REPORT

Mirny (Kazakhstan) 1GW Wind Farm Project

ESBS Report Chapter 04 - Baseline Conditions, Physical Environment

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4.0 BASELINE CONDITIONS – PHYSICAL ENVIRONMENT

4.1 Methodological approach

The Project site's Environmental conditions set the benchmark against which Environmental physical impacts are considered.

The analysis of the Project site-specific impacts is based on the information and data collected and detailed in this chapter. This baseline information gathering describes the relevant physical existing conditions.

The collection of baseline primary and secondary data is an important task. Primary data is directly collected onsite. Secondary data is sourced from previously conducted studies and from publicly available databases.

Considering that the Project is likely to have specific impacts on sensitive receptors and that the sensitivity of receptors is unknown, sites specific primary data have been collected.

Primary baseline data gathered helped for understanding the context at the Project sites; specifically, it was necessary for:

- Identifying and characterising potential Environmental receptors;
- Verifying the land uses and the existing infrastructures and services;
- Characterising the receiving environments relating existing direct and indirect impacts;
- Identifying the use of natural resources.

Moreover, to support and integrate the assessment, secondary baseline data were collected.

Considering the Project sites-specific context and the data availability, quantitative field research and surveys have been conducted.

This chapter describes the baseline Environmental physical conditions by using summarised information and maps, graphs and other tools that allow concise presentation of key contextual for identification and analysis of Project impacts.

The Biodiversity aspects are addressed in a standalone document.

The following sections detail the context and then narrow the topics at Project site level.

4.2 Geology, Geomorphology & Seismicity

4.2.1 Geology and geomorphology

4.2.1.1 Geological Framework of Kazakhstan

The peculiar geology of Kazakhstan is due to its location at the intersection of several major tectonic units. The western part of the country includes the Caspian Syneclise, a large subsidence basin within the Turan Plate, characterized by thick Mesozoic and Cenozoic sedimentary sequences, reflecting long-term subsidence and sediment accumulation. The Turan Plate itself is a stable platform extending across much of western and southwestern Kazakhstan, having significant oil and gas reserves.

To the north, the Folded Region of the Southern Urals and Mugalzhar Mountains marks the prosecution of the Ural orogeny, featuring a mix of Precambrian metamorphic rocks and Paleozoic volcanogenic-sedimentary complexes. This area exhibits a combination of narrow anticlines and broad synclines, indicative of its complex tectonic history.

Central Kazakhstan is dominated by the Kazakh Shield, an ancient cratonic block that forms part of the larger Central Asian Orogenic Belt. This Region is composed of Precambrian basement rocks overlain by Paleozoic sediments, hosting significant mineral deposits, including copper, lead, and zinc.

The southeastern portion of Kazakhstan encompasses the edge of the Siberian Plate, a stable cratonic Region with a foundation of ancient crystalline rocks. The southeastern Siberian Plate merges into the Tien Shan Orogenic Zone, a highly active tectonic belt associated with the collision between the Eurasian and Indian plates. This zone is characterized by intense seismicity, significant crustal deformation, and a series of high mountain ranges, including the Tien Shan and Altay, where ongoing tectonic processes continue to shape the landscape [25].

The tectonic features of Kazakhstan are illustrated on the Geomorphological Zoning Map of Kazakhstan in Figure 1.

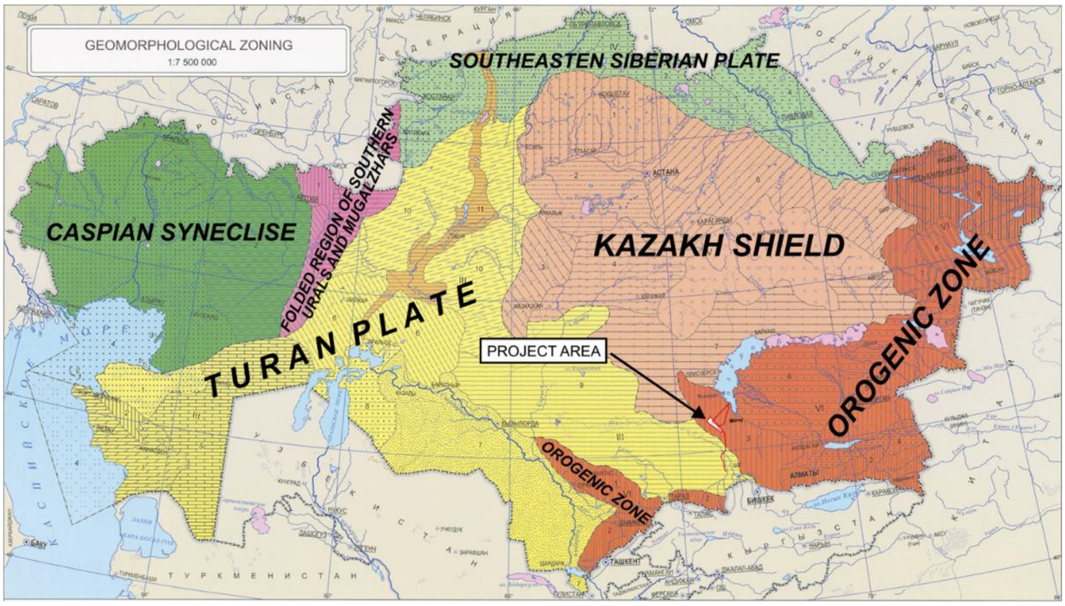


Figure 1: Geomorphologica Zoning on Tectonic Map of Kazakhstan.

The Project area is located within the Orogenic Zone, specifically in the Shu-Ili Low Hill Terrain (also known as the Shu-Ili Mountains). The projected 500 kV High voltage power lines (HV or OHTL) towards Shu Substation extend southward, entering the Turan Plate zone, specifically the Accumulative and Denudational Plains of the Shu-Sarysu Basin, as depicted in Figure 2 on the Geomorphological Zoning Map of Kazakhstan.

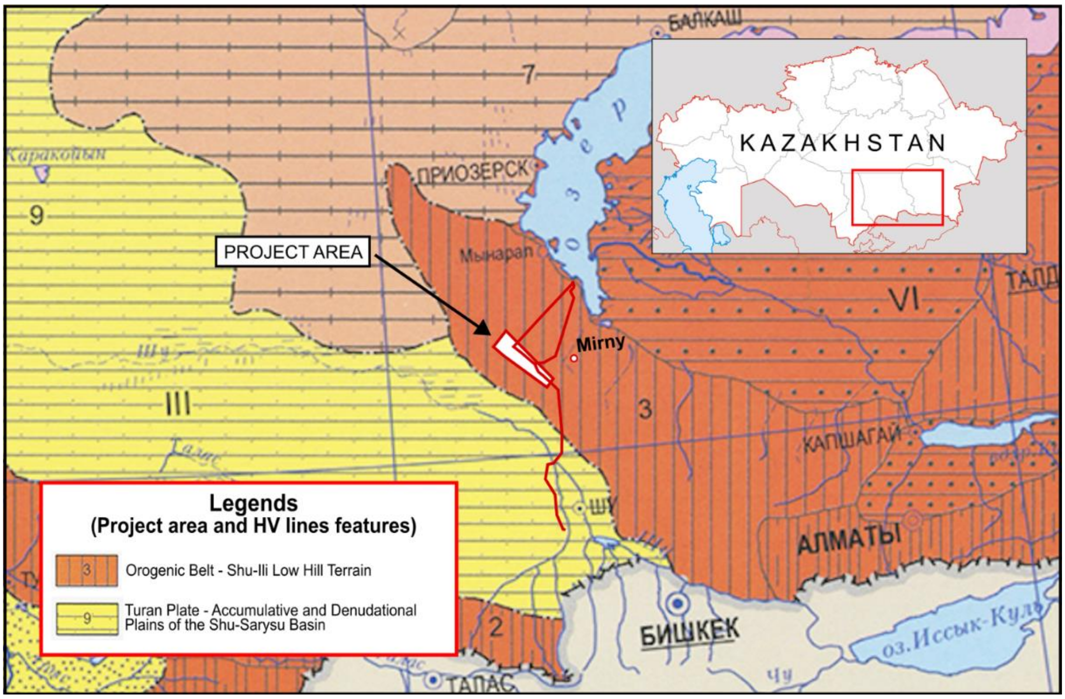


Figure 2: Project Area and OHTL Layout on Geomorphological Zoning Map of Kazakhstan.

4.2.1.2 Project site and OHTL

According to the official geological and geographical as well as geomorphological zoning schemes, the Shu-Ili Low Hill Terrain (also spelled as the Shu-Ili or Chu-Ili Mountains, Range) is located within the Shu-Balkhash Region (also known as the Shu-Balkhash Uplift or the Shu-Ili Watershed, see Figure 4). It is bounded by the Zhalair-Naiman Fault to the west and southwest, the western flank of the Ili Basin (the valley of the Kopy River) to the south and Lake Balkhash with the South-Balkhash Depression to the east; the northern boundary runs approximately along 46° N latitude. The Shu-Balkhash Uplift includes several low-mountain and small-hill massifs, such as the Dolankara, Sarybastau, Zharthas, Kulzhabasy mountains, among others, and the Shu-Ili Low Hill Terrain [18].

The Shu-Ili Low Hill Terrain is oriented from northwest to southeast and extends for almost 300 km from Mount Baykara (45°13' N, 72°26' E, 665 m above sea level) in the northwest to the Kendyktas Mountains (excluding the latter, approximately up to 43°40' N) in the southeast. Its eastern edge dips under the waters of Lake Balkhash, forming a rugged lake shoreline with numerous bays, peninsulas, and islands. The highest point is Mount Tymlayshoky (43°58' N, 75°12' E, 1242 m above sea level). The low mountain range is formed by the Zheltau Low Hill Terrain with elevations around 500 m above sea level and the Aitau Low Hill Terrain with elevations of 800–1000 m above sea level. The Zheltau Low Hill Terrain includes low and flat-topped mountains such as Shagyrly, Jambyl, Maizharylgan, and some other less significant massifs. The Aitau Low Hill Terrain stretches southeastward, encompassing the Khantau, Kuyel-Karatau, Dormen, Alaman mountains, along with others, as they ascend toward the Tien Shan Mountains (see the following figures). The Project area is primarily situated within the Maizharylgan Mountains, with a small portion extending into the the Jambyl Mountains in the northern area.

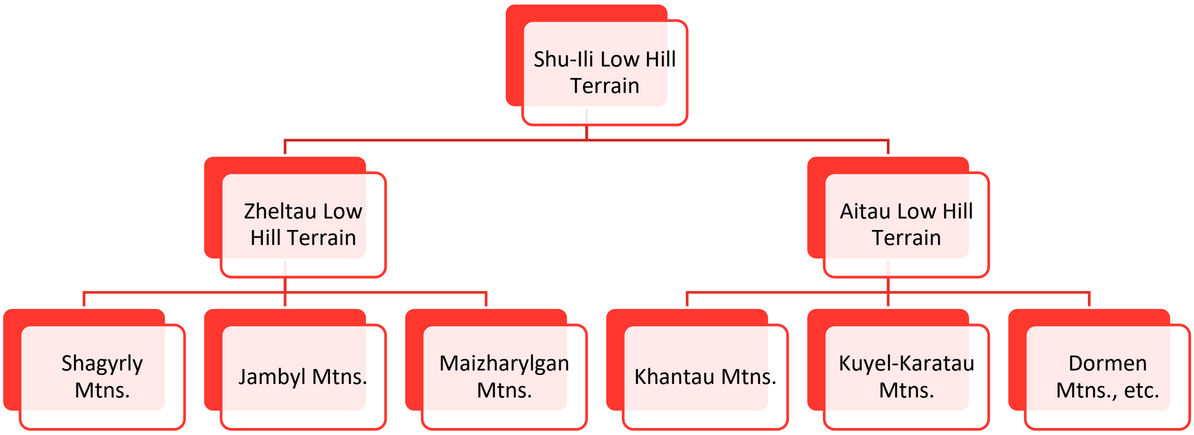


Figure 3: Shu-Ili Low Hill Terrain Structure.

Figure 4: Project site and OHTL Layout on Physical Map of Kazakhstan.

The formation history of the Shu-Ili Low Hill Terrain is subject to various interpretations. According to the geomorphological characteristics described by A.V. Vislozuzova et al. [1991] and E.A. Finko [1975], the Shu-Ili Low Hill Terrain, except for its southern portion, is considered a distinct province within the Central Kazakhstan Low Hills [13, 14]. V. Gorbunov [1939], N.P. Kostenko, and V.F. Shlygina [1971] suggest that the geological structure and genesis indicate that the Shu-Ili Low Hill Terrain, excluding their northern part, form the extreme northwestern extension of the Northern Tien Shan [15, 16]. The northern segment of the Shu-Ili Low Hill Terrain is identified as a separate geological structure, a "transition zone" between the epi-platform Tien Shan Orogenic Belt and the Kazakh Shield due to its relatively lower uplift during the Alpine orogeny [17].

Tectonically, the Shu-Ili Low Hill Terrain is part of the ancient Kokshetau-North Tien Shan system of Caledonian folding, within the Ural-Mongolian (Central Asian) fold belt. Accretionary-collisional processes played a key role in its development. The differentiation of structures in the Kokshetau-North Tien Shan fold system began in the late Neoproterozoic, around 650–630 million years ago, due to the breakup of the Tarim-Tien Shan-Kazakhstan paleocontinent, a remnant of the supercontinent Rodinia that had fully fragmented by that time. Various geological environments within the emerging Kazakhstan-North Tien Shan microcontinent originated several geological formations.

During the Early to Middle Cambrian (530–515 million years ago), the Kazakhstan-North Tien Shan massif differentiated into several structural-formational zones characterized by significant differences in magmatism and sedimentation. Along with the Ile Alatau region, Southern Dzungaria, and partly the Kendyktas Mountains, the future Shu-Ili Low Hill Terrain formed part of the tectonically active margin of the disintegrating massif, within a vast eugeosynclinal region. The seabed was unstable, with periodic uplift and active intrusive processes. The thick Cambrian deposits included sedimentary, volcanogenic-sedimentary, and volcanic formations. The formation of ophiolite associations, vanadium-bearing rocks, and various shales was notable. It has been established that the ophiolites in the Zhalair-Naiman Trough are approximately 520 million years old, making them the oldest in the Paleozoic rocks of Kazakhstan.

In the late Cambrian-Ordovician (500 - 440 million of years ago), the geosynclinal regime continued, but a transition to orogenic development (inversion stage) began. This period was marked by increased tectonic and volcanic activity, alternating uplifts and subsidence, and intensified accretion-collision processes as microcontinental blocks converged. The area remained submerged under the sea, but the land area expanded as islands grew, and the marine basin shrank and shallowed, as indicated by the appearance of flyschoid sediments. Active, predominantly carbonate-terrigenous sedimentation occurred in the Zhalair-Naiman Trough, which by the Silurian had transformed into a shear-collision zone between the flanking microcontinental blocks.

The Caledonian orogeny, particularly intense during the Devonian (416–359 million years ago), brought increased crustal mobility and volcanic activity across the region. Thick Devonian deposits included volcanic, molasse-like, and volcanogenic-sedimentary formations. As a result of accretion-collision processes initiated in the Ordovician, the microcontinental blocks of Central Kazakhstan and the Northern Tien Shan consolidated, gradually closing adjacent basins. By the end of the Devonian, tectono-magmatic activity had largely ceased across the Shu-Ili Low Hill Terrain, although the southeastern margin remained highly active. The tectonic development of the Shu-Ili Low Hill Terrain concluded by the Middle to Late Carboniferous, during the Hercynian orogeny, with the final convergence of all continental microblocks and the folding of peripheral regions at collision sites. Extensive linear nappe-fold structures, including the Shu-Ili Low Hill Terrain, formed during this time, and by the Carboniferous-Permian (359–251 million years ago), the Shu-Ili Low Hill Terrain had become an elevated landmass.

In the Mesozoic (251–66 million years ago), the region's active tectonic phase gave way to a calmer period of platform continental development, characterized by the denudation of mountain structures, the formation of ancient weathering crusts, and the accumulation of sediments from epicontinental seas along the periphery of the Shu-Ili Low Hill Terrain. By the early Cenozoic, the area had evolved into a relatively level hilly plain with isolated remnants. The first signs of Alpine orogeny appeared in the Late Oligocene. Renewed tectonic activity in the Late Pliocene (5.4–1.8 million years ago) and the subsequent Quaternary period led to broad domal uplift and differentiated tectonic movements along faults, forming large block uplifts, horsts, and grabens. These structures were later subjected to denudation, alluvial fan formation, and the development of the region's current landscape.

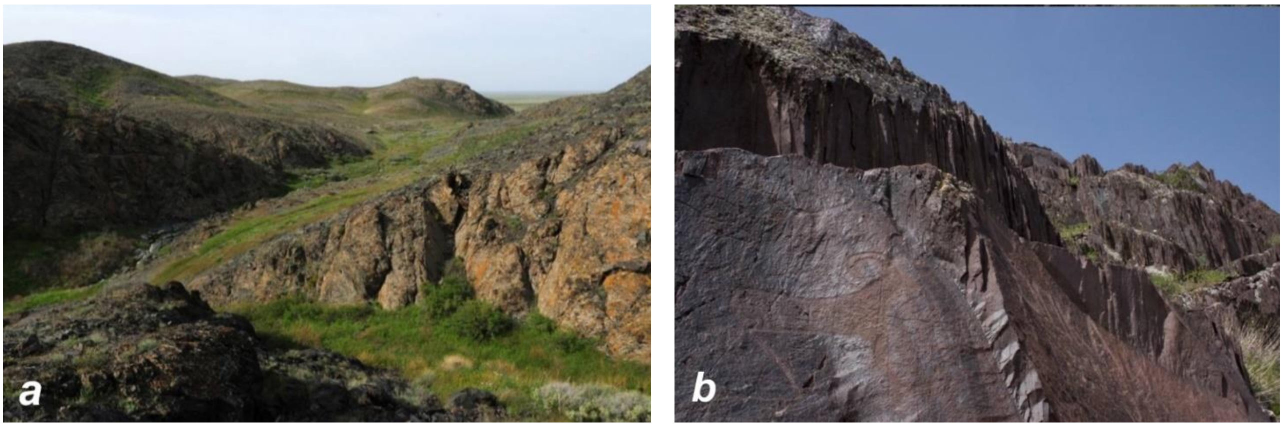


Figure 5: Erosional-tectonic features of the Khantau Mountains on the east of the proposed 500 kV OHTL route to Shu Substation: a) gorge in the Khantau Mountains; b) steep southwestern slopes (Photos by: O.V. Belyalov (a) and T.N. Duisebayeva (b) [19, 18]).

The tectonic and geological evolution of the Shu-Ili Low Hill Terrain has endowed the Region with rich mineral resources. The Shu-Ili gold belt, containing significant deposits of gold, copper, and iron, extends through the Shu-Ili Low Hill Terrain. The Akbakay gold ore deposit group, located in the southwestern branch of the Devonian volcano-plutonic belt overlying the Shu-Ili region, holds up to 8.2% of Kazakhstan's balance reserves and up to 15.4% of its potential gold reserves, accounting for a quarter of the country's gold production [20]. The Shu-Ili Low Hill Terrain are also part of the Betpaqdala-Shu-Ili uranium ore province of Kazakhstan, with substantial uranium reserves [21]. Additionally, the Shu-Ili Low Hill Terrain are known for occurrences of tungsten, molybdenum, and tin, along with significant deposits of mineral raw materials such as carbonate rocks, hydromica shales, gabbro, and fluorite [17]. The Khantau Mountains, in addition to gold deposits, are rich in lead-zinc ores [22]; coal-bearing deposits have also been discovered in Jurassic sediments [23].

Regarding the landscape elevation profile, the Project area is predominantly located within the Maizharylgan Mountains, with a minor section extending into the Jambyl Mountains in the northern area. Khantau Mountains are located to the southeast from the Project area. A notional dashed line drawn in a northeastern direction from the Sekseul Dala Steppes (~345 meters) to the Kulanketpes Valley along the shores of Lake Balkhash would reveal a sharp elevation increase at the Maizharylgan Mountains (~450–550 meters), followed by a gradual decline toward the Kulanketpes Valley (~425-350 meters). The elevation in this direction of the Project area begins at around 440 meters, peaks at 542 meters, and then decreases to around 500 meters (see the figure below).

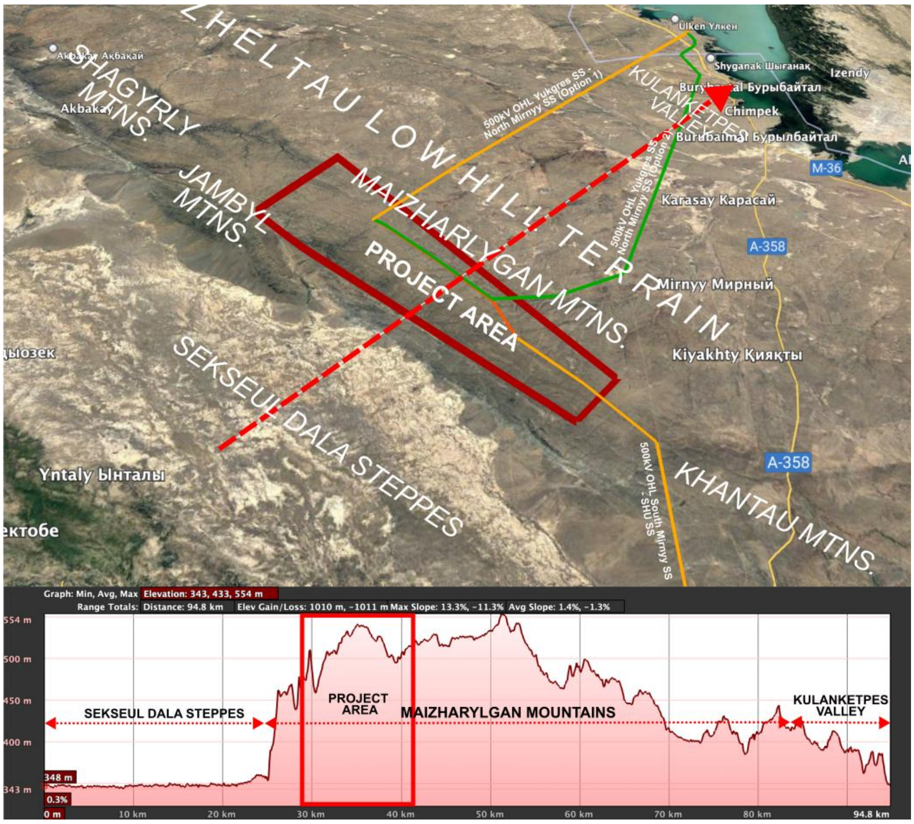


Figure 6: Landscape elevation changes in the Project area landscape, extending northeast from the Sekseul Dala steppes to the Kulanketpes Valley (a red dashed line).

By drawing a notional dashed line through the center of the Project area towards the southeast, it becomes evident that the elevations, starting at 570-600 meters in the northwest, gradually decline to about 500 meters towards the southeast (see the figure below).

