GeoResource Development Service Consultant Co.

TOPOGRAPHIC AND GEOTECHNICAL FINAL REPORT FOR WESCO PLANT-KISMAYO DISTRICT, LOWER JUBBA REGION, JUBBALAND STATE-SOMALIA

GeoResource Techniques and tools:
Integration of Remote sensing, GIS, and geophysical techniques to delineate Natural Resource.

Client: Waamo Energy Service Compony (WESCO)

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Executive summary:

The Geo-Resources Development Services Consultant Co., commissioned by the WAAMO Energy Service Company (WESCO), has conducted a topographic and geotechnical assessment of the proposed WESCO Solar Plant site in Kismayo, Somalia. This report presents the findings of that assessment. The assessment was conducted to identify and characterize the physical features of the site, assess the suitability of the site for solar development, and identify and evaluate potential geotechnical hazards.

The topographic survey showed that the site is relatively flat, with a gradual slope from west to east. The elevation ranges from 29.06 meters to 31.03 meters. The soil conditions are also good, with a high bearing capacity and low permeability.

The geotechnical investigation revealed that the soil at the site is coarse sand, with no plasticity and no chemicals or minerals. The general appearance of the soil is hard, with rock starting at a depth of 5-15 centimeters below the fine sand.

Based on the findings of the assessment, the site is suitable for the construction of a solar plant. The following recommendations are made:

- The solar panels should be installed on the east-facing side of the site, considering the slope of the site.
- A drainage system should be installed to collect and divert stormwater (in south and east directions) away from the solar panels.
- The soil should be compacted and graded to create a smooth and level surface for the solar panels, especially in the areas with gentle and relative slope.

Overall, the WESCO Solar Plant site is a good location for the development of a solar plant. The site is relatively flat, with good soil conditions and a low risk of geotechnical hazards.

1 Introduction

1.1 Purpose of the Assessment

The purpose of a topographic and geotechnical assessment for a solar plant development project in Somalia is to:

- Identify and characterize the physical features of the site. This includes the topography, geology, soils, and groundwater conditions.
- Assess the suitability of the site for solar development. This includes evaluating the site's slope, aspect, solar radiation potential, and other factors that may impact the project's feasibility.
- Identify and evaluate potential geotechnical hazards. This includes hazards such as flooding, landslides, and liquefaction.
- Develop recommendations for mitigation measures and foundation design. This information is essential for ensuring the safe and reliable operation of the solar plant.

Overall, the purpose of the topographic and geotechnical assessment is to provide the information necessary to make informed decisions about the feasibility, design, and construction of the solar plant project.

1.2 Scope of the Assessment

The scope of the topographic and geotechnical assessment for a solar plant development project in Somalia will typically include the following:

Topographic Survey

- Site survey: This involves surveying the entire site to create a detailed topographic map of the area. The survey will include the following:
    - Establishing survey control points
    - Measuring the elevation of the ground at various points throughout the site
    - Identifying and mapping any natural or man-made features on the site
- Digital elevation model (DEM) of the site. The DEM can be used to generate contour maps, slope maps, and other topographic data.

Geotechnical Investigation

- Subsurface exploration: This involves drilling boreholes into the ground to collect soil samples. The soil samples will be tested in a laboratory to determine their engineering properties.

- Laboratory testing: The laboratory testing will include the following:
    - Grain size analysis
    - Atterberg limits testing
    - Determination of flakiness index
    - Specific gravity and water absorption
- Geotechnical characterization: The geotechnical characterization will involve analyzing the soil test results to determine the geotechnical properties of the site. This information will be used to assess the suitability of the site for solar development and to develop recommendations for foundation design and other geotechnical engineering considerations.

1.3 Site Location and Description

Kismayo is a port city in the southern Lower Juba (Jubbada Hoose) province of Somalia. It is the commercial capital of the autonomous Jubaland region. The geographical coordinates of the town are 0° 21′ 29″ S and 42° 32′ 43″ E. The city is situated 528 kilometres (328 miles) southwest of Mogadishu, near the mouth of the Jubba River, where the waters empty into the Indian Ocean.

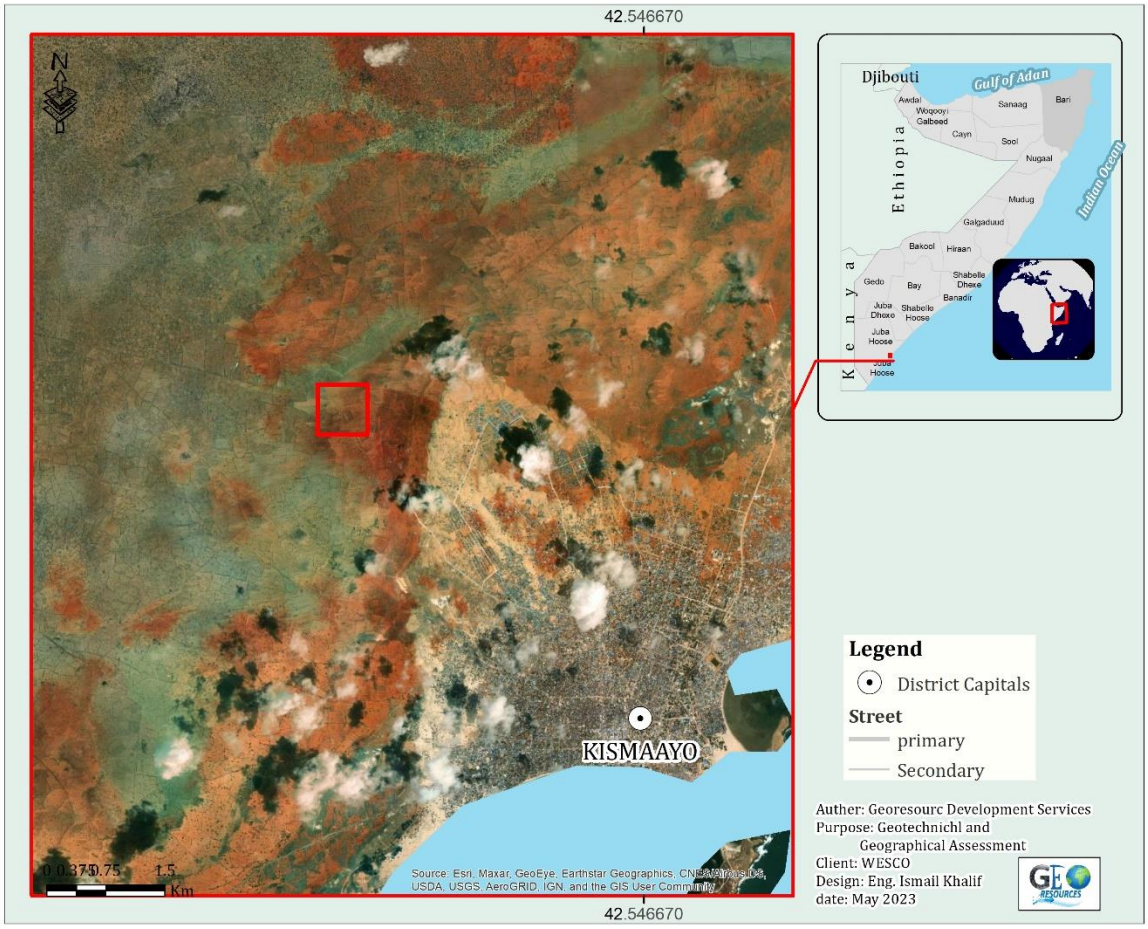


Figure 1: location Map

2 Topographic Survey

Topographic Survey of WESCO Solar Plant is a survey that is carried out to investigate the topography of the land where the solar plant is to be built. The survey will help to determine the best location for the solar plant, as well as the best way to design the plant.

2.1 Survey Methodology

Topographic survey methodology is the process of collecting and processing data to create a map of the Earth's surface. The map shows the elevation and position of natural and man-made features. During this assignment the following steps were typically involved:

1. Planning: The first step is to plan the survey, which includes determining the area to be surveyed, the level of detail required, and the desired accuracy.
2. Data collection: Data collection can be done using a variety of methods, including:
    - Ground surveying: This involves using instruments such as RTK (Real Time Kinematic) and GNSS receivers to measure the distance and elevation of points on the ground to create a digital elevation model (DEM).
    - Remote sensing: This involves using satellite imagery and other remote sensing data to collect information about the topographic feature and existing structure.
3. Data processing: Once the data has been collected, it needs to be processed to create a map. This involves correcting the data for errors, such as atmospheric refraction and instrument errors. It also involves generating contour lines, which are lines that connect points of equal elevation.
4. Map preparation: The final step is to prepare the map for delivery to the client. This may involve adding features such as labels, legends, and scale bars.

To conduct a topographic survey using **RTK,** the following steps are typically followed:

1. Establish a base station. This can be done by setting up the base receiver at a known location, such as a control point or benchmark.
2. Collect data with the rover station. The rover station is carried around the survey area, taking measurements at regular intervals. The data collector will display the real-time coordinates of the rover station, which can be used to guide the surveyor to the desired locations.
3. Post-process the data. Once the data collection is complete, the data is post-processed to remove any errors and to adjust the coordinates to a desired coordinate system.

2.2 Topographic Features

The topographic shows a small area of land with a relatively flat elevation. The elevation ranges from 29.06 meters to 31.03 meters, with a gradual slope from north to east. The map also shows several man-made features, including roads, buildings, and a power line.

