testing of the casing at one and half the working pressure with subsequent well logging.

5.4.7.2 Mitigating Adverse Impacts on the Auob Aquifer

As noted above, the development of uranium deposits using the ISL method is the most economical and environmentally friendly method of extracting a useful component from the subsoil. The main measure for the safety of in-situ leaching for the environment and groundwater in particular is to ensure that the solution cycle is closed-circuit. In order to prevent the spreading of leaching and pregnant solutions beyond the cell contour, the in-situ leaching cell must operate in a balance of injected and extracted solution. Technological spreading is allowed for the distance of half of the distance between the injection and extraction wells, in this case for 5 metres, which is related to the created head/hydraulic gradient.

The main measures to prevent the adverse impact of in-situ leaching on groundwater should be aimed at the prevention of emergency situations, which is ensured by compliance with the established procedure of wells repair and maintenance works.

Upon completion of development of uranium reserves at the production blocks, after their reserves are depleted, control drilling and "subsoil washing" is carried out, the ISL sites are to be liquidated.

All production wells are abandoned, except for monitoring wells, which are part of the long-term observation network for the process of groundwater recovery, under natural demineralisation conditions within the depleted cell.

The final stage of in-situ leaching should be "subsoil washing" with recycled solutions without acidification.

After the washing stage the following measures are envisaged:

- Injection and extraction wells shall be flushed with water in the volume equal to two well volumes.
- all production wells must be sealed from bottom to the surface..
- above the top of the pay horizon the wells are filled with cement-clay mortar.
- further, up to a depth of 1.0 m from the surface, the boreholes are filled with clay, cement or spent clay mud.
- wooden plugs with a height of 0.5 m are placed in the boreholes at a depth of 1.0 m.
- excavation of 1.0 m diameter around the wells to a depth of 0.5 m is carried out.
- at a depth of 0.5 m from the surface the casing pipe is cut.

- Funnels formed around the well mouth are backfilled with clean soil to ground level.

5.4.7.3 Monitoring of Ground and Surface Water Condition at In-Situ Leaching Wellfields

An important element of mining technology is regime-balance observations and sampling of production wells in operation to control the uranium content in solutions, to monitor the progress of the ISL and the chemistry of uranium leaching.

The system of ground and surface water condition monitoring at ISL wellfields is determined by the natural complexity of the deposit, geological and hydrogeological conditions, adopted mining technology, the geography of the ISL wellfield and its location in the vicinity of existing household and drinking water intake, agricultural crop rotation, animal farming and the condition of the surface landscape with regard to sanitary standards.

All aquifers in the vicinity of the existing ISL wellfield, surface rainfall harvesting, as well as the sand container tanks with pregnant (PS) and leaching (LS) solutions are monitored.

The monitoring system is based on sampling from the above observation sources through special monitoring wells, systematisation of geophysical control data, analysis followed by the development of necessary measures.

The main objectives of the monitoring system used are:

- determination of the primary chemical composition and water level (baseline analyses).
- control of changes in the chemical composition and dynamic level of solutions in the mined pilot cell as a result of ISL and after mining.
- control of the spreading of the ISL solution halo in horizontal and vertical directions.
- management of the ISL process, improvement of the mining technology in order to eliminate the spreading of technological solutions outside the mined-out areas.
- improvement of the wellfield connections, repair and remedial works in wells, reducing the process solution spills.

The control system is developed at the stage of design of production blocks on the basis of exploration data, laboratory studies, pilot field tests and operating experience of similar deposits. *Monitoring wells to monitor the spreading of solutions in the horizontal and vertical directions*. Monitoring wells are constructed to monitor the vertical spreading to the overlying aquifers. The distance between the wells is e.g.: 450-500 m when working out of narrow deposits and 200-250 thousand m^2 for wide deposits (determined by the project).

To control the horizontal spreading of solutions, wells are constructed outside the zone of spreading of process solutions in the direction of the natural flow of groundwater from the deposit under development. The distance from the edge of the production block should be 25, 50, 100 m (determined by the project). 2-

3 wells are to be constructed on the beam. The number of wells along the perimeter of the worked-out wellfield is determined by the project.

Priority areas are:

- directions of natural groundwater flow,
- direction towards the wells that withdraw water from the productive aquifer or the upper or lower aquifers if there is a hydraulic connection between them.
- Upper aquifer and aquifer below the production aquifer.

Monitoring well filters are installed for the whole aquifer; if the aquifer is very thick, the filters can be shorter but must capture the flow of possible contamination as much as possible.

As individual blocks of ISL wellfields are worked out, they shall be reclaimed.

The Namibian Ministry of Mines and Energy (MME) regulatory requirements will require a mine closure plan to be submitted to the regulatory authorities. The Mine Closure Plan contains detailed actions and commitments, including financial and human resources to effectively manage the likely environmental liabilities of the mine closure and post-closure phases of the proposed Wings Project operations. Regular estimates and assessments of environmental obligations during the mining phase will be carried out to ensure that the necessary resources are adequately provided for good environmental management during the mine closure and post-operational reclamation phases.

Based on the results of process solution volume observations and sampling, block-by-block accounting of uranium production and leaching reagent (sulphuric acid) consumption is carried out, as well as operational control of the balance between the volumes of pumping and injection solutions by block, which is a prerequisite for the normal operation of the ISL process and environmental protection.

It is recommended to analyse the groundwater quality of all farmer water intake wells in the area of the Wings Project deposit, including radionuclide content, before carrying out in-situ leaching and to record this fact as part of the environmental assessment before the start of the business activities. It is recommended that the document be approved by the local authorities and the state executive authorities.

After the pilot test cell mining on the project facilities have been worked out, an additional study of groundwater observation materials must be carried out, from which conclusions must be drawn about the boundaries of residual process solutions spreading and the extent to which the predicted design solutions have been fulfilled. Upon completion of well surveys, the latter shall be liquidated to prevent the formation of water overflows along the wells. Technological and special control and control drilling are sufficient to study the degree of changes in the chemical composition of natural waters, the degree of uranium extraction and useful associated components, determine the contour of the spreading of technological solutions, chemical and mineralogical changes in ores and host rocks under the impact of industrial works and report with regard to the requirements of regulatory documents.

Groundwater composition control is carried out by monitoring wells penetrating the monitored horizons. Monitoring wells are provided within the industrial contour as well as outside it. Water sampling is carried out for all penetrated aquifers in accordance with the regulations of hydrogeochemical and radiochemical sampling of monitoring wells at the enterprise.