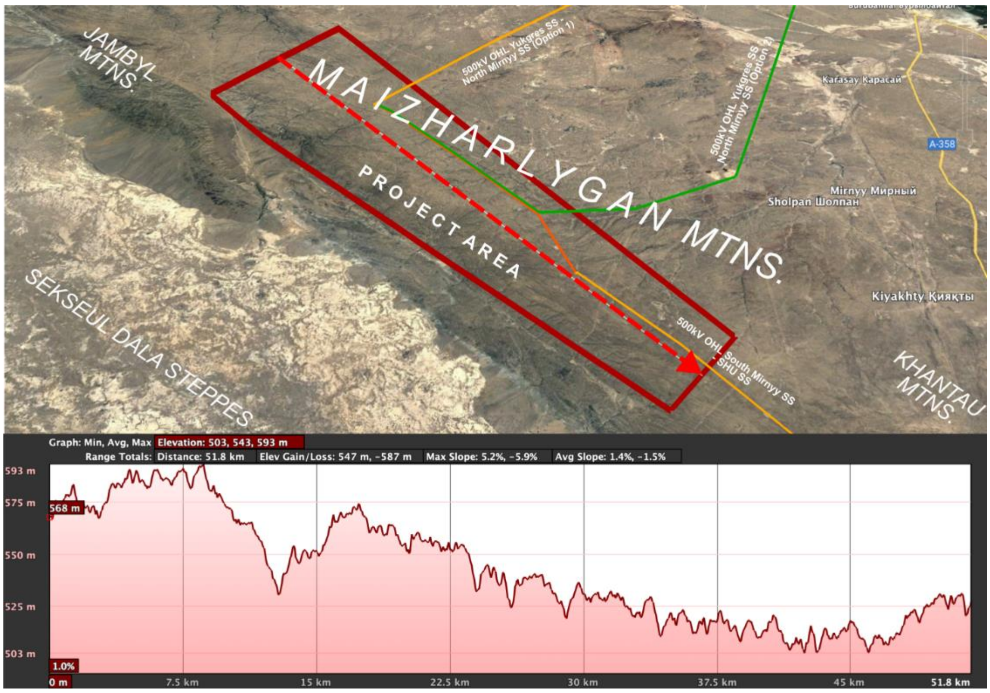


Figure 7: Landscape elevation changes across the landscape from southeast through the center of the Project area (a red dashed line).

Regarding the site-specific stratigraphy, the Project area, as shown on the geological map of Kazakhstan in Figure 8, is situated on Lower Silurian formations (northeastern part), Cambrian-Unsubdivided formations, and Ultramafic Intrusive rocks, to the west, with the southeastern part lying on Lower to Middle Devonian formations. The area is characterized by early Paleozoic sedimentary sequences, deep-seated intrusive activity, and significant tectonic processes. The presence of ultramafic intrusive rocks indicates mantle-derived magmatism. The transition from Cambrian and Devonian formations in the Project area to the varied geological structures in the Shu-Ili Low Hill Terrain highlights the influence of accretionary-collisional processes that have shaped the broader area [11, 12].

The 500kV OHTL from North Mirny Substation to Ulken Substation traverse from northwest to southeast, crossing Devonian intrusive rocks, Lower to Middle Devonian formations, Vendian (Proterozoic) formations, and concluding at Cambrian-Ordovician formations (see Figure 8). This route traverses a sequence of formations that spans from the late Proterozoic to the Paleozoic. The transition from older Vendian units to younger Devonian and Ordovician formations mirrors the geological evolution observed in the Shu-Ili Low Hill Terrain, where significant orogenic processes have contributed to the formation of extensive nappe-fold structures.

The 500kV OHTL from South Mirny Substation to Shu Substation route extends (from the Project area to the north) over Upper Pliocene-Lower Quaternary deposits, Middle Quaternary deposits, recent deposits, and Upper Quaternary deposits, before finishing at Middle Quaternary deposits formations (see Figure 8). The route traverses the geologically complex Shu-Sarysu Basin, particularly the structurally intricate Eastern Shu Foredeep. This foredeep, characterized by significant tectonic activity, including steep inclines and Paleozoic-Cenozoic rock thrusts, highlights the dynamic tectonic environment [24].

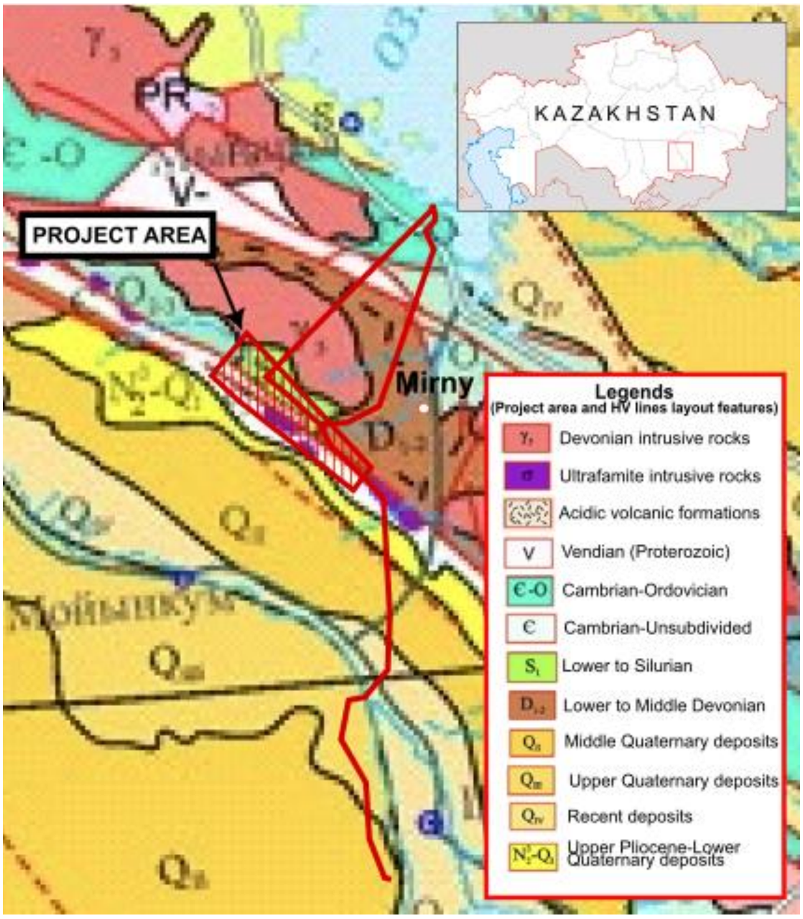


Figure 8: Project Area and OHTL Routes within Geological Map of Kazakhstan.

On the Project site the Company appointed technical experts from GeoExploration LLP for conducting the geotechnical assessment. The surveys are still ongoing. The first geotechnical assessment results highlighted that on site there are 3 soil elements (i.e., engineering-geological elements RGE/IGE):

- **Topsoil -** Dark gray clayey sand, hard, weakly grassed with plant roots (layer thickness - 0.10 m).
- **RGE-1 -** Loam soil, more rarely sedentary clayey sand, gruss-rock and coarse medium gravels, light brown in color, hard, loose, with preserved source structure. The soil is very non-uniform in terms of the percentage of very coarse material (soil thickness is 0.2 - 1.8 m). The standard density of soil is 2.03 g/cm3.
- **RGE-2 -** Gruss-rock and coarse medium gravels with sand clay aggregate-eluvium of rocky soils, with preserved source structure. Crushed stone is represented with fragments of fractures sandstone, siltstones, mudstones. Shape of fragments is angular, the fragments are strong (the thickness of the soil is 0.2 - 3.6 m). The standard density of soil is 2.14 g/cm3.
- **IGE-3 -** Rocky soil - represented by interlayered siltstones, sandstones, mudstones from brownish-red to light gray. The soil is weathered, cracked, dense (soil thickness is 2.0 – 9.3 m). Standard soil density is 2.71 g/cm3.

During the survey, the groundwater table was not reached/detected.

The geotechnical survey pointed out no major issues or limitations for the Project structures construction.

4.2.1.3 Project 500 kV OHTL Route to Shu Substation

The Shu-Sarysu Basin (also known as the Shu-Sarysu Depression), extends northwestward for nearly 900 km, with a width of approximately 300 km. It is bounded to the north and west by the Sarysu-Teniz Uplift and the Ulytau Mountain Fold Structures, to the northeast by the Shu-Ili Law Hill Terrain, to the south and southwest by the Kishi and Ulken Karatau Ranges, and to the east and southeast by the Kendyktas Mountains and the Kyrgyz Alatau Range [26].

The basin is geologically characterized by a complex assemblage of Devonian-Permian and Mesozoic-Cenozoic sediments, reaching a thickness of up to 6000 meters. Its foundation is composed of Proterozoic metamorphic rocks, with some areas in the central part containing heavily deformed Lower Paleozoic rock layers in the upper sections. The overlying sedimentary cover is mainly Upper Paleozoic and Meso-Cenozoic, with minimal deformation. Two primary structural levels can be identified: a Cretaceous-Eocene level and an Oligocene-Quaternary level, the latter being dominated by continental terrigenous rocks. The thickest accumulation, ranging from 400 to 600 meters, is found in the Suzak Depression near the Karatau Range. To the south, the Shu-Sarysu Basin transitions into the Eastern Shu Foredeep at the base of the Kyrgyz Alatau Range, which is filled with Neogene-Quaternary molasse deposits, up to 3000 meters thick. This structural arrangement, with the deepest depressions along the southwestern edge and a gradual rise toward the northeastern margin near the Shu-Ili Law Hill Terrain, results in a distinctly asymmetrical Meso-Cenozoic stratigraphic profile [26].

The proposed OHTL towards Shu Substation will pass through this segment of the Eastern Shu Foredeep, entering from the north near the Shu-Ili Law Hill Terrain. This foredeep represents the most subsided area of the basin's southeastern margin and is a typical one-sided graben-synclinal structure with a steep incline (up to 10°) towards the Kyrgyz Alatau Range. In some areas, Paleozoic rocks have been thrust over Cenozoic layers. The depression was formed during the Neogene-Quaternary due to tectonic movements along the Pre-Kyrgyz Fault, which marks the boundary of the uplifted epi-platform orogeny to the north. The Paleozoic surface within the fault zone descends in steps to depths of 2000-3000 meters, while Cenozoic deposits are marked by steep flexures with dip angles reaching 70° [26].

The landscape elevation profile for projected 500 OHTL from South Mirny Substation at Project area towards Shu Substation is depicted in Figure 9. Following the proposed route from the South Mirny substation within Project area to the Shu Substation, the elevation begins at approximately 520 meters at the Maizharylgan Mountains, then descends to 400 meters between the foothills of the Maizharylgan and Khantau Mountains, and gradually increases again to 500 meters with a steep incline (up to 10°) as it approaches the Kyrgyz Alatau Range.

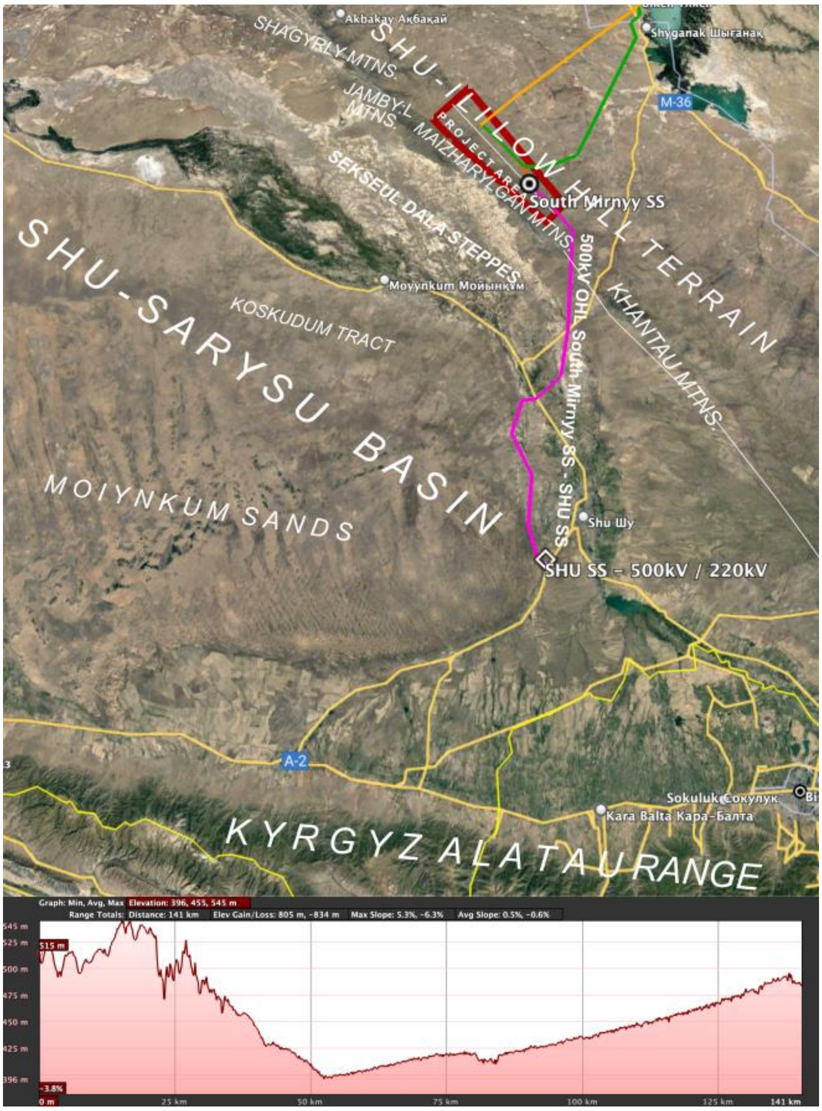


Figure 9: Landscape elevation changes in the proposed 500 OHTL from South Mirny Substation to Shu Substation (purple line).

4.2.2 Seismicity

4.2.2.1 Seismicity of Southeastern Kazakhstan

Southeastern Kazakhstan experiences significant seismic activity, largely due to its location near the convergent boundary between the Eurasian and Indo-Australian tectonic plates. This Region is part of the Tien Shan Orogenic Belt, known as one of Central Asia's most seismically active areas. The tectonic activity here is driven by the northward movement of the Indian Plate, which applies pressure to the Eurasian Plate, resulting in stress accumulation and periodic earthquakes [29].

Historically, the Region has been the site of several major earthquakes. Notable among these are the Verny earthquake of 1887, with an estimated magnitude of 7.3, and the Kemin earthquake of 1911, which reached a magnitude of 8.2. Both events caused widespread destruction in the Almaty City area, leading to significant loss of life and infrastructure damage. The seismicity of southeastern Kazakhstan is marked by both shallow and intermediate-depth earthquakes.

The recent data collected suggest that the Region remains highly susceptible to future earthquakes. Ongoing monitoring is conducted by national seismic networks, including those managed by the Institute of Seismology under the Ministry of Emergency Situations of Kazakhstan, the Kazakhstan National Data Center, etc..

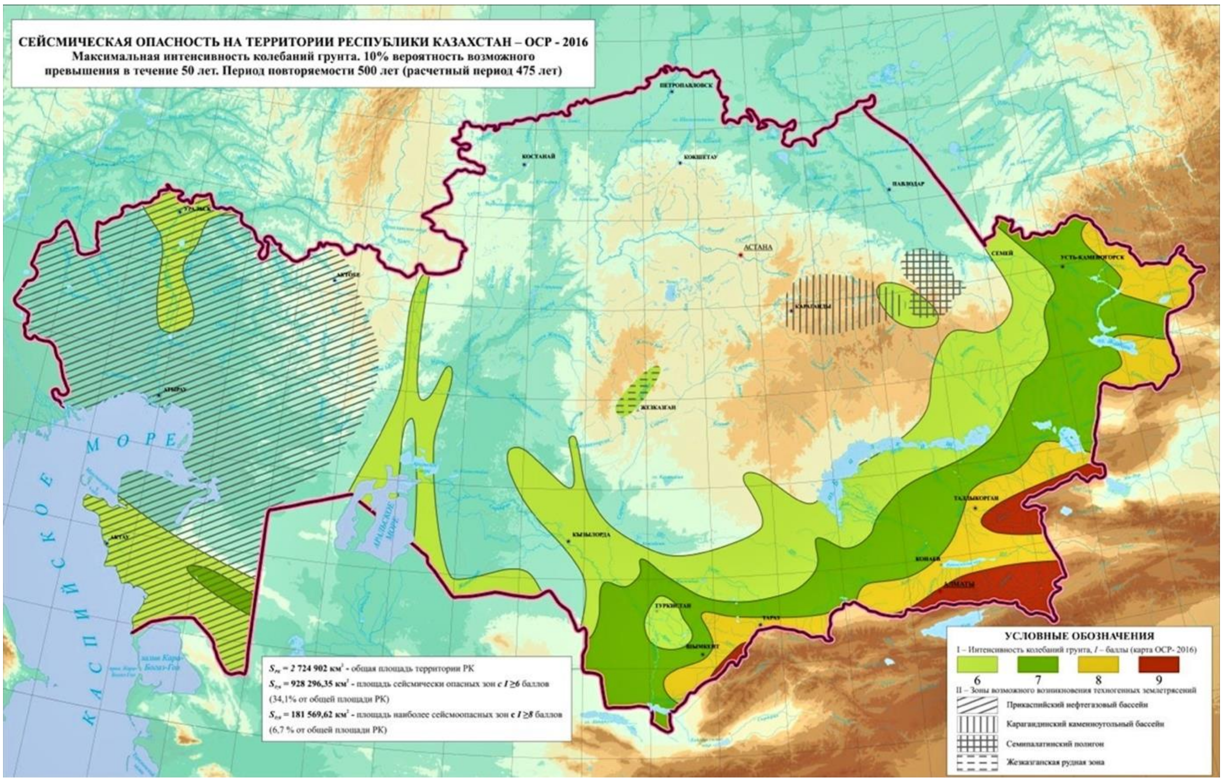


Figure 10: Seismic Hazard Map of Kazakhstan.

4.2.2.2 Seismicity of the Jambyl Region

Due to its location in southeastern Kazakhstan, adjacent to the seismically active Tien Shan Orogenic Belt, Jambyl Region is characterized by a significant risk of severe earthquakes. Out of its 10 districts, 8 are situated in a seismic hazard zone where earthquakes with magnitudes of up to 8 can occur, affecting nearly 70% of the Region's population [27].

In the last four decades, Jambyl Region has been struck by two major and damaging earthquakes. The first, the Jambyl earthquake on May 10, 1971, registered a magnitude of 5.5 and caused damage to over 28,000 buildings in the regional center. The second, the Lugovskoye earthquake on May 23, 2003, had a magnitude of 5.4 at its epicenter, resulting in the deaths of two people at Lugovaya Station, leaving more than 20,000 people homeless, severely affecting 18 settlements, damaging over 7,000 homes, and impacting 44 social infrastructure facilities.

Based on Kazakhstan's seismic hazard map (see Figure 11), over 22% of Jambyl Region's territory lies within a zone of active seismic influence with potential intensities up to magnitude 8. This area includes 85% of the Region's industrial assets, key international transport corridors, and vital life support and economic infrastructures.

4.2.2.3 Seismicity of the Project Area

According to the seismic hazard map of Kazakhstan in Figure 11, the Project area and proposed HV lines/OHTL layout are located on areas with lower seismic activity compared to the northern Jambyl region, with an intensity of 6 to 7 on the seismic magnitude scale [28]. This leads to an expected minor potential impact on the Project from potentially occurring seismic activities.

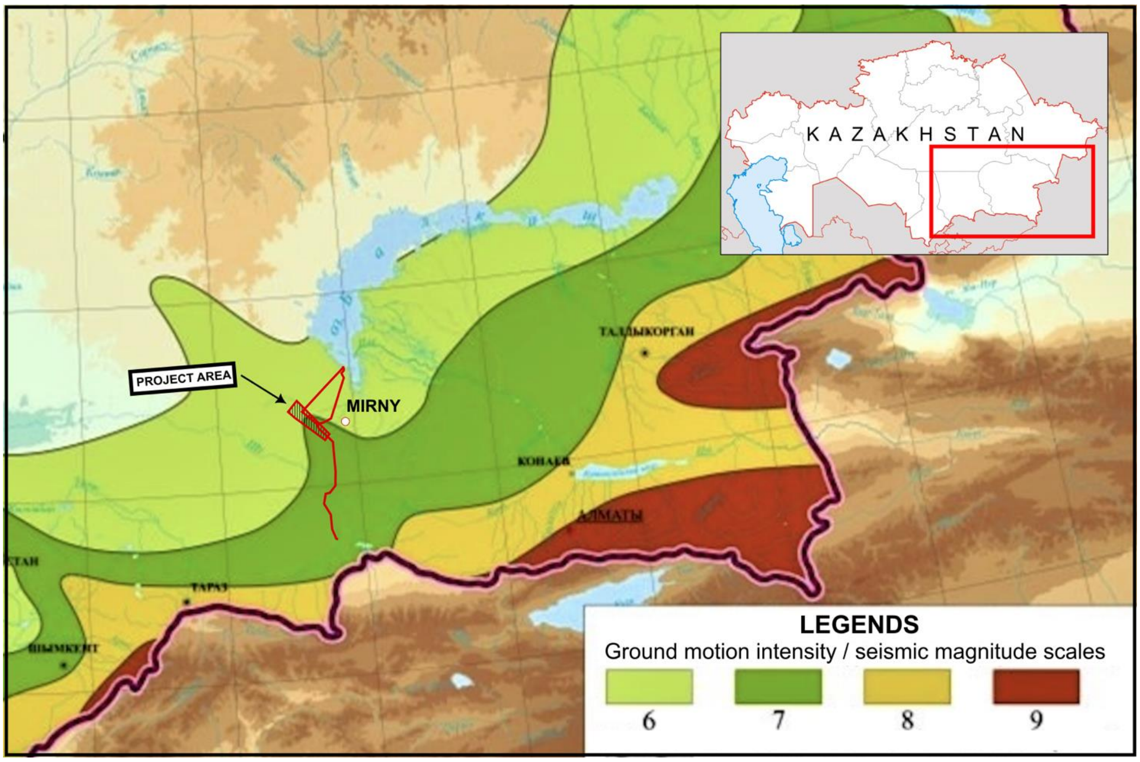


Figure 11: Project area and proposed OHTL layout on Seismic Hazard Map of Kazakhstan.

4.3 Natural Hazards

4.3.1 Natural Hazards in the Jambyl Region

The Jambyl Region has a diverse topography and climate with a wide range of natural hazards that pose significant risks. The annual periodicity of these hazards is indicated in Figure 12, based on the Natural Hazards Map from the Ministry of Emergency Situations of the Republic of Kazakhstan.