The contour lines on the map are spaced at 10-cente intervals, which means that each contour line represents a change in elevation of 10 cent meters. The contour lines are closer together in areas with a steeper slope (South, southern east and Northwest, and farther apart in areas with a flatter slope).

This contour map illustrates the layout and features of a site managed by Waamo Energy Service Company, with the consultation of Geo-Resource Service. Here's an interpretation of the map based on profiling data:

Elevation and Contours:

The site has varied elevation, with the west side (left) being slightly higher than the east side (right). This can be seen as the contour lines are more spaced out on the west side and closer together on the east side.

The contour lines indicate the slope direction, with the elevation decreasing from the west to the east.

Natural Features: There are contour lines that form closed loops indicating areas of higher elevation and depressions.

No specific streams or ponds are marked on this map, but the general flow direction of water would be from the higher west side to the lower east side.

Man-made Features:

Solar Panels: Indicated by the blue filled rectangular areas on the south-eastern part of the site, covering a significant portion of the lower ground.

Solar Street Poles: Represented by small square symbols with a pink outline, these are distributed across the site, especially around paths and structures.

Existing Structures: Shown in yellow shading, indicating buildings or other established constructions.

Trail Pits: Marked with a triangular symbol with a red outline.

Elevated Water Tank: Highlighted with a yellow outline, indicating the location of water storage infrastructure.

Site Boundaries: The boundaries are marked with black lines enclosing the site, with red lines showing the measured dimensions of the site boundary.

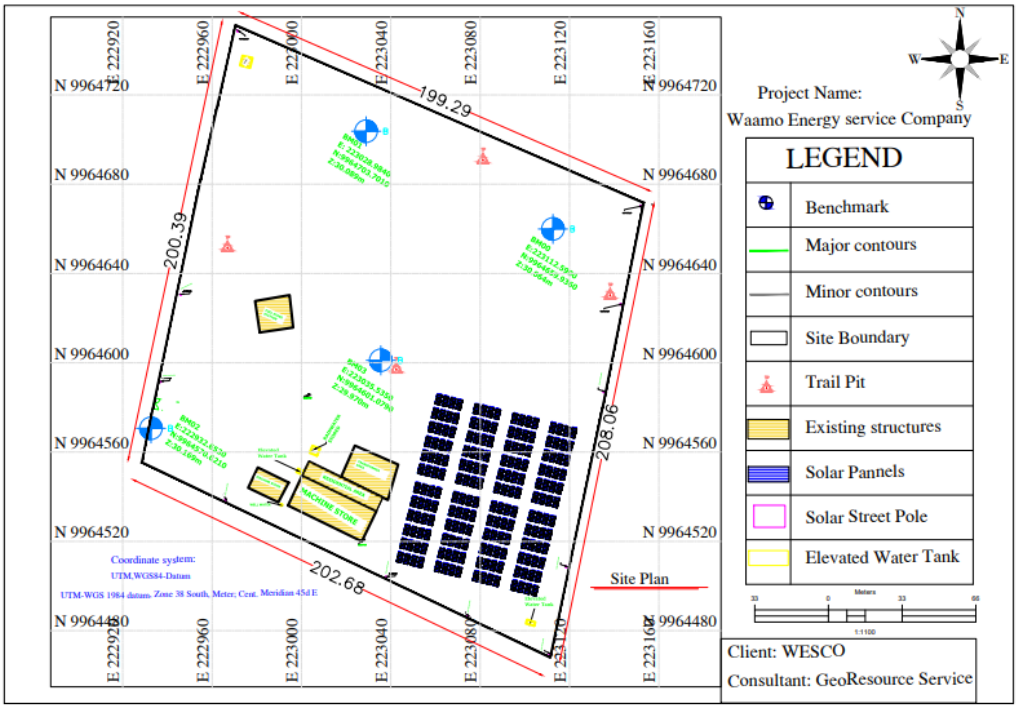
Benchmark Locations: Blue symbols (cross inside a circle) indicate benchmarks, which are reference points for surveying.

General Layout: The site has a grid layout with clearly marked coordinates for precise location identification.

Infrastructure like solar panels and existing structures are strategically placed to avoid low-lying areas that might be prone to water accumulation or flooding.

Coordinate System: The map uses the UTM-WGS84 datum, Zone 38 South, with a central meridian of 45.0 E, ensuring accurate geographic referencing.

This map effectively combines both natural and man-made features, providing a comprehensive overview of the site's topography and infrastructure.



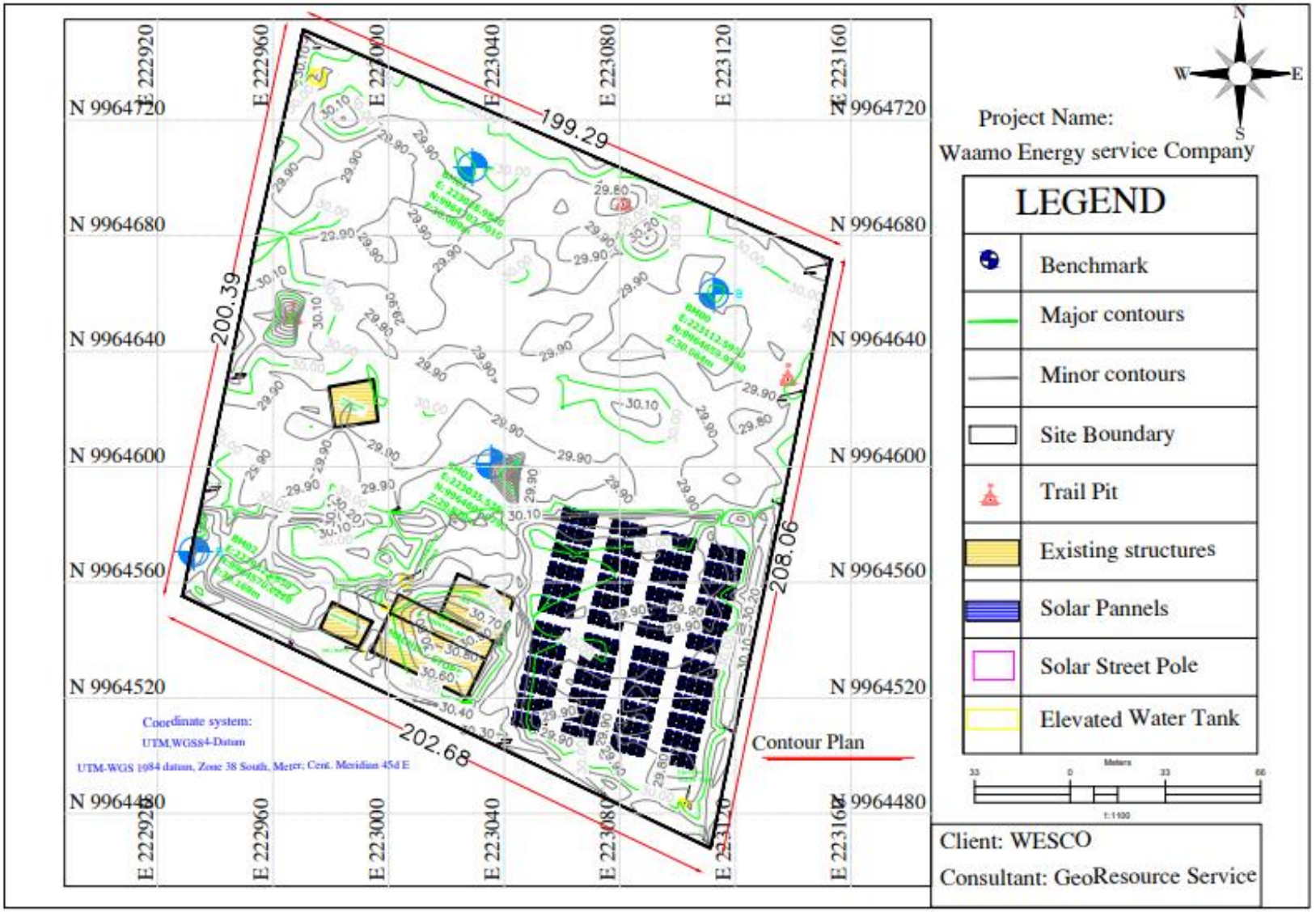


Figure 2:Contour map (WESCO Plant)