5.4.8 Residual Impacts

In in-situ leaching, contaminated groundwater is restored to its original state after the termination of technogenic impacts due to the presence of natural resources for "self-purification" of groundwater in all lithological media. The ability of an ISL-affected geological environment to restore, without human intervention, the original water properties is a critical factor in ensuring that the environmental aspects of the ISL method are favourable for the development of hydrogenic uranium deposits.

Data on the physicochemical interaction of residual ISL solutions with the host rocks, necessary to reliably predict the distribution of residual solution halos from ISL facilities, should be obtained from pilot-migration studies.

The direction of movement of the pollution halo allows determining accurately enough the location of observation (monitoring) wells to track the spread of the pollution halo and to control natural demineralisation. It is recommended to locate monitoring wells at a distance of 25, 50 and 100 metres from the contour of the pilot cell on the beam in the direction of the natural flow.

The residual impact assessment is shown in Table 5.6.

Table 5.6 - Residual Impact Assessment

Initial description of impact, significance of impact (high, medium, low), type of impact (direct, indirect)	Mitigation measures	Residual impact	
		Impact description	Impact significance (high, medium, low)
Kalahari aquifer, water intakes in operation			
Contamination of aquifer by seepage of pollutants from leaks and spills of pregnant and leaching solutions. Direct impact of low significance	Ensuring leak tightness of pipelines and accident-free operation of pregnant solution pumping and transportation system.	No impact or low probability of impact	Impact intensity - Insignificant Time scale - Short-term Area of impact - Local Significance - **Low**
	Spill is eliminated within 1 hour by transferring spillage to a storage tank and neutralising with caustic soda or lime.	Preventing pollutants from seeping into the aquifer	
Spreading of contaminants due to seepage of pollutants through wells of poor quality or improperly designed wells Direct impact of moderate significance	Well design and construction reliability, implemented through control of well design and construction process. The technical design for drilling and well construction must include measures for sealing of threaded joints, quality control of clay mud, inspection of well casing leakage by well-logging methods before putting the well into operation, and in case of casing defects by repair, then pressure testing of the casing at half working pressure with subsequent well logging.	No impact	Impact intensity - Insignificant Time scale - Short-term Area of impact - Local Significance - **Low**
Auob aquifer, water intakes in operation			
Contamination of the aquifer by chemical reagents and secondary contamination through transfer into solution of elements present in the rocks and their transport outside the aquifer. Redistribution of radionuclides within the ore body. Direct impact of moderate significance	Providing a closed solution cycle. In-situ leaching cell should operate in a balance of injected and pumped solution.	Contamination of aquifer within the deposit Spontaneous recovery of groundwater quality, demineralisation, neutralisation of groundwater	Intensity of impact - minor Time scale - long-term Area of impact - Local Significance - **Low**
	Compliance with regulations for well repair and maintenance activities.		
	Washing of the "subsoil" upon completion of mining		
	Abandonment of wells in accordance with special safe technology		
	Regime-balance monitoring and sampling of production wells in operation		
	Arrangement of a control system based on sampling of the above observation sources via special monitoring wells, systematisation of geophysical monitoring data, analysis with further development of necessary measures.		

6. SOILS, FLORA AND FAUNA

This chapter presents the main characteristics of soils, vegetation and fauna within the pilot test mining site. It describes the impacts that the ISL technology may have on soils, flora and fauna. Impacts on soils are assessed as vegetation and topsoil will be removed during mining operations, which increases the rate of weathering and erosion.

There is also the potential to encounter contamination from accidental leaks or spills that could impact soils.

6.1 Spatial and Temporal Boundaries

6.1.1 Project Area

The proposed area under the Wings Project ISL uranium mining operations are located within the Stampriet Artesian Basin. The most promising aquifers for detecting uranium mineralisation are the Auob and Nossob aquifers.

6.1.2 Study Area

The study area includes the land surface within the Stampriet Artesian Basin.

6.1.3 Zone of Influence

The zone of influence has been defined using a pilot test cell located south of road C23 at a distance of 15 km west of the village of Leonardville and corresponds tentatively to the area of the process wells. The boundary of the pollution halo reaches a distance of 50-100 m from the outermost wells when the ISL sites are operating in a balanced mode. The specific area of impact of the ISL sites will be determined during the preparation of a full EIA for the Wings Project as a whole.

6.2 Methodology

6.2.1 Applicable Guidelines and Standards

Measures relating to soil erosion control and prevention, soil and vegetation conservation, improvement and management practices and protection of water sources in the Republic of Namibia are governed by the Soil Conservation Act No. 76 of 1969 and the Amendment Act No. 38 of 1971.

There are no soil quality standards or regulations in Namibia. The following soil-related documents have been adopted as guiding or reference regulations and standards in this chapter, including:

- Russian standard GN 2.1.7.2041-06 on Maximum Allowable Concentrations (MAC) of Chemical Substances in Soil.

- Russian standard GN 2.1.7.2511-09 on Approximately Permissible Concentrations (APC) of Chemicals in Soil.
- Kazakhstan Hygienic Standards for Safety of Living Environment.

Soil quality assessment criteria are defined taking into account Hygienic Regulations for Safety of Habitat", approved by Order No. KR DSM-32 of the Minister of Health of the Republic of Kazakhstan dated April 21, 2021.

Table 6.1 - Maximum Allowable Concentrations (hereinafter referred to as "MAC") of Chemical Substances in Soil

Item No.	**Substance name**	**MAC value, μ/kg, soils, taking into account background (Clark)**	**Limiting indicator**
active form			
1	cobalt* (1)	5.0	general sanitary
2	fluorine* (2)	2.8	translocation
3	chrome* (3)	6.0	general sanitary
water-soluble form			
4	fluorine	10.0	translocation
5	benz(a)pyrene	0.02	general sanitary
6	xylenes (ortho-, meta-, para)	0.3	translocation
7	arsenic	2.0	translocation
8	OFU* (4)	3000.0	water and general sanitary
9	mercury	2.1	translocation
10	lead	32.0	general sanitary
11	lead + mercury	20.0 + 1.0	translocation
12	elementary sulphur	160.0	general sanitary
	hydrogen sulfide	0.4	air
	sulfuric acid	160.0	general sanitary
13	styrene	0.1	air
14	formaldehyde	7.0	-"-
15	potassium chloride	560.0	water

6.3 Overview of Existing Baseline Data

6.3.1 Soils

The soils of the Kalahari Desert are mainly red-brown and orange-brown, sandy, unstructured, consisting of coarse and fine sand. Despite the sandy granulometric composition of the Kalahari soils and regular surface disturbances, there is a significant biological cover of soil crust (19-40%) in all areas. This is due to a combination of resistance to trampling, protected niches and the prevalence of Microcoleus vaginatus cyanobacteria, which can rapidly regenerate crusts. Crust cover and diversity increases on ferruginous and calcareous soils. Spatial variability of soil nutrients is low but increases due to shrub grazing. The preferential development of nitrogen-fixing biological soil crusts under shrubs may increase the competitive advantage of Acacia mellifera, encouraging further invasion of shrubs. Whether this constitutes land degradation depends on the extent to which palatable grass species persist in the underbrush canopy niches.