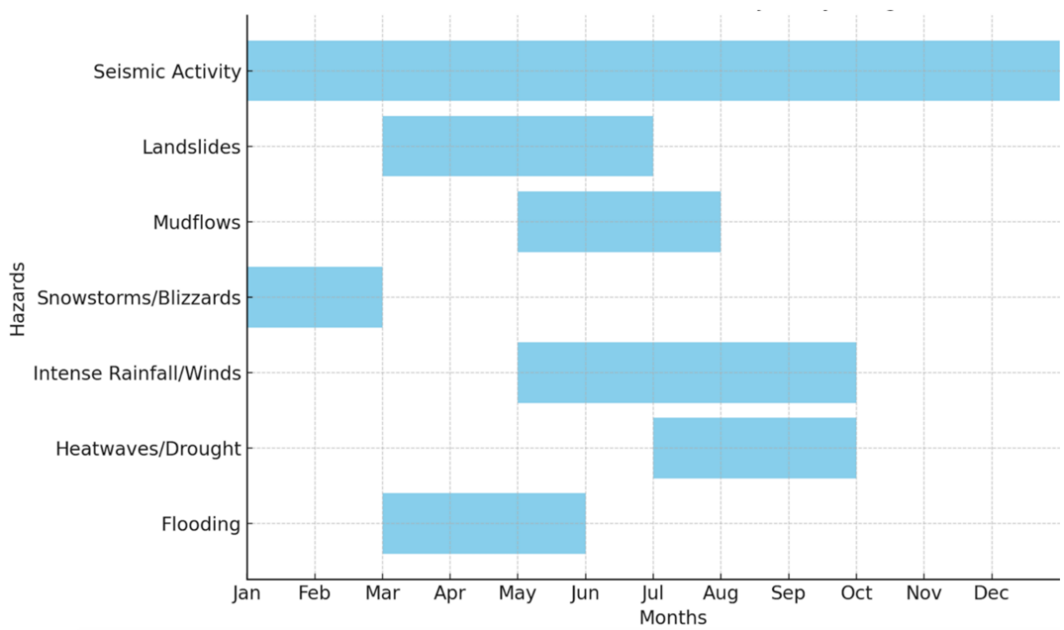


Figure 12: Annual Periodicity of Natural Hazards in the Jambyl Region (Source: Ministry of Emergency Situations of the Republic of Kazakhstan). The main seismic risk is in the South-Eastern portion of the country, where there are PGA values > 0.6 g. In Mirny area, the PGA values are less than 0,1 g.

Seismic Activity

The district is located in the seismic zone with seismic hazard - according to the map of seismic zoning OSZ-2475 - 6 (six) points, according to the map of seismic zoning OSZ-22475 - 7 (seven) points. The category of soils by seismic properties is IБ. Specified seismicity on the map of seismic zoning OSZ-2475 - 6 points, on the map of seismic zoning OSZ-22475 - 7, peak ground accelerations are agR(475) - 0.050 on OSZ-1475, agR(2475) - 0.093 on OSZ-12475.

The calculated acceleration is 0.074 according to the type of soil conditions.

The seismic activity is a constant threat across the Jambyl Region due to its proximity to the active Tien Shan fault system, but the aforementioned acceleration enters on normal values, considering no additional seismic loads will be needed for the equipment and components foundation design to be installed on project site.

Landslides

Landslides represent a significant threat from March to June, frequently caused by heavy rainfall or seismic events in the region’s mountainous areas in southern Jambyl region, particularly in the foothills of the Karatau, Talas Alatau and Kyrgyz Alatau mountains ranges.

Mudflows

Between May and July, the southern districts of the Jambyl Region are highly vulnerable to mudflows. These districts are situated in the high-altitude areas of the Karatau, Talas Alatau and Kyrgyz Alatau mountains ranges, where mudflows triggered by snowmelt and heavy rainfall frequently occur. Mudflows in these regions typically develop in source areas due to the interaction between rock material and water. The primary cause of these events are heavy and prolonged rains, often coinciding with mountain snowmelt. Additionally, sudden water releases from glacial lakes or seismic activity can also trigger mudflows. The Jambyl Region contains 25 moraine lakes, 20 of which are located in the Merke and Ryskulov districts at elevations between 2,600 and 4,400 meters. The regional Department of Emergency Situations, in collaboration with its mudflow management subsidary “Kazselezashita” representatives, oversees issuing mudflow hazard warnings to mountain communities [38]. The National Hydrometeorological Service “Kazhydromet” provides daily updates on rain-induced mudflow risks from May to August[1].

Snowstorms/Blizzards

During the winter months, from January to February, the Jambyl Region is impacted by severe snowstorms and blizzards, with strong winds frequently leading to the formation of deep snowdrifts. These conditions often result in infrastructure damage, such as power lines being brought down, leaving thousands without electricity, and causing significant disruption to transportation, which can leave travellers stranded. Rescue operations, often involving military personnel and emergency services, are commonly required. The region's ongoing challenge stems from the unpredictable and powerful winds, which can reach speeds of up to 45 m/s, creating persistent difficulties for both local communities and emergency responders.

Intense Rainfall/Winds

From May to September, the Jambyl Region experiences heavy rains and hurricane-force winds, which pose a significant threat to infrastructure and local populations. The areas most vulnerable to these phenomena are those districts with high mountainous and foothill terrain. In these regions, moisture accumulation on mountain slopes creates the risk of landslides and mudflows, which can block roads and destroy buildings. In lowland areas, such as the Sarysu and Shu districts, intense rainfall can lead to flooding, damaging agricultural lands and irrigation systems.

Heatwaves/Drought

During the summer months, from July to September, the Region experiences intense heatwaves and drought conditions, exacerbating water scarcity, impacting agriculture. Agricultural lands, mainly situated in the Baizak, Jambyl, Korday, Merki, Ryskulov and Talas districts, are severely affected by drought, resulting in thousands of hectares of parched fields where farmers cultivate sugar beets, corn, onions, and other vegetables. The lack of irrigation water has caused significant crop losses for many farmers, leading to millions in financial losses. In addition, heatwaves and droughts increase the risk of wildfires in the steppe zones. In recent decades, numerous dead wood fires have occurred in the steppes of the Zhambyl region, including in areas designated for forest and wildlife protection. These fires have spread across large areas and resulted in environmental disasters [40, 41, 42].

Flooding

From mid february to May, the Jambyl Region is at risk of flooding. Based on factors such as precipitation levels, snow water reserves, autumn moisture levels, soil frost depth, and river ice conditions, the Region is classified as having a moderate flood risk. The deepest soil frost is recorded in the Moiynkum District, reaching 30 centimeters, while in the other nine districts, frost depths are less than five centimeters. The highest snow reserves, up to 20 centimeters, are found in the Korday District, with 15 centimeters recorded in the Zhambyl District. In most areas, snow reserves range between 5-8 centimeters. Additionally, the potential for flooding of residential and economic areas arises from rising water levels in the Shu, Talas, and Asa rivers, as well as from meltwater and rainwater in the foothill regions. The flood risk affects 42 settlements across the Jambyl Region, including two in the Moiynkum District, three in the Sarysu District, four each in the Zhambyl, Shu, Merke, Talas, and Zhambyl districts, five in the Kordai District, and six each in the Ryskulov and Baizak districts [39].

[1] Accessible at the following link: **https://www.kazhydromet.kz/ru/selevedenie-str/ezhednevnyy-byulleten-selevoy-opasnosti-dozhdevogo-genezisa**.

4.3.2 Natural Hazards in the Project Area

The natural hazards in the Project area are assessed according to the topography and climate of the southern Shu-Ili Low Hill Terrain.

Seismic Activity

The Project area is not subjected to a major seismic risk. Refer to Section 4.2.2.3.

Landslides

No major information is available in open sources. Based on the data collected and the site observations, the Project area is located on the elevated slopes of Maizharylgan mountains with a 100-meter steep descent to the West. The arid climate generally reduces the likelihood of landslides by limiting water saturation; however, there is a moderate landslide risk due to the annual spring snowmelt.

The seismic activity also has the potential to destabilize the slopes, especially if the ground has already been weakened by snowmelt.

As detailed in the section 4.2.1 and 4.3 above, the Project area is made of sedimentary sequences with deep-seated intrusive ultramafic rocks, mainly desert soils which consist of sandy soil (90–95%) found in low-rainfall regions with gravels. This soil characteristics make the risk of landslides unlikely.

The ongoing geotechnical survey will help assessing the soil stability and gain a clearer understanding of the associated risks. The turbines and other structures foundation design depends on the outcomes of the geotechnical assessment.

Mudflows

No major information is available in open sources. Mudflows are most relevant to the high-altitude areas of the southern Jambyl region. According to the World Bank Climate Change Knowledge Portal, the risk of flooding, landslides and mudslides is expected to be most severe in the foothills of the south and east of Kazakhstan, where terrain is more mountainous and rainfall levels are higher.

The Project area falls within the semi-arid steppe zone, so the overall annual average precipitation amounts are not of concern.

Heavy rainfalls are unlikely to happen, and the soil mainly consists of sand and gravel, consequently, consistent mudflows have low probability to be generated.

Snowstorms/Blizzards

During the winter months, from December to February, the Project area is impacted by severe snowstorms and blizzards, with strong winds frequently generating deep snowdrifts. These conditions often lead to infrastructure damage, primarily causing power lines and utility poles to be brought down, resulting in electricity outages. Additionally, this leads to significant transportation disruptions due to snow-covered roads [43, 44].

Intense Rainfall/Winds

Heavy rainfalls are uncommon in the Project area, but strong winds are a constant feature. Hurricane-force winds, in particular, can create significant risks for both infrastructure and local communities.

Heatwaves/Drought

The Project area is situated in the Moiynkum District, which is susceptible to extreme drought conditions from July to September. These dry conditions often lead to the ignition of dry vegetation, triggering steppe fires.

In addition to natural factors, human activities also contribute to these fires. Herders often use fire to clear land for grazing, believing that in open spaces, grass regrows more effectively in the spring, and the ash from the fire acts as a fertilizer for the soil. In the past decade, several such disasters have occurred in the area, burning nearby lands, including forest reserves and nature protected areas, resulting in ecological damage.

According to publicly available information, similar fires have occurred near the Project site, in the Moiynkum District, notably in the Sekseul Dala steppes where saxaul trees burned, and along the Shu River where reeds caught fire.

During the highest fire risk period – classified as level five – the "Kazavialesokhrana" aviation team conducts aerial surveillance to detect fire hotspots. Firefighting efforts involve personnel from the local Emergency Situations Department, local forest and wildlife protection services, as well as volunteers [40, 41, 42, 45, 46, 47].

The meteorological alert map covering the next 24-72 hours for all regions of Kazakhstan, including the Moiynkum district where the Project area is situated, can be accessed online through the National Hydrometeorological Service “Kazhydromet” website: **https://www.kazhydromet.kz/ru/meteoalert**.

Figure 13: Steppe fire damages in the Moiynkum District (Source: Kazakh Base of Aviation Forest Protection and Forestry Service).

Flooding

From March to May, during spring snowmelt, meltwater collects at the Project area, flowing down from the mountain creeks via streams into the lowland areas both to the west and east. Notably, on the eastern side of the Maizharylgan and Khantau mountain lowlands, it contributes to flooding, inundating roads and posing a risk to the local community (see photo of flooded road below) [48]. The topographic study of the Project area, which points out that the surface slopes from NW toward SE, make the risk of flooding unlikely.

Figure 14: A flooded section of the "Almaty-Astana" state road in late February (to the east from Project area near Ulken and Shyganak villages - Frame from the report of the Khabar 24 TV channel [48]).

4.4 Meteorology & Climatic Data

4.4.1 Climate of the Jambyl Region

The characteristic features of the climate in the Jambyl Region are significant aridity and continentality. This is due to the location of the Region within the Eurasian continent, its distance from the oceans, the nature of atmospheric circulation that contributes to frequent formation of clear or partly cloudy weather, as well as the southern position, which ensures a large influx of solar heat. In addition, a significant part of the Region is occupied by deserts (Betpaqdala and Moiynkum), and only the southwestern, southern, and southeastern edges are occupied by mountains (Karatau Ranges, Kyrgyz Alatau Ranges, and Shu-Ile Low Hill Terrain). These differences in the relief bring great diversity to the region’s climate. The continentality of the climate is manifested in sharp temperature contrasts between day and night, winter and summer, and in the rapid transition from winter to summer. In the southern mountainous part of the region, the characteristics of continentality are softened: winter here is milder, and the precipitation is better [3].

The desert plains of the northern and central districts of the Region are particularly arid. Summers are very hot, with average July temperatures ranging from 21 to 25°C, and on some days, the air temperature reaches 45-48°C (absolute maximum). However, the winter severity does not correspond to the geographical latitude. The coldest month is January, with an average temperature of -8 to -12°C in the northern part of the Region and -4 to -7°C in the southern part. Cold Arctic air penetrating the south of the Region during winter causes severe frosts, reaching -45 to -50°C (absolute minimum).

The period with an average daily air temperature above 0°C is quite prolonged. In the northern part of the region, it lasts 240-250 days, and in the central districts, 260-270 days.

Overall, the Region receives little precipitation, especially in its plains (140-220 mm per year). A minimal amount of precipitation (135 mm per year) is noted in the northeast of the Region near the shores of Lake Balkhash. In the foothill areas, the amount of precipitation increases to 210-330 mm. In the mountains of the Kyrgyz Alatau, precipitation reaches 400-500 mm. Precipitation is distributed extremely unevenly throughout the seasons, with the majority occurring in the winter-spring period.

Throughout most of the region, the prevailing wind directions are east and northeast, with only the extreme south experiencing more frequent south and southeast winds. Their average speed is 2.5-3.5 m/s. In the mountainous areas, winds are influenced by local conditions (foehns, mountain-valley winds, etc.).

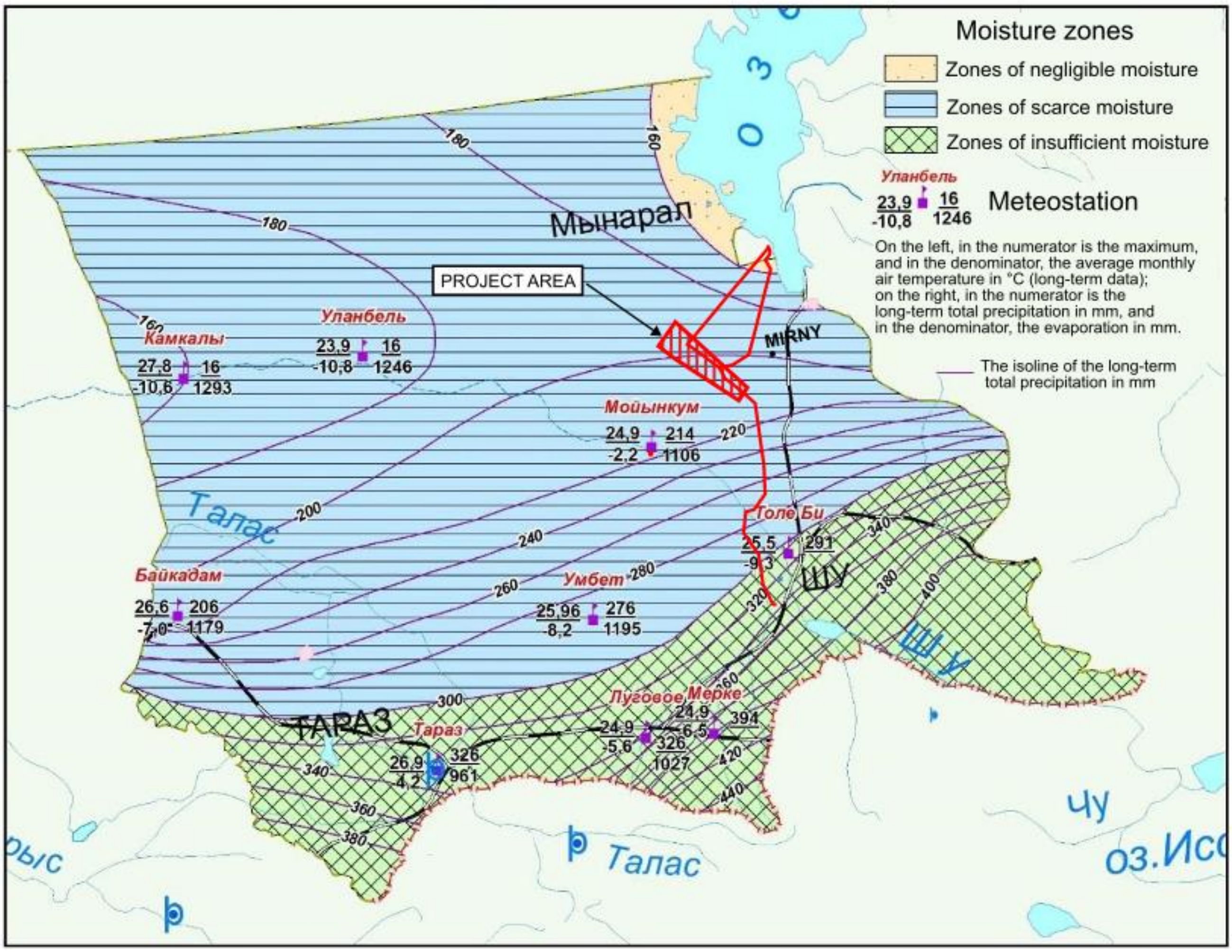


Figure 15: Project Area on the Climatic Map of Jambyl Region.

The closest meteostation to the Project area is managed by the National Hydrometeorological Service “Kazhydromet” and is situated in the Moiynkum village.

The meteorological characteristics of the Moiynkum district, based on the records from the Moiynkum meteostation are summarized in below.

Table 1: Meteorological characteristics of the Moiynkum district of Jambyl Region (2023).

Climatic Indicators	Values
Coefficient depending on atmospheric stratification, A	200
Terrain coefficient	1.0
Average annual wind rose, %	21
North	21
North-East	31
East	11
South-East	3
South	2
South-West	8
West	10

North-West	14
Calm	18
Wind speed (according to long-term average data), with a 5% exceedance probability, U*, m/s	6.0
Average temperature of the coldest month	-9.9ºC
Absolute maximum air temperature	+31.6ºC

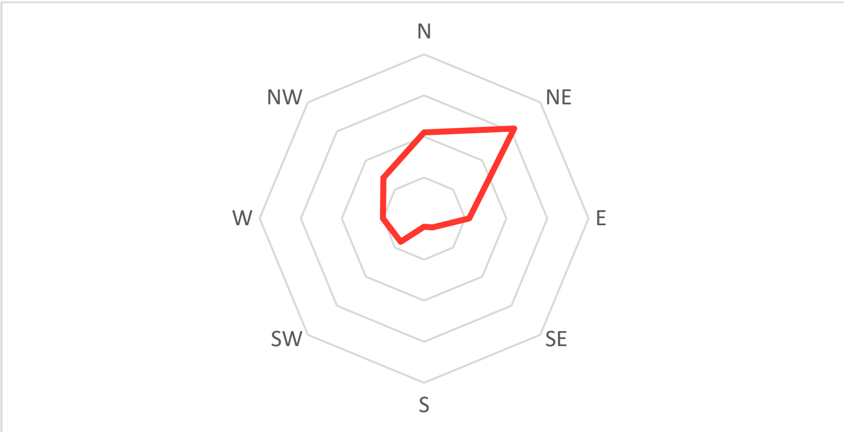


Figure 16: Wind Rose in accordance with Moiynkum Meteostation (2023).

4.4.2 Climate of the Project Area

The climate at the Project area is primarily influenced by its location within the Shu-Ili Low Hill Terrain. Based on climatic data, this Region exhibits a temperate continental climate, or, following the Köppen classification, is identified as a semi-arid steppe zone. The extremes in air temperature range from a maximum of +47°C to a minimum of -46°C. During July, average summer temperatures remain moderate, between +24°C and +27°C, while in January, winter averages fluctuate between -7°C and -11°C. The Region experiences a significant annual temperature variation, between 33°C and 38°C, although the uneven terrain helps moderate these fluctuations to some extent during certain times of the year. The frost-free period lasts for roughly half the year, spanning 180 to 190 days [18, 49].

Annual precipitation levels range from 150 to 300 mm, decreasing as one moves northward. Nearly half of this precipitation occurs during the warmer months, from April to October, with a less pronounced peak in spring and summer, characteristic of a Central Asian-Kazakhstani moisture regime. A consistent snow cover typically forms from late November to early December, melting by the third week of February, with a depth of 10 to 20 cm [50].

The Region is prone to strong winds, with velocities reaching up to 40 m/s and occurring for 10 to 100 hours annually. The hydrothermal coefficient across the Project area is 0.2 or lower towards Lake Balkhash, indicating a highly arid climate [51, 52]. Over the decades, the Balkhash-Alakol river basin, encompassing much of the Project area, has experienced an average increase in air temperature of 0.35°C per decade, particularly during transitional seasons like spring and autumn. There has also been a minor decrease in annual precipitation by approximately 0.1 mm per decade, with the most significant reductions in spring. As a result of these shifts in temperature and precipitation, the Region has seen an extension of the frost-free period, prolonged droughts during the warmer months, diminished snow cover, and other indicators of increasing regional aridification [51].

Table 2: Climatic Indicators of the Project Area.

№	Climatic Indicators	Values
1	Average temperature of the coldest month (January), °C	–7–11
2	Average temperature of the warmest month (July), °C	26–27
3	Annual precipitation, mm	250
	of which during the warm period, mm	50–100
4	Frosts	
	Dates of the first autumn frosts	10.10–30.10
	Dates of the last spring frosts	10.04–20.04
5	Snow cover depth, cm	10–25
6	Number of days with snow cover	80–100
7	Stable snow cover	
	Formation dates	30.11–10.12
	Melting dates	20.02–30.02
8	Number of days per year	
	Drought (warm period: April–October)	140–160
	Dust storms	0–5
9	Wind speed (according to long-term average data), with a 5% exceedance probability, U*, m/s	6
10	Duration of the period with air temperature above +10°C, days	Over 190

Regarding the paleoclimatic conditions of the Project area, throughout the late Pleistocene and Holocene, the climate and landscapes of the Shu-Ili Low Hill Terrain consistently exhibited steppe or semi-desert characteristics. The area, situated outside major glaciation zones and permafrost regions, maintained a relatively stable climate despite the dramatic climatic shifts of the Last Glacial Maximum and the mid-Holocene optimum. During the mid-Holocene, the piedmont plains and the Shu-Ili Low Hill Terrain were dominated by a 'steppified' landscape, a trait shared with other arid regions of Central Asia, influenced by westerly air mass flows. During colder periods, the mountains saw an increase in boreal vegetation, while the piedmont plains became more xerophytic, resembling a semi-desert environment. Despite the harsh conditions of the last glacial period (20,000–18,000 years ago), the Shu-Ili Low Hill Terrain' ecosystems remained relatively hospitable to human life [53, 54, 55].

4.5 Climate Change

The Republic of Kazakhstan identified the country's vulnerability to climate change in the areas of agriculture (both crops and livestock), water resources, human health and social and economic development. Adaptation priorities in these areas include technical and administrative measures and technological and infrastructural improvements.

The World Bank Climate Change Knowledge Portal provides global data on historical and future climate, vulnerabilities, and impacts. The information retrieved includes high-level data for Kazakhstan's climate zones and its seasonal cycle for mean temperature and precipitation for the latest climatology, 1991-2020.