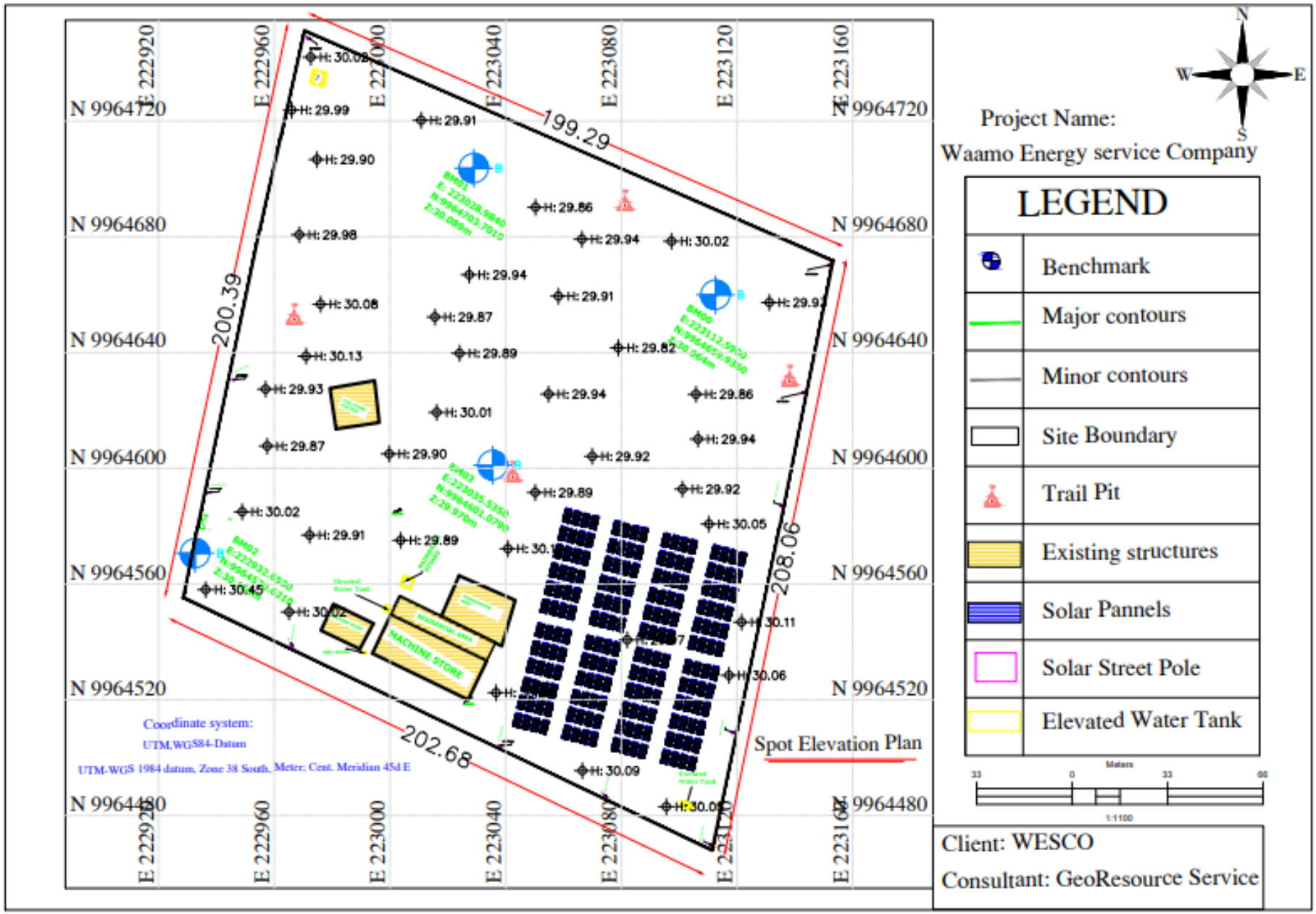


Figure 3: 3D topo Map

3 Geotechnical Investigation

This chapter presents the results of the geotechnical fieldwork and laboratory testing conducted for the proposed WESCO solar plant development site in Kismaayo. Geotechnical fieldwork collects data about the subsurface conditions at a site. This data is used to assess the site's suitability for development and to design foundations and other structures. The laboratory testing included grain size analysis, Atterberg limits testing, water quality analysis and Specific gravity and water absorption of aggregate. The results of the geotechnical fieldwork and laboratory testing were used to characterize the geotechnical properties of the site and to assess the suitability of the site for solar development.

3.1 Fieldwork and sampling

The fieldwork was conducted on 15/05/2024 and consisted of the following.

- Material Sampling.
- Particle Size Distribution of Soil.
- Atterberg Limit.
- Water quality analysis.
- Specific Gravity and Water Absorption of Aggregate

a. <u>Material Sampling:</u>

Figure 4: Soil Samplin

The side was selected randomly from 10 trail pits as you can see the image below.

Table 1:Soil Sampling information

Trial Pit No.	Coordinates		Sample depth (m)	Sample collected for lab work
	Northing	**Easting**		
1.	8.400162	48.503204	1.5	Sample# (TP-1)
2.	8.399829	48.503352	1.5	Sample# (TP-2)
3.	8.399229	48.50419	1.5	Sample# (TP-3)
4.	8.399051	48.50371	1.5	Sample# (TP-4)
5.	8.398675	48.50392	1.5	Sample# (TP-5)
6.	8.398008	48.50485	1.5	Sample# (TP-6)
7.	8.397324	48.50460	1.5	Sample# (TP-7)
8.	8.39637	48.505958	1.5	Sample# (TP-8)
9.	8.397653	48.506623	1.5	Sample# (TP-9)
10.	8.398171	48.506295	1.5	Sample# (TP-10)

3.2 Laboratory Testing

3.2.1 Particle Size Distribution of Soil:

Particle size distribution (PSD) is an important engineering property of soils used in a wide range of engineering applications. It helps in determining the soil's geotechnical properties, including uniformity coefficient (Cu) and coefficient of curvature (Cc). The following interpretation is based on the sieve analysis results for the five soil samples from the WESCO S-17 site in Kismayo.

Key Parameters:

Uniformity Coefficient (Cu): $Cu=D60D10$Cu=D10D60

Coefficient of Curvature (Cc): $Cc=(D30)2D60\times D10$Cc=D60×D10(D30)2

General Interpretation:

The curves for the five samples show a well-graded soil with a wide range of particle sizes. The soil samples appear to be well-graded, indicated by a relatively high Cu and appropriate Cc values.

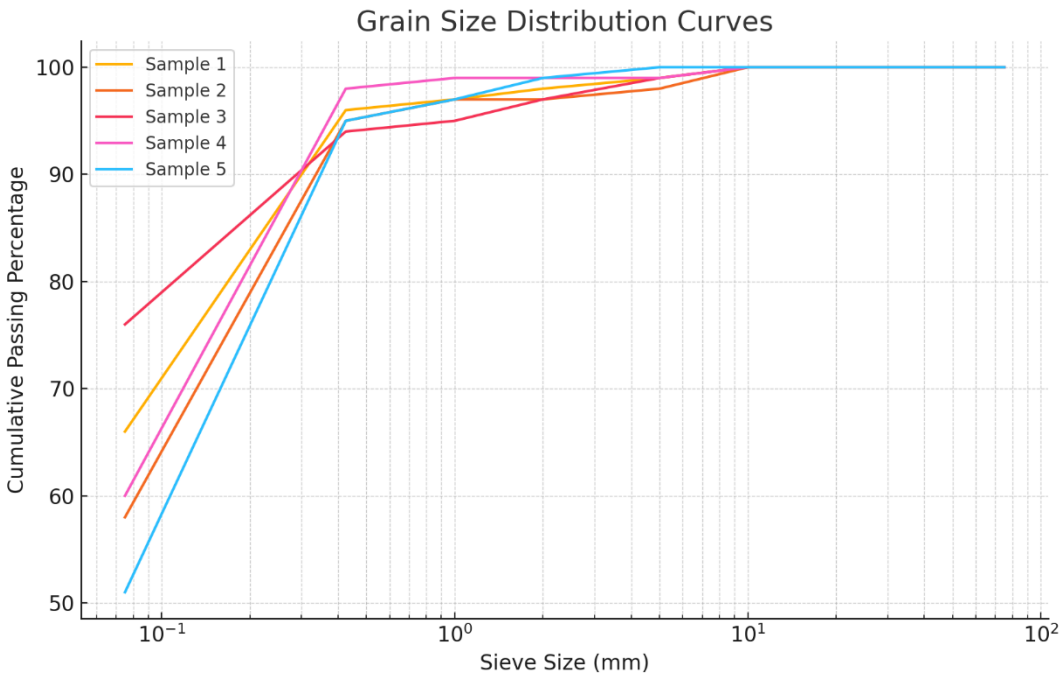


Figure 5: Grain size distribution size curves

Here is a more detailed interpretation of the curve:

Sample 1 (Trial Pit 01)

- 0-75 mm: 100% of the soil passes through the 75 mm sieve.
- 10 mm: 100% passing, indicating no particles larger than 10 mm.
- 5 mm: 99% passing, indicating 1% particles in the size range of 5-10 mm.
- 2 mm: 98% passing, indicating 2% particles in the size range of 2-5 mm.
- 1 mm: 97% passing, indicating 3% particles in the size range of 1-2 mm.
- 0.425 mm: 96% passing, indicating 4% particles in the size range of 0.425-1 mm.
- 0.075 mm: 66% passing, indicating 34% particles in the size range of 0.075-0.425 mm.

Sample 2 (Trial Pit 02)

- 0-75 mm: 100% of the soil passes through the 75 mm sieve.
- 10 mm: 100% passing, indicating no particles larger than 10 mm.

- 5 mm: 98% passing, indicating 2% particles in the size range of 5-10 mm.
- 2 mm: 97% passing, indicating 3% particles in the size range of 2-5 mm.
- 1 mm: 97% passing, indicating 3% particles in the size range of 1-2 mm.
- 0.425 mm: 95% passing, indicating 5% particles in the size range of 0.425-1 mm.
- 0.075 mm: 58% passing, indicating 42% particles in the size range of 0.075-0.425 mm.

Sample 3 (Trial Pit 03)

- 0-75 mm: 100% of the soil passes through the 75 mm sieve.
- 10 mm: 100% passing, indicating no particles larger than 10 mm.
- 5 mm: 99% passing, indicating 1% particles in the size range of 5-10 mm.
- 2 mm: 97% passing, indicating 3% particles in the size range of 2-5 mm.
- 1 mm: 95% passing, indicating 5% particles in the size range of 1-2 mm.
- 0.425 mm: 94% passing, indicating 6% particles in the size range of 0.425-1 mm.
- 0.075 mm: 76% passing, indicating 24% particles in the size range of 0.075-0.425 mm.