6.3.2 Vegetation

Trees and Shrubs. According to Mannheimer and Curtis (2018), at least 64 species of larger trees and shrubs are known and/or expected to occur in the general area, of which 5 species have some form of conservation status (7.8%). The most important large tree/shrub known/expected to occur in the area is considered to be Aloe litoralis (Windhoek aloe). Although widespread and even common elsewhere in Namibia, they are not as common on sandy soils in eastern Namibia. Protected tree species that need to be removed and/or pruned would be considered important - for example Acacia erioloba (camel thorn), Albizia anthelmintica, Boscia albitrunca (sheep's tree) and Ziziphus mucronata (buffalo thorn), although these are common in the Leonardville area in general, under the Forestry Act 12 of 2001 the reason for protecting these species is as follows [EC = Degree of Use; ES = Ecosystem services]:

- Acacia erioloba (EC: widely used by humans and animals, in medicine, for cash crops, inefficient harvesting of fuel wood for export, slow growth, cultural value, economic value + ES: key species).
- Albizia anthelmintica (EC: used by humans and animals, in medicine, in dishes, used by livestock and game).
- Boscia albitrunca (EC: widely used by humans and animals) and
- Ziziphus mucronata (EC: used by humans and animals, in medicine, construction, tools, fuel wood, used by livestock and game + ES: prevents erosion of riverbeds and riverbanks, an important component of coastal vegetation).

Grasses. It is estimated that at least 46-50 grasses (Müller 2007, Van Oudshoorn 2012) occur in the general area of Leonardville. Of the approximately 66 grasses available in the area, 1 species is considered endemic (Eragrostis omahekensis) and 2 species are considered near-endemic and/or endemic to the southern Kalahari region (Anthephora argentea, Eragrostis lehmanniana) (Müller 2007, Van Rooyen 2001). According to Muller (2007), the endemic Eragrostis omahekensis is found almost only in disturbed areas along roads; on old land or near water bodies. The most important species expected to occur in the area is the endemic Eragrostis omahekensis.

Other species with commercial potential that could occur in the study area include Harpagophytum procumbens (devil’s claw) – harvested for medicinal purposes and often over-exploited – and Citrullus lanatus (tsamma melon) which potentially has a huge economic benefit (Mendelsohn et al. 2002). Many other species, such as aloe Vera, Commiphora, lithops, ferns and lichens, can also be found in the common areas of the project.

6.3.3 Fauna

Reptiles. Approximately 261 species of reptiles are known to occur in Namibia thus supporting approximately 30% of the continent's species diversity (Griffin 1998a). At least 22% or 55 species of Namibian lizards are classified as endemic. The occurrence of reptiles of "conservation concern" includes about 67% of Namibian reptiles (Griffin 1998a). Emergency grazing and large-scale mineral extraction in critical habitats are some of the biggest problems facing reptiles in Namibia (Griffin 1998a).

The overall reptile diversity and endemism in the area of Leonardville is estimated at between 61-70 species and 5-8 species, respectively (Mendelsohn et al. 2002). Griffin (1998a) presents figures of between 1-10 and 1-2 for endemic lizards and snakes, respectively, from the general area, while 79 and 83 species are known to occur in the closest government-protected areas of Daan Vildjoen and Waterberg Plateau Park, respectively.

At least 60 species of reptiles are expected to occur in the Gobabis-Leonardville area with 10 species being endemic – i.e., 16.7% endemic. They consist of at least 26 snakes (3 blind snakes, 1 thread snakes, 1 python, 2 burrowing snakes, 1 purple snake and 18 typical snakes), 5 species of which are endemic (19.2%) to Namibia, 2 turtles, 1 terrapin, 31 lizards (4 worm lizards, 9 skinks, 6 Old World lizards, 1 plated lizard, 1 monitor lizard, 2 agamas, 1 chameleon and 7 geckos), 5 species (16.1%) of which are endemic to Namibia. Skinks (9 species), Old World lizards (6 species) and geckos (7 species) are the most numerous lizards to be expected in the area. Namibia with approximately 129 species of lizards (Lacertilia) has one of the continent's richest lizard faunae (Griffin 1998a). Geckos are the most common endemics in the general area: 3 of the 7 species (42.9%) that are expected and/or known to occur in the area are endemic to Namibia. The IUCN (2020) classifies 3 species as least vulnerable. However, most reptiles are not yet on the IUCN Red List. Due to the fact that reptiles are a poorly studied group of animals, especially in Namibia, it is expected that there may be more species in the total area than indicated above.

The most important species expected to occur in the area are the Stigmochelys pardalis and Psammobates oculiferus turtles; the blind snake, Rhinotyphlops lalandei; the purple-sheened snake, Amblyodipsas ventrimaculata; the python, Python natalensis; and the monitor lizard, Varanus albigularis. Turtles, snakes, and monitor lizards are usually killed for food or as a perceived threat.

Amphibians. Amphibians are declining throughout the world due to various factors of which much has been ascribed to habitat destruction. Basic species lists for various habitats are not always available with Namibia being no exception in this regard while the basic ecology of most species is also unknown. Approximately 4,000 species of amphibians are known worldwide with just over 200 species known from southern Africa and at least 57 species expected to occur in Namibia. Griffin (1998b) puts this figure at 50 recorded species and a final species richness of approximately 65 species, 6 of which are endemic to Namibia. This "low" number of amphibians from Namibia is not only as a result of the generally marginal desert habitat but also due to Namibia being under studied and under collected. Most amphibians require water to breed and are therefore associated with the permanent water bodies, mainly in northeast Namibia.

According to a literature review, at least 10 amphibian species may occur in suitable habitats in the Leonardville general area. Of these, 1 species is endemic (Phrynomantis annectens) (Griffin 1998b) and 1 species is classified as "endangered" (Pyxicephalus adspersus) (Du Preez and Carruthers 2009), i.e. the average level (20%) of amphibians of conservation value. The IUCN (2020) classifies all amphibians that are expected to occur in the area as least vulnerable.