Climate zone classifications shown below are derived from the **Köppen-Geiger climate classification system**, which divides climates into five main climate groups divided based on seasonal precipitation and temperature patterns. The five main groups are **A** (tropical), **B** (dry), **C** (temperate), **D** (continental), and **E** (polar). All climates except for those in the E group are assigned a seasonal precipitation sub-group (second letter). The Project site is classified as Cold-semi arid climate (**BSk**).

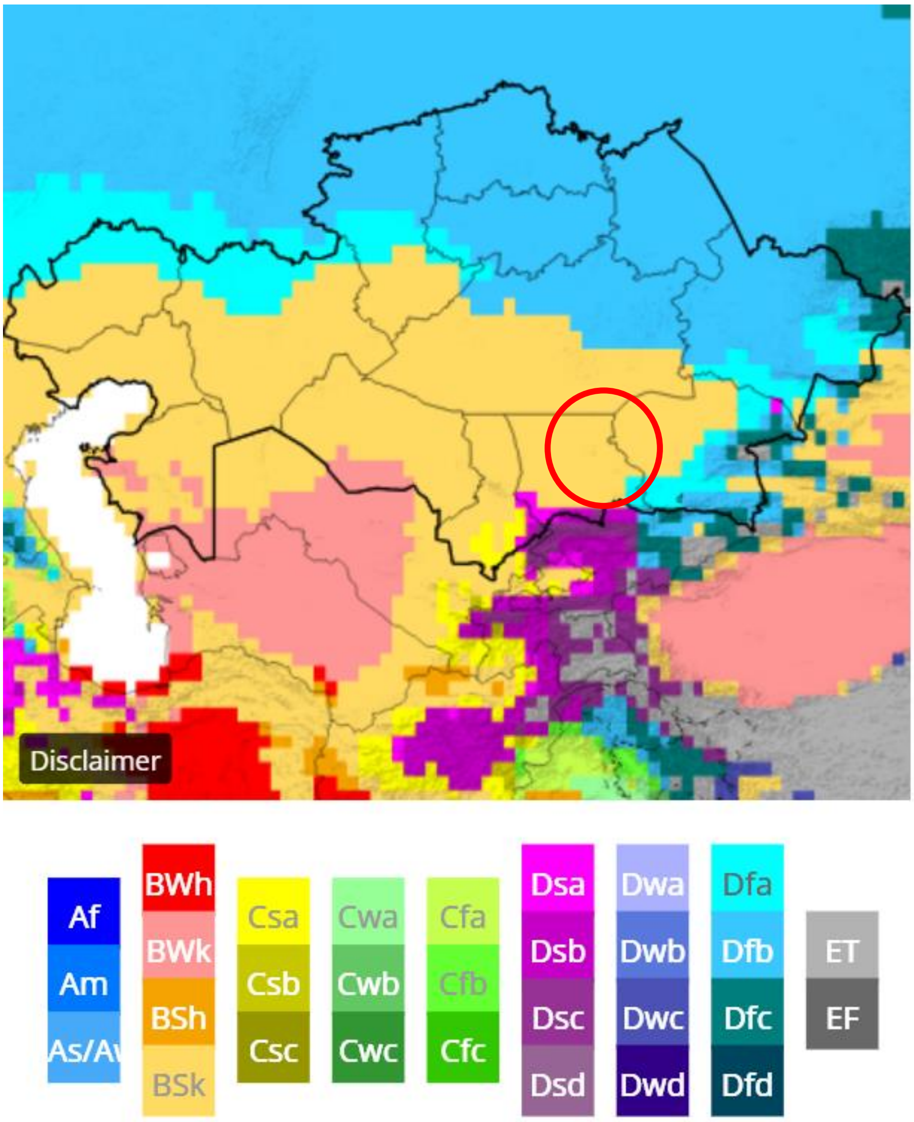


Figure 17: Köppen-Geiger Climate Classification, 1991-2020 from the World Bank Climate Change Knowledge Portal (Project area circled in red).

The natural hazards that pose the highest threat to Kazakhstan are droughts, floods, pests and diseases. Many of the climate changes projected are likely to disproportionately affect the poorest groups in society.

According to the data retrieved from the World Bank Group and Asian Development Bank 2021 CLIMATE RISK COUNTRY PROFILE report and from the World Bank Climate Change Knowledge Portal:

- Temperatures in Kazakhstan are projected to rise at a faster rate than the global average and faster than most other Asian nations, with potential warming of 5.3°C by the 2090s, compared with the 1986–2005 baseline under the highest emissions pathway;

- Warming is projected to be even stronger for maximum and minimum temperatures and the extreme temperatures which will result are likely to threaten human lives, livelihoods, and ecosystems;
- Projected temperature rise in the 2090s under Representative Concentration Pathways RCP8.5 is 3.7°C greater than the rise projected under the lowest emissions pathway (RCP2.6), indicating the large difference in outcome for Kazakhstan that could be achieved by controlling global emissions;
- Severe droughts are expected to occur more frequently under all but the lowest emissions pathway. Increased drought risk is likely to contribute to land degradation, desertification, and associated issues such as dust storms;
- Temperature rises will accelerate the melting of Kazakhstan’s glaciers, which is projected to lead to an increase in river flow and flood risk through the middle of the 21st century, followed by a longer-term decline in river flow;
- Mudflows are forecast to increase in frequency by a factor of 10 and pose a threat to 156 towns and cities in Kazakhstan, among them the country’s largest city, Almaty;
- More frequent droughts and reduced water security could damage agricultural productivity of crop and livestock farming. In the absence of adaptation, spring wheat yields in Kazakhstan are projected to decline by as much as 50% by the 2050s due to higher temperatures and reduced soil moisture;
- Grain yield losses due to climate change in Kazakhstan are expected to have serious implications for global food security as the nation represents one of the world’s largest exporters;
- In combination, the above changes represent a major threat to the lives and livelihoods of the poorest and most marginalized communities in Kazakhstan. Unless adaptation and disaster risk reduction support is provided, inequalities are likely to grow and poverty to prevail.

Kazakhstan national adaptation policies and strategies related to climate change are the following:

- Nationally Determined Contribution to Paris Climate Agreement, submitted December, 2016;
- Technology Needs Assessment, Completed 2013;
- National communications to the UNFCCC, a total of seven submitted, the lates in 2017.

As reported by the World Bank, in 2016, Kazakhstan submitted its First Nationally Determined Contribution to the UNFCCC, which commits the country to a 15% reduction in greenhouse gas emissions by 2030 (relative to 1990 levels). Kazakhstan’s Seventh National Communication and Third Biennial Update Report (2017) identifies the country’s vulnerability to climate change in the areas of agriculture (both crops and livestock), water resources, human health and social and economic development. The report sets out adaptation priorities in these areas, including technical and administrative measures and technological and infrastructural improvements. The Ministry of Environment and Water Resources of Kazakhstan was the central executive body coordinating and leading the development and implementation of government policies on environment protection and management, including climate change issues. The Ministry was closed in 2014, and its functions divided between a newly created Ministry of Energy and the Ministry of Agriculture. This function was finally transferred to the Ministry of Ecology, Geology and Natural Resources that was created in 2019. Kazakhstan ratified the Paris Agreement on December 6, 2016.

At Project site level, no major events have been reported; however, the studies (e.g., World Bank Group and Asian Development Bank 2021 CLIMATE RISK COUNTRY PROFILE report) reveal that the risk of flooding, landslides and mudslides is expected to be most severe in the foothills of the south and east of Kazakhstan, where terrain is more mountainous, and rainfall levels are higher.

Moreover, according to the UNDP - United Nations Development Program Climate Change Adaptation portal, while Kazakhstan has a rapidly growing economy, rural population, farmers and pastoralists outside of the main urban centers (like those located at the Project area) face significant climate change risks to their livelihoods stemming from increased aridity, water management challenges and extreme weather events.

4.6 Soil and Land Use

4.6.1 Jambyl Region

The soil cover in the Jambyl Region exhibits significant diversity due to the varied conditions of soil formation [10]. The mechanical composition of soils is closely linked to the underlying parent materials, which vary greatly across the region. Climatic factors play a crucial role in shaping the soil cover, particularly with the influence of the Tien Shan Mountain ranges in the southern part of the region, which introduces a complex pattern of soil and vegetation cover governed by vertical zonation:

- Alpine Zones (2000-4000 meters) - This zone, including the Kyrgyz Alatau ridges, is characterized by alpine mountain-meadow, subalpine mountain-meadow, high-altitude meadow-steppe, and mountain-chestnut soils. These soils are rich in humus (7-20%) and feature a thick, dark-colored turf layer (15-20 cm) with a granular humus horizon. Soil formation follows a vertical sequence, with mountain-forest soils featuring a peat horizon composed of juniper and moss litter. The vegetation includes feather grass, bluegrass, and creeping juniper;
- Piedmont Zones (1300-2200 meters) - The slopes of the Kyrgyz Alatau Range, Karatau Range, and northern Shu-Ili Low Hill Terrain are home to mountain chernozems, dark chestnut mountain soils, and poorly developed mountain-steppesoils. Soil formation occurs under shrub-grass and grassland vegetation. Mountain chernozems are similar to those in foothill plains, while the chestnut soils are shallow with a gravelly humus horizon;
- Low Mountain Zones (600-1300 meters) - This zone, spanning the low-mountain and mid-mountain regions, including the Karatau, Kyrgyz Alatau, Kordai ridges, and the southern Shu-Ili Low Hill Terrain, as well as the areas of the Kurgat-Shu valley and the Talas-Assy interfluve, is characterized by light chestnut soils and gray soils. Light chestnut soils, common in semi-desert areas, contain up to 2.5% humus and are slightly alkaline, making them suitable for agriculture with proper irrigation. Gray soils, which develop under sharply continental climates, have favorable water-physical properties and contain 1-3.5% humus. These soils are noted for their low humus content and high carbonate levels;
- Desert Zones with Lowland Plains, Low Hill Plains and Elevated Plains (280-600 meters) - This zone covers most of the Jambyl region, including the Betpaqdala desert, Moiynkum sands, and northwestern ridges of the Shu-Ili Low Hill Terrain. It features gray-brown soils, gray-brown saline soils, takyr-like soils, floodplain meadowsoils, meadow-bog soils, and sands. The arid climate leads to soils with low humus content, strong mineralization, and high carbonate content. Xerophilous plants dominate the vegetation, adapted to moisture scarcity and extreme temperatures.

4.6.2 Project Area and OHTL

The soils of the Project area should be primarily assessed in relation to its position on the northwestern ridges of the Shu-Ili Low Hill Terrain, which falls within the elevated plains of the Desert zone. Vertical zonation plays a key role in determining the patterns of soil distribution throughout the Shu-Ili Low Hill Terrain, dictating the presence and combination of specific soil types within various vertical zones. This zonation is influenced not only by elevation but also by regional climate factors, the spatial arrangement of orographic systems, and the prevailing direction of air mass movement [30].

The northwest alignment of the main ridges in the Shu-Ili Low Hill Terrain along the path of moist air masses results in similar altitudinal zones on both the southwestern and northeastern slopes. On the northeastern slope, soil zone boundaries descend only 100-150 meters lower than on the southwestern slope, and in the low-mountain and small-hill areas of the Shu-Ili Low Hill Terrain, they are nearly at the same elevation. The vertical zonation and soil cover in this area are influenced by the arid conditions of the Shu-Ili Low Hill Terrain, which stem from their peripheral location within the Northern Tien Shan ridges, the impact of the adjacent desert zone to the north, and their relatively low elevation above sea level. The increasing aridity and continentality also lead to broader transition zones between belts, which, despite a limited vertical range, extend significantly horizontally. This factor contributes to the development of light desertified sierozems on the piedmont plains of the northwestern Shu-Ili Low Hill Terrain.

In arid environments, the characteristics of the underlying soil-forming rocks significantly influence the soil cover, affecting its thermal and moisture regimes. As a result, the vertical zonation in this area is characterized by fragmented altitudinal soil belts, shaped by lithological and geomorphological conditions. In addition to the light desertified sierozems, piedmont brown desert soils do not form a continuous belt but instead create extensive homogeneous areas within leveled denudation-accumulative plains composed of loose, light-textured deposits. In more dissected, predominantly denudation landscapes with shallow underlying rocks, piedmont brown desert soils are interspersed with gray-brown desert soils. In general, the lowest parts of the piedmont plains of the Shu-Ili Low Hill Terrain, along with the small-hill massifs in the northwest, are part of the piedmont desert zone, with the upper boundary at an elevation of 550–650 meters above sea level, where the Project area is located. The primary zonal soil type here is piedmont brown desert soils.

For the Project area specifically, an overlay on the soil map of Kazakhstan in Figure 18 indicates that the northern section predominantly features piedmont brown desert soils mixed with gray-brown desert soils, consistent with the denudation landforms in this part of the Jambyl and Maizharylgan mountains. The southeastern portion of the site contains piedmont brown desert soils, while the far southern area near the southern foothills of the Maizharylgan mountains is characterized by light desertified sierozems. The western part of the Project area is mainly covered by gray-brown gravelly soils, indicates transitions from Maizharylgan mountains to flatter terrains of Sekseul Dala Steppes.

The layout of the proposed OHTL from the Project area to Ulken Substation exhibits similar soil cover characteristics, with both routes traverse areas with different types of piedmont brown desert soils (see Figure 18).

The soils along the route of the proposed OHTL from the Project area towards Shu Substation exhibit a diverse soil type reflecting the varied landscapes traversed. As the OHTL crosses between the foothills of the Maizharylgan and Khantau mountains, the soils are predominantly northern light piedmont sierozems, which marks the transitional zones between the mountainous regions and the plains. Crossing the Sekseul Dala Steppes, the soil composition shifts to takyr-like soils, indicative of the arid environments. Further along the route, as the HV lines approach the northeastern borders of the Shu-Sarusy basin and Shu river, the soil profile changes to include northern ordinary piedmont sierozems, floodplain meadow soils and piedmont meadow-sierozem soils. Approaching Shu Substation, as the proposed HV lines layout cross the Moiynkum sands, the soils transition to desert sands with brown soil formation (see Figure 18).

Figure 18: Project Area and proposed OHTL layout on Soil Map of Kazakhstan.

4.6.3 Project area land use and land covers

4.6.3.1 Land Use in the context of Specially Protected Reserve Areas

The southern portion of the Project area overlaps with the Zhusandala State Reserve Zone. The proposed layout for the 500 kV OHTL toward Shu Substation also partially intersects the Zhusandala State Reserve Zone. Additionally, the Project area borders the Andasay State Nature Reserve to the northwest (Figure 19).

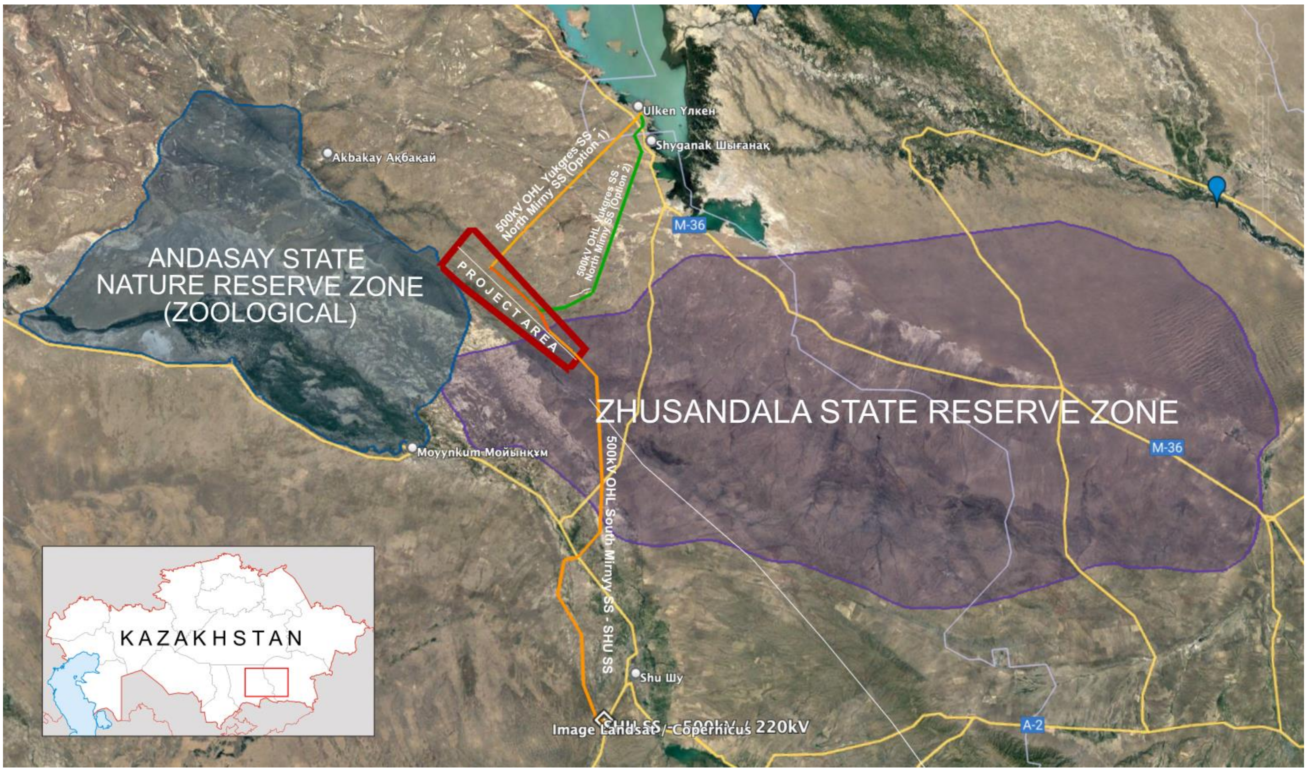


Figure 19: Project Area and Proposed OHTL Layout within the context of Specially Protected Reserve Areas (Zhusandala state reserve zone boundaries outdated).

Zhusandala reserve territory pertinence area was reduced in 2019, specifically in the northwestern part. This reduction was formalized through the Government Decree of the Republic of Kazakhstan No. 282 dated May 14, 2019, "On the Reduction of the Territory of the Zhusandaly State Nature Reserve Zone," amounting to 491.32 hectares. The lands were allocated for the extraction of common minerals to support the reconstruction of the "Merke-Burylbaital" and "Kurty-Burylbaital" road sections as part of the State Infrastructure Development Program "Nurly Zhol" for 2015–2019. Prior to this reduction, the reserve's boundaries completely included the Project area. Following the reduction, only the southern part of the Project area remains within the reserve's boundaries as shown in Figure 19 and as per available international sources[2].

However, more detailed and accurate studies carried out to delineate the Project biological components and most recent updates of the protected area boundaries, pointed out that the Project area falls entirely within the Zhusandala state reserve zone. This topic is better addressed in the biodiversity-related chapters and section of this study.

4.6.3.1.1 Land Use within Zhusandala State Reserve Zone

Zhusandala State Reserve Zone is a reserve zone of the national relevance, located in the northwestern part of the Almaty Region and the northeastern part of the Jambyl Region. It occupies 2,757,500 hectares, extending westward into the Taukum Desert and bordering the Andasai State Nature Reserve to the northeast [32].

It was established by Resolution No. 382 of the Government of the Republic of Kazakhstan, dated March 15, 2001, "On the Organization of State Reserve Zones of Republican Significance" over an area of 2,757,500 hectares. The following regimes were established: Reserve regime (80,660 hectares), sanctuary regime (353,236 hectares), and regulated regime (2,323,604 hectares).

[2] https://www.protectedplanet.net/555705874

The Government of the Republic of Kazakhstan issued Resolution No. 282 on May 14, 2019, "On the Reduction of the Territory of the Zhusandala State Natural Reserve Zone" by 491.32 hectares to allocate areas for the extraction of common minerals for the reconstruction of the "Merke-Burylbaytal" and "Kurty-Burylbaytal" road sections within the framework of the State Infrastructure Development Program "Nurly Zhol" for 2015-2019.

The territory is managed by the Committee for Forestry and Wildlife of the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan.

Legal Framework and Classification of State Reserves in Kazakhstan. Under the Law of the Republic of Kazakhstan "On Specially Protected Natural Areas" dated July 7, 2006, No. 175, a State Reserve Zone (Kazakh: Мемлекеттік қорық аймағы, Russian: Государственная заповедная зона) is a specially protected area characterized by various protection regimes. These zones are designated to conserve and restore the components of the state natural reserve fund and to preserve biological diversity on lands and water bodies earmarked for state nature reserves, national parks, and nature sanctuaries [31].

State reserve zones can be established on land of any category without requiring the expropriation of land from its owners or users; also, landowners and users must allow restricted and specific use of the land within the reserve zones.

As for the protection and use regulations in State Reserve Zones:

- Activities are prohibited in state reserve zones if they could lead to changes in the natural appearance of protected landscapes, disrupt the stability of ecosystems, or threaten the conservation and reproduction of especially valuable natural resources;
- State reserve zones include areas with reserve and sanctuary regimes, as well as areas with a regulated economic activity regime;
- State reserve zones may be used for all purposes provided for specially protected natural areas, taking into account the specifics of the types of protection regimes.

Restrictions on the economic activities of landowners and land users in State Reserve Zones are established by the laws of the Republic of Kazakhstan.

Environmental protection institutions, state forestry institutions, and specialized wildlife protection organizations responsible for State Reserve Zones organize activities for the protection and restoration using special security services in accordance with Article 32 of this Law.

Geological exploration and mineral prospecting are permitted in state reserve zones with the approval of the authorized body, taking into account the special environmental requirements established by the Environmental Code of the Republic of Kazakhstan. Mineral extraction is allowed in exceptional cases based on a decision of the Government of the Republic of Kazakhstan, upon the proposal of the authorized body for subsoil study, coordinated with the authorized environmental body, and taking into account the special environmental requirements established by the Environmental Code of the Republic of Kazakhstan.

4.6.3.1.2 Land Use within Andasay State Nature Reserve

Andasay State Nature Reserve is situated in the Betpaqdala Desert within the Moyinkum District of the Zhambyl Region, along the right bank of the Shu River, west of Moyinkum village. The reserve is classified as a zoological area and was created to safeguard and bolster the populations of species like the kulan, argali, saiga antelope, goitered gazelle, wild boar, roe deer, various pheasants, cream-colored courser, black-bellied sandgrouse, houbara bustard, little bustard, along with other important wildlife species [33].

Designated as a reserve of republican importance, its creation was mandated by the Council of Ministers of the Kazakh SSR through Resolution No. 220 on March 29, 1966. The reserve's status has since been reaffirmed by several subsequent resolutions from the Government of the Republic of Kazakhstan, including No. 887 on June 27, 2001, No. 746 on July 19, 2005, No. 1074 on November 10, 2006, an order from the Acting Minister of Agriculture on May 28, 2015, and Resolution No. 593 on September 26, 2017. The reserve covers an area of 1,000,000 hectares and is permanently managed by the State Enterprise "OkhotZooProm" under the Committee for Forestry and Wildlife within the Ministry of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan.

Legal Framework and Classification of State Nature Reserves in Kazakhstan. Under the Law of the Republic of Kazakhstan "On Specially Protected Natural Areas" dated July 7, 2006, No. 175, a State Nature Reserve (Kazakh: Мемлекеттік табиғи қаумал, Russian: Государственный природный заказник) is designated as a specially protected area, governed by either a sanctuary regime or a regulated economic activity regime. These reserves are established to conserve and restore specific elements of the state’s natural reserve fund [31].