Sample 4 (Trial Pit 04)

- 0-75 mm: 100% of the soil passes through the 75 mm sieve.
- 10 mm: 100% passing, indicating no particles larger than 10 mm.
- 5 mm: 99% passing, indicating 1% particles in the size range of 5-10 mm.
- 2 mm: 99% passing, indicating 1% particles in the size range of 2-5 mm.
- 1 mm: 99% passing, indicating 1% particles in the size range of 1-2 mm.
- 0.425 mm: 98% passing, indicating 2% particles in the size range of 0.425-1 mm.
- 0.075 mm: 60% passing, indicating 40% particles in the size range of 0.075-0.425 mm.

Sample 5 (Trial Pit 05)

- 0-75 mm: 100% of the soil passes through the 75 mm sieve.
- 10 mm: 100% passing, indicating no particles larger than 10 mm.

- 5 mm: 100% passing, indicating no particles larger than 5 mm.
- 2 mm: 99% passing, indicating 1% particles in the size range of 2-5 mm.
- 1 mm: 97% passing, indicating 3% particles in the size range of 1-2 mm.
- 0.425 mm: 95% passing, indicating 5% particles in the size range of 0.425-1 mm.
- 0.075 mm: 51% passing, indicating 49% particles in the size range of 0.075-0.425 mm.
- Conclusion:
- The curves and data indicate that the soil samples from the WESCO S-17 site in Kismayo are well-graded. Well-graded soils are generally better suited for solar plant foundations than poorly graded soils due to their higher stability and better compaction properties. However, due to the relatively high fines content, additional compaction might be necessary to achieve the desired bearing capacity for the solar panel foundations.
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3.2.2 SOIL STANDARD TESTS

3.2.3 CPD

Test pit Number	Avg. CBR	Nature of soil/ rock	Penetration index value (mm/blow)	Elastic modulus (e) (KPA)	odulus of subgrade reaction k (kn/m3)	Ultimate bearing capacity (kPa)	Allowable bearing capacity (kPa)
TP1	9.6	Brownish silty clay	6.2	56,595	2265	3001.94	100.65
TP2	10.0	Brownish silty clay	8.37	68,581	0762	331.16	110.39
TP3	10.8	Brownish silty clay	5.61	53,061	0830	282.46	94.15
TP4	9.6	Reddish silty clay	5.42	51,891	0032	272.72	90.91
TP5	9.7	Reddish silty clay	5.64	53,245	0956	283.43	94.48

Atterberg Limit:

Atterberg Limits are critical parameters used to describe the plasticity and behavior of fine-grained soils. The three primary Atterberg Limits are the Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI). These limits help in understanding the soil's ability to retain water and its potential for swelling and shrinkage, which are essential considerations for foundation design.

Key Parameters:

- Liquid Limit (LL): The water content at which soil changes from a plastic to a liquid state.
- Plastic Limit (PL): The water content at which soil changes from a semi-solid to a plastic state.
- Plasticity Index (PI): The range of water content over which the soil remains plastic (PI = LL - PL).

The Atterberg Limits for the five samples from WESCO S-17 indicate the soil's plasticity and help in classifying the soil type. Below is a summary table of the Atterberg Limits for the five samples:

Table: Atterberg Limits of the Five Soil Samples.

Sample ID	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
Sample 1	40.0	17.0	23.0
Sample 2	39.0	16.0	23.0
Sample 3	48.0	20.0	28.0
Sample 4	33.0	14.0	19.0
Sample 5	33.0	15.0	18.0

3.2.4 Specific Gravity of Aggregate:

These values indicate the relative density of the soil particles compared to water. Specific gravity is important for understanding the soil's compaction characteristics and its load-bearing capacity, which are critical factors for designing stable foundations for structures, including solar panel installations.

To summarize:

- Specific Gravity (Gs) is the ratio of the weight of soil solids to the weight of an equal volume of water.
- The average specific gravity of the samples from WESCO S-17 is 2.271, which is typical for silty and clayey soils.

This information is crucial for assessing the suitability of the soil for construction projects, including the foundations for solar panels. Soils with consistent specific gravity values close to the average suggest uniformity in the soil composition across different trial pits, which helps in predicting soil behavior under load.

Trial Pit	Specific Gravity
Trial Pit 01:	2.260
Trial Pit 02:	2.270
Trial Pit 03:	2.276
Trial Pit 04:	2.270
Trial Pit 05:	2.278

Interpretation:

Sample 1: Moderate plasticity, typical of silty clay.

Sample 2: Similar to Sample 1, indicating consistent soil conditions.

Sample 3: Higher plasticity, suggesting more clay content.

Sample 4: Lower plasticity, indicating a slightly coarser soil composition.

Sample 5: Similar to Sample 4, reinforcing the consistency in soil characteristics across different trial pits.

The Atterberg Limits indicate that the soil at the WESCO S-17 site ranges from low to high plasticity silty clay. These characteristics are important for foundation design, as they affect the soil's behavior under varying moisture conditions. Ensuring proper compaction and moisture control will be key to maintaining the stability of the foundations for solar panel infrastructure.

3.3 Groundwater Analysis

The groundwater analysis report for the WESCO solar plant site in Kismayo provides detailed measurements of various water quality parameters. These results are crucial for determining the suitability of the groundwater for drinking and other purposes. The parameters measured include pH, electrical conductivity, calcium, magnesium, coliforms, chlorine, total dissolved solids (TDS), turbidity, iron, potassium, nitrates, sodium, and sulfate. The results are compared with the World Health Organization (WHO) standards to evaluate compliance.

Table: Groundwater Analysis Results

Parameter	Unit	Result	WHO Standard	Higher/Lower than Standard
pH	-	7.6	6.5 - 8.5	Within
Electrical Conductivity	ms/cm	14930	< 5000	Higher
Calcium	ppm	130	< 150	Lower
Magnesium	ppm	80	< 100	Lower
Coliforms	CFU	0	0 CFU/100ml	Within
Chlorine	mg/L	0.05	< 0.2	Lower

Parameter	Unit	Result	WHO Standard	Higher/Lower than Standard
Total Dissolved Solids	ppm	7470	< 2500	Higher
Turbidity	NTU	5	< 5	Within
Iron	ppm	0.08	< 0.3	Lower
Potassium	ppm	8.1	< 12.0	Lower
Nitrates	ppm	30	< 50	Lower
Sodium	ppm	140	< 200	Lower
Sulfate	ppm	350	< 400	Lower

Interpretation:

The groundwater quality at the WESCO S-17 site shows that most parameters are within the acceptable limits set by WHO standards, except for Electrical Conductivity and Total Dissolved Solids (TDS), which exceed the recommended limits. High Electrical Conductivity and TDS indicate a high concentration of dissolved salts, which could affect the water's suitability for drinking without treatment.

- **pH:** The pH level is within the acceptable range, indicating neutral water.
- **Electrical Conductivity:** Higher than the recommended limit, suggesting high salinity.
- **Calcium and Magnesium:** Both are within acceptable limits, indicating no significant hardness issues.
- **Coliforms:** Absence of coliforms indicates microbiologically safe water.
- **Chlorine:** Well below the limit, indicating safe levels.
- **Total Dissolved Solids:** Higher than the standard, indicating potential issues with dissolved minerals.
- **Turbidity:** Within the acceptable range, indicating clear water.
- **Iron, Potassium, Nitrates, Sodium, and Sulfate:** All are within the acceptable limits, indicating no immediate health risks.

Overall, while the water quality is largely acceptable, the high Electrical Conductivity and TDS levels suggest that treatment may be necessary to reduce the salinity and make the water suitable for drinking and other uses.

3.4 Conclusion

The comprehensive topographic and geotechnical assessment conducted for the WESCO Solar Plant in Kismayo, Somalia, provides an in-depth analysis of the site's suitability for solar development. The topographic survey reveals a relatively flat terrain with a gradual slope from west to east, ideal for solar plant construction. Key features such as existing roads, buildings, and a power line on higher ground offer potential infrastructural advantages. The presence of natural elements like a stream and a small pond necessitates careful planning to preserve these features.

Geotechnically, the site predominantly consists of well-graded coarse sand with high void ratios, indicating loose soil conditions. The soil's lack of plasticity, as per the AASHTO soil classification, and the presence of hard rock substrates at shallow depths, suggest strong foundational support for construction. The site's deep-water table and the absence of a shallow aquifer further contribute to its suitability, reducing the risk of groundwater-related issues.

4 Recommendations.

The topographic and geotechnical assessment of the WESCO Solar Plant site has shown that the site is suitable for the construction of a solar plant. The site is relatively flat, with a gradual slope from west to east. The soil conditions are also good, with a high bearing capacity and low permeability.

Based on the findings of the assessment, the following recommendations are made:

- The solar panels that could be installed on the east-facing should considered the slope of the site.
- A drainage system should be installed to collect and divert stormwater away from the solar panels.
- The soil should be compacted and graded to create a smooth and level surface for the solar panels for gentle and relative slope area as it clears in the map.
- A perimeter fence should be installed around the solar plant to prevent unauthorized access.