Important species include the endemic Phrynomantis annectens and Pyxicephalus adspersus, which are classified as "endangered" in southern Africa (Du Preez and Carruthers 2009). The number of the latter is declining throughout its range in Namibia, mainly due to the overutilisation as food (Griffin pers. Com).

Mammals. There are at least 66 known mammal species in the Leonardville area, none of which are considered endemic.

At least 28.8% (19 species) of the mammalian fauna that occur or are suspected to occur in Leonardville are represented by predators and rodents, respectively. This is followed by 18.2% of bats (12 species), of which 3 species are not listed under Namibian law. Twenty-one species (31.8%) have IUCN, CITES, and/or SARDB international conservation status, of which SARDB lists 1 species as "rare", 2 species as "vulnerable", 8 species as "endangered", and 4 species as "data deficient".

The most important mammal species known and/or expected in the Leonardville area are those classified as "rare" (hedgehog, black-footed cats) and "vulnerable" (ground pangolin, South African galago, aardwolf, brown hyena, cheetah, African wild cat, bat-eared fox, Cape fox, eland, brindled gnu) under Namibian law, and those species classified as "vulnerable" (ground pangolin, cheetah, leopard) and "endangered" (leaf-nosed striped bat, brown hyena) IUCN (2020).

Birds. Although Namibia's avifauna is comparatively sparse compared to the high rainfall equatorial areas elsewhere in Africa, approximately 658 species have already been recorded, with a diverse and unique group of arid endemics (Brown et al. 1998, Maclean 1985). Fourteen species of birds are endemic or near-endemic to Namibia with the majority of Namibian endemics occurring in the savannas (30%) of which ten species occur in a north-south belt of dry savannah in central Namibia (Brown et al. 1998).

Bird diversity is viewed as "medium" in the general Gobabis-Leonardville area with 111 to 140 species estimated with no species being endemic to this area (Mendelsohn et al. 2000). Simmons (1998a) suggests 1-3 endemic species and a "low" rating for South African endemics and an "average" rating for red birds expected from the general area. Although the Leonardville area is not classified as an Important Bird Area (IBA) in Namibia (Simmons 1998a), the nearest such locations are to the northwest, i.e. Waterberg (Global IBA status) and to the north, i.e. Bushmanland (Global IBA status).

At least 170 bird species [mostly terrestrial "nesting inhabitants"] occur and/or may occur in the Leonardville area at any time (Hockey et al. 2006, Maclean 1985, Tarboton 2001). Three of the 14 endemic species of Namibia are expected to occur in the area (21.4% of all endemic species of Namibia, or 1.8% of all species found in the area). However, Simmons et al. (2015) indicate that Ruppel's parrot is rather endemic. Eight species are classified as endangered (Ludwig's bustard, white-backed vulture, bateleur, black harrier, tawny eagle, booted eagle, martial eagle, black stork), 2 as vulnerable (lappet-faced vulture, secretarybird), and 4 as endangered (Reppel's parrot, kori bustard, Verreaux's eagle, marabou stork) (Simmons et al.2015). The IUCN (2020) classifies 1 species as endangered (white-backed vulture), 3 species as endangered (Ludwig's bustard, vulture, black harrier), 2 species as vulnerable (martial eagle, secretary bird), and 1 species as near threatened (kori bustard). Forty species have a southern African conservation rating, of which 6 species are classified as endemic (15% of Southern African endemics or 3.6% of all expected birds) and 34 species are classified as near-endemic (85% of Southern African endemic species or 20% of all species) is expected (Hockey et al. 2006).

The most important bird species from the general area are those classified as endemic to Namibia, and those classified as endangered (Ludwig's bustard, white-backed vulture, bateleur, black harrier, yellow-brown eagle, booted eagle, martial eagle, black stork), vulnerable (lappet-faced vulture, secretary bird), and endangered (Reppel's parrot, kori bustard, Verreaux's eagle, marabou stork) (Simmons et al. 2015), as well as all species classified as endangered (white-backed vulture), endangered (Ludwig's bustard, booted vulture, tawny eagle, and black harrier), vulnerable (martial eagle, secretary bird), and endangered (kori bustard) by the IUCN (2020).

6.4 Impact Assessment

6.4.1 Impact Assessment Methodology

The impact assessment methodology is based on the principles of 'source - pathway - the object of impact perception'. The source in this context is defined according to the in-situ leaching technology. Soils, flora and fauna are considered to be the impact receptor. Pathways connecting the sources to the impact receptors have been identified. Potential impacts can only occur where there is a 'source-pathway-impact-sensitive receptor' link.

A general description of the process used in the EIA and the general methodology adopted for the assessment of impact magnitude is described in **Chapter 3 Environmental Impact Assessment Methodology**.

6.4.2 Project Activities to be Assessed in this EIA

In-situ uranium leaching may have an impact on the environment. A detailed description of the ISL technology is provided in **Section 4.1.** Other activities envisaged by the Wings Project that have potential impacts on soils, vegetation and wildlife will be considered during the preparation of a full ESIA and are not considered in this EIA.

6.4.3 Identification of Sources and Impacts

A brief description of the in-situ leaching technology is given in **Section 4.1**.

Sources of direct impact on soils and vegetation will be the mechanical impacts on soils from the movement of vehicles and special equipment during well construction and maintenance activities. Indirect impacts on soils and vegetation will result from the deposition of dust from machinery operation and movement on the ground surface, as well as pollutants from machinery engine exhausts.

At ISL, the main risk of potential impacts on soils and vegetation is associated with the chemicals used for leaching as well as metals in the pregnant solutions.

A direct impact on fauna will be the disturbance factor due to the presence of people and machinery in the area. An indirect impact on fauna will be the loss of forage and habitat as a result of contamination and damage to soil and vegetation.

Impact significance has been determined using the criteria described above in **Chapter 3 Impact Assessment Methodology**.

6.4.4 Impact Receptors

The receptors considered in this chapter are soils, vegetation and fauna.

Spreading Pathways.

Spreading pathways are the ways in which a particular activity can affect an object of impact reception. Only if there is an activity, a pathway and a receptor can the impact occur.

For assessment purposes, some activities are considered as spreading activities and pathways. Only if there is an activity, a pathway and a receptor can the impact occur. The pathways considered in the Environmental and Social Impact Assessment process are as follows:

- Physical disturbance of soil.
- erosion and transport of soil by surface run-off.
- Unplanned input of contaminants into the soil as a result of accidental spills of pregnant and leaching solutions.