State nature reserves are categorized by their primary conservation objectives into the following types:

- Complex Reserves - Focused on the preservation and restoration of particularly valuable natural ecosystems;
- Biological Reserves (including botanical and zoological) - Aimed at conserving and restoring valuable, rare, and endangered species of flora and fauna;
- Paleontological Reserves - Dedicated to the preservation of fossilized remains of animals, plants, and their associated ecosystems;
- Hydrological Reserves (encompassing wetlands, lakes, and rivers) - Established for the protection of significant wetland ecosystems;
- Geomorphological Reserves - Concerned with preserving rare and unique landforms;
- Geological and Mineralogical Reserves - Focused on safeguarding rare geological and mineral formations;
- Soil Reserves - Intended for the conservation of typical and rare soil types;
- Hydrogeological Reserves - Established to protect unique groundwater resources;

State Nature Reserves can be established on land of any category without requiring the expropriation of land from its owners or users. The boundaries of state nature reserves are aligned with the land plots' ownership or use boundaries, or with natural geographical features, and are clearly marked with specific signs. Landowners and users are required to allow limited, purpose-specific use of their land within these reserves.

Restrictions on economic activities within state nature reserves are imposed by local executive authorities, in accordance with the Land Code of the Republic of Kazakhstan, to ensure the protection of the reserve’s resources.

The specific rules for the protection and use of state nature reserves are outlined in their respective management plans or "passports." These reserves may be utilized for scientific research, ecological education, tourism, recreation, and restricted economic activities. Landowners and users within these areas must conduct their activities in compliance with these established restrictions.

In Zoological State Nature Reserves activities such as hunting, capturing animals (except for fish), introducing non-native species, destroying nests, burrows, dens, or other habitats, and collecting eggs are prohibited unless authorized for scientific research, reproduction, or reclamation purposes by the competent authority.

4.6.3.2 Pastures and Fodder Resources

The Project area and surrounding areas are actively used by farms for livestock grazing, which occurs seasonally from spring to autumn. According to the fodder resources map of Kazakhstan provided by the Kazakh Research Institute of Livestock and Fodder Production, the Project area and the routes of the proposed HV lines toward the Ulken substation are located on low-hill pastures and hayfields. Part of the power transmission line toward the Shu substation is crossing plain pastures and hayfields, including foothill plains and saxaul desert forests [34].

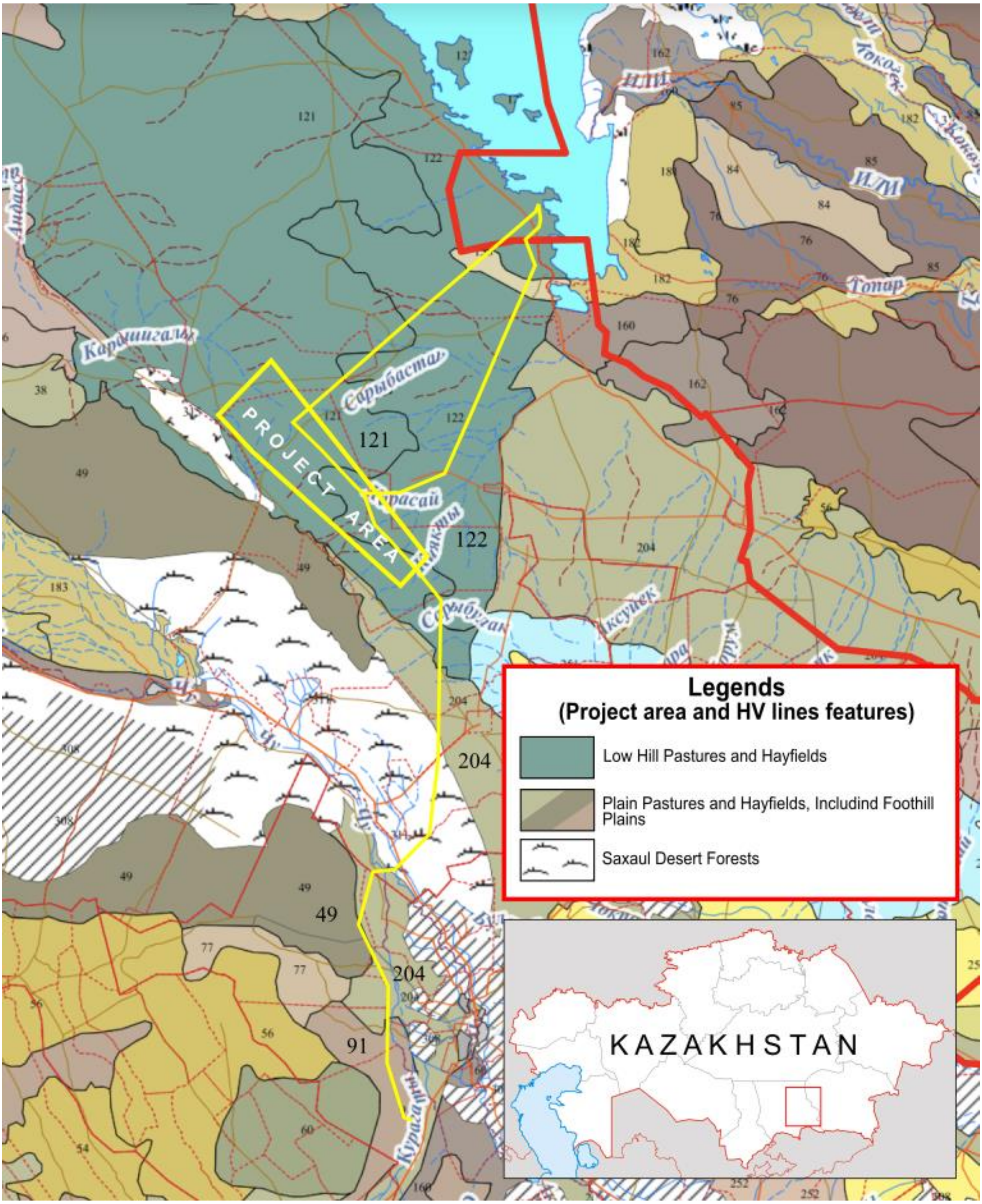


Figure 20: Project Area and Proposed OHTL Layout (depicted in yellow lines) within the Fodder Resources Map of Kazakhstan.

Based on the pasture zoning map and division of these zones by fodder potential, the Project area is primarily situated on low-hill pastures and hayfields designated by field No. 121 in the northern and partially southern sections (see photo below) and field No. 122 in the central section. The fodder potential for these zones are detailed in the tables below, respectively.

Figure 21: The livestock pen located on low-hill pastures in the southern part of Project area.

Table 3: Forage potential of low-hill pastures designated by Field No. 121.

Field Number	**121**	
Department	Low-hill pastures and hayfields	
Pasture Class	Sagebrush-Boyalich, Boyalich-Sagebrush desert pastures with saltwort, sagebrush-saltwort pastures on solonetz soils (120-123)	
Group	Gray sagebrush-Boyalich, Sagebrush-Boyalich on loamy, sometimes gravelly soils, often with biyurgun on solonetz soils up to 20% in broad interhill depressions	
Group (Latin)	*Artemisia terrae-albae, A. turanica, Salsola laricifolia, Anabasis salsa, A. ramosissima*	
Forage Resources of the Field	**c/ha**	**c/ha of forage units**
Spring	*1,7*	*1,1*
Summer	*2,8*	*1,5*
Autumn	*2,6*	*1,1*
Winter	*1,9*	*1*
Usage Recommendation	Spring-Summer-Autumn	
Livestock Recommendations	For small ruminants, horses, camels	

Table 4: Forage potential of low-hill pastures designated by Field No. 122.

Field Number	**122**
Department	Low-hill pastures and hayfields
Pasture Class	Sagebrush-Boyalich, Boyalich-Sagebrush desert pastures with saltwort, sagebrush-saltwort pastures on solonetz soils (120-123)
Group	Boyalich-Gray Sagebrush on heavy loamy and loamy soils with kokpek, kokpek-sagebrush, tasbiyurgun-biyurgun on solonetz soils in broad interhill depressions up to 15-30%
Group (Latin)	*Salsola laricifolia, Artemisia terrae-albae, Atriplex cana, Artemisia pauciflora, A. schrenkiana, Anabasis salsa, Nanophyton erinaceum*

Forage Resources of the Field	c/ha	c/ha of forage units
Spring	*3*	*1,9*
Summer	*6*	*3,3*
Autumn	*2,4*	*1*
Winter	*1,5*	*0,4*
Usage Recommendation	Spring-Summer-Autumn	
Livestock Recommendations	For small ruminants, horses, camels	

A segment of the OHTL route heading south towards the Shu substation starts on low-hill pastures and hayfields marked by field No. 121 and No. 122. The route then moves through plain pastures and hayfields, including foothill plains, near the Maizharlygan and Khantau mountains, designated as No. 204. After crossing through the unsuitable saxaul desert forests of the Sekseul Dala steppes, it returns to plain pastures and hayfields identified by field No. 204 and No. 49. As the route approaches the Shu substation, the proposed OHTL is crossing plain pastures and hayfields marked by field No. 91.

Table 5: Forage potential of plain pastures and hayfields designated by Field No. 204.

Field Number	204	
Department	Plain pastures and hayfields, including foothill plains	
Pasture Class	Sagebrush, Sagebrush-Ephemeral, Shrub-covered in sands, Desert-Steppe, and Desert pastures with saltwort, sagebrush-saltwort on solonetz soils, yerkek-sagebrush, shagyr or shrub-covered in sands (32,37-41,62-69,71,72,143,199,204,206-210)	
Group	Sagebrush-Ephemeral, in places degraded, sometimes with gray sagebrush-saltwort and tufted grass-sagebrush up to 20%	
Group (Latin)	*Artemisia terrae-albae, A. sublessingiana, A. serotina, Poa bulbosa, Carex pachystylis, Bromus tectorum, Papaver pavonicum, Trigonella arcuata, Ceratocarpus turkestanicus, Salsola rigida, S. laricifolia, Stipa capillata*	
Forage Resources of the Field	**c/ha**	**c/ha of forage units**
Spring	*3*	*2,1*
Summer	*3,5*	*1,9*
Autumn	*3,5*	*1,6*
Winter	*2,8*	*0,8*
Usage Recommendation	Spring-Summer-Autumn	
Livestock Recommendations	For all types of livestock	

Table 6: Forage potential of plain pastures and hayfields designated by Field No. 49.

Field Number	49
Department	Plain pastures and hayfields, including foothill plains
Pasture Class	Black saxaul-Sagebrush, Sagebrush-Black saxaul, Black saxaul-Saltwort pastures of ancient alluvial plains (49,51,44)
Group	Gray sagebrush-Black saxaul-Saltwort on takyr-like soils, sometimes with shrub-covered gray sagebrush and yerkek on hummocky sands up to 30%
Group (Latin)	*Artemisia terrae-albae, A. turanica, Haloxylon aphyllum, Salsola lanata, S. brachiata, S. rigida, Haloxylon aphyllum, Astragalus paucijugus, Agropyron fragile*

Forage Resources of the Field	c/ha	c/ha of forage units
Spring	*1,4*	*0,8*
Summer	*3,1*	*1,7*
Autumn	*2,6*	*1,2*
Winter	*1,6*	*0,5*
Usage Recommendation	Autumn pastures with potential use in other seasons	
Livestock Recommendations	For small ruminants, camels	

Table 7: Forage potential of plain pastures and hayfields designated by Field No. 91.

Field Number	91	
Department	Plain pastures and hayfields, including foothill plains	
Pasture Class	Shrub-Ephemeral, Ephemeral-Shrub sandy, Ephemeral-Mixed herb foothill pastures (78-82,87-91,211-214)	
Group	Weed-Ephemeral degraded on small hummocky and leveled sands	
Group (Latin)	*Artemisia scoparia, Cannabis ruderalis, Alhagi desertorum, Syrenia silliculosa, Salsola pellucida, Carex physodes, Bromus tectorum, Secale silvestre, Elymus giganteus, Artemisia arenaria*	
Forage Resources of the Field	c/ha	c/ha of forage units
Spring	*0,9*	*0,6*
Summer	*1*	*0,5*
Autumn	*0,5*	*0,4*
Winter	*0,2*	*0*
Usage Recommendation	Spring pastures with moderate grazing	
Livestock Recommendations	For small ruminants, camels	

4.6.3.3 Subsoil Use

According to the Interactive Subsoil Use Map of the National Geological Service of Kazakhstan, the Project area and proposed OHTL routes are located near various mineral deposits. The following figure highlights active and inactive subsoil use contracts in close proximity to the Project area and OHTL routes, providing details on deposit types, operating company names, land allocations, and the validity of these contracts [35].

As the proposed OHTL continue toward Shu substation, no subsoil use areas are detected in the immediate vicinity.

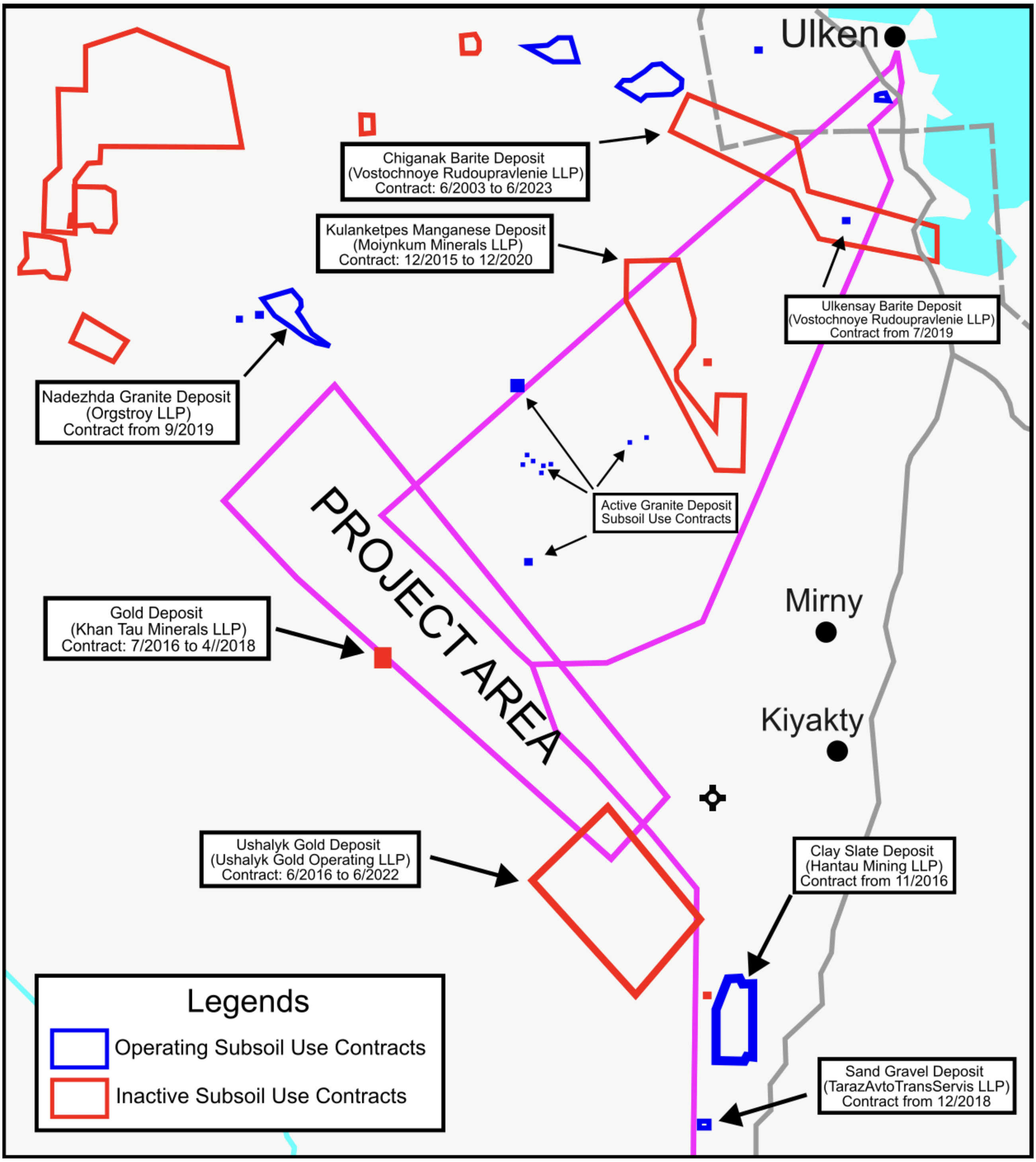


Figure 22: Operating and Inactive Subsoil Use Contracts at the Project site Area.

Figure 23: The active granite mine located near central-eastern boundaries of the Project site area.

4.7 Surface Water

4.7.1 Surface water in Kazakhstan and in the Jambyl Region

Kazakhstan is one of the few regions globally that face a significant shortage of water resources. These resources are distributed unevenly across the country, with the majority being transit rivers that originate outside its borders. Currently, over one-third of Kazakhstan's population lacks consistent access to safe drinking water, and by 2050, the demand may outstrip available supplies. This presents a potential risk of severe water scarcity, which could place Kazakhstan among nations experiencing a critical water crisis. The southeastern regions, particularly the mountainous and foothill plains, enjoy the highest availability of freshwater. However, in most of the country, the combination of industrial activities, heavy pollution from industrial and municipal effluents, and other factors have resulted in a severe shortfall of clean freshwater [36, 37].

Kazakhstan is divided into eight river basins:

- Aral-Syrdarya River Basin;
- Balkhash-Alakol River Basin;
- Yertis River Basin;
- Zhaiyk-Caspian River Basin;
- Yesil River Basin;
- Nura-Sarysu River Basin;
- Shu-Talas River Basin; and
- Tobyl-Torgay River Basin.

Figure 24: Project site area location on the map of Kazakhstan's river basins (Source of the map: Institute of Geography and Water Security of Kazakhstan).

The Project area lies at the intersection of the Shu-Talas and Balkhash-Alakol river basins:

- Balkhash-Alakol Basin - this basin covers a large Region in southeastern Kazakhstan and a portion of northern China, with a total area of 413,000 square kilometers, of which 353,000 square kilometers are within Kazakhstan. The Kazakhstani section includes parts of the Almaty region, Moiynkum, Korday, and Shu districts of the Jambyl region, as well as the Aktogay, Shet, and Karkaraly districts of the Karagandy region, and Urzhar and Ayagoz districts in the East Kazakhstan region. The Chinese section spans the northwestern part of the Xinjiang Uygur Autonomous Region. Notably, Kazakhstan's largest city, Almaty, is also situated within this basin. Approximately 3.3 million people live in the Kazakhstani portion, with the majority (1.6 million) residing in the Almaty region, and 1.5 million in rural areas. Although the basin holds substantial water reserves of 149.4 cubic kilometers, most of this (77%) is stored in lakes, particularly Lake Balkhash, and cannot be used for irrigating key agricultural areas in the Almaty region. River waters account for 14%, and reservoir water makes up 5%;
- Shu-Talas Basin - this basin is fed by the Shu, Talas, and Asa rivers, spanning 64,300 square kilometers, including a section in the Kyrgyz Republic. In Kazakhstan's portion (mainly Jambyl region), the population totals 980,000. The basin's total water resources are 6.11 cubic kilometers, which is about 3.6 times less than those in the Aral-Syrdarya Basin. Groundwater reserves of 1.65 cubic kilometers exceed those of the Aral-Syrdarya Basin, making up 27% of the basin's water balance. The remaining water is concentrated in surface sources, with 6% in lakes, 8% in reservoirs, and 59% in rivers. The majority of the basin (73%) consists of desert and semi-desert areas, while 14% is occupied by the foothills of the Tien Shan mountains. The foothill steppe zone, which covers 13% of the Jambyl region, holds the greatest agricultural potential. In addition to major rivers, the basin is home to 204 small rivers (140 in the Shu basin, 20 in the Talas basin,

and 64 in the Asa basin), along with 35 lakes and 3 large reservoirs. The Kyrgyz Republic hosts the Orto-Tokoy Reservoir on the Shu River, with a capacity of 0.42 cubic kilometers, and the Kirov Reservoir on the Talas River, with a capacity of 0.55 cubic kilometers. There is also the Ters-Ashybulak Reservoir on the Ters River, with a capacity of 158 million cubic meters, and the Tasotkel Reservoir on the Shu River, with a capacity of 620 million cubic meters. The flows of the Shu, Talas, and Asa rivers are fully regulated, and the basin's reservoirs are primarily used for irrigation purposes. The flow of these rivers, as well as that of the Kukureu-su, the main tributary of the Asa River, is generated entirely in the Kyrgyz Republic.

4.7.2 Surface water in the Project site area

In evaluating the major surface water bodies that could be affected by the Project, Lake Balkhash and the Shu River stand out as the most prominent. This includes the planned routes for the 500kV OHTL from the North Mirny Substation to the Ulken Substation, for both option 1 and option 2. The YUKGRES substation in the Ulken village is situated approximately 350 meters from the shore of Lake Balkhash. The proposed 500kV OHTL route from the South Mirny Substation to the Shu Substation crosses the Shu River. Given the scale of the OHTL construction, the lack of wastewater discharges, and strict adherence to HSE measures, the impact on these water bodies is expected to be minimal.

Figure 25: Surface water bodies in the Project site area.

The hydrographic network of the Project area is considered in relation to its position within the Shu-Ili Low Hill Terrain. The relatively low elevation of the Shu-Ili Low Hill Terrain, its distance from the main high ridges of the Tien Shan, and its location between two major arid depressions - the Shu-Sarysu and Pre-Balkhash basins - combined with the proximity of the hyper-arid clay-stone desert of Betpaqdala to the northwest, create a dry climate and a general lack of water resources. Lake Balkhash lies about 50 km to the east of the Project area. Two significant permanent rivers, the Shu and Kurty, run tens of kilometers away from the mountain foothills to the west and east, respectively. The Shu-Ili Low Hill Terrain, including the Maizharylgan mountains where the Project area is situated, have a poorly developed surface water network. Small mountain creeks flowing toward the Shu-Sarysu basin are part of the Shu-Talas River basin, including Andasay, Karashygaly, Almaly, Sarybulaksay, Suyksay, Sarybulak, Kotyr, Sunkar, Zhideli, Ulken-Zhideli, and others. Creeks descending from the eastern slopes of the Shu-Ili Low Hill Terrain toward the Zhusandala plain (such as Karasay, Karaulkashkan, Aksuek, Kuyelikara, Zhalpakshi, Tesik, Sholak, Zhingyldy, and others) belong to the Balkhash-Alakol River basin. These streams primarily flow during spring floods, but by summer they either dry up completely or remain as isolated pools sustained by groundwater. Illustrations of these mountain creeks and springs, using the Khantau Mountains as an example (which extend beyond the Maizharylgan Mountains and have similar geomorphology), are shown below.