APPENDIXES ATTACHED:

Appendix A: Soil

Appendix B: Lab and Field Photographs

Appendix C: Topographic Row Data

5. Appendices

5.1 Appendix A: SOIL STANDARD TESTS

Sample 1 (Trial Pit 01)

- **Initial weight of dry sample + pan: 861 grams**
- **Weight of dry sample + pan after washing: 291.1 grams**
- **Weight of fines washed: 569.9 grams**

Sieve Size (mm)	Weight Retained (g)	% Retained	% Passing
75	0	0.00	100.00
63	0	0.00	100.00
50	0	0.00	100.00
37.5	0	0.00	100.00
28	0	0.00	100.00
20	0	0.00	100.00
10	0	0.00	100.00
5	7.7	0.9	99
2	10.8	1.3	98
1	9.9	1.1	97
0.425	7.8	0.9	96
0.075	254.9	29.6	66

Sample 2 (Trial Pit 02)

- **Initial weight of dry sample + pan: 806 grams**
- **Weight of dry sample + pan after washing: 339.6 grams**
- **Weight of fines washed: 466.4 grams**

Sieve Size (mm)	Weight Retained (g)	% Retained	% Passing
75	0	0.00	100.00
63	0	0.00	100.00
50	0	0.00	100.00
37.5	0	0.00	100.00
28	0	0.00	100.00
20	0	0.00	100.00
10	0	0.00	100.00
5	13.6	1.7	98
2	7.9	1.0	97
1	4.3	0.5	97
0.425	11.0	1.4	95
0.075	302.8	37.6	58

Sample 3 (Trial Pit 03)

- **Initial weight of dry sample + pan: 794.5 grams**
- **Weight of dry sample + pan after washing: 188.3 grams**
- **Weight of fines washed: 606.2 grams**

Sieve Size (mm)	Weight Retained (g)	% Retained	% Passing
75	0	0.00	100.00
63	0	0.00	100.00
50	0	0.00	100.00
37.5	0	0.00	100.00
28	0	0.00	100.00
20	0	0.00	100.00
10	0	0.00	100.00
5	4.9	0.6	99
2	15.8	2.0	97
1	17.1	2.2	95
0.425	12.9	1.6	94
0.075	137.6	17.3	76

Sample 4 (Trial Pit 04)

- **Initial weight of dry sample + pan: 877.2 grams**
- **Weight of dry sample + pan after washing: 350.1 grams**
- **Weight of fines washed: 527.1 grams**

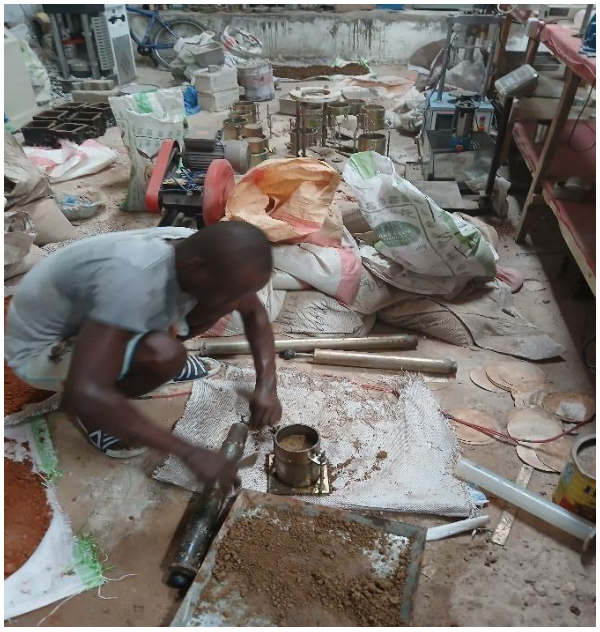
Sieve Size (mm)	Weight Retained (g)	% Retained	% Passing
75	0	0.00	100.00
63	0	0.00	100.00
50	0	0.00	100.00
37.5	0	0.00	100.00
28	0	0.00	100.00
20	0	0.00	100.00
10	0	0.00	100.00
5	2.2	0.3	100
2	4.9	0.6	99
1	5.1	0.6	99
0.425	8.0	0.9	98
0.075	329.9	37.6	60

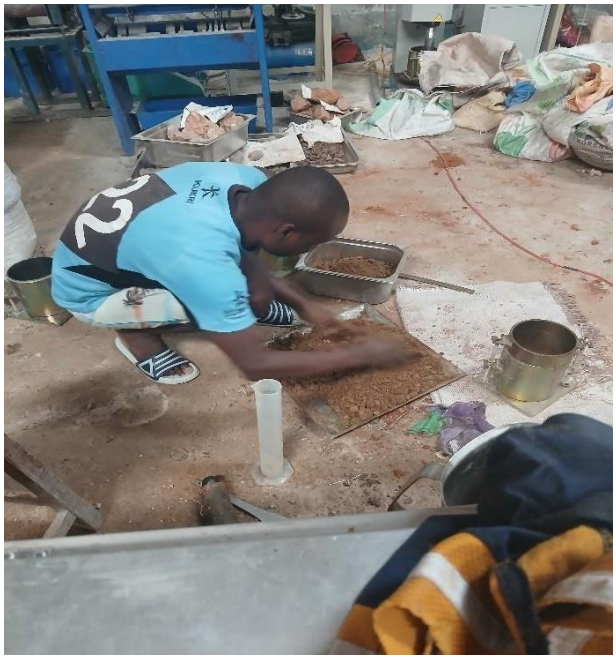
Sample 5 (Trial Pit 05)

- **Initial weight of dry sample + pan: 820 grams**
- **Weight of dry sample + pan after washing: 400.1 grams**
- **Weight of fines washed: 419.9 grams**

Sieve Size (mm)	Weight Retained (g)	% Retained	% Passing
75	0	0.00	100.00
63	0	0.00	100.00
50	0	0.00	100.00
37.5	0	0.00	100.00
28	0	0.00	100.00
20	0	0.00	100.00
10	0	0.00	100.00
5	3.2	0.4	100
2	7.9	1.0	99
1	10.1	1.2	97
0.425	19.0	2.3	95
0.075	359.9	43.9	51

5.2 Appendix B: Lab and Field Photographs





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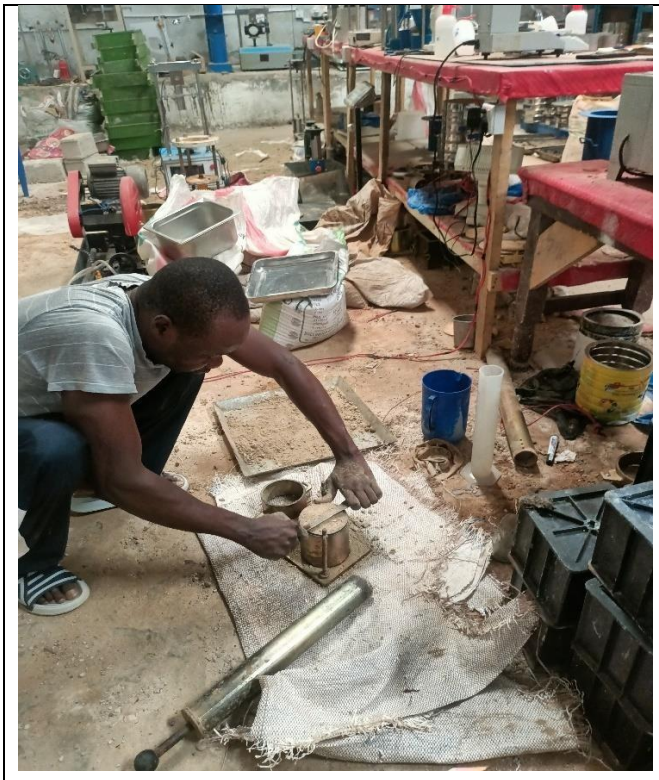