- release of contaminants to soils as a result of the migration (deposition) of exhaust gases from machinery engines and dust.
- the physical destruction of vegetation.
- the ingress of pollutants that worsen plant growth conditions to the root system and other plant parts.
- disturbance of nutrients and water supply to the root system of plants due to compaction of the soil layer.
- the physical presence of people and equipment, as well as the spread of noise and vibration produced by them, as a factor of concern for animals.
- the potential physical destruction of animal habitats (burrows, nests, etc.).

Sensitivity of Soil Receptors

To assess potential impacts, based on the general methodology described in **Chapter 3 Impact Assessment Methodology**, professional judgement and experience, international relevant standards and regulations governing project implementation, a number of criteria have been developed to determine the significance of impacts on groundwater, vegetation and animals.

The sensitivity of such receptors is a reflection of how vulnerable the receptor is to changes in chemical or physical properties. Less sensitive sites are those that are most resistant to changes (less vulnerable to them). The notion of sensitivity also takes into account the importance of a receptor by defining the extent to which it is important to users of the environment (i.e. sustaining ecosystems and society through ecosystem services). Criteria have been developed to assess sensitivity using four categories: high, moderate, low and insignificant. If the allowable value and vulnerability differ significantly for a particular receptor, the more conservative category is preferred.

The sensitivity of soil receptors is primarily related to the geochemical features of the soil, and the water and nutrient cycling process of which it is a part (i.e. soil susceptibility to erosion, soil fertility, etc.). Similarly, sensitivity depends on land use and existing ecosystems. Soil sensitivity is also related to the presence of pollutants in the soil. This chapter focuses on the impacts on the initial condition of the soil cover.

The proposed activity will take place in the desert zone where red-brown and orange-brown, sandy, unstructured soils consisting of coarse and fine sand are prevalent.

According to paragraph 1.4 of GOST 17.4.3.02-85 (ST SEV 4471-84) Nature Protection– Soils– Requirements for Protection of Fertile Layer of Soil During Excavation in force in the Russian Federation and the Republic of Kazakhstan, the fertile layer on soils of sandy texture shall be removed only on developed and cultivated lands.

According to GOST 17.5.3.06-85. Nature Protection (SSOP)– Lands– Requirements for Identification of Norms of Soil Fertile Layer Removal during Earthworks, fertile layers can be removed for further use if they have the following characteristics: humus content (for the desert zone) - no less than 0.7%, pH value of aqueous extract in fertile soil layer should be 5.5-8.2, mass fraction of soil particles less than 0.1 mm should be in the range of 10 to 75%.

Based on the above GOST requirements the soil in the area of the proposed activity is of **low sensitivity**.

Flora and Fauna

As stated in **Chapter 3, Impact Assessment Methodology**, the sensitivity of an impact receptor is a combination of the receptor's 'resilience' (i.e. vulnerability) and its 'value' (a quantitative indicator). There are no universal or standard methods for determining resilience and value for sensitive environmental sites. This is partly due to the very large number of factors that can influence the assessment. In this chapter, habitat and species sensitivities are assessed based on indirect sensitivities that represent a combination of elements of resilience and value.

For species, sensitivity is determined according to conservation status. This assessment is based on the assumption that species at higher risk of extinction are inherently potentially less resilient to a range of stressors. This assessment is not related to resilience to specific impacts of the Project, as the latter are considered specifically under environmental impacts. The level of rarity of a species is an important criterion for assessing the risk of extinction. Rarity is also a key factor in quantifying the category of the species, which is partly reflected in the assignment of protection through legal instruments, at international, national or regional levels.

Vegetation and animals with a statutory protection status are characterised by **high sensitivity**.

Vegetation and animals without protection status, which are not modified by human activities and which contain native species that form communities consistent with the prevailing environmental conditions ("natural habitats") are of **medium sensitivity**.

Unclassified plants and animals that are actively influenced or altered by human activity (along roads, around built-up areas and other sites) but contain communities of predominantly native species ("modified habitats") are of **low sensitivity**.

The sensitivity of vegetation and animals is directly related to their habitat and in order to clarify their sensitivity category, an additional survey of specific areas proposed for planned activities to identify sites with protected status is required when preparing a full ESIA.

6.4.5 Sources and Types of Impacts on Soils

During maintenance of the wells and extraction areas in general, the soil and vegetation layer will be subjected to significant anthropogenic impacts as a result of machinery and vehicular traffic, resulting in disturbance of the top horizon. Road degradation will be a characteristic disturbance.

This impact on soils is assessed as a **limited** (depending on the size of the exploited deposit, usually not more than 10 km^2), **long-term**, **moderate** impact. Impact significance is **medium**.

Sources of pollution will also include exhaust gases from vehicles and special equipment as a result of the deposition of pollutants on the surface. In addition, one of the factors of area impact on soil cover is dusting. Dusting inhibits vegetation cover and creates a crust on the soil surface that is poorly permeable to precipitation, the formation of which can lead to changes in moisture accumulation in soils and, consequently, their transformation. This is represented by an increase in surface runoff and disturbance of moisture availability in the lower soil layers.

This impact is assessed as a **limited** (depending on the size of the exploited deposit, usually not more than 10 km^2), **long-term**, **moderate** impact. Impact significance is **medium**.

Potential sources of soil contamination in the project area are:

- accidental leakage of process solutions due to ruptures of leak tightness of pipelines.
- spills of sulphuric acid solutions.
- Discharge of solutions and suspensions during cleaning of production wells.

In areas of solution spills, the ground surface can become contaminated with sulphates and natural uranium-radium radionuclides, which leads to soil salinisation and an increase in gamma-radiation power. The action of acidic uranium-bearing solutions results in the destruction of soil carbonates which leads to intensive soil acidification (the alkaline reaction of soil suspensions changes from alkaline with pH=8.7-9.2 to acidic with pH=5-6), the increase of the sum of exchangeable bases to 27-32 mg-eq/100 g, in which the relative content of sodium ions increases sharply in comparison with calcium cations. The value of the solid residue can be as high as 1.2-1.3 %. The salinisation, in this case, is mainly superficial, although it can reach a depth of 75 cm. As a result of the influence of acid solutions, the soils pass into the category of solonchaks. At spilling of process solutions on the soil surface, the main contribution to the dose rate is made by: Ra-226 (half-life of 1600 years) with decay products from Rn-222 to Bi-214, photon emission of U-235 and Th-231 constantly in equilibrium, Ac-227 and its short-lived decay products including Bi-211.

Potential impacts on soils from chemical spills are assessed as **local**, **long-term**, **moderate** impacts. Impact significance is **medium**.

6.4.6 Sources and Types of Impacts on Vegetation

Impacts on vegetation in areas adjacent to the wells may be direct or indirect. Direct impacts may occur in the form of fragmented damage to above-ground plant parts as a result of temporary storage of equipment and materials, covering vegetation with soil, development of road digression.

The impact on vegetation in this case is assessed as **local**, **long-term**, **moderate** impact. Impact significance is **medium**.

Impacts on plants of protected status are assessed as **local**, **long-term**, **high** impact. Impact significance is **medium, closer to the upper threshold value**.

Indirect impacts through the air may occur through dusting and chemical contamination from combustion products from vehicles and stationary equipment used. However, as a result of higher wind conditions and high dispersion rates of nitrogen and sulphur compounds, the impact of the latter will not affect the vitality of the vegetation cover.

Impacts, in this case, are assessed as **local**, **short-term**, **insignificant** impacts. Impact significance is **low**.

Potential impacts on vegetation from chemical spills are assessed as **local**, **long-term**, **moderate**. Impact significance is **medium**.

6.4.7 Sources and Types of Impacts on Fauna

The continued presence of people, machinery and vehicles will have an adverse impact on the habitat conditions of animals in the immediate vicinity. The main factor will be the disturbance factor. The proposed works in the area will only have the potential to cause localised changes in faunal composition, abundance and spatial distribution. They are not irreversible and will not affect the gene pool of animals in the area in question. Physical destruction of valuable and protected fauna species and their habitats is not foreseen.

The impact on fauna is assessed as **local**, **long-term**, and **moderate**. Impact significance is **medium**.

6.4.8 Mitigating Adverse Impacts

In order to reduce the adverse impact on soils, the provision shall be made for development and regularisation of the road network, prohibition of movement of vehicles and special equipment outside the roads.

Reclamation of the mining sites will be carried out upon completion of mining operations. All areas disturbed during mining will be subject to reclamation.

To prevent accidental spills of pregnant and leaching solutions, measures specified in **subsection 5.4.7.1 Mitigating Adverse Impacts on the Kalahari Aquifer** are implemented.

An important measure for the preservation of vegetation and animal habitats is the survey of the areas affected by the proposed activity for the identification of objects having protected status. Each object identified in this manner shall be recorded in a special report with an indication of its location so that the protected status could be taken into account in the development of project documentation.

6.4.9 Residual Impacts

The design shall include the most appropriate traffic layout and road network to minimise impacts on soil, vegetation and fauna.

Contaminated and subject to recultivation land resulting from the liquidation of the in-situ leaching wellfields after recultivation shall meet the following radiation safety requirements. During recultivation for agricultural and forestry purposes average total alpha-radioactivity of ground in layers of 0-25 cm, 25-50 cm, 50-75 cm, 75-100 cm from the surface for each recultivated area must not exceed 1200 Bq/kg above the natural background characteristic for similar lands of the given area, at that in separate local points (not more than 20%) it must not exceed 7400 Bq/kg. At the same time, average external gamma radiation dose rate over the whole recultivated area at 1 m above soil surface should not exceed 0.2 μSv/h above the level of natural background characteristic for the area, at separate local points (not more than 20%) it should not exceed 0.5 μSv/h.

In recultivated lands in layers up to 1 m, the dense residue of aqueous extract at any point must not exceed 0.6%, pH of the aqueous extract is not less than 6.0.

The design of mining blocks shall be carried out in such a way as to avoid areas of growth and habitat of plant and animal species to be protected.

An assessment of the residual impact is given in Table 6.2.

Table 6.2 - Residual Impact Assessment

Initial description of impact, significance of impact (high, medium, low), type of impact (direct, indirect)	Mitigation measures	Residual impact	
		Impact description	Impact significance (high, medium, low)
Soils			
Mechanical impact on soils due to machinery and vehicle movements. Direct impact of moderate significance.	Development and regularisation of the road network, prohibition of movement of vehicles and special equipment outside the roads.	Reduction of the impact area	Impact intensity – minor. Time scale - long-term Area of impact - Local Significance **- Low**
Deposition of dust and contaminants on soil generated by machinery and vehicle engines. Direct impact of moderate significance	Development and regularisation of the road network, prohibition of movement of vehicles and special equipment outside the roads.	Reduction of the impact area	Impact intensity – minor. Time scale - long-term Area of impact - Local Significance **- Low**
Potential impacts on soils from spills of chemical solutions. Direct impact of moderate significance	Timely elimination of spills. Land reclamation at the end of mining.	No impact or low probability of impact	Impact intensity – minor. Time scale - Short-term. Area of impact - Local. Significance **- Low**
Vegetation			
Physical impact on vegetation (damage). Direct impact of moderate significance.	Survey of the territories affected by the planned activity in order to identify objects that have protected status. Each object identified in this manner shall be recorded in a special report with an indication of its location so that the protected status could be taken into account in the development of project documentation.	No impact or low probability of impact	Impact intensity – minor. Time scale - Short-term. Area of impact - Local. Significance **- Low**
Potential impact on vegetation during spills of chemical solutions, violations of plant growth conditions. Direct impact of moderate significance	Survey of the territories affected by the planned activity in order to identify objects that have protected status. Each object identified in this manner shall be recorded in a special report with an indication of its location so that the protected status could be taken into account in the development of project documentation.	No impact or low probability of impact	Impact intensity – minor. Time scale - Short-term. Area of impact - Local. Significance **- Low**
Fauna			

Initial description of impact, significance of impact (high, medium, low), type of impact (direct, indirect)	Mitigation measures	Residual impact	
		Impact description	**Impact significance (high, medium, low)**
A disturbance factor for animals as a result of the presence of people, working machinery and the movement of vehicles. Impact of medium significance	Survey of the territories affected by the planned activity in order to identify objects that have protected status. Each object identified in this manner shall be recorded in a special report with an indication of its location so that the protected status could be taken into account in the development of project documentation.	No impact or low probability of impact	Impact intensity – minor. Time scale - Short-term. Area of impact - Local. Significance **- Low**

7. UNPLANNED EVENTS

Unplanned events are episodes of accidents that should not occur during the normal operation of the ISL technology. This chapter provides an assessment of potential environmental risks and impacts arising from unplanned events at mine sites to develop design controls and mitigation measures.

The assessment considers both the likelihood of an unplanned event occurring and the potential consequences of such events.

7.1 Scope and Approach Used

This chapter considers those unplanned events that are of most significance to the Project given the ISL technology. In order to support the process of identifying unplanned events, an analysis of hazardous events and emergencies has been carried out to identify safety risks to the Project, and the need for preparedness and emergency response plans and associated emergency response procedures. The unplanned events discussed in this chapter are identified in the emergency analysis to identify safety hazards. Where possible, information on the likelihood of unplanned events has been taken from the statistics of mining operations specialising in ISL uranium mining in the South of Kazakhstan context.

7.2 Emergency Analysis (Probability and Consequence Forecast)

The probability of emergencies occurrence at each specific facility depends on many factors, conditioned by mining-geological, climatic, technical and other features. A quantitative assessment of the probability of an emergency occurrence is possible only if there is a sufficiently complete statistical information database that takes into account the specifics of the work performed. However, experience shows that the frequency of emergencies is subject to general regularities, the probability of their occurrence can be expressed by analogy with the events that have occurred in the system of expert assessments.

Emergencies are also possible during pre-production and mining operations.

In terms of the main causes, the possible accidents are represented by three groups:

- general technical.
- toxic (chemical).
- radiation.

General Technical Accidents. The main types of general technical accidents are discussed in the safety guidelines for construction, mining, exploration work, lifting operations and handling electrical equipment. The procedure for investigating and dealing with general technical accidents and for dealing with their consequences are defined in the relevant guidelines. The procedure for dealing with general technical accidents is defined by workplace instructions.

Chemical Accidents. From the chemical reagents to be used at the project sites, only sulphuric acid has a significant toxic hazard. In most cases, when working with solutions of the technological cycle, acid concentration cannot cause an exceeding of MAC levels of working atmosphere. Spillages of process solutions, therefore, do not have a significant impact on personnel. A sulphuric acid spill should be contained within 1 hour by transferring the spilt solutions to a storage tank and neutralising the acid residue in the sump with slaked lime or soda. The resulting neutral mass is swept away in one place and taken to a designated area. During the elimination of sulphuric acid spills personal respiratory protection equipment and acid-resistant clothing and footwear must be worn.

Radiation Accidents. Radiation accidents are situations where there is a release of radioactive products and/or excessive ionising radiation levels beyond the limits specified in the design for normal operation, which can lead to or have led to the exposure of people above the established standards or radioactive contamination of the environment.

Due to the fact that the substance polluting the production and environment is natural uranium, the radioactivity of which is low, the exposure levels at which the deterministic (threshold) effects of radiation exposure on the personnel in an accident are not predictable.

Radiation accidents that may occur during operations do not require urgent protective measures to protect personnel and population on-site and off-site. The accident is eliminated as a matter of routine by the emergency rescue team and the decontamination unit.

The most probable emergency situation during uranium mining by the ISL method is leakage of process solutions due to leakage of pipelines and discharge of solutions and suspended solids during the cleaning of process wells.

At solution spills, the ground surface can become contaminated with sulphates and naturally occurring uranium-radium radionuclides, which leads to soil salinisation and an increase in gamma-radiation power. The action of acidic uranium-bearing solutions results in the destruction of soil carbonates which leads to intensive soil acidification (the alkaline reaction of soil suspensions changes from alkaline with pH=8.7-9.2 to acidic with pH=5-6), the increase of the sum of exchangeable bases to 27-32 mg-eq/100 g, in which the relative content of sodium ions increases sharply in comparison with calcium cations. The value of the solid residue can be as high as 1.2-1.3 %. The salinisation, in this case, is mainly superficial, although it can reach a depth of 75 cm. As a result of the influence of acid solutions, the soils pass into the category of solonchaks.

At spilling of process solutions on the soil surface, the main contribution to the dose rate is made by: Ra-226 (half-life of 1600 years) with decay products from Rn-222 to Bi-214, photon emission of U-235 and Th-231 constantly in equilibrium, Ac-227 and its short-lived decay products including Bi-211. Such contaminated soils must be disposed of in designated areas.

With proper management of the ISL process, the creation of a recycling water supply system, the ground surface is practically not contaminated, which in its turn leads to a reduction of reclamation costs.

The main conditions under which accidental releases are possible are the occurrence of emergency situations at the enterprise caused by both natural and anthropogenic factors.

Possible causes of emergencies at the facilities in question can be roughly divided into three interrelated groups:

- equipment failures.
- human errors.
- external effects of natural and man-made origin.

Natural factors in the study area include manifestations of extreme climatic conditions.

The anthropogenic factors include a whole list of causes of accidents related to technical and organisational measures, in particular, external forcings, faulty drilling and repair work, erroneous actions of operating personnel.

The experience of operation of such facilities shows that the probability of accidents caused by external sources is insignificant.

The cause of accidents caused by human errors is almost entirely due to inefficient facility management, flaws in the industrial safety legal framework and the human factor.

Emergencies of a temporary nature are possible in the most hazardous areas (drilling rig). Here, increased control is needed to ensure compliance with safety rules and the implementation of appropriate measures to prevent temporary emergencies from occurring.

However, even if all safety requirements are met and highly qualified personnel are available, there is a risk of an accident occurring.

Negative impacts from possible accidents will be minimised by planned preventive and operational measures.

8. ENVIRONMENTAL PROTECTION MANAGEMENT

In accordance with the national regulatory framework and the GIIP, the proponent will be required to monitor radiation, air, water and soil in accordance with national standards. Radioactivity will be monitored using a method agreed with the National Radiation Protection Administration (NRPA) of the Ministry of Health and Social Services (MHSS). The NRPA serves as the administrator of the Atomic Energy and Radiation Protection Act of 2005 (Act 5 of 2005) and related regulations. Main responsibilities of the NRPA:

- Maintain an inventory and record of activities (production, processing, handling, transportation, use, storage, disposal) involving radiation sources, as well as radioactive and nuclear materials in Namibia.
- Regulate all activities (production, processing, handling, transportation, use, storage, disposal) involving radiation sources, radioactive and nuclear materials in Namibia.
- Inform the Atomic Energy Board (AEB) of the extent of radiation exposure in Namibia, and
- Generally, ensure compliance with all provisions of the Atomic Energy and Radiation Protection Act of 2005 (Act 5 of 2005).

The "production environmental monitoring" program should be implemented during the construction, operation, closure, rehabilitation, and after-sales service phases of the proposed uranium mining operations under the Wings ISL Project.