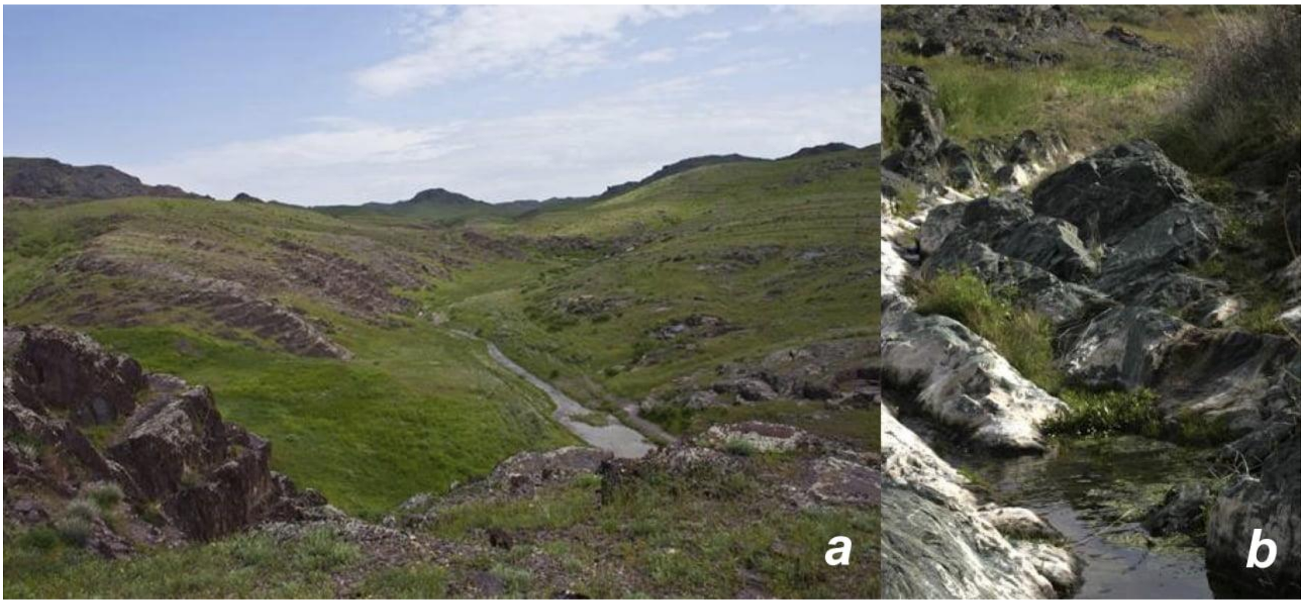


Figure 26: Surface water resources of the Shu-Ili Low Hill Terrain, using the Khantau Mountains as an example: a) seasonal mountain creeks that dry up during the warm season; b) spring (Photos by T.N. Duisebayeva [18]).

Within the Project site area itself, the northwestern zone includes Sarybulaksay creeks which flow westward from the Maizharylgan foothills. Further down along the western boundary, other streams also flow westward from the mountains. On the northern boundary, the Shagyrlysay creek follows a similar westward course. On the eastern side of the Project area, the Karasay and Kiyakty creeks flow eastward. In addition, there are some springs in the Project site area. See seasonal creeks’ locations in the Project area and flow directions in the figure below.

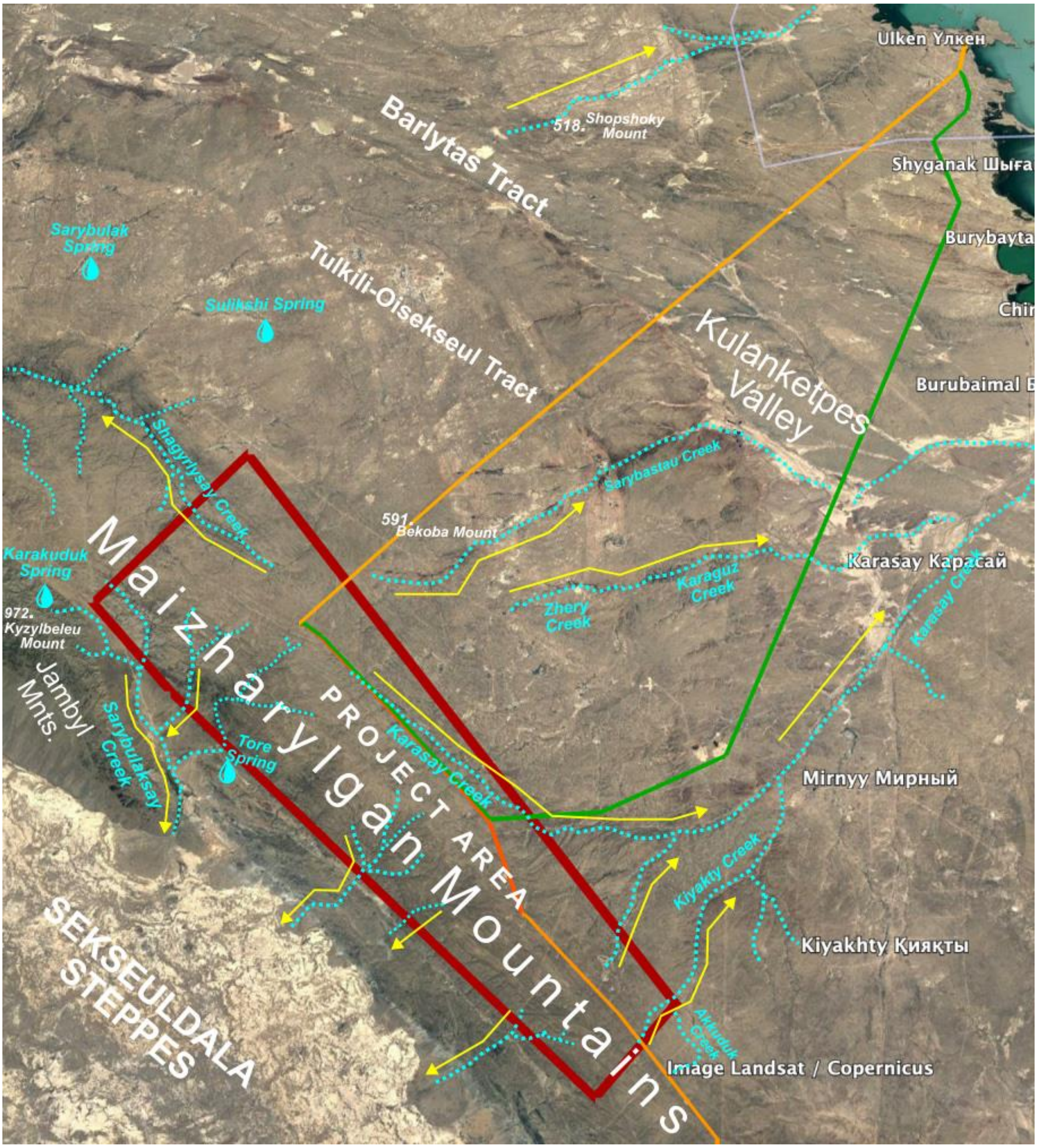


Figure 27: Seasonal mountain creeks (blue dashed lines) on the Project site area with flow directions (yellow lines).

4.8 Groundwater

4.8.1 Jambyl Region hydrogeological context

The Jambyl Region hosts numerous large groundwater deposits, which are used for irrigation among other purposes. The hydrographic network includes the Shu, Talas, Kuragaty, and Assa rivers, along with numerous small streams flowing from the northern slopes of the Kyrgyz Alatau range. The average annual flow of the basin of all rivers is estimated at 4.15 km³/year, with 3.92 km³/year available for use. During low-water periods, the flow decreases to 2.77 km³/year, with 2.32 km³/year available for use. On average, 27.1 thousand m³/year of surface water resources are available for use per 1 km² in a typical year, while in low-water years, this figure drops to 16.0 thousand m³/year [6].

The Region coincides with the distribution of a large hydrogeological structure, the Shu-Sarysu basin of porous and stratified groundwater, composed of thick Mesozoic-Cenozoic loose formations. It is surrounded by mountain structures, including the Shu-Ili Mountains, the Kyrgyz Alatau, and the Karatau ranges, where Paleozoic and pre-Paleozoic metamorphic and magmatic rocks form similar basins. These are characterized by the presence of vein, fissure, and fissure-karst groundwater (in the south and southwest—Karatau and Kyrgyz Alatau, and in the east—Shu-Ili basins). The Region provides favourable hydrogeological conditions for the formation and accumulation of significant groundwater reserves.

The most promising areas for identifying fresh groundwater are the Quaternary alluvial-proluvial deposits of the outwash fans and foothill plains of the Kyrgyz Alatau, as well as the alluvial deposits of the Shu, Talas, Assa, and Kuragaty river valleys. The groundwater from these deposits is widely used for domestic water supply in cities, rural settlements, industrial, and agricultural facilities. In the northern part of the region, in the Betpakdala and Western Pribalkhash areas, the Paleozoic and pre-Paleozoic rocks have very limited fresh groundwater resources. However, the water-bearing zones of tectonic faults and carbonate structures in these areas are considered promising.

Paleozoic and pre-Paleozoic rocks that form mountainous structures are characterized by widespread fracturing zones, which create favorable conditions for the infiltration of atmospheric precipitation and the formation of fresh groundwater in all rock complexes. Among them, carbonate formations are the most promising, where significant groundwater resources have been identified in karst zones, capable of supplying large consumers, such as mining enterprises and cities.

In the Jambyl region, the following aquifers and complexes containing fresh and slightly saline groundwater are considered promising for practical use:

- Groundwater of alluvial-proluvial and alluvial deposits of the foothill plains of the Kyrgyz and Talas Alatau, and the M. Karatau range, where the total thickness of the water-bearing rocks ranges from 100 to 500 meters. Well yields range from 5-30 to 130-150 l/s. The water is mainly fresh on the outwash fans and slightly saline on the plains;
- Groundwater of aeolian-alluvial deposits in the sandy massifs of Moiynkum, with groundwater levels at depths of 5-50 meters. Well yields are 0.5-10 l/s;
- Groundwater of Neogene, Paleogene, and Cretaceous deposits, distributed in intermountain basins (Kopin, Shu-Sarysu, Zhualyn, etc.);
- Fissure and fissure-karst groundwater of Devonian-Carboniferous carbonate formations, lying at depths of 50-80 meters. The depth of the active fracturing zone is between 80-160 and 200-300 meters. Well and spring yields vary from 1 to 5 l/s, but in tectonic fault zones, well yields reach 25-100 l/s, and some springs (e.g., Zhilybulak) associated with this zone have flows of 300-580 l/s. The water is mostly fresh;
- Groundwater of effusive-sedimentary and intrusive rocks, distributed in the folded mountain regions of the area. The depth of occurrence is 10-50 meters. Spring yields range from 0.1-0.5 to 2-5 l/s in tectonic fault zones. Well yields range from 0.1-6.0 l/s, increasing in fault zones. The water is fresh to slightly saline, varying from bicarbonate to sulfate sodium types. On the Betpak-Dala plateau, water mineralization reaches up to 10 g/l, and in some places, up to 30 g/l.

The forecasted operational resources of groundwater with mineralization up to 10 g/l are estimated at 22,567.10 thousand m³/day, including by mineralization level, g/l: up to 1 – 14,933.03; 1-3 – 7,547.8; 3-10 – 86.3. Freshwater with mineralization up to 1 g/l constitutes 66.2% of the total forecasted resources, while water with mineralization between 1-3 g/l constitutes 33.4%. The forecasted groundwater resources with mineralization up to 1 g/l per 1 km² amount to 103.51 thousand m³/day, and with mineralization between 1-3 g/l – 52.32 thousand m³/day. The natural groundwater resources are estimated at 12,004.02 thousand m³/day, with an average module of 82.94 m³/day per 1 km². The highest module values, ranging from 172.8 to 432.0 m³/day per 1 km², are observed on the foothill plains of the northern slopes of the Kyrgyz ridge, and the lowest are north of the Shu River, in the Shu-Ili Mountains, and on the Betpak-Dala plateau. The operational reserves of groundwater are 4,739.158 thousand m³/day, including 4,679.124 thousand m³/day with mineralization up to 1 g/l. The operational reserves of groundwater with mineralization up to 1 g/l amount to 33.05 thousand m³/day per 1 km².

Groundwater reserves have been explored and approved at the Kokterek deposit on the left bank of the Shu River in the northeastern part of the sands. Bringing this deposit into operation could significantly improve the water supply to the settlements of Aksuyek, Mirny, and Shyganak [4].

4.8.2 Anthropogenic Impact on Groundwater Quality in Jambyl Region

The Jambyl region's extensive industrial and agricultural activities heighten the risk of groundwater contamination. This Region hosts the largest phosphorite basin in the Karatau Mountains, with phosphate ore processing concentrated near the city of Taraz. Key facilities such as the NovoJambyl Phosphate Plant, the Jambyl Chemical Industry Complex, and the Jambyl Superphosphate Plant are significant contributors to industrial wastewater containing high levels of fluoride and phosphorus. Beyond these major industrial operations, the Region is also home to construction material plants, a tractor parts plant, a large thermal power station, and various enterprises in the light and food industries. Notably, both surface and groundwater in this area naturally exhibit elevated levels of fluoride [6].

In the middle reaches of the Talas River valley, the filtration fields of JSC "Kozhobuv" are used for discharging industrial and municipal wastewater from the northeastern industrial zone of Taraz. The absence of adequate treatment facilities means that most enterprises in the city release untreated wastewater, leading to high concentrations of pollutants in the environment.

Additional smaller pollution sources have been identified, including filtration fields for industrial wastewater from the Taraz oil depot, the Shu Sugar Plant, the Shu Repair and Mechanical Plant RMZ, and facilities like the oil plant, the brewery in the village of Merke, the Georgievskaya Leather Factory, livestock complexes in villages such as Merke, Kulan, and Buryl, the tailings storage facility of the Karatau Concentrator, and the reservoir in the city of Zhanatas. The primary pollutants from these sources include phenols, Biochemical Oxygen Demand (BOD), surfactants, fats, and petroleum products. These contaminants are also present in the region's groundwater.

4.8.3 Hydrogeological context of the Project site area

The Project site area, as depicted in the groundwater map of Kazakhstan (Figure 28), is situated within fracture zones of Precambrian undifferentiated rocks and other formations of various geological ages. Geological structures in much of the surveyed area are overlain by unconsolidated sediments, with clay accumulations in some locations acting as aquitards, inhibiting the downward movement of moisture. Furthermore, the presence of loose deposits, characteristic of semi-arid environments, contributes to elevated salinity levels in the groundwater. The area is marked by numerous disjunctive faults, which have been reactivated by Alpine geotectonic processes. These faults efficiently drain the groundwater, resulting in a very limited number of surface discharge points, even in areas with slight topographic elevations. It is probable that the groundwater in this area is associated with a shallow, cover-type circulation system [5, 9].

Consequently, the yield of many groundwater sources is directly influenced by the topographic ruggedness, particularly the ratio between the elevations of positive landforms and their bases. Groundwater levels are strongly controlled by the local topography. In low-lying areas, groundwater can be accessed via wells and boreholes at depths of 1 to 3 meters, or it may emerge as springs. In higher terrain, groundwater is found at much greater depths, often extending to several tens of meters.

Granite formations are considered the most auriferous, followed by limestones and, to a lesser extent, sandstones. The substantial water-bearing capacity of these rocks is closely linked to fault zones and is largely dependent on the density, size, and degree of openness of fractures.

The groundwater system in the area can be classified into several distinct aquifers, including those within Quaternary alluvial deposits, Devonian and Carboniferous strata, Ordovician formations, and various-aged intrusions. Groundwater in these aquifers is typically unconfined and is generally found at shallow depths, ranging from 0.8 to 10 meters, and occasionally reaching 13 to 30 meters.

The water-bearing potential of intrusive rocks is primarily dependent on the structural integrity of the massif, the extent of neotectonics activity, and the distance from the watershed, which together determine the type and extent of fracturing. Groundwater in this area is particularly saline. Mineralization levels range from 1 to 3 g/L.

Due to the area's largely unexplored hydrogeological characteristics, the dynamics of groundwater flow remain uncertain.

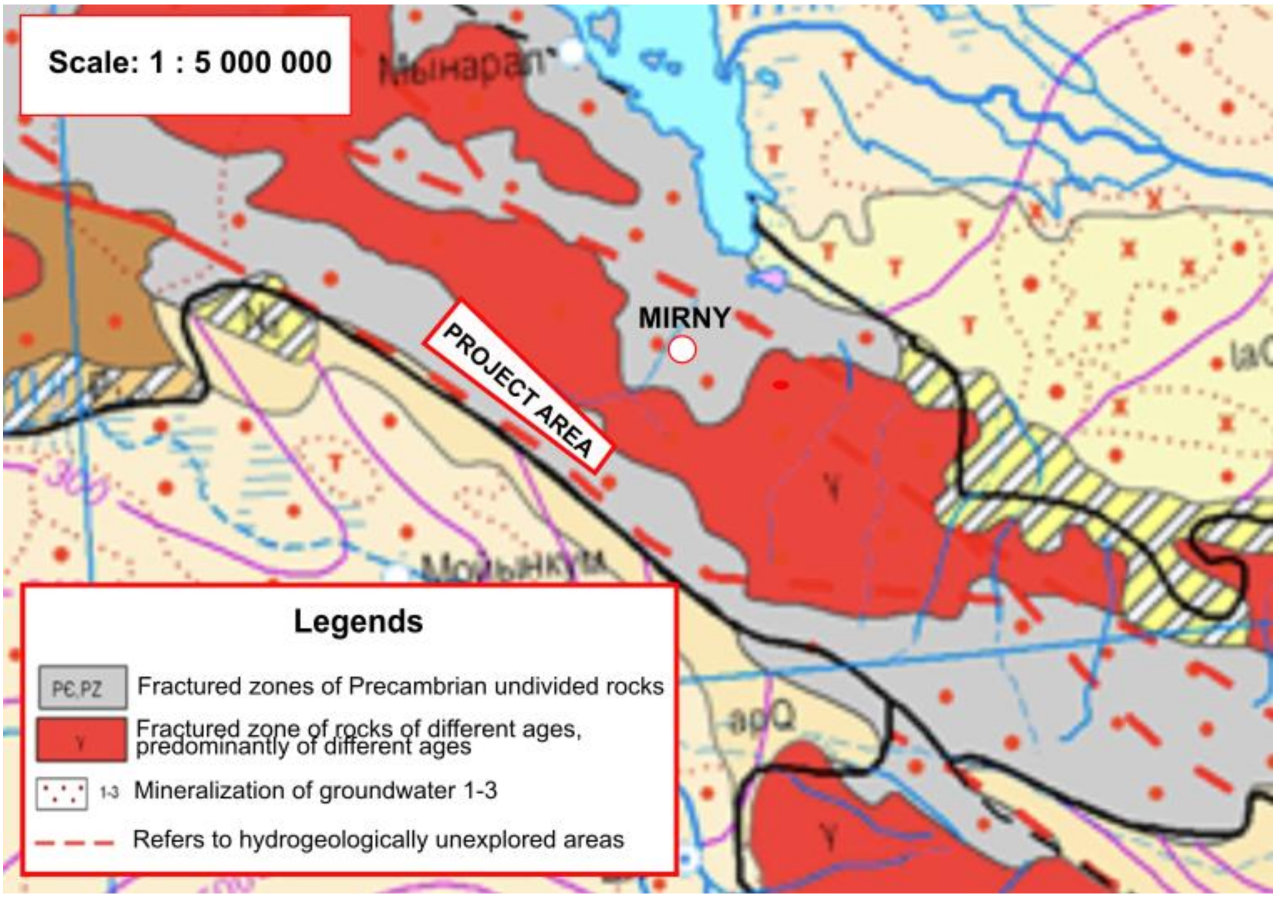


Figure 28: Project Site Area on Hydrogeological Map of Kazakhstan.

4.8.4 Groundwater in the Project area

Groundwater samples were collected from existing wells drilled for local herders' camps, situated within the Project site area. These wells serve as sources for domestic water supply. All the wells are equipped with electric pumps served by generators fed by diesel fuel. The following table and figures detail the coordinates of the groundwater wells and their locations and provide a few notes on the sampling activities and conditions.

Table 8: Groundwater Sampling Points Locations

Sample ID	Location	Coordinates		Photographs	Notes
		X	Y		
Groundwater Well #1	Project area	44°30'48.20"N	73°32'48.10"E		The well is in a mountainous area. According to the herder, the depth of the well is approximately 2-3 meters.
Groundwater Well #2	Project area	44°43'11.00"N	73°24'2.80"E		According to the herder, the depth of the well is approximately 3-4 meters. During the visual inspection (as shown in the photo), the well surfaces were contaminated with biological surface substances. However, the samples were taken using a pump that is submerged much deeper, where the water is assumed to be cleaner than at the surface.
Groundwater Well #3	Project area	44°39'1.10"N	73°29'2.70"E		According to the herder, the depth of the well is approximately 4-4,5 meters. During the visual inspection, the well surfaces were contaminated with biological surface substances. However, the samples were taken using a pump that is submerged much deeper, where the water is expected to be cleaner than at the surface.

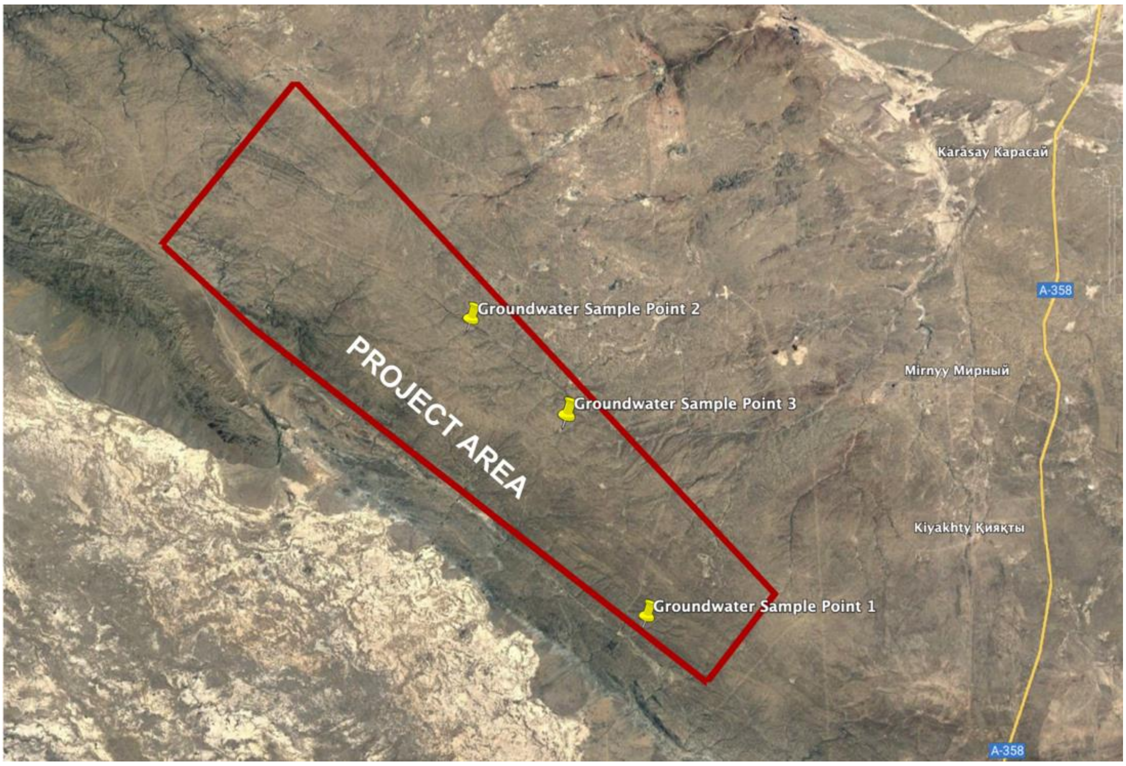


Figure 29: Groundwater Sampling Points within Project Site Area

The following tables provide the results of the groundwater sampling and analysis conducted on site on the water wells Well #1, Well #2 and Well #3. The Maximum Allowable Concentrations (MAC) of the following tables are adopted according to the Hygienic Standards for Safety Indicators of Domestic-Drinking and Cultural-Household Water Use, approved by the Order of the Minister of Health of the Republic of Kazakhstan dated November 24, 2022, No. ҚР ДСМ-138" [7].

Table 9: Groundwater Well #1 Lab Testing Results.

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Metals					
Aluminum (Al)	mg/dm³	0,118	0,5	Drinking Water	0,24
Potassium (K)	mg/dm³	<0,1	0,1	Domestic Water Bodies	<1
Copper (Cu)	mg/dm³	0,05	1	Drinking Water	0,05
Chromium (Cr)	mg/dm³	<0,01	0,05	Drinking Water	<0,2
Zinc (Zn)	mg/dm³	0,14	5	Drinking Water	0,03
Nickel (Ni)	mg/dm³	0,01	0,01	Drinking Water	1
Iron (Fe)	mg/dm³	0,02	0,3	Drinking Water	0,07
Manganese (Mn)	mg/dm³	0,7	0,5	Drinking Water	**1,4**
Barium (Ba)	mg/dm³	<0,2	0,1	Drinking Water	**<2**

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Silicon (Si) & Compounds	mg/dm^3	<0,0023	10	Drinking Water	<0,00023
Boron (B)	mg/dm^3	0,364	0,5	Drinking Water	0,73
Mercury (Hg)	mg/dm^3	<0,0001	0,0005	Drinking Water	<0,2
Arsenic (As)	mg/dm^3	<0,001	0,05	Drinking Water	<0,0002
Cadmium (Cd)	mg/dm^3	<0,0001	0,001	Drinking Water	<0,1
Lead (Pb)	mg/dm^3	<0,0001	0,03	Drinking Water	<0,003
Thorium (Th)	mg/dm^3	<0,0001	None	None	–
Gold (Au)	mg/dm^3	<0,001	None	None	–
Inorganic Ions					
Bicarbonate (HCO_3^-)	mg/dm^3	396	400	Drinking Water	0,99
Chloride (Cl^-)	mg/dm^3	107	305	Drinking Water	0,35
Sulfate (SO_4^{2-})	mg/dm^3	93	500	Drinking Water	0,19
Phosphate (PO_4^{3-})	mg/dm^3	1,59	3,5	Drinking Water	0,45
Sodium (Na)	mg/dm^3	564	200	Drinking Water	**2,82**
Other					
Ammonium-N (NH_4^+-N)	mg/dm^3	0,11	0,5	Fishery Water Bodies	0,22
Nitrate (NO_3^-)	mg/dm^3	2,5	45	Drinking Water	0,06
Nitrite (NO_2^-)	mg/dm^3	0,023	3,3	Domestic Water Bodies	0,01
Petroleum Hydrocarbons	mg/dm^3	<0,01	0,1	Drinking Water	<0,1
Suspended Solids (SS)	mg/dm^3	6	0,25	Drinking Water	**24**
Biochemical Oxygen Demand (BOD_5)	mgO_2/dm^3	2,5	3	Domestic Water Bodies	0,83
Chemical Oxygen Demand (COD)	mgO_2/dm^3	8,3	15	Drinking Water	0,55
Hardness (Ca, Mg)	mg-eq/L	5	7	Drinking Water	0,71
Permanganate Oxidizability	mg/dm^3	2,6	5	Drinking Water	0,52
Microbial Indicators					
Total Microbial Count	Microbial count/ml	125 CFU/ml detected	Not more than 50 CFU/ml	Drinking Water	**2,5**

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Total Coliform Bacteria	100.0 ml	3 CFU/ml detected	Absence in 100 ml	Drinking Water	**Detected**
Thermotolerant Coliform Bacteria	100.0 ml	2 CFU/ml detected	Absence in 100 ml	Drinking Water	**Detected**

Below is the summary of groundwater conditions encountered at Well #1:

- The concentrations of Manganese, Sodium, and Suspended Solids exceed their respective MACs by factors of 1.40, 2.82, and 24.00, respectively.
- Barium could potentially exceed the MAC by a factor of up to 2.
- These exceedances indicate significant concerns for the suitability of the water for drinking without proper treatment.
- The microbial analysis shows that the Total Microbial Count is 125 CFU/ml, exceeding the MAC of 50 CFU/ml, with a factor of 2.50.
- Presence of Coliform Bacteria (TCB 3 CFU/ml and Thermotolerant Coliform Bacteria (2 CFU/ml)) was detected, which must be absent in drinking water, indicating microbial contamination.

Table 10: Groundwater Well #2 Lab Testing Results.

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Metals					
Aluminum (Al)	mg/dm³	0,087	0,5	Drinking Water	0,17
Potassium (K)	mg/dm³	<0,1	0,1	Domestic Water Bodies	<1
Copper (Cu)	mg/dm³	0,39	1	Drinking Water	0,39
Chromium (Cr)	mg/dm³	<0,01	0,05	Drinking Water	<0,2
Zinc (Zn)	mg/dm³	0,57	5	Drinking Water	0,11
Nickel (Ni)	mg/dm³	0,03	0,01	Drinking Water	**3**
Iron (Fe)	mg/dm³	0,03	0,3	Drinking Water	0,1
Manganese (Mn)	mg/dm³	1	0,5	Drinking Water	**2**
Barium (Ba)	mg/dm³	<0,2	0,1	Drinking Water	**<2**
Silicon (Si) & Compounds	mg/dm³	<0,0023	10	Drinking Water	<0,00023
Boron (B)	mg/dm³	0,286	0,5	Drinking Water	0,57
Mercury (Hg)	mg/dm³	<0,0001	0,0005	Drinking Water	<0,2
Arsenic (As)	mg/dm³	<0,001	0,05	Drinking Water	<0,002
Cadmium (Cd)	mg/dm³	<0,0001	0,001	Drinking Water	<0,1

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Lead (Pb)	mg/dm³	<0,0001	0,03	Drinking Water	<0,003
Thorium (Th)	mg/dm³	<0,0001	None	None	-
Gold (Au)	mg/dm³	<0,001	None	None	-
Inorganic Ions					
Bicarbonate (HCO_3^-)	mg/dm³	262,3	400	Drinking Water	0,66
Chloride (Cl^-)	mg/dm³	100	305	Drinking Water	0,33
Sulfate (SO_4^{2-})	mg/dm³	97	500	Drinking Water	0,19
Phosphate (PO_4^{3-})	mg/dm³	0,16	3,5	Drinking Water	0,05
Sodium (Na)	mg/dm³	210	200	Drinking Water	**1,05**
Other					
Ammonium-N (NH_4^+-N)	mg/dm³	0,05	0,5	Fishery Water Bodies	0,1
Nitrate (NO_3^-)	mg/dm³	0,6	45	Drinking Water	0,01
Nitrite (NO_2^-)	mg/dm³	0,028	3,3	Domestic Water Bodies	0,01
Petroleum Hydrocarbons	mg/dm³	<0,01	0,1	Drinking Water	<0,1
Suspended Solids (SS)	mg/dm³	<5,0	0,25	Drinking Water	**<20**
Biochemical Oxygen Demand (BOD_5)	mgO_2/dm³	5	3	Domestic Water Bodies	**1,67**
Chemical Oxygen Demand (COD)	mgO_2/dm³	13,1	15	Drinking Water	0,87
Hardness (Ca, Mg)	mg-eq/L	20	7	Drinking Water	**2,86**
Permanganate Oxidizability	mg/dm³	2,1	5	Drinking Water	0,42
Microbial Indicators					
Total Microbial Count	Microbial count/ml	86 CFU/ml detected	Not more than 50 CFU/ml	Drinking Water	**1,72**
Total Coliform Bacteria	100.0 ml	2 CFU/ml detected	Absence in 100 ml	Drinking Water	**Detected**
Thermotolerant Coliform Bacteria	100.0 ml	2 CFU/ml detected	Absence in 100 ml	Drinking Water	**Detected**

Below is the summary of groundwater conditions encountered at Well #2:

- The concentrations of Nickel, Manganese, Sodium, Barium and Suspended Solids exceed their respective MACs by factors of 3.00, 2.00, 1.05, up to 2, up to 20, respectively, while BOD_5 and Hardness (Ca, Mg) also surpass their limits with factors of 1.67 and 2.86.
- These exceedances indicate significant concerns for the suitability of the water for drinking without proper treatment.
- The microbial analysis shows that the Total Microbial Count is 86 CFU/ml, exceeding the MAC of 50 CFU/ml, with a factor of 1.72. Additionally, the presence of Total Coliform Bacteria (2 CFU/ml) and Thermotolerant Coliform Bacteria (2 CFU/ml) was detected, which must be absent in drinking water, indicating microbial contamination.

Table 11: Groundwater Well #3 Lab Testing Results.

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Metals					
Aluminum (Al)	mg/dm³	0,067	0,5	Drinking Water	0,13
Potassium (K)	mg/dm³	<0,1	0,1	Domestic Water Bodies	<1
Copper (Cu)	mg/dm³	0,07	1	Drinking Water	0,07
Chromium (Cr)	mg/dm³	<0,01	0,05	Drinking Water	<0,02
Zinc (Zn)	mg/dm³	0,1	5	Drinking Water	0,02
Nickel (Ni)	mg/dm³	0,01	0,01	Drinking Water	**1**
Iron (Fe)	mg/dm³	0,06	0,3	Drinking Water	0,2
Manganese (Mn)	mg/dm³	0,9	0,5	Drinking Water	**1,8**
Barium (Ba)	mg/dm³	<0,2	0,1	Drinking Water	**<2**
Silicon (Si) & Compounds	mg/dm³	<0,0023	10	Drinking Water	<0,00023
Boron (B)	mg/dm³	0,631	0,5	Drinking Water	**1,26**
Mercury (Hg)	mg/dm³	<0,0001	0,0005	Drinking Water	<0,02
Arsenic (As)	mg/dm³	<0,001	0,05	Drinking Water	<0,02
Cadmium (Cd)	mg/dm³	<0,0001	0,001	Drinking Water	<0,1
Lead (Pb)	mg/dm³	<0,0001	0,03	Drinking Water	<0,003
Thorium (Th)	mg/dm³	<0,0001	None	None	-
Gold (Au)	mg/dm³	<0,001	None	None	-
Inorganic Ions					
Bicarbonate (HCO_3^-)	mg/dm³	530,7	400	Drinking Water	**1,33**
Chloride (Cl^-)	mg/dm³	27	305	Drinking Water	0,09

Parameter	Measurement Unit	Testing Results	MAC	Type of MAC	Factor
Sulfate (SO_4^{2-})	mg/dm³	104	500	Drinking Water	0,21
Phosphate (PO_4^{3-})	mg/dm³	0,12	3,5	Drinking Water	0,03
Sodium (Na)	mg/dm³	1141	200	Drinking Water	**5,71**
Other					
Ammonium-N (NH_4^+-N)	mg/dm³	0,06	0,5	Fishery Water Bodies	0,12
Nitrate (NO_3^-)	mg/dm³	0,2	45	Drinking Water	0,004
Nitrite (NO_2^-)	mg/dm³	0,008	3,3	Domestic Water Bodies	0,002
Petroleum Hydrocarbons	mg/dm³	<0,01	0,1	Drinking Water	<0,01
Suspended Solids (SS)	mg/dm³	<5,0	0,25	Drinking Water	**<20**
Biochemical Oxygen Demand (BOD_5)	mgO_2/dm^3	2,2	3	Domestic Water Bodies	0,73
Chemical Oxygen Demand (COD)	mgO_2/dm^3	6,5	15	Drinking Water	0,43
Hardness (Ca, Mg)	mg-eq/L	11	7	Drinking Water	**1,57**
Permanganate Oxidizability	mg/dm³	1,2	5	Drinking Water	0,24
Microbial Indicators					
Total Microbial Count	Microbial count/ml	86 CFU/ml detected	Not more than 50 CFU/ml	Drinking Water	**1,72**
Total Coliform Bacteria	100.0 ml	5 CFU/ml detected	Absence in 100 ml	Drinking Water	**Detected**
Thermotolerant Coliform Bacteria	100.0 ml	2 CFU/ml detected	Absence in 100 ml	Drinking Water	**Detected**

Below is the summary of groundwater conditions encountered at Well #3:

- The concentrations of Bicarbonate, Manganese, Hardness, Sodium, Suspended Solids, Barium and Boron exceed their respective MACs by factors of 1.33, 1.80, 1.57, 5.71, up to 20, up to 2 and 1.26, respectively.
- These exceedances are a concern for the suitability of the water for drinking without proper treatment.
- The microbial analysis shows that the Total Microbial Count is 86 CFU/ml, exceeding the MAC of 50 CFU/ml, with a factor of 1.72.
- Additionally, the presence of Total Coliform Bacteria (5 CFU/ml) and Thermotolerant Coliform Bacteria (2 CFU/ml) was detected, which must be absent in drinking water, indicating microbial contamination.

In order to adopt the most stringent threshold limit values, WSP considered the following Project standards:

- World Health Organization (WHO) Guidelines for drinking-water quality (4th edition 2022).

- Hygienic Standards for Safety Indicators of Domestic-Drinking and Cultural-Household Water Use, approved by the Order of the Minister of Health of the Republic of Kazakhstan dated November 24, 2022, No. ҚР ДСМ-138" (*Adilet.zan.kz. 2022 - О внесении изменений и дополнений в некоторые законодательные акты Республики Казахстан по вопросам защиты животных, On Amendments and Additions to Certain Legislative Acts of the Republic of Kazakhstan on Animal Protection*). Reference standard values considered consist of thresholds set for drinking water (almost all parameters), domestic water bodies (only K, NO2 and BOD5) and fishery water bodies (only NH4).

For further details, please refer to *Chapter 03 – Legal Requirements*.

The table below illustrates the results of the groundwater analysis by comparing them to the Project standards reference threshold limit values.

The values which exceeded the thresholds are marked in red.

Table 12: Groundwater sampling and analysis, results of the measured pollutants compared to the threshold limit values adopted as Project standards.

Parameters	Units	Project Standards	Parameters measured		
			Well #1	Well #2	Well #3
As Arsenic	µg/l	**10**	<1	<1	<1
Al Aluminium	µg/l	**200**	118	87	67
Ba Barium	µg/l	**100**	<200	<200	**<200**
B Boron	µg/l	**500**	364	286	**631**
Cd Cadmium	µg/l	**1**	<0.1	<0.1	<0.1
Cr Chromium	µg/l	**50**	<10	<10	<10
Cu Copper	µg/l	**1,000**	50	390	70
Fe Iron	µg/l	**300**	20	30	60
Pb Lead	µg/l	**10**	<0.1	<0.1	<0.1
Mn Manganese	µg/l	**80**	**700**	**1000**	**900**
Hg Mercury	µg/l	**0,5**	<0.1	<0.1	<0.1
Ni Nickel	µg/l	**10**	10	**30**	10
Th Thorium	Bq/l	**0**	<0.1	<0.1	<0.1
Zn	µg/l	**3,000**	140	570	100

Parameters	Units	Project Standards	Parameters measured		
			Well #1	Well #2	Well #3
Zinc					
Hardness (Calcium Ca and Magnesium Mg)	mg-eq/L	**7**	5	**20**	**11**
Na Sodium	µg/l	**200,000**	**564,000**	**210,000**	**1,141,000**
K Potassium	µg/l	**100**	<100	<100	<100
Cl Chloride	µg/l	**5,000**	**107,000**	**100,000**	**27,000**
HCO3 Bicarbonate	µg/l	**400,000**	396,000	262,300	**530,700**
SO4 Sulfate	µg/l	**500,000**	93,000	97,000	104,000
BOD Biochemical Oxygen Demand	µgO2/l	**3,000**	2,500	**5,000**	2,200
COD Chemical Oxygen Demand	µgO2/l	**15,000**	8,300	13,100	6,500
TSS Total Suspended Solids	µg/l	**250**	**6000**	**<5,000**	**<5,000**
TPH Petroleum Hydrocarbons	µg/l	**100**	<10	<10	<10
Total faecal coliform	µg/l	**0**	**Detected**	**Detected**	**Detected**
Phosphate	µg/l	**3,500**	1,590	160	120
Oxidizability	µg/l	**5,000**	2,600	2,100	1,200
Ammonium NH4	µg/l	**500**	110	50	60
Nitrate NO3	µg/l	**45,000**	2,500	600	200
Nitrogen Dioxide NO2	µg/l	**3,000**	23	28	8

In conclusion, the groundwater sampling and analysis campaign revealed exceedances of the Project standards threshold limit values for:

- WELL #1 – Manganese, Sodium, Chloride, Total Suspended Solids and Total faecal coliform;
- WELL #2 – Manganese, Nickel, Calcium and Magnesium (hardness), Sodium, Chloride, Biochemical Oxygen Demand, Total Suspended Solids and Total faecal coliform;
- WELL #3 – Barium, Boron, Manganese, Calcium and Magnesium (hardness), Sodium, Chloride, Bicarbonate, Total Suspended Solids and Total faecal coliform.

The following considerations apply:

- According to WHO standards, **Bicarbonate**, **Sodium** (in not excessive quantities), **Calcium** and **Magnesium** are considered not of major health concern when found in drinking-water;
- **Chloride** is a naturally occurring element that is common in most natural waters and is most often found as a component of salt (sodium chloride) or in some cases in combination with Calcium. The presence of chloride in groundwater can be due to soils weathering or salt sources, as in our case. Chloride is considered to be an essential nutrient for human health and its concentration in drinking water is not harmful, most concerns are related to the frequent association of high Chloride levels with excess of Sodium;
- **Manganese** is a common, naturally-occurring mineral – one of the most abundant metals in Earth's crust – and can be found in groundwater because of the dissolution of manganese oxides, silicates and carbonates within rocks and soil. Manganese is not a pollutant of major concern; however, according to United States Environmental Protection Agency, many years of exposure to high levels of manganese can cause harm to the nervous system;
- According to WHO, **Nickel** is a naturally occurring element. Nickel may leach from metal alloys that are in contact with the water. Specifically, the major source of nickel in drinking-water is due to its leaching from stainless steel devices or materials used in water supply systems or taps used in plumbing, particularly after periods of stagnation. Elevated Nickel amounts in drinking-water can also be natural and result from its mobilization from natural deposits in rocks and soils to groundwater. Human oral exposure to Nickel is primarily associated with gastrointestinal and neurological symptoms pus reproductive and developmental toxicity after acute oral exposure;
- **Boron** is classified as moderate to high toxic element in the aquatic environment. Its presence can be due to both natural and anthropogenic sources, specifically to the weathering of igneous rocks and leaching from sedimentary deposits and to agricultural runoff (Boron is minor constituent in fertilizers or pesticides) or sewage effluents (Boron is also found in detergents);
- **Barium** occurs in various compounds in the environment either naturally or from human activities. Barium is used in a wide array of products, such as fertilizers and pesticides. Naturally occurring barium can be found in most types of rocks and can enter surface and groundwater by leaching and eroding from sedimentary rocks. The U.S. Environmental Protection Agency concluded that Barium is not likely to be carcinogenic to humans from exposure through ingestion. Other studies have found links between the ingestion of barium and adverse effects on kidneys and blood pressure;
- **Total Suspended Solid** are often found in groundwater due to natural causes and are related to the turbidity (cloudiness) of the groundwater. The solids might include organic materials – such as algae or human waste, due to the lack of a wastewater treatment and collection system – and inorganic materials such as silt and sediment. The high turbidity detected in the groundwater wells might be also due to the wells characteristics or the sampling system adopted (i.e., lack of properly functioning pumping mechanism or lifting device to remove the water presenting high turbidity and debris content before starting the sampling);
- High levels of **Biochemical Oxygen Demand** are key indicators of organic pollution in water, confirmed by the detected **Total faecal coliform**.

Such high concentrations of pollutants detected in the local groundwater are likely due to the following aspects:

- Jambyl region's extensive industrial and agricultural activities (see section 4.8.2);
- Absence of a proper wastewater/sewage water collection and treatment system in and around the Project area;
- Use of salty water to fill the former uranium mines voids;

- Type of soils and local lithology.

The pollutants detected/measured do not influence the use of groundwater for construction and operation purposes; however, their concentrations imply that the groundwater must not be used for drinking purposes (is not potable) because the groundwater contains pollutants of major concern for human health.

4.9 Ambient Air Quality

As of 2023, according to the Department of Statistics of Jambyl region, total pollutant emissions from stationary sources in the Jambyl Region reached 55.8 thousand tons. In the city of Taraz alone, these emissions amounted to 29.2 thousand tons. The Region has 259.5 thousand vehicles, with an annual growth of 36.9 thousand units. In terms of residential heating, 99.6% of private homes across the Region use gas. These homes include 36,474 in Taraz, 1,439 in Zhanatas, 3,185 in Karatau, and 6,650 in Shu [56].

There are no air quality monitoring stations operated by the National Hydrometeorological Service "Kazhydromet" in the immediate vicinity of the Project area and in the Moiynkum district generally, meaning no local air pollution data is available. The closest monitoring station is located in the Shu town, about 100 km from the Project area. Although the impact on Shu is negligible, it lies within the area affected by the construction of OHTL toward the Shu substation. Therefore, the air quality data from Shu are considered somewhat relevant [56]. In Shu town, air quality is continuously monitored every 20 minutes at an automatic station near the city hospital. Eight key indicators are measured, including PM 2.5, PM 10, sulfur dioxide, carbon monoxide, nitrogen dioxide, nitrogen oxide, ground-level ozone, and hydrogen sulfide.

In 2023, Shu's air quality was classified as "low" based on the atmospheric pollution index (API5=3.7), with a 1% occurrence of elevated pollution levels. The most significant contributor was nitrogen dioxide, with 139 exceedances of the maximum allowable concentration (MAC). Maximum one-time concentrations reached 1.7 MAC for nitrogen dioxide, 1.4 MAC for hydrogen sulfide, 1.3 MAC for carbon monoxide, and 1.1 MAC for ground-level ozone. Other pollutants remained below their respective MACs. Exceedances of daily average standards were observed for sulfur dioxide (1.4 MAC) and nitrogen dioxide (1.3 MAC). No cases of extremely high or high pollution were recorded (values exceeding 10 MAC or 50 MAC). The specific values, the magnitude of exceedances, and the number of incidents are detailed in the table below.