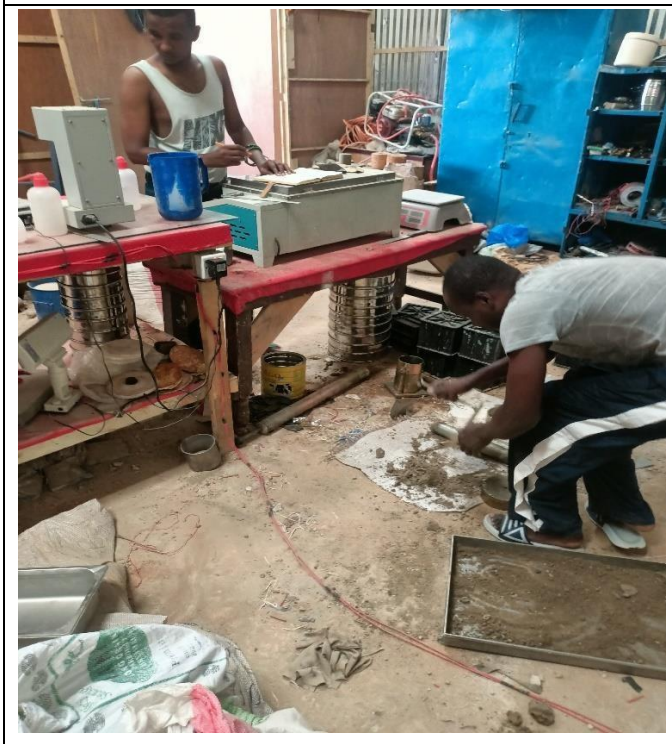

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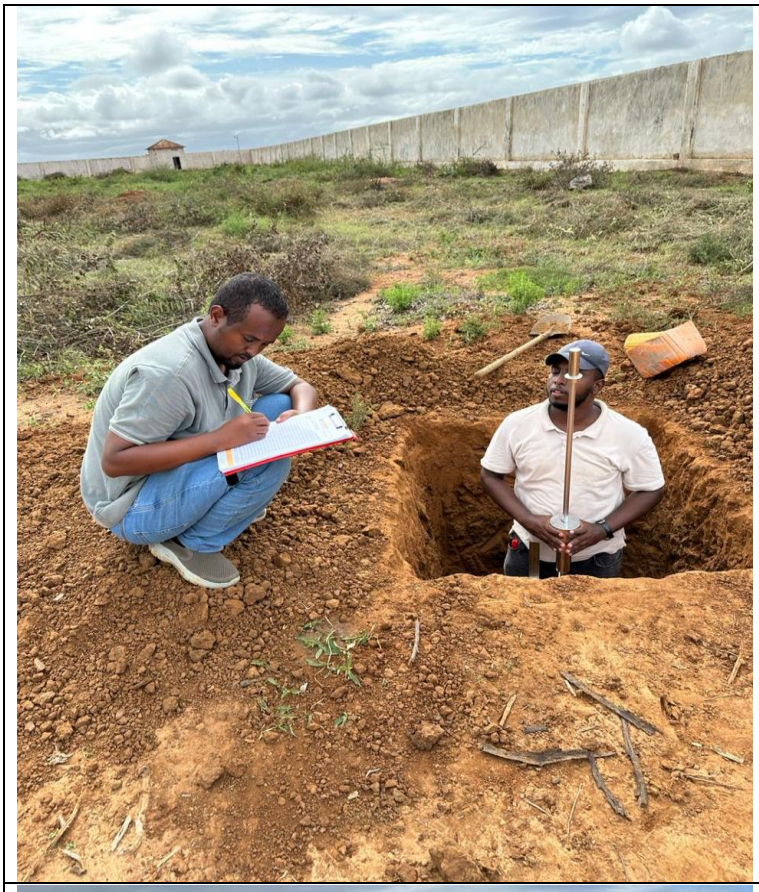

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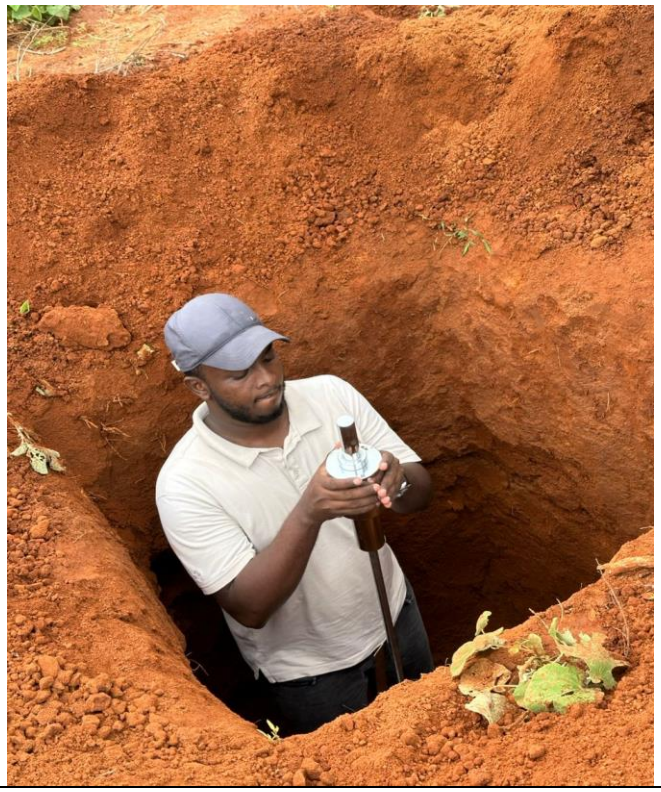

5.3 Appendix C: Topographic Survey Maps

(Contour with plant facilities and Spot map)

LEGEND				
TPOGRAPHICAL SURVEY FOR WAAMO ENERGY SERVICE COMPANY				
WESCO				
	ABBREVIATIONS			
	BM		Benchmarks	
	TPS		TRAIL PIT SOIL	
	TF		TRANSFORMER	
	WTS		WATER TANK STORAGE	
	W		WELL	
	SLP		Solar Lights poles	
	SP		SOLAR PLANT	
	ELP		ELECTRIC POLE	
	G		GATE	
	BW		BOUNDRY WALL	
	FS		FUEL STATION	
	WLL		WALL	
	SE		SPOT ELEVATION	
	MS		MACHINE STORE	
	R-OF		RESIDENTIAL+OFFICE	
	ST		STORE	
	TBS		TEMPORARY BUILDING SHEET	
	EWT		ELEVATED WATER TANK	
UTM-WGS 1984 datum, Zone 38 South, Meter; Cent. Meridian 45d E				
S.NO	**NORTHING**	**EASTING**	**ELEVATION**	**CODE**
1	9964671.622	223153.2	30.227	BW
2	9964670.14	223151.916	30.196	SLP
3	9964680.845	223131.766	30.196	WLL
4	9964690.111	223110.584	29.97	WLL
5	9964703.47	223079.825	29.961	WLL
6	9964719.712	223042.324	30.061	WLL
7	9964735.095	223007.546	29.957	WLL
8	9964751.285	222970.52	30.271	BW
9	9964714.509	222962.245	29.976	WLL
10	9964681.863	222954.824	30.071	WLL
11	9964638.279	222945.918	30.276	WLL
12	9964601.2	222938.497	30.018	WLL
13	9964584.042	222934.704	30.598	G
14	9964579.364	222933.44	30.738	G
15	9964555.397	222928.596	30.487	BW
16	9964539.533	222961.85	30.221	WLL
17	9964521.037	223000.567	30.397	WLL

18	9964504.457	223035.431	30.25	WLL
19	9964483.349	223079.356	30.077	WLL
20	9964467.939	223111.367	30.257	BW
21	9964506.576	223119.651	30.051	WLL
22	9964548.716	223128.419	30.031	WLL
23	9964579.865	223134.771	30.041	WLL
24	9964612.241	223141.11	29.994	WLL
25	9964647.045	223148.209	29.972	WLL
26	9964626.35	223142.9	30.099	SLP
27	9964587.094	223135.279	30.038	SLP
28	9964547.856	223126.766	30.05	SLP
29	9964508.49	223118.71	30.069	SLP
30	9964469.593	223110.716	30.032	SLP
31	9964486.633	223074.628	30.097	SLP
32	9964503.939	223038.016	30.211	SLP
33	9964521.068	223001.963	30.359	SLP
34	9964538.591	222965.996	30.224	SLP
35	9964555.752	222930.041	30.326	SLP
36	9964591.766	222936.979	30.185	SLP
37	9964630.74	222945.765	30.165	SLP
38	9964748.639	222971.568	30.114	SLP
39	9964701.293	223082.185	30.036	SLP
40	9964736.574	222978.051	29.886	ST
41	9964737.485	222973.651	29.947	ST
42	9964733.225	222972.573	29.841	ST
43	9964732.11	222977.011	29.883	ST
44	9964627.635	222979.268	29.916	FS
45	9964630.406	222994.708	30.03	FS
46	9964615.794	222996.317	29.911	FS
47	9964613.588	222981.35	29.914	FS
48	9964612.877	222981.129	29.889	SLP
49	9964614.959	222996.411	29.906	SLP
50	9964553.097	222980.484	30.161	MS
51	9964546.355	222994.298	30.354	MS
52	9964537.521	222989.616	30.317	MS
53	9964543.966	222976.151	30.296	MS
54	9964536.048	222993.982	30.149	MS
55	9964549.536	223000.378	30.468	MS
56	9964520.004	223027.002	30.544	MS
57	9964533.555	223033.573	30.811	MS
58	9964539.926	223036.582	30.858	R-OF
59	9964555.767	223003.459	30.316	R-OF
60	9964559.673	223003.704	30.206	EWT
61	9964562.843	223004.964	30.105	EWT
62	9964561.454	223008.306	30.094	EWT
63	9964558.431	223006.931	30.37	EWT

64	9964560.396	223001.196	30.136	TBS
65	9964556.492	222999.924	30.326	TBS
66	9964557.128	222997.791	30.564	TBS
67	9964554.562	222996.316	30.572	TBS
68	9964555.224	222994.642	30.45	TBS
69	9964561.79	222997.25	30.031	TBS

70	9964563.284	222999.99	29.933	TBS
71	9964567.116	223001.675	30.074	TBS
72	9964566.362	223003.326	30.034	TBS
73	9964563.481	223002.447	30.073	TBS
74	9964564.235	223000.541	30.022	TBS
75	9964570.779	223003.434	29.896	TBS
76	9964572.14	222999.975	29.934	TBS
77	9964568.959	222998.514	30.186	TBS
78	9964570.199	222995.137	29.916	TBS
79	9964566.328	222993.473	29.909	TBS
80	9964551.048	222997.816	30.402	EWT
81	9964552.516	222998.516	30.45	EWT
82	9964551.732	223000.309	30.459	EWT
83	9964536.683	222991.219	30.265	W
84	9964536.485	222990.643	30.286	W
85	9964535.933	222990.916	30.28	W
86	9964536.298	222991.515	30.289	W
87	9964482.211	223104.13	29.879	EWT
88	9964483.788	223104.681	29.91	EWT
89	9964484.936	223101.021	29.969	EWT
90	9964483.187	223100.496	30.036	EWT
91	9964511.938	223081.06	29.863	SP
92	9964518.859	223080.973	29.884	SP
93	9964518.987	223111.578	29.84	SP
94	9964576.889	223111.63	29.766	SP
95	9964576.798	223050.254	29.937	SP
96	9964511.586	223050.262	29.852	SP
97	9964538.542	223038.672	30.466	TF
98	9964554.388	223043.309	30.297	TF
99	9964562.812	223024.091	30.356	TF
100	9964549.196	223017.9	31.03	TF
101	9964614.158	222995.644	29.926	ELP
102	9964613.02	222985.098	29.89	ELP
103	9964585.561	223003.517	29.903	ELP
104	9964561.844	223008.681	30.101	ELP
105	9964551.76	223018.404	30.798	ELP
106	9964520.758	223028.113	30.638	ELP
107	9964483.071	223099.421	29.936	ELP
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113	9964604.838	223139.486	30.092	SE
114	9964614.992	223141.638	29.994	SE
115	9964617.421	223132.448	29.796	SE
116	9964627.503	223133.879	29.953	SE