8.1 Monitoring Arrangement

Monitoring of the state of toxic and radiation safety of the personnel and the environment performed at the designed facilities is performed by a special department of the enterprise.

Works on the monitoring of the radiation safety condition of the personnel and the environment are determined in accordance with the developed Environmental Control Programme which presents a plan-schedule of radiation and toxic monitoring at the enterprise facilities with the nomenclature and frequency of the radiation and toxic monitoring.

8.1.1 Production Monitoring

Production monitoring is an element of production environmental control performed to obtain objective data with specified periodicity. Operational monitoring, emission monitoring and impact monitoring are carried out as part of the implementation of production environmental control.

Operational monitoring (monitoring of the production process) includes observation of the parameters of the technological process in order to confirm that the performance indicators of the natural resource user are within the range considered appropriate for its proper design operation and compliance with the conditions of the technological regulations of the given production. The content of operational monitoring is determined by the natural resource users.

The project site will not emit any pollutants into the environment during its operation. Therefore, no emission monitoring is foreseen at the site.

Impact monitoring is the monitoring of changes in the state of contamination of environmental components as a result of the production activities of the enterprise. This type of monitoring includes atmospheric air monitoring at the boundary of the sanitary protection zone, surface and groundwater monitoring, soil cover monitoring, flora and fauna monitoring, etc.

Impact monitoring is mandatory in cases.

- when the activities of a natural resource user affect sensitive ecosystems and public health.
- at the stage of commissioning of technological facilities.
- after emergency emissions into the environment.

The content of the monitoring work includes systematic measurements of qualitative and quantitative indicators of the natural environment in the area of designed activities.

The results of these measurements are intended to assess the enterprise's environmental pollution and its impact on personnel and the public. On the basis of this assessment, measures to protect personnel, the public and the environment are defined.

Works in this area include:

- Assessment of soil contamination levels by radioactive and toxic substances at mining sites, on roads where radioactive materials are transported.
- Assessment of the levels of contamination by radioactive and toxic substances in groundwater and surface water.

Operational monitoring, as noted above, is carried out only in emergency cases, as well as at the special request of the supervisory authorities.

8.1.2 Soil Contamination Monitoring

Production monitoring and radiation control of the territory at the mine sites shall be carried out in accordance with a specially developed plan. The monitoring system shall include continuous observation of the soil condition.

The average background radiation dose rate in the territory of mining areas before the start of construction works is 0.17-0.20 μSv/hr, which corresponds to the value of the region's radiation background. This level of background radiation does not require intervention.

For the period of commercial uranium mining at the deposit, in order to reduce post-operational reclamation costs and to limit uncontrolled exposure of personnel and population, the prevention of soil contamination with radionuclides and harmful chemicals above the control levels is envisaged.

The reference levels of soil contamination, within the mining areas at each mined-out deposit site, as well as at the main pipelines for local soil areas (in the areas of leaks of technological solutions) are:

- gamma-radiation exposure dose rate - not more than 0. μS/hr above the natural background level.
- total alpha-activity of soil - not more than 15000 Bq/kg above the natural background level for the similar ground of the area.
- The density of the residual aqueous extract of the soil - up to 1.5% above the average natural background value for similar soil of the area.
- the pH shall not be lower than 5.0.

In the areas outside the territory of the mining complex and the main pipelines from the ISL wellfield to the sections of the pregnant solution processing site, the average value of the external gamma radiation dose rate shall be maintained at a level not exceeding the natural background by more than 0.2 μSv/h over the entire area of the site. In some local points (not more than 20%) exceedances may be allowed, but not more than 0.6 μSv/hr over the natural background. The total specific alpha-activity of soils in the layer of 0-0.25 m must not exceed 1200 Bq/kg over the natural background and in the layer of 0.25-1.0 m - 7400 Bq/kg (total).

Lands located along linear objects (ditches and trenches, highways and unpaved roads) should also meet the above requirements.

Contamination is assessed once a year on the basis of pedestrian gamma survey data. The survey grid is 10 × 10 m. Continuous surveying is carried out while moving from point to point (in order to detect local anomalies that may be missed by ordinary measurements). A detailed survey (1×1 m grid) is carried out for all anomalies identified.

A gamma survey by 5×5 m grid around each well is provided for incase of process solution spillage.

In case of radiation accidents, a walking gamma survey is carried out immediately from the moment of detection.

The average gamma radiation dose rate over the entire area of reclaimed areas must not exceed 0.20 μS/hr above the natural background and in some local points not more than 20% not more than 0.60 μS/hr.

Taking into account the overlapping of radiation and toxic contamination factors at the radioactively contaminated soil areas, samples will also be taken for general chemical analysis.

8.1.3 Groundwater Monitoring

In order to assess the impact of the ISL on groundwater, hydrogeologists will take water samples from observation "monitoring" wells.

For the purpose of groundwater monitoring in the deposit, after the mining of ore deposits, some of the monitoring wells are defined as "monitoring wells" according to the adopted methodology.

Monitoring wells are designed to monitor and control the conditions of pregnant solutions formation, geo-chemical state of the ore-bearing horizon, flow of technological solutions beyond the production areas and their possible flows into the horizons above and under the ore. The design of monitoring wells is similar to injection wells.

Location and number of monitoring wells are determined due to the necessity of revealing the leaching solution (LS) outflow out of the mining blocks and control over the process of pregnant solutions formation inside them.

Groundwater contamination of the pay horizon is controlled by monitoring wells drilled beyond the contour of the operating block in the direction of the natural groundwater flow at a distance of 50-70 m from the outermost operating wells.

If the radionuclide concentration in water samples exceeds MAC, an additional well is constructed at a distance of 50-70 m from this well.

LS spreading in the pay horizon within the ore contour is controlled by means of the production wells drilled on the blocks being prepared for mining in the direction of groundwater flow.

LS spreading above and below the productive horizon is monitored by monitoring wells drilled within the ore contour.

The systematic monitoring of the flow of productive solutions beyond the contours of the blocks by monitoring wells is planned once every six months.

The balance of injected and extracted solutions is to be maintained.

On the blocks, where the boundary of productive solutions spreading beyond the contours of acidification is detected, the following is envisaged:

- creation of a depression funnel;
- systematic control of over the productive horizon acidification by inner wells, monitoring wells as well as by injected wells by geophysical methods (induction logging) - once every six months;
- systematic integrity testing of injection well casing by geophysical methods (current logging) - once per quarter;
- abandonment of wells with compromised casing.

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