Table 13: Characteristics of atmospheric air pollution in the Shu town (2023).

Impurity	Average concentration		Maximum one-time concentration		HO	Number of exceedances of the maximum one-time concentration (MAC)		
	mg/m^3	Exceedance of MAC (average daily limit)	mg/m^3	Exceedance of MAC (maximum one-time concentration)	%	> MAC	>5 MAC	>10 MAC
							Including	
PM 2.5	0,001	**0,04**	0,003	**0,02**	0,00	0	0	0
PM 10	0,001	**0,02**	0,002	**0,01**	0,00	0	0	0
Sulphur dioxide	0,068	**1,36**	0,398	**0,80**	0,00	0	0	0
Carbon monoxide	0,36	**0,12**	6,66	**1,33**	0,08	22	0	0
Nitrogen dioxide	0,05	**1,32**	0,34	**1,69**	0,91	139	0	0
Nitrogen oxide	0,02	**0,25**	0,37	**0,92**	0,00	0	0	0
Ozone (ground-level)	0,02	**0,79**	0,17	**1,09**	0,05	13	0	0

Impurity	Average concentration		Maximum one-time concentration		HO	Number of exceedances of the maximum one-time concentration (MAC)		
	mg/m³	Exceedance of MAC (average daily limit)	mg/m³	Exceedance of MAC (maximum one-time concentration)	%	> MAC	>5 MAC	>10 MAC
							Including	
Hydrogen sulphide	0,001		0,011	**1,35**	0,75	33	0	0

The Project area is situated on greenfield, predominantly used for grazing livestock. The primary emission sources in the vicinity include medium-scale mining operations, located at a significant distance from the Project site, consisting mainly of small granite extraction quarries. Anthropogenic emissions are primarily generated by earthmoving activities and the movement of vehicles and machinery on unpaved roads. A granite processing plant in the Sholpan village, 15 km to the south of the Project site, also contributes emissions, although its impact on local air quality is negligible. Among the large industrial operations is the Akbakay Gold Mining Plant, located 50 km far to the north of the Project area. The Mirny-Akbakay paved road was constructed to serve this plant, but traffic remains low, largely consisting of heavy trucks and specialized equipment. More substantial traffic is observed on the A-358 "Burybaital (Merke" highway), located 20 km southeast of the Project area. To the east, the "Moiynty – Shu" railway provides both passenger and freight railway transport, with a small rail spur extending towards the Sholpan village granite processing facility.

Regarding the air emissions receptors at Project area, the residential areas are located at considerable distances from it, with the nearest settlements being the Kiyakty village (approximately 20 km away) and the Mirny village (approximately 25 km away). Additionally, nomadic shepherds or any other seasonal farmers and animals potentially crossing the Project area, may also be temporarily exposed to atmospheric emissions caused by the planned construction activities of the Wind power plant; however, these will be limited in time and in their amounts.

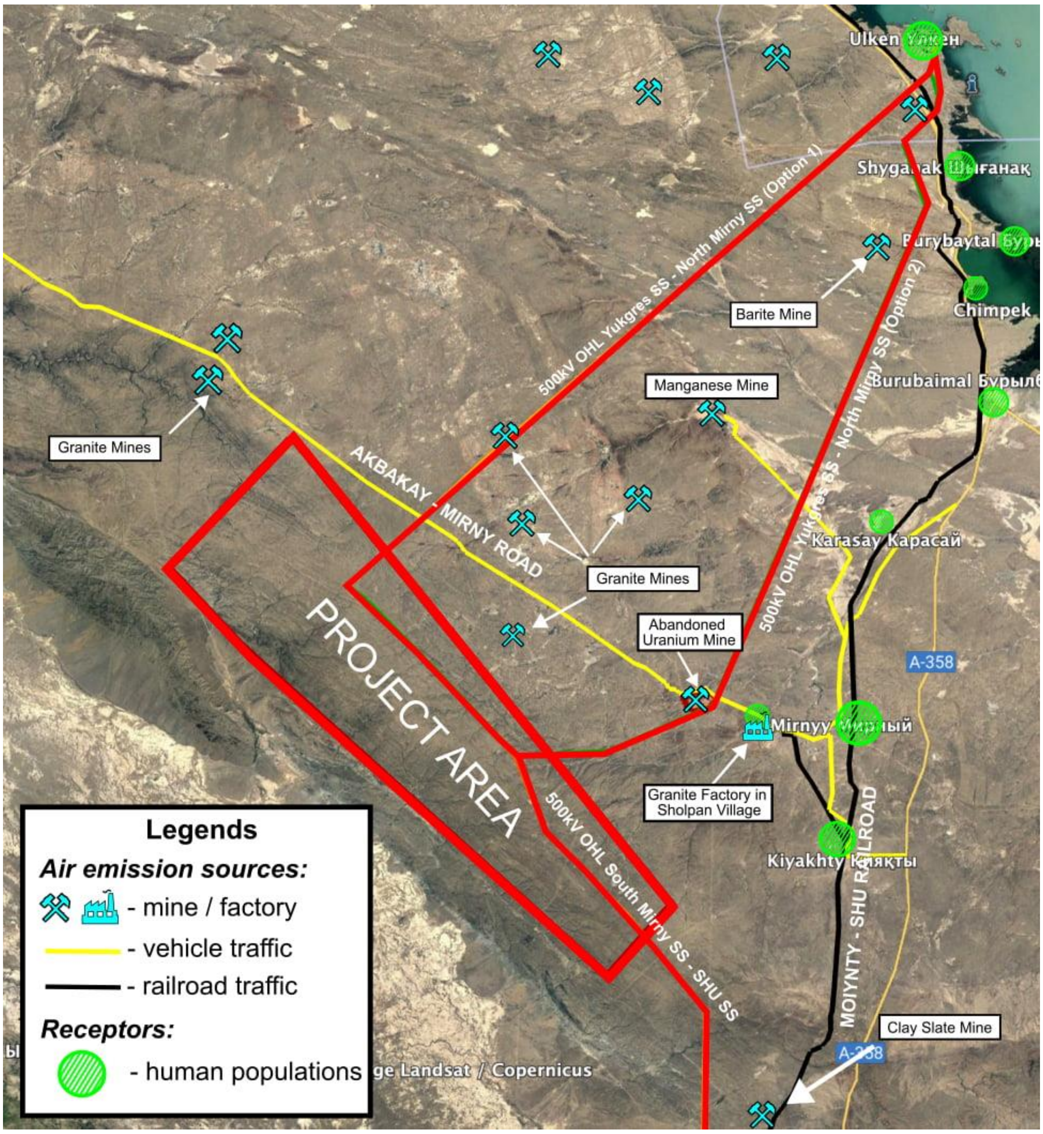


Figure 30: Air emission sources and receptors at Project Site area.

4.10 Ambient Noise

The Project Site area is uninhabited and there are no anthropogenic sources of noise. Three noise measurement points were established within the Project area, evenly covering the whole perimeter (see the figure below).

On July 9, 2024, noise levels were measured by the Testing Laboratory of Ecoservice-S LLP (Accreditation Certificate No. KZ.T.02.E0122, dated April 6, 2021), under the supervision of WSP representative Abat Amankul. The measurements were conducted using the "ASSISTANT SIU V3" Class 1 precision sound level meter, complied with GOST ISO 9612–2016 and GOST 12.1.003-2014 standards.

During the assessment, environmental noise was primarily influenced by strong gusty winds and insects activity, with no anthropogenic sources detected. The noise exhibited a broadband spectrum and intermittent characteristics.

The Project will be scrutinised by Kazakh authorities and will require to be permitted before construction can commence.

Ambient noise investigations have been conducted and are summarized in Table 15.

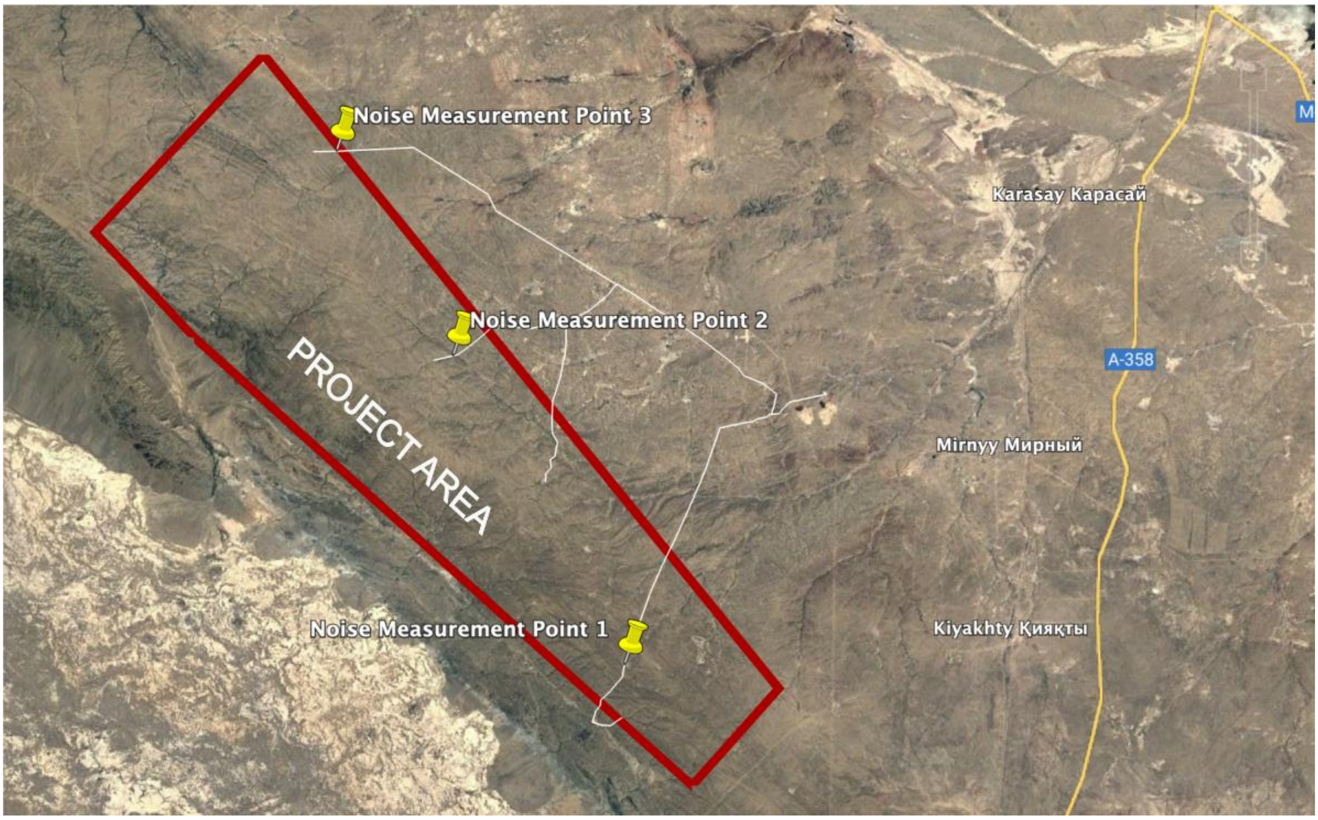
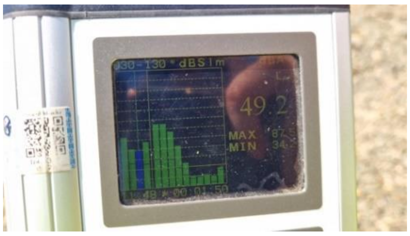


Figure 31: Noise Measurement Points at Project Site Area

The table below illustrates the details of the noise assessment conducted onsite.

Table 14: Noise monitoring points locations and observations

Sample ID	Location	Coordinates		Photographs	Site observation notes
		X	Y		
Noise Measurement Point #1	Project area	44°32'40.04"N	73°32'55.10"E		During the measurements, noise levels were primarily influenced by strong gusty winds and, to a lesser extent, the sounds of insects. No anthropogenic noise sources were observed.
Noise Measurement Point #2	Project area	44°43'18.00"N	73°24'34.47"E		During the measurements, noise levels were primarily influenced by strong gusty winds and, to a lesser extent, the sounds of insects. No anthropogenic noise sources were observed.

Sample ID	Location	Coordinates		Photographs	Site observation notes
		X	Y		
Noise Measurement Point #3	Project area	44°50'20.10"N	73°18'52.63"E		During the measurements, noise levels were primarily influenced by strong gusty winds and, to a lesser extent, the sounds of insects. No anthropogenic noise sources were observed.

The results of the noise measurements are detailed in the following table.

Table 15: Summary of noise measurement results

Monitoring Period	L_{min} dB	L_{max} dB	$L_{AVERAGE}$dB
Noise Measurement Point #1			
Average			
Daytime (9 July 2024 – 10:30)	32 dB	49 dB	40 dB
Noise Measurement Point #2			
Average			
Daytime (9 July 2024 – 12:30)	35 dB	50 dB	43 dB
Noise Measurement Point #3			
Average			
Daytime (9 July 2024 – 15:30)	39 dB	50 dB	43,8 dB

Considering the threshold values set in WB EHS General Guidelines for the industrial/commercial environment the maximum allowed value is of 70 LAeq [dB] for both nighttime and daytime), the baseline noise is not considered an issue for the workers that will be involved in Project construction activities on site. Considering the thresholds for residential and public buildings, which are 55 dBA during the day and 45 dBA at night, the noise is also not considered as an issue for potential seasonal farmers/herders. No major sources of noise have been identified.

4.11 Waste Management Practices and Infrastructure

4.11.1 Waste management regulations in Kazakhstan

Waste management in Kazakhstan is regulated by the following laws and regulations:

- Environmental Code of the Republic of Kazakhstan dated January 2, 2021, No. 400-VI;
- Order of the Acting Minister of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan dated August 9, 2021, No. 318 'Rules for the Development of a Waste Management Plan;
- Waste Classifier. Approved by the Acting Minister of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan on August 6, 2021, No. 314; and
- Sanitary rules 'Sanitary-epidemiological requirements for the collection, use, application, neutralization, transportation, storage, and disposal of production and consumption waste' (approved by the Order of the Minister of Health of the Republic of Kazakhstan dated December 25, 2020, No. ҚР ДСМ-331/2020)".

In accordance with Article 329 of the Environmental Code of the Republic of Kazakhstan, waste generators and owners are required to follow a hierarchy of measures to minimize waste generation and to manage existing waste. This hierarchy, listed in decreasing order of preference to promote environmental protection and sustainable development, includes:

1) Waste prevention;
2) Preparation of waste for reuse;
3) Waste recycling;
4) Waste recovery;
5) Waste disposal.

For the operations outlined in points 2 through 5, waste generators and owners may, when necessary, engage in supplementary activities such as sorting, processing, and storage.

Waste prevention encompasses actions taken prior to a material, substance, or product becoming waste for:

- Reducing the volume of waste generated (for example, by reusing products or prolonging their service life);
- Minimizing the harmful effects of waste on the environment and human health;
- Lowering the content of hazardous substances in materials or products;
- Reuse refers to any activity in which products or components that have not yet turned into waste but are utilized again for the same purpose for which they were originally intended.

When such measures cannot be implemented, waste must be subject to recycling processes.

Waste that cannot be recycled must be safely disposed of in accordance with the provisions of Article 327 of the Environmental Code.

In applying the waste hierarchy, the precautionary principle, the principle of sustainable development, technical feasibility, economic practicality, as well as the overall impact on the environment, human health, and socio-economic development, must be considered.

4.11.2 Waste management practices and infrastructure in the Project area

During the construction phase of a wind farm, the following hazardous and non-hazardous waste are likely generated:

- Non-hazardous - Construction debris such as soil, sand, concrete, and metal scrap and packaging materials like plastic, wood, cardboard. etc.;
- Hazardous - Waste from electrical components, such as cables and electronic parts, lubricants, paints, solvents, etc..

In Mirny there is a municipal solid waste landfill; however, given its operational status, the potential use of it need to be discussed in advance with the local akimat.

As for liquid waste, the construction of a wind farm will likely generate hazardous materials like oils and chemicals, as well as wastewater from equipment cleaning and domestic wastewater from worker facilities.

At the Project area exists no sewage system, so the Company will likely option for septic tanks or other similar systems to manage these liquid wastes.

Liquid household waste of the area is generally transported by specialized companies using vacuum trucks to the nearest disposal sites.

The possibility of using such services should be coordinated with the local akimat.

4.12 Energy Sources

Kazakhstan's energy system is divided into three main zones: North, South, and West.

The North and West zones are technologically connected to the Russian power grid, while the South zone maintains links with the Central Asian power systems.

Most of Kazakhstan's electricity production is located in the northern regions, where major coal-fired power plants and hydropower plants are situated. In contrast, the southern regions have limited energy sources, primarily small hydroelectric stations and the Jambyl GRES (i.e., state regional power plant) located in Taraz city, which runs on fuel oil.

Consequently, the surplus of electricity is transmitted from the northern regions to the southern regions via the "North-South" power lines.

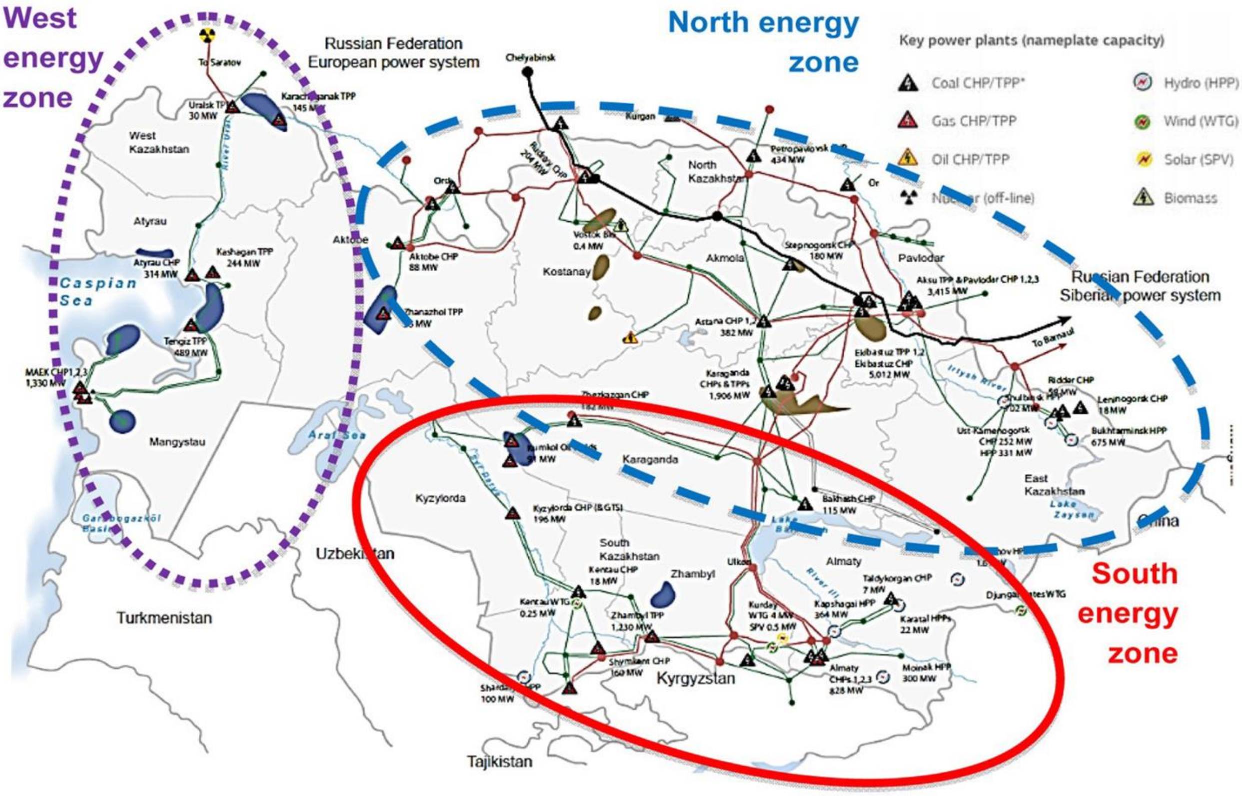


Figure 32: Energy zones of Kazakhstan (Source: Temirgaliyeva, N. and Junussova, M. (2020). Renewable Electricity Production and Sustainability of the National and Regional Power Systems of Kazakhstan. Silk Road: A Journal of Eurasian Development [60]).

The Jambyl Region is a top player in Kazakhstan in terms of the number and capacity of renewable energy projects. As of 2024, there are 9 wind, 6 hydro, and 6 solar power plants in the Jambyl Region, with a total capacity exceeding 450 MW. This accounts for 20 percent of the total 'green energy' generated in the country and 30 percent of the total electricity produced in Jambyl. According to the Ministry of Energy of Kazakhstan, by 2030, it is planned to increase the number of all renewable energy sources facilities in the Jambyl Region from 21 to 32, and their total capacity from 451 MW to 2.4 GW, which is a fivefold increase [8].

Due to the ongoing issue of energy shortages in Kazakhstan, the construction of the country's first nuclear power plant is being considered alongside development of renewable energy sources. The projected balance of electrical capacity for 2024–2030 shows a significant power deficit of up to 6.2 GW by 2030. In June 2022, Kazakhstan's Ministry of Energy announced that the Ulken village, located on the shores of Lake Balkhash, was chosen as the site for the nuclear power plant. The Ulken village is close to the Project area, 70 km to the northeast. This location is considered a priority by the authorities because it lies within the "North-South" transmission line zone and is close to major consumers in the southern Region of the country. On August 22, 2023, in Ulken village, Kazakhstan Nuclear Power Plants LLP and the akimat of the Zhambyl district of the Almaty Region held a public discussion aimed at gauging local residents' attitudes toward the construction of a nuclear power plant in their area. The villagers of Ulken expressed support for the construction of a nuclear power plant in Kazakhstan during the public hearings. However, several public groups and a considerable number of independent experts oppose the construction of a nuclear power plant in Kazakhstan. On September 1, 2023, President Kassym-Jomart Tokayev proposed putting the question to a nationwide referendum. The referendum on the use of nuclear energy in Kazakhstan held on the 6 October 2024 [57, 58, 59] was approved by a majority of voters.

4.13 Natural Radioactivity and Radiation Study

According to the information retrieved, there are two decommissioned uranium mines located close to the site. WSP team while conducting the Scoping Phase visit saw banners and signs warn about radiation hazard.

The typical radiological releases from underground uranium mines are radon and radon progeny, and water and dust radioactively contaminated by uranium.

No publicly available information was found regarding the existence of radon or uranium in the soil, water or air-suspended dust of the Project site. Moreover, considering that no information was made available regarding how the uranium mines excavated materials and waste have been managed (i.e., where and how have been temporarily accumulated), WSP has undertaken an environmental radiological survey for understating the prevailing radiation levels.

The German company IAF-Radioökologie GmbH ("IAF") conducted the Radiation Survey on behalf of WSP together with the accredited radiological laboratory WISUTEC.

The results of the study indicate very poor radiological activity in the Project area that is not considered to pose any risk to human health.

The Natural Radioactivity and Radiation study conducted onsite is presented in **APPENDIX A**.

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