117	9964625.517	223143.643	29.984	SE
118	9964634.98	223145.475	30.031	SE
119	9964638.294	223135.625	29.892	SE
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121	9964647.462	223148.02	30.025	SE
122	9964657.779	223150.298	29.989	SE
123	9964660.643	223139.111	29.973	SE
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126	9964669.834	223130.294	30.005	SE
127	9964658.586	223128.514	29.926	SE
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130	9964627.213	223123.483	29.888	SE
131	9964616.359	223121.69	29.754	SE
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135	9964585.207	223106.293	29.907	SE
136	9964596.471	223108.014	29.85	SE
137	9964608.218	223109.935	29.929	SE
138	9964619.064	223111.533	29.876	SE
139	9964630.137	223113.364	29.912	SE
140	9964641.135	223114.566	29.828	SE
141	9964651.543	223116.462	29.87	SE
142	9964662.847	223118.179	29.964	SE
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144	9964685.246	223121.381	30.162	SE
145	9964689.543	223111.915	30.011	SE
146	9964679.752	223110.161	29.992	SE
147	9964669.345	223108.807	29.854	SE
148	9964659.085	223107.185	29.879	SE
149	9964648.814	223105.723	29.806	SE
150	9964638.571	223104.269	29.895	SE
151	9964628.173	223102.795	29.852	SE
152	9964617.323	223101.182	29.954	SE
153	9964606.71	223099.496	29.935	SE
154	9964596.859	223097.998	29.926	SE
155	9964585.236	223096.357	29.997	SE

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157	9964595.719	223087.885	29.916	SE
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159	9964617.491	223090.973	30.162	SE
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201	9964612.075	223059.17	29.984	SE

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204	9964585.338	223055.235	29.954	SE
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218	9964710.999	223062.498	30.104	SE
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222	9964676.408	223046.901	29.911	SE
223	9964666.733	223045.366	30.035	SE
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225	9964646.539	223042.026	29.983	SE
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227	9964626.538	223039.28	29.904	SE
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239	9964661.327	223033.688	29.958	SE
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250	9964676.046	223025.063	29.89	SE
251	9964666.163	223023.49	29.959	SE
252	9964656.751	223022.165	29.92	SE
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264	9964614.794	223004.956	29.965	SE
265	9964624.731	223006.501	29.977	SE
266	9964633.5	223008.019	29.917	SE
267	9964642.672	223009.89	29.949	SE
268	9964642.994	223009.365	29.929	SE
269	9964652.72	223010.881	29.833	SE
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271	9964671.367	223014.103	29.865	SE
272	9964682.711	223016.006	29.94	SE
273	9964691.973	223017.479	29.87	SE
274	9964701.981	223018.961	29.887	SE
275	9964713.077	223021.065	29.966	SE
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281	9964691.334	223007.331	29.898	SE
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304	9964691.385	223003.506	29.882	SE

305	9964698.252	223005.347	29.973	SE
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308	9964725.717	223011.971	29.922	SE
309	9964732.204	223013.678	30.067	SE
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311	9964726.628	223001.652	29.948	SE
312	9964717.571	222999.389	29.86	SE
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315	9964689.971	222992.379	29.947	SE
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318	9964663.831	222985.739	29.884	SE
319	9964654.727	222983.335	29.984	SE
320	9964645.48	222981.182	29.96	SE
321	9964636.596	222979.008	30.083	SE
322	9964627.85	222976.973	29.921	SE
323	9964619.216	222974.991	29.782	SE
324	9964613.915	222973.234	30.003	SE
325	9964605.421	222971.235	29.81	SE
326	9964596.97	222969.261	29.85	SE
327	9964586.57	222966.768	29.96	SE
328	9964584.349	222966.081	30.117	SE
329	9964584.406	222953.95	29.942	SE
330	9964593.646	222956.543	29.808	SE
331	9964603.785	222958.997	29.887	SE
332	9964612.725	222960.84	29.863	SE
333	9964622.166	222962.844	29.823	SE
334	9964631.796	222964.902	29.885	SE
335	9964640.768	222966.851	30.192	SE
336	9964649.787	222968.897	30.192	SE
337	9964658.801	222970.885	30.148	SE
338	9964667.722	222972.86	29.864	SE
339	9964676.374	222974.697	29.814	SE

340	9964684.661	222976.422	30.05	SE
341	9964693.48	222978.599	29.967	SE
342	9964702.409	222980.206	29.86	SE
343	9964711.233	222983.538	29.848	SE
344	9964720.363	222984.321	30.218	SE
345	9964729.198	222986.013	30.022	SE
346	9964738.338	222987.976	29.945	SE
347	9964742.535	222989.1	29.985	SE
348	9964747.27	222979.447	30.168	SE
349	9964738.909	222977.109	29.906	SE
350	9964729.226	222974.888	29.917	SE
351	9964732.894	222966.63	30.145	SE

352	9964722.237	222964.041	30.002	SE
353	9964719.865	222972.753	29.867	SE
354	9964710.507	222971.951	29.94	SE
355	9964712.679	222962.05	30.126	SE
356	9964703.037	222959.896	30.016	SE
357	9964700.015	222969.173	29.809	SE
358	9964690.064	222968.236	29.845	SE
359	9964692.47	222957.806	29.917	SE
360	9964683.035	222955.351	29.998	SE
361	9964680.243	222964.338	29.995	SE
362	9964671.219	222962.794	30.06	SE
363	9964673.562	222953.369	29.965	SE
364	9964663.968	222951.176	30.065	SE
365	9964661.144	222961.428	30.156	SE
366	9964652.191	222959.87	30.215	SE
367	9964653	222948.864	30.19	SE
368	9964645.211	222947.409	30.361	SE
369	9964643.984	222956.313	30.133	SE
370	9964633.255	222955.45	29.908	SE
371	9964634.132	222945.405	30.234	SE
372	9964626.16	222943.679	29.965	SE
373	9964624.316	222953.987	29.958	SE
374	9964614.384	222953.089	29.818	SE
375	9964615.978	222941.446	29.814	SE
376	9964607.681	222939.733	30.117	SE
377	9964605.095	222950.284	29.926	SE
378	9964595.636	222949.414	29.909	SE
379	9964586.723	222948.177	29.904	SE
380	9964586.679	222935.279	30.107	SE
381	9964594.726	222937.152	30.209	SE
382	9964578.628	222943.647	30.126	SE
383	9964559.542	222939.812	30.107	SE
384	9964551.116	222937.848	30.387	SE
385	9964546.31	222947.605	30.24	SE

386	9964554.397	222952.113	30.038	SE
387	9964562.62	222955.423	30.004	SE
388	9964571.955	222958.518	30.169	SE
389	9964579.081	222960.544	30.127	SE
390	9964578.096	222971.259	29.913	SE
391	9964569.34	222968.85	29.96	SE
392	9964560.085	222965.108	29.988	SE
393	9964550.733	222961.628	30.013	SE
394	9964541.975	222957.529	30.243	SE
395	9964537.048	222967.132	30.249	SE
396	9964545.938	222970.469	30.043	SE
397	9964554.054	222973.461	30.011	SE
398	9964562.499	222976.584	30.179	SE

399	9964571.107	222979.883	29.911	SE
400	9964579.394	222983.335	30.122	SE
401	9964579.23	222993.326	30.024	SE
402	9964571.124	222991.278	29.888	SE
403	9964562.283	222989.032	29.936	SE
404	9964551.111	222985.065	30.255	SE
405	9964550.505	222995.83	30.424	SE
406	9964555.013	222988.111	30.278	SE
407	9964558.947	222979.689	30.14	SE
408	9964563.211	222970.879	30.233	SE
409	9964566.99	222962.656	30.265	SE
410	9964571.034	222953.999	30.255	SE
411	9964575.121	222945.437	30.251	SE
412	9964579.047	222936.688	30.379	SE
413	9964582.187	222936.862	30.41	SE
414	9964582.011	222948.096	30.267	SE
415	9964581.834	222957.413	30.272	SE
416	9964581.767	222967.214	30.229	SE
417	9964581.702	222976.092	30.221	SE
418	9964581.789	222985.755	30.311	SE
419	9964581.638	222994.557	30.183	SE
420	9964581.653	223004.22	30.255	SE
421	9964581.3	223013.115	30.276	SE
422	9964581.149	223022.734	30.322	SE
423	9964581.468	223031.67	30.269	SE
424	9964581.96	223041.312	30.262	SE
425	9964582.081	223049.899	30.194	SE
426	9964582.162	223060.007	30.226	SE
427	9964582.22	223068.467	30.283	SE
428	9964582.16	223077.349	30.302	SE
429	9964582.203	223086.22	30.307	SE
430	9964582.481	223095.112	30.282	SE
431	9964582.521	223104.165	30.225	SE

432	9964582.291	223113.021	30.206	SE
433	9964582.187	223121.933	30.25	SE
434	9964581.228	223130.996	30.199	SE
435	9964583.434	223129.307	30.232	SE
436	9964574.572	223128.055	30.206	SE
437	9964579.091	223125.521	30.079	SE
438	9964579.526	223113.054	29.928	SE
439	9964570.312	223113.165	29.876	SE
440	9964569.674	223124.008	29.959	SE
441	9964560.862	223122.15	29.957	SE
442	9964561.751	223112.314	29.839	SE
443	9964551.022	223112.578	29.884	SE
444	9964549.389	223120.287	29.947	SE
445	9964539.709	223119.666	30.079	SE

446	9964539.517	223112.227	29.907	SE
447	9964529.031	223111.907	29.77	SE
448	9964528.382	223117.209	30.055	SE
449	9964573.275	223128.114	30.194	SE
450	9964564.596	223126.528	30.282	SE
451	9964555.704	223124.752	30.302	SE
452	9964547.564	223123.305	30.248	SE
453	9964538.698	223121.694	30.198	SE
454	9964529.675	223119.701	30.173	SE
455	9964520.876	223117.734	30.178	SE
456	9964511.996	223115.77	30.153	SE
457	9964503.243	223114.154	30.134	SE
458	9964494.458	223112.193	30.132	SE
459	9964485.093	223110.265	30.111	SE
460	9964473.707	223107.261	30.185	SE
461	9964475.683	223109.513	30.081	SE
462	9964479.168	223100.949	30.139	SE
463	9964482.69	223092.861	30.147	SE
464	9964486.182	223085.541	30.068	SE
465	9964490.276	223076.747	30.242	SE
466	9964493.662	223069.352	30.139	SE
467	9964497.518	223061.393	30.056	SE
468	9964501.736	223052.729	30.25	SE
469	9964505.065	223044.677	30.264	SE
470	9964509.149	223037.418	30.337	SE
471	9964512.981	223029.248	30.348	SE
472	9964516.436	223021.168	30.405	SE
473	9964520.5	223014.35	30.434	SE
474	9964524.328	223006.512	30.448	SE
475	9964527.6	222999.044	30.4	SE
476	9964531.185	222990.816	30.238	SE
477	9964534.714	222982.169	30.37	SE

478	9964538.3	222975.072	30.397	SE
479	9964542.149	222967.746	30.396	SE
480	9964545.987	222959.883	30.376	SE
481	9964549.724	222951.973	30.389	SE
482	9964553.68	222943.722	30.394	SE
483	9964557.357	222936.162	30.47	SE
484	9964558.978	222932.647	30.482	SE
485	9964557.508	222934.289	30.549	SE
486	9964565.823	222936.149	30.371	SE
487	9964573.964	222937.787	30.348	SE
488	9964576.795	222938.278	30.341	SE
489	9964579.209	223002.282	29.965	SE
490	9964575.033	223001.138	29.865	SE
491	9964571.934	222998.082	29.881	SE
492	9964571.664	223006.286	29.843	SE

493	9964565.848	223006.27	29.955	SE
494	9964564.566	223010.483	30.143	SE
495	9964557.068	223008.917	30.417	SE
496	9964557.033	223005.357	30.413	SE
497	9964557.174	223001.823	30.255	SE
498	9964554.355	223011.889	30.565	SE
499	9964552.267	223018.567	30.757	SE
500	9964558.675	223020.724	30.402	SE
501	9964561.419	223015.006	30.307	SE
502	9964567.813	223013.277	30.19	SE
503	9964576.215	223014.213	30.078	SE
504	9964579.385	223020.205	30.101	SE
505	9964572.379	223020.72	30.137	SE
506	9964568.195	223020.017	30.314	SE
507	9964563.978	223024.914	30.349	SE
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510	9964579.536	223028.151	30.16	SE
511	9964579.618	223034.312	30.191	SE
512	9964571.826	223033.021	30.172	SE
513	9964565.042	223031.491	30.26	SE
514	9964561.167	223030.517	30.281	SE
515	9964558.565	223037.144	30.35	SE
516	9964567.078	223037.616	30.231	SE
517	9964575.913	223038.121	30.142	SE
518	9964580.493	223038.918	30.191	SE
519	9964580.344	223044.055	30.25	SE
520	9964575.845	223044.408	30.197	SE
521	9964570.397	223044.127	30.161	SE
522	9964563.793	223044.049	30.288	SE
523	9964559.008	223043.954	30.279	SE

524	9964555.006	223043.506	30.23	SE
525	9964512.38	223045.084	30.138	SE
526	9964514.007	223040.953	30.317	SE
527	9964517.556	223032.527	30.275	SE
528	9964526.766	223035.572	30.432	SE
529	9964525.483	223041.663	30.247	SE
530	9964524.06	223046.93	30.125	SE
531	9964533.369	223048.209	30.142	SE
532	9964535.514	223043.573	30.346	SE
533	9964537.456	223039.665	30.425	SE
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535	9964546.987	223045.522	30.456	SE
536	9964547.261	223048.776	30.038	SE
537	9964557.89	223048.846	30.089	SE
538	9964559.119	223045.878	30.321	SE
539	9964569.428	223046.358	30.243	SE

540	9964569.948	223050.544	30.041	SE
541	9964569.915	223064.618	29.993	SE
542	9964569.88	223078.037	29.939	SE
543	9964569.87	223091.275	29.884	SE
544	9964570.03	223104.471	29.964	SE
545	9964569.998	223111.571	29.859	SE
546	9964562.599	223111.577	29.869	SE
547	9964562.448	223098.553	29.967	SE
548	9964562.575	223085.563	29.934	SE
549	9964562.553	223071.843	30.06	SE
550	9964562.496	223060.134	30.03	SE
551	9964562.434	223050.009	30.061	SE
552	9964555.184	223049.466	29.989	SE
553	9964555.295	223061.277	30.01	SE
554	9964555.076	223074.363	29.909	SE
555	9964554.909	223086.997	29.956	SE
556	9964554.976	223100.319	29.971	SE
557	9964555.321	223111.66	29.895	SE
558	9964547.584	223111.322	29.865	SE
559	9964547.876	223099.47	29.841	SE
560	9964547.822	223087.394	29.867	SE
561	9964547.735	223074.66	29.911	SE
562	9964548.449	223062.199	29.892	SE
563	9964548.11	223049.991	30	SE
564	9964540.373	223050.473	30.039	SE
565	9964540.274	223062.491	30.001	SE
566	9964540.167	223074.878	29.999	SE
567	9964540.147	223087.963	29.954	SE
568	9964540.246	223100.734	29.971	SE
569	9964540.114	223111.65	29.923	SE

570	9964533.167	223111.814	29.851	SE
571	9964532.967	223099.59	29.937	SE
572	9964532.942	223086.17	29.94	SE
573	9964532.947	223073.985	30.004	SE
574	9964532.887	223062.462	29.895	SE
575	9964533.246	223050.78	29.986	SE
576	9964525.673	223050.368	29.984	SE
577	9964525.743	223062.321	29.787	SE
578	9964525.838	223073.984	29.894	SE
579	9964525.853	223086.635	29.89	SE
580	9964525.624	223098.396	29.829	SE
581	9964525.429	223111.614	29.862	SE
582	9964518.758	223111.64	29.875	SE
583	9964509.238	223110.717	29.827	SE
584	9964501.491	223109.427	29.899	SE
585	9964492.257	223107.692	29.82	SE
586	9964484.877	223104.8	29.843	SE

587	9964488.003	223096.836	29.907	SE
588	9964497.126	223099.099	29.696	SE
589	9964506.462	223100.652	29.859	SE
590	9964514.549	223101.497	29.886	SE
591	9964518.265	223101.484	29.824	SE
592	9964517.401	223092.154	29.89	SE
593	9964508.409	223093.174	29.835	SE
594	9964499.868	223092.954	29.907	SE
595	9964490.557	223089.094	29.905	SE
596	9964494.157	223080.261	29.912	SE
597	9964503.048	223080.965	29.931	SE
598	9964510.791	223081.745	29.691	SE
599	9964518.703	223081.683	29.936	SE
600	9964518.27	223069.536	29.866	SE
601	9964518.651	223058.07	29.991	SE
602	9964518.164	223049.83	29.942	SE
603	9964510.449	223049.81	29.897	SE
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605	9964502.117	223059.948	29.969	SE
606	9964510.831	223062.445	29.796	SE
607	9964511.38	223070.297	29.991	SE
608	9964504.566	223070.056	29.956	SE
609	9964496.793	223069.333	29.977	SE
610	9964493.595	223075.976	30.055	SE
611	9964501.504	223077.6	29.829	SE
612	9964511.572	223076.88	29.871	SE
613	9964659.936	223112.59	30.064	BM0
614	9964703.687	223028.991	30.088	BM01
615	9964570.621	222932.653	30.169	BM02
616	9964601.079	223035.535	29.97	BM03
617	9964596.901	223042.397	29.026	TPS
618	9964690.699	223081.185	29.617	TPS
619	9964630.103	223138.217	29.949	TPS
620	9964630.103	223138.283	29.946	TPS
621	9964651.377	222966.877	29.365	TPS