

PROJECT:

BARRETT SOLAR (RAINS COUNTY, TEXAS, USA)

OWNER:



CONTRACTOR:

TBD

AZTEC Engineering, Inc.

501 N. 44th Street, Suite 300

Phoenix, Arizona 85008

(602) 454-0402

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The logo for AZTEC TYPSA, with 'AZTEC' in orange and 'TYPSA' in white on a red square background.		Doc. Nº: CV-09		Final Submittal	01

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1 INTRODUCTION

The purpose of this document is to describe the results of the preliminary earthwork analysis that was conducted for the Barrett Solar site.

The plant, detailed below in Figure 1, will be constructed above ground and will be located approximately 50 miles east northeast of Dallas, Texas. The project is located within Rains County limits. For purposes of this analysis, the project has been divided into 6 subgroups.

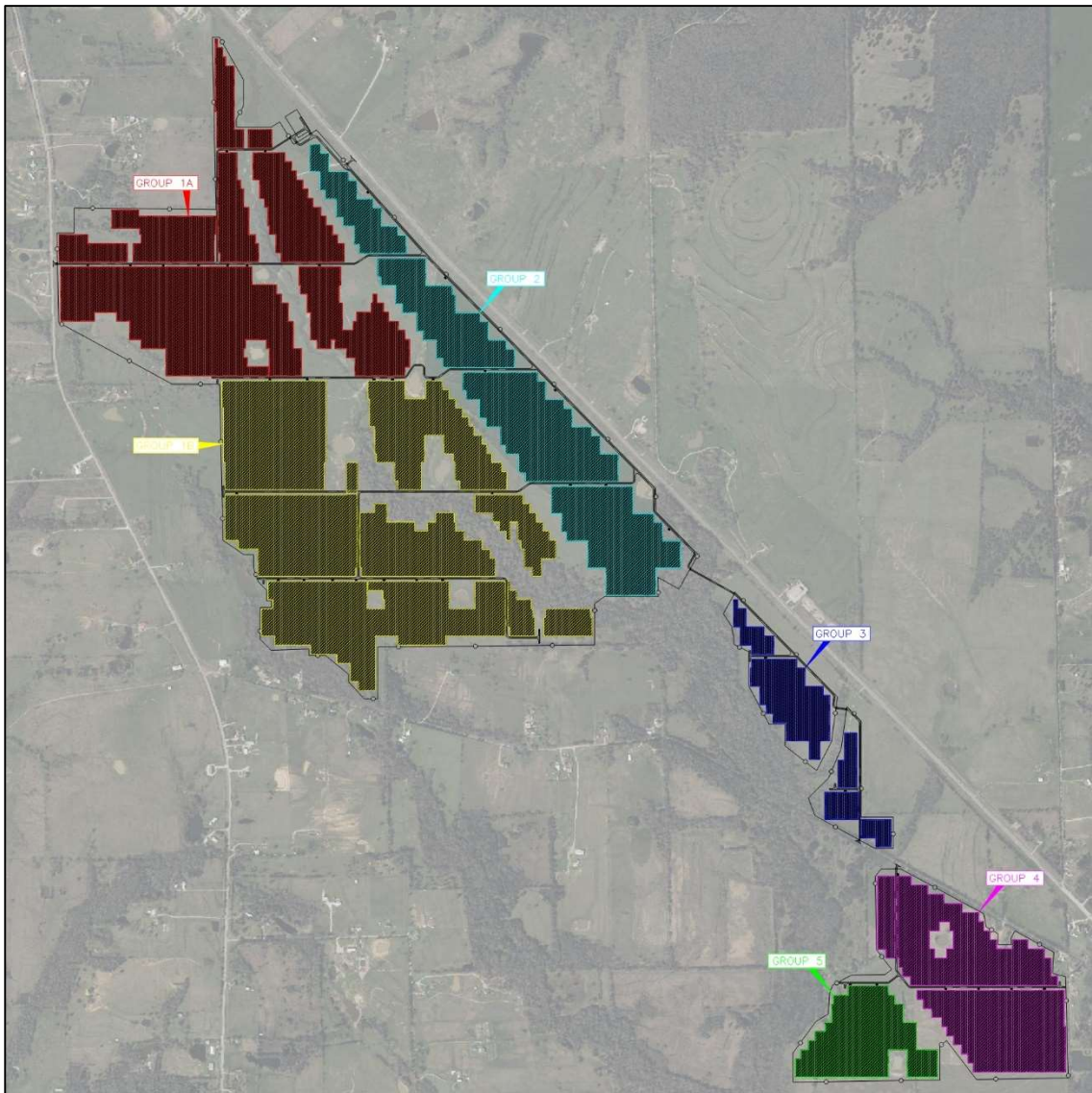


Figure 1: PVGrad Grading Subgroup Delineation

2 WHAT IS PVGRAD?

As mentioned in the previous section, the grading analysis will be conducted using the PVGrad software, which is a software developed by Aztec for the automatic design of the civil works and structural design of photovoltaic solar plants with horizontal axis trackers. PVGrad processes the topography of the terrain and the layout of the plant in a 3D environment to determine the minimum amount of grading necessary to meet geometric restrictions of the tracker system being analyzed.

In order to determine the amount of grading necessary to construct the proposed solar arrays, the analysis first classifies terrain irregularities in one of two ways:

1. Small-scale topographical irregularities (terrain roughness). These have a characteristic dimension smaller than the length of a tracker and will require earthwork to the extent that the length of the tracker supports are insufficient to absorb them. The intensity of the earthwork necessary to adapt the roughness of the terrain depends exclusively on the difference between the maximum and minimum heights of the tracker posts (reveal window), according to the manufacturer's requirements

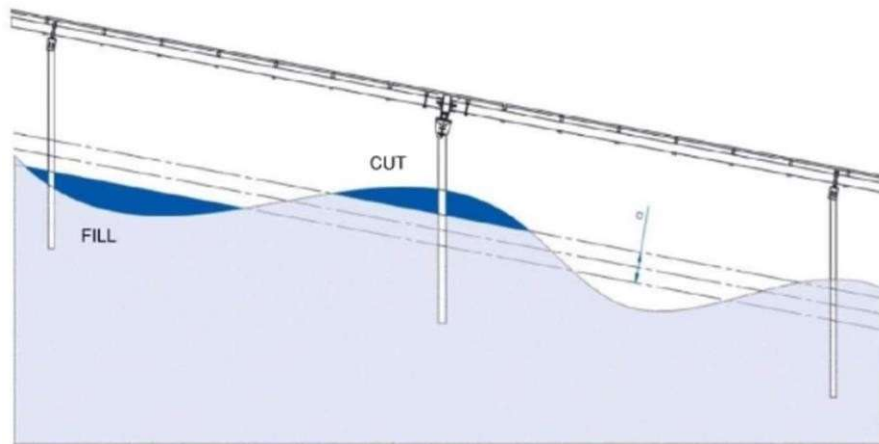


Figure 2: Small-scale Irregularities

2. Large-scale topographic irregularities (orography). These have a characteristic dimension greater than the size of tracker and define the average slopes of the terrain in different areas of the plot. The intensity of the earthworks required to adapt the orography depends exclusively on the angular tolerances of the tracker in N-S direction -as well as E-W for shading issues-, and to a lesser extent on the maximum cross slope of the interior roads between blocks.

Low-resolution topography captures large-scale irregularities but may be insufficient to determine the earthwork required to adapt the roughness of the terrain to the tracker specifications.

3 PVGRAD STARTING ELEMENTS

The PVGrad software requires different parameters to be able to perform the earthwork design, these parameters are the following:

1. Topography of the natural terrain: the topography should be represented by triangulations as closed as possible to capture as much terrain information as possible.
2. Project layout: it is necessary that the drawing has the position of the trackers and the posts with coordinates in X, Y, Z. Likewise, within the layout it is possible to obtain the maximum and minimum separation between trackers, established within PVGrad as maximum and minimum width for roads; and the maximum inclination that can exist between blocks of trackers.

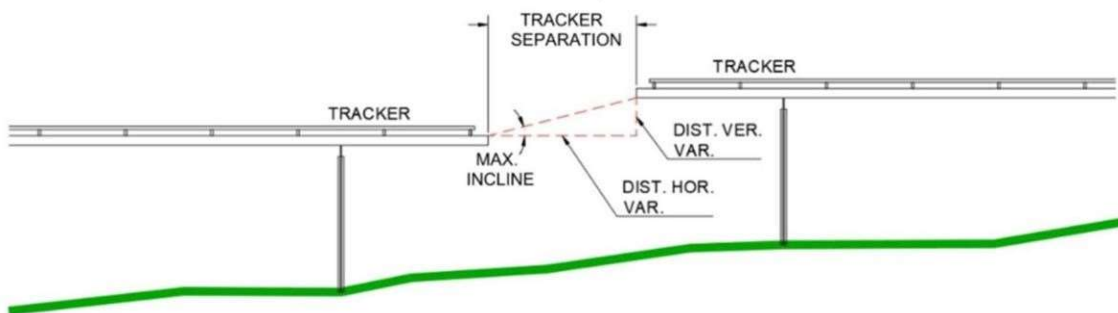


Figure 3: Separation Between Trackers

3. Pole Heights: the maximum and minimum heights allowed to place the tracker must be entered, generally the trackers have a nominal height of the poles and then a difference or increment is applied to obtain the required heights (Figure 4).

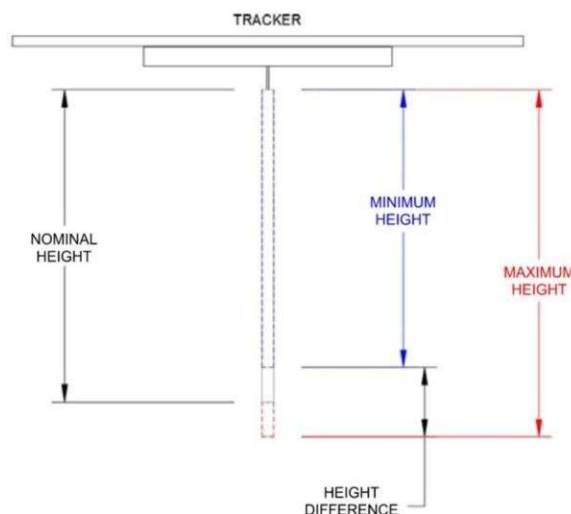


Figure 4: Tracker Post Heights

- Maximum angular deflection in the N-S & E-W direction: both heights and maximum slopes are factors that determine how platforms will be shaped and subsequently where earthworks will be performed.

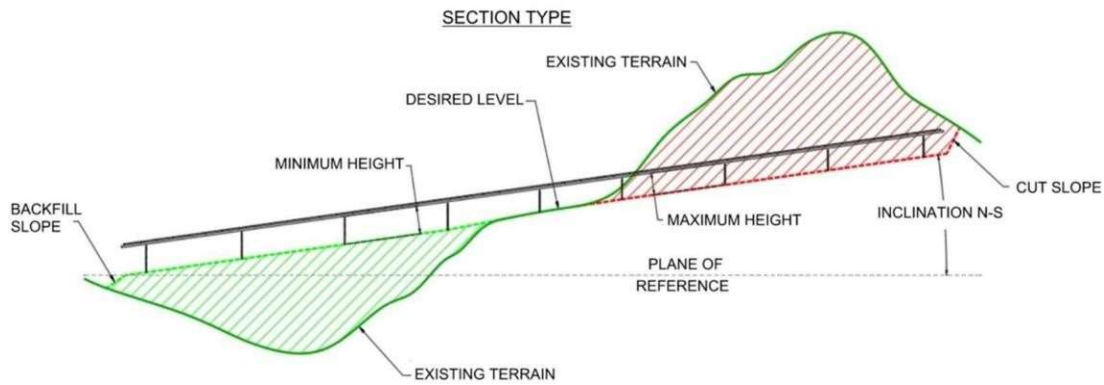


Figure 5: View in N-S Direction

- Cut and fill slope: the slope that shall be used to daylight, or “tie in” the proposed array grading to existing ground. For this analysis, values of 4H:1V have been selected for cut and fill slopes, unless otherwise noted within the construction drawings.

4 INITIAL TOPOGRAPHY

The existing site conditions topography is shown within (Figure 6). This topography has been provided by Grupo Cobra (dated 1/19/2023) and shall be the one used in the PVGrad analysis and subsequent grading design.

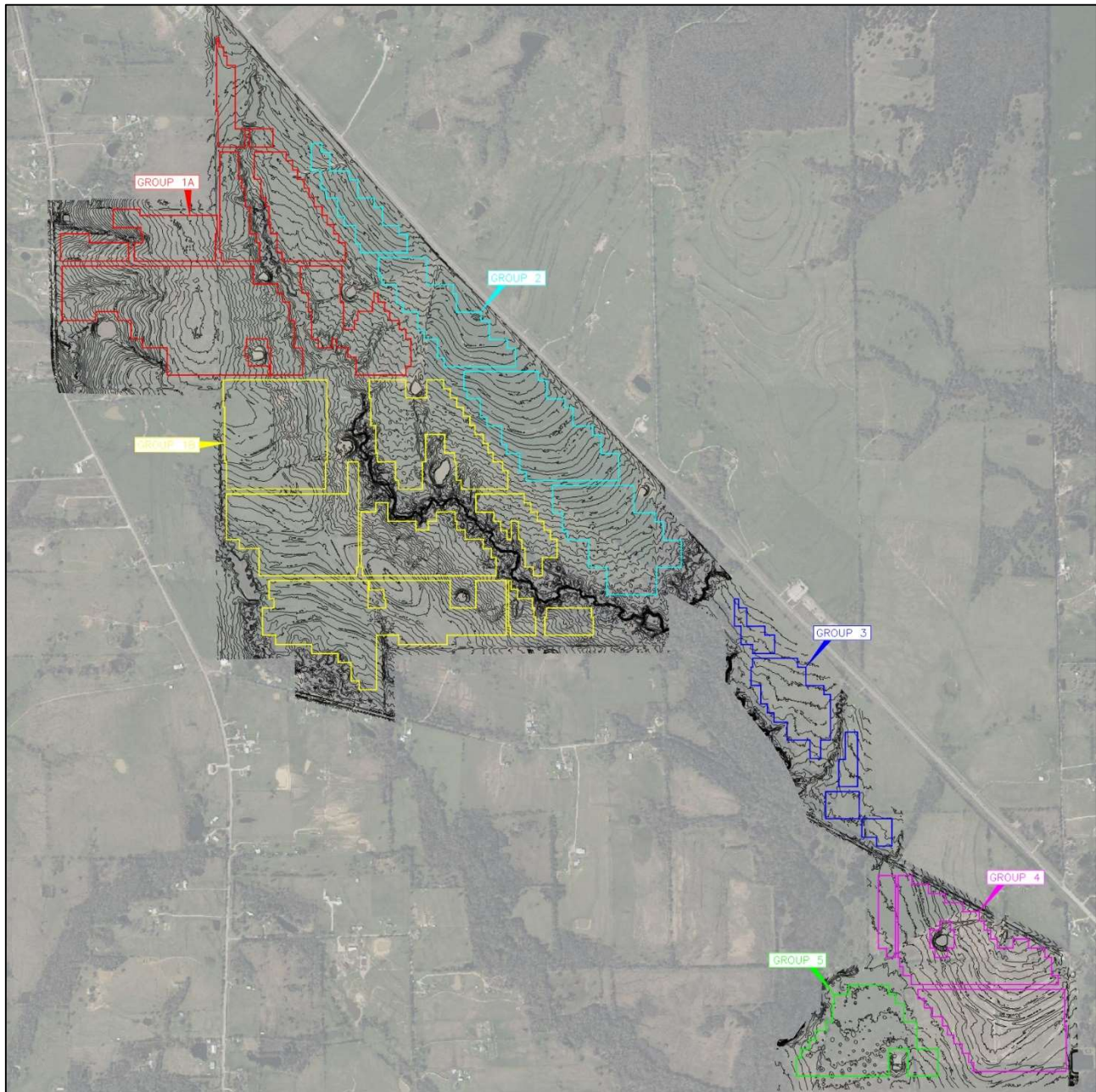


Figure 6: Topographic Configuration

The following figures (Figures 7- 12) exhibit the slopes of the existing topography. The analysis of the Barrett Solar project considers a maximum north-south slope of 15% and east-west slope of 15%, i.e., the trackers must be accommodated with a slope less than or equal to these values in the respective direction. As grading will be required in order to bring the finish grade's slopes into compliance with the slope design parameters. It is considered as a preliminary analysis and there may be areas where earthwork is necessary.

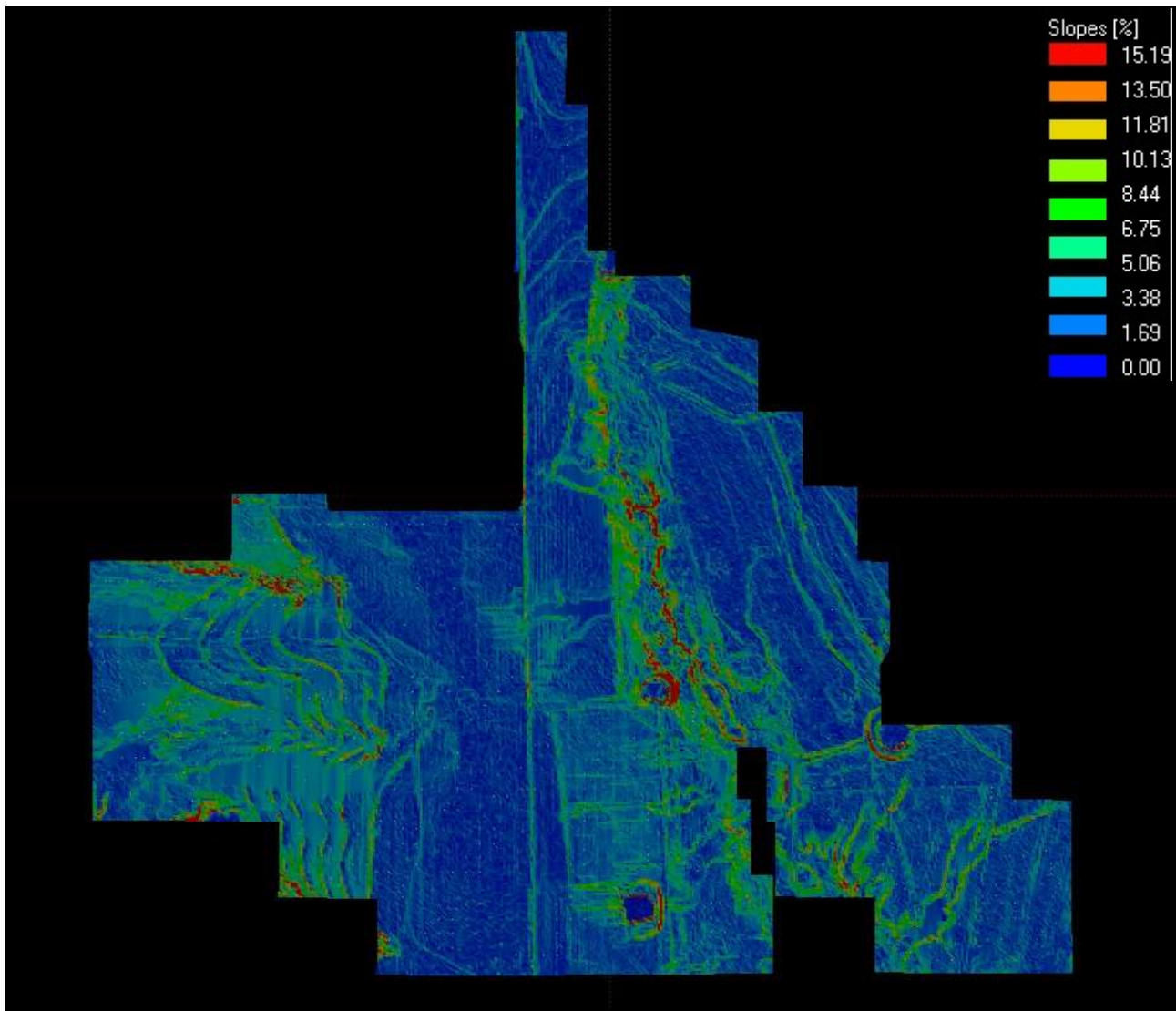


Figure 7: Slope Model – Group 1A

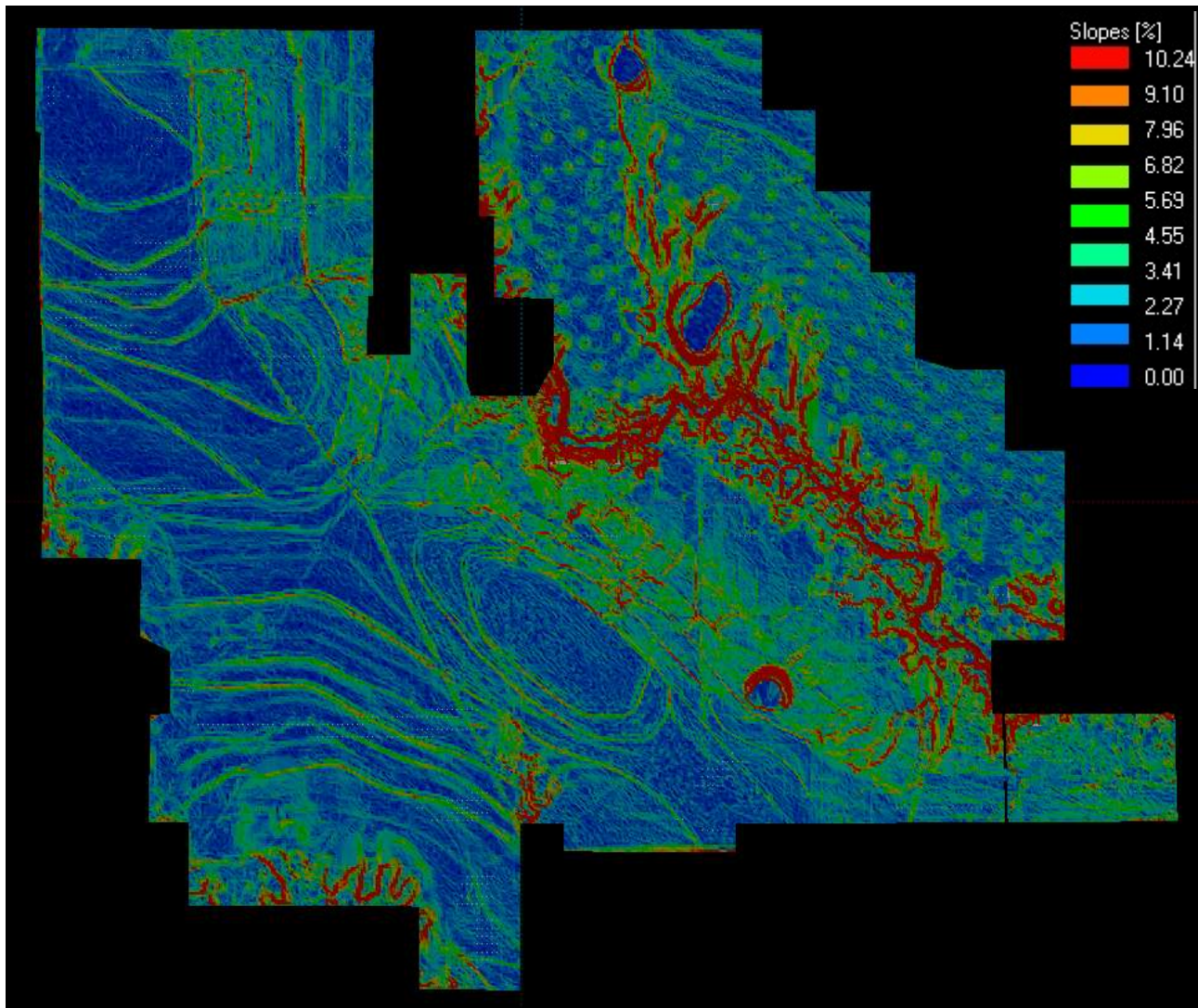


Figure 8: Slope Model – Group 1B

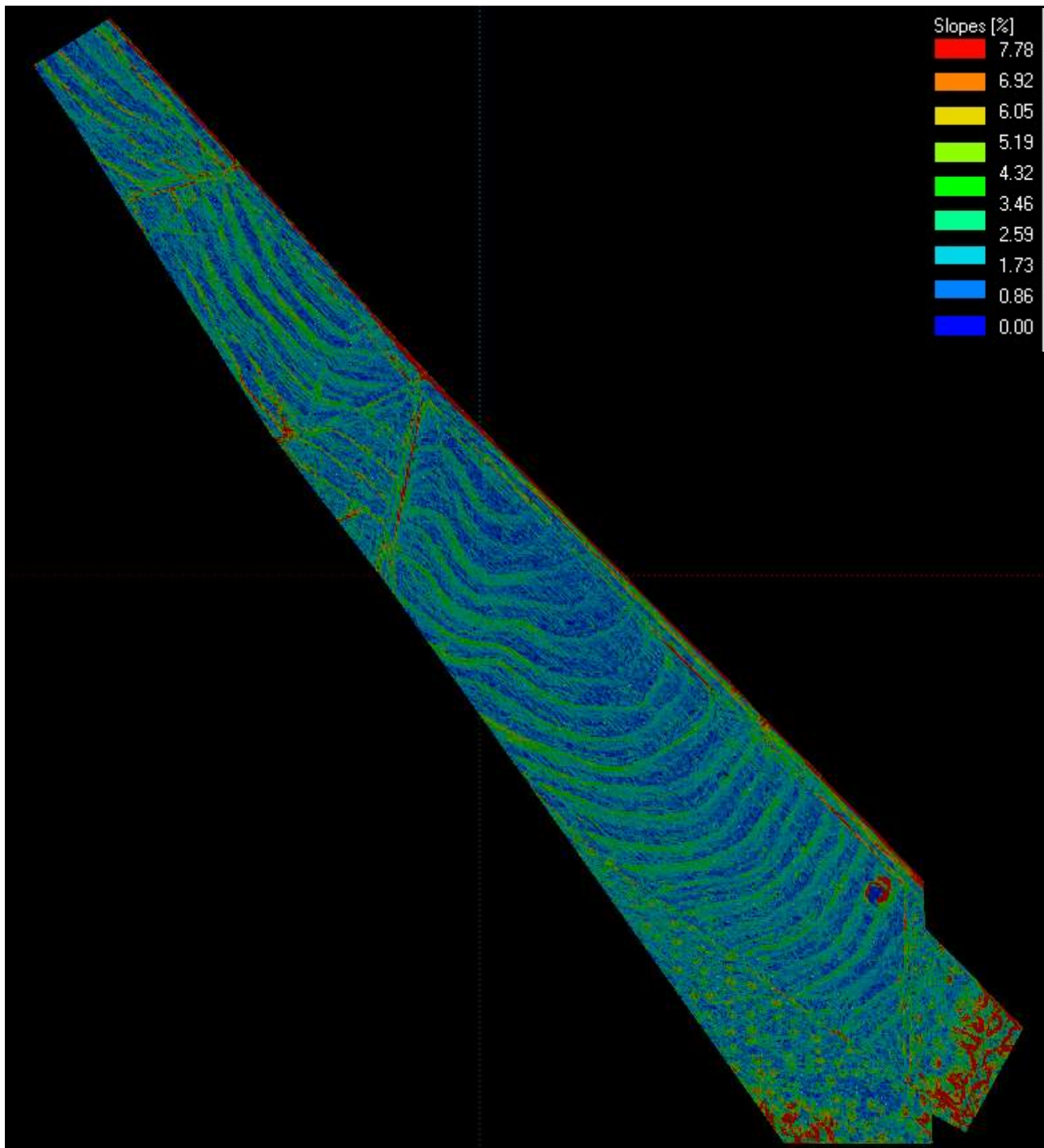


Figure 9: Slope Model - Group 2

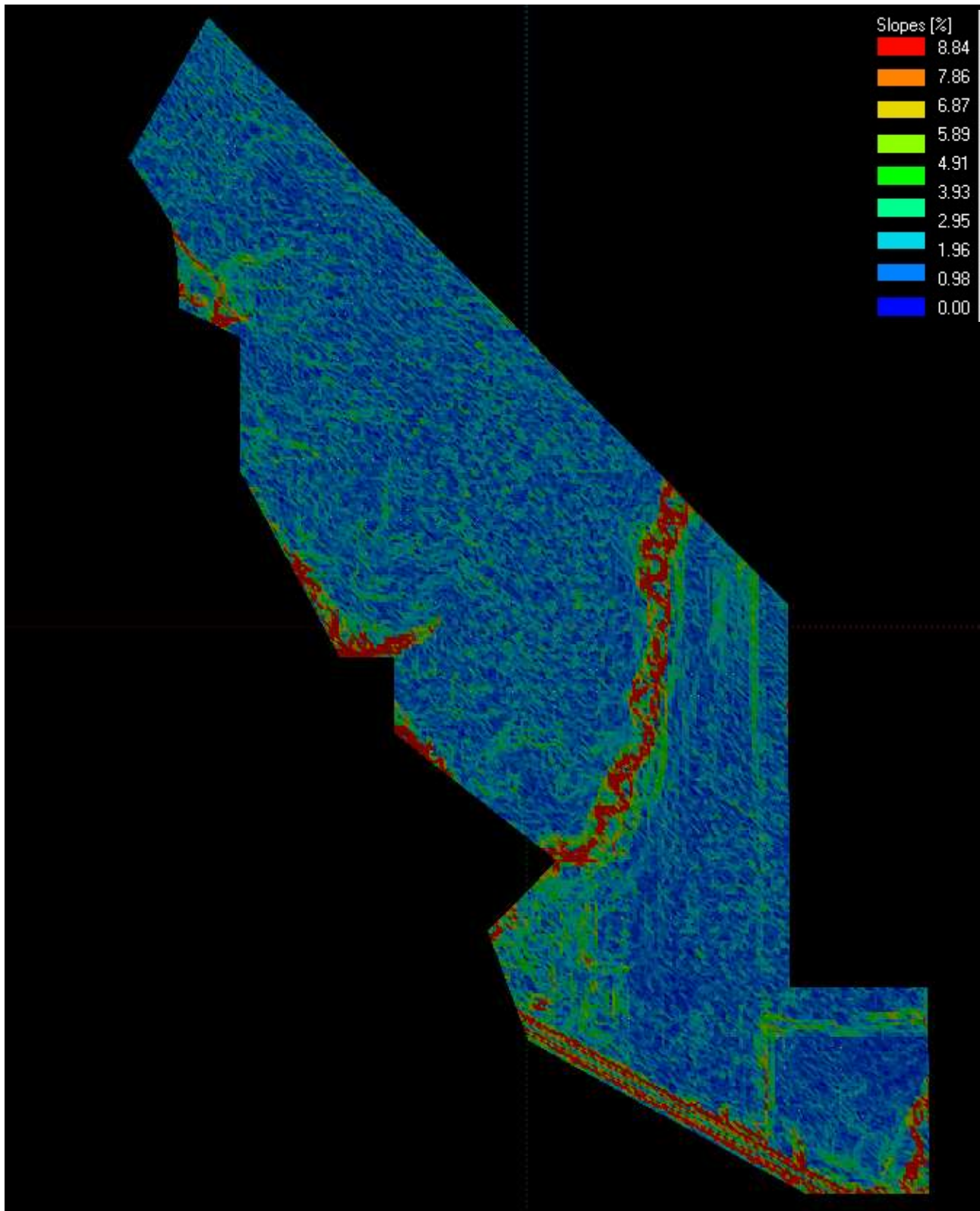


Figure 10: Slope Model – Group 3

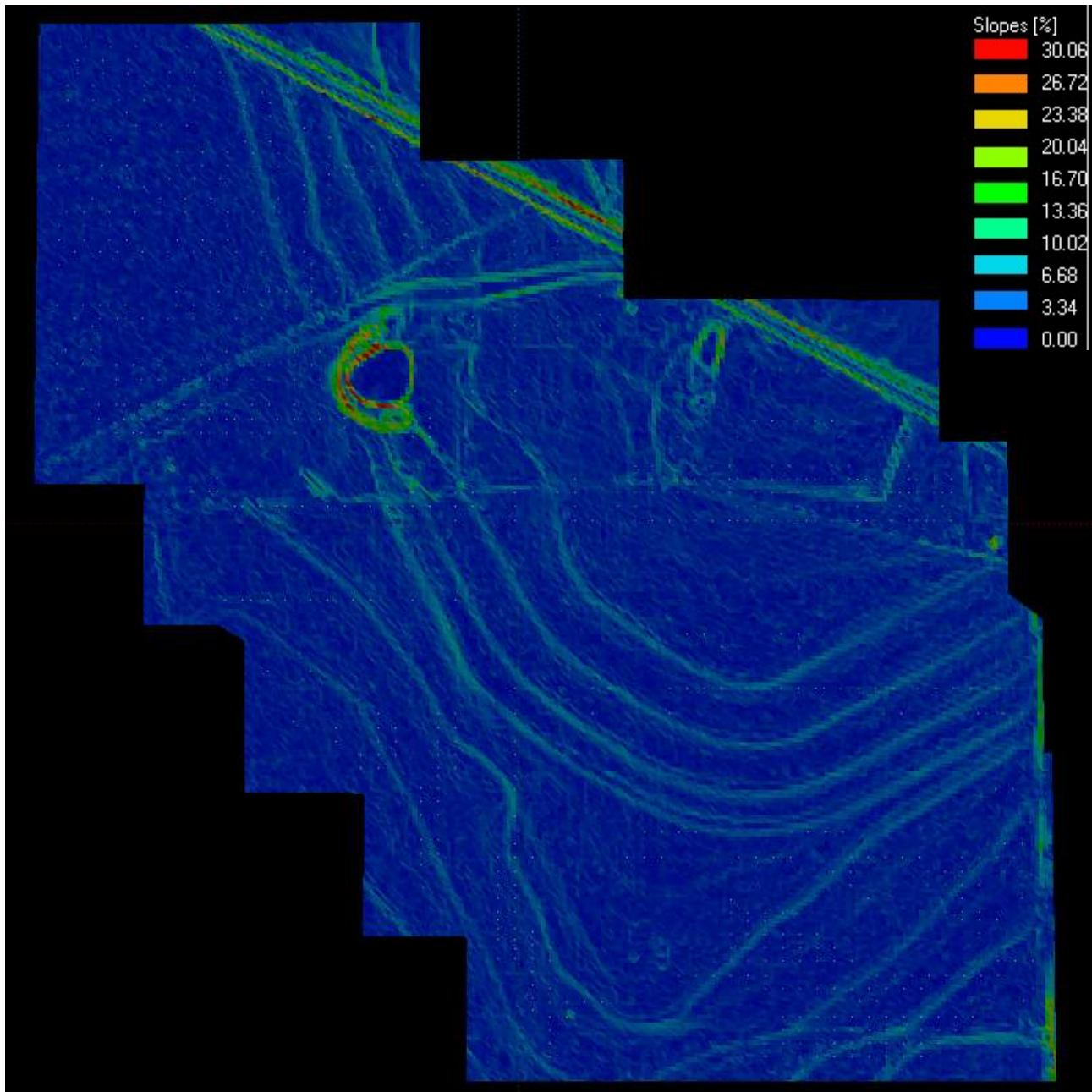


Figure 11: Slope Model – Group 4

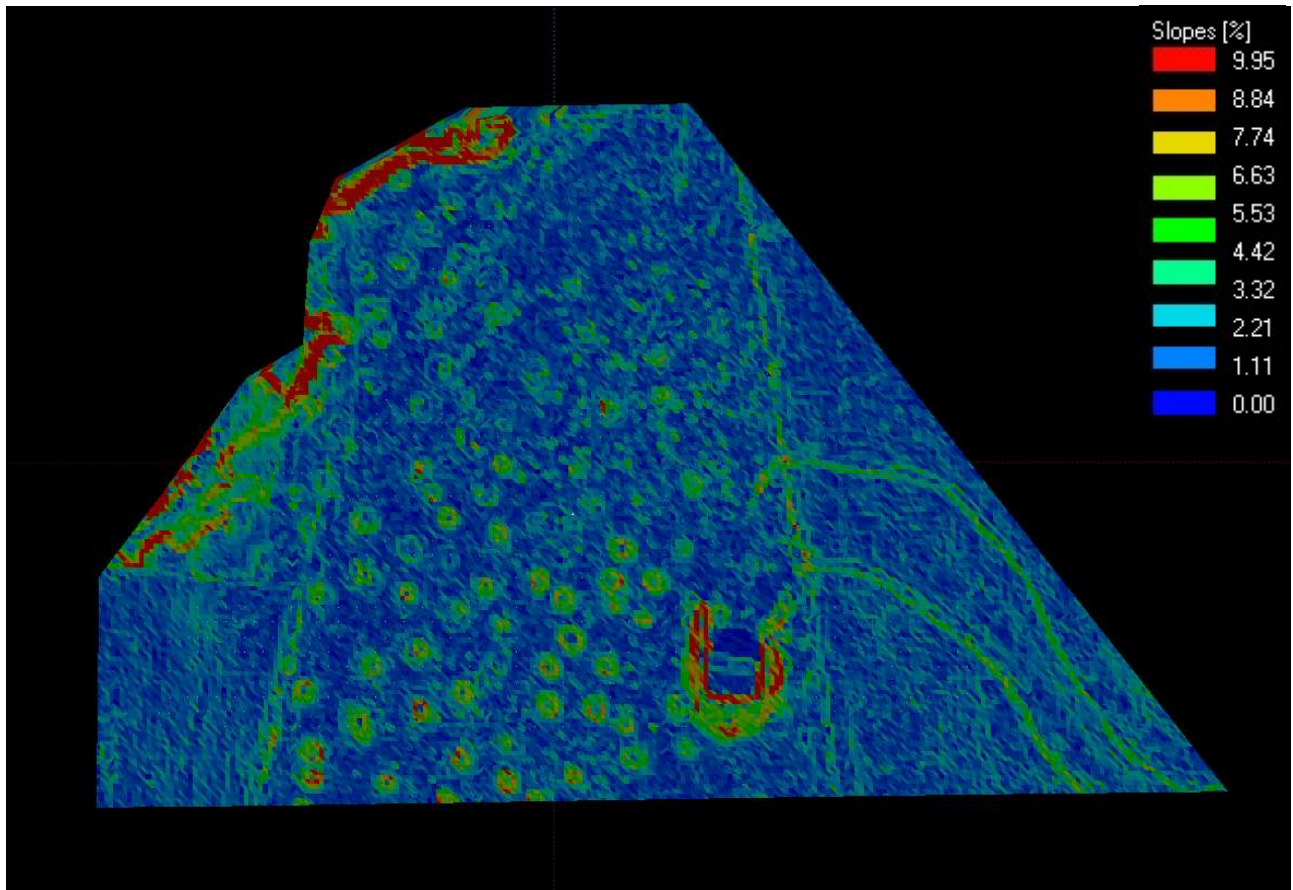


Figure 12: Slope Model – Group 5

Within the PVGrad software, the topography is inserted to create a representative digital model of the terrain. In (Figures 13-18), a 3D view of the model can be seen for each group.

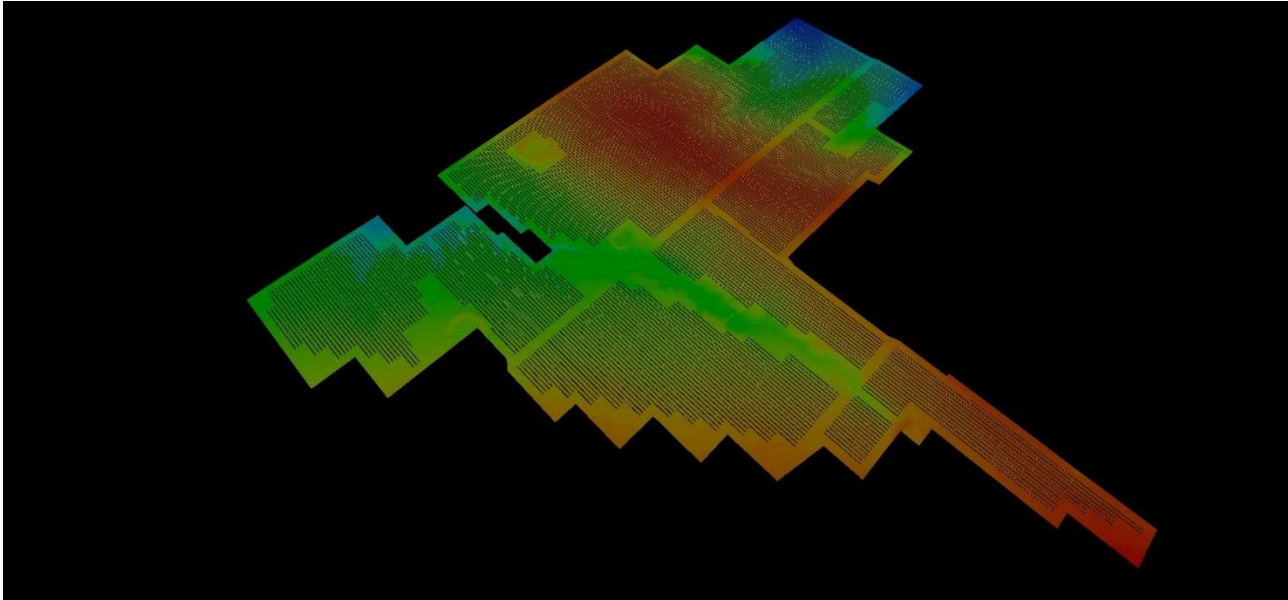


Figure 13: Representative Digital Model – Group 1A

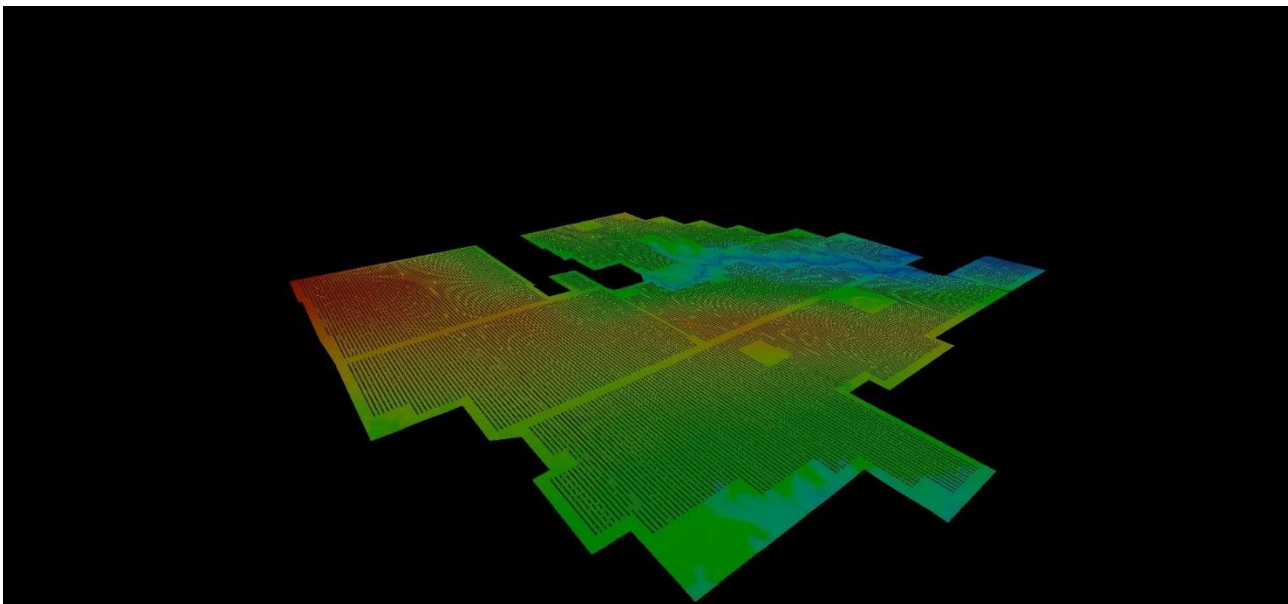


Figure 14: Representative Digital Model – Group 1B

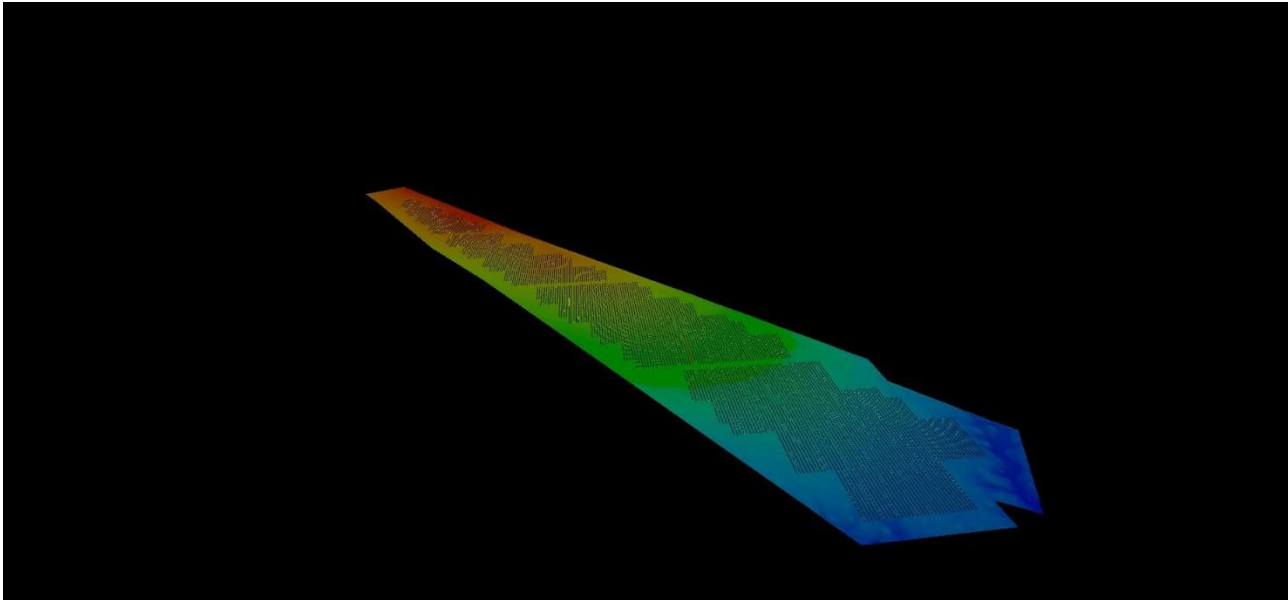


Figure 15: Representative Digital Model – Group 2

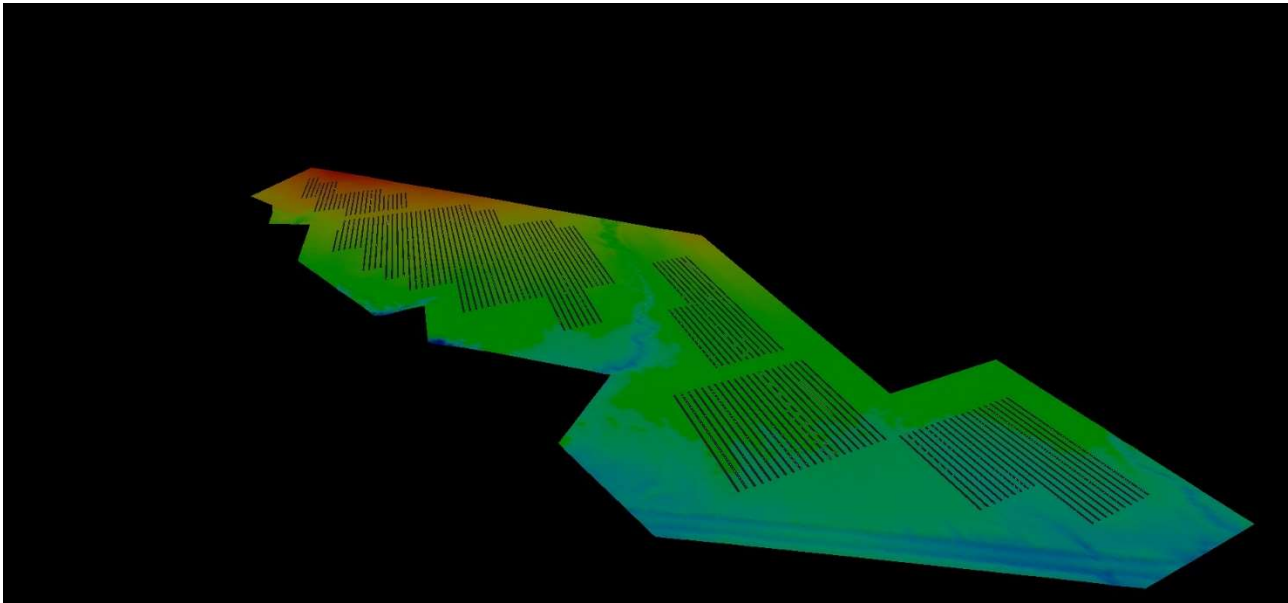


Figure 16: Representative Digital Model - Group 3

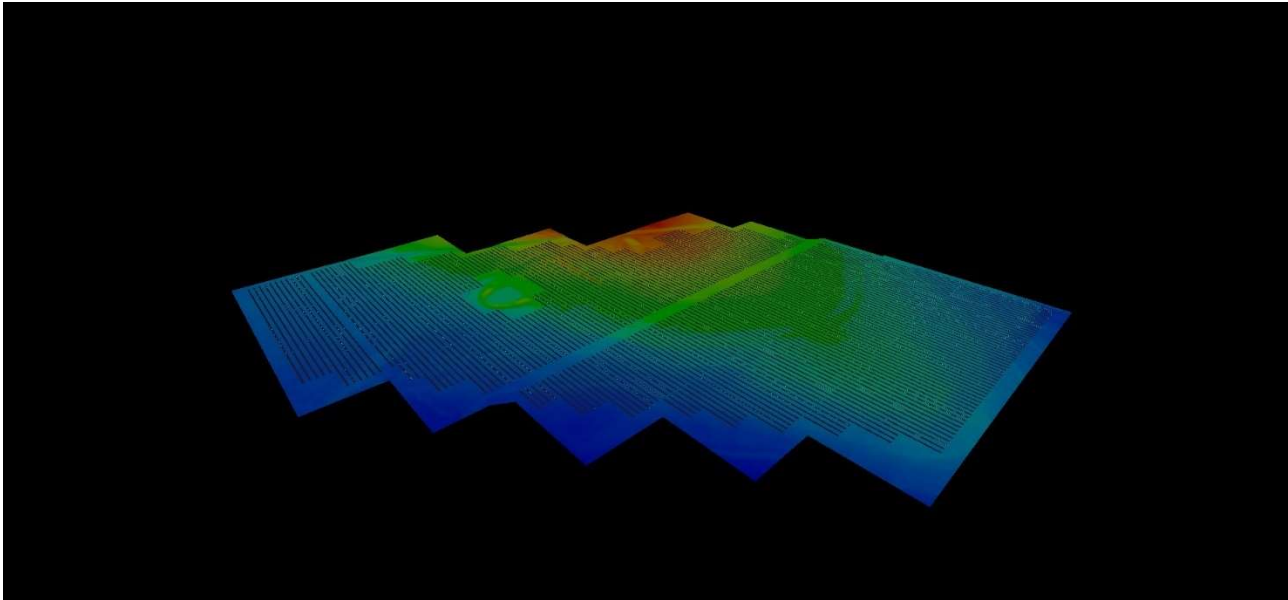


Figure 17: Representative Digital Model - Group 4

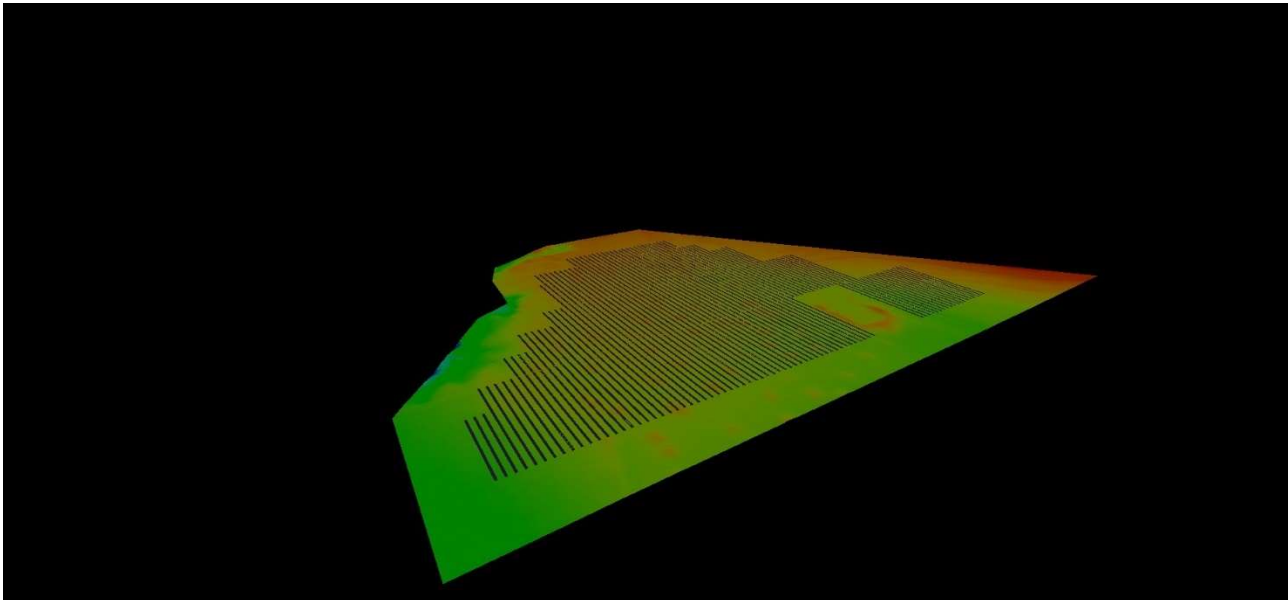


Figure 18: Representative Digital Model - Group 5

5 EARTH MOVEMENTS

Table 1 shown below, provides the various parameters that have been implemented within the preliminary PVGrad grading analysis. These parameters have been used for all groups.

Table 1: Considerations for Tracker Analysis

Description	Data
Minimum Torque Tube Height	5.00 ft.
Maximum Torque Tube Height	7.00 ft
Reveal Window	2.00 ft
Minimum Tracker Inclination N-S	15%
Maximum Tracker Inclination E-W	15%

The required input parameters are summarized below within Figure 19, which reflects the limitations of both the tracker itself and the designer's requirements. It is important to mention that the software requires the data to be in English system units, as well as slopes to be defined in degrees.

Figure 19: PVGrad Input Data

General Data
Define general project data. These will apply to all blocks

Units: Imperial (ft)
Currency: American dollar (\$)

Torque Tube Elevations

Minimum Torque Tube Height: 5.000 ft
Maximum Torque Tube Height: 7.000 ft

Tracker Angular Restrictions

Maximum Tracker Tilt (North): 8.530 deg
Maximum Tracker Tilt (South): 8.530 deg
Maximum E-W Drop Angle: 8.530 deg

Roads and Corridors

Maximum Road Width (N-S): 65.000 ft
Minimum Road Width (N-S): 20.000 ft

Slope Restrictions

Maximum Slope for Internal Roads: 1.146 deg
Maximum Slope for Non-Road corridor: 2.862 deg
Cut Soil Slope: 14.036 deg
Fill Soil Slope: 14.036 deg

This analysis has not considered the prescense of top soil, or any otherwise deleterious material that may be present on site.

After defining the governing parameters, the analysis may now be performed within PVGrad in order to determine the theoretical minimum amount of grading required in order meet the tracker system constraints/limitations. In the following figures (Figures 20-25), the resulting earthwork is shown for the simulation optimized with an Offset 0, where the blue zones represent fills, while the red zones represent cuts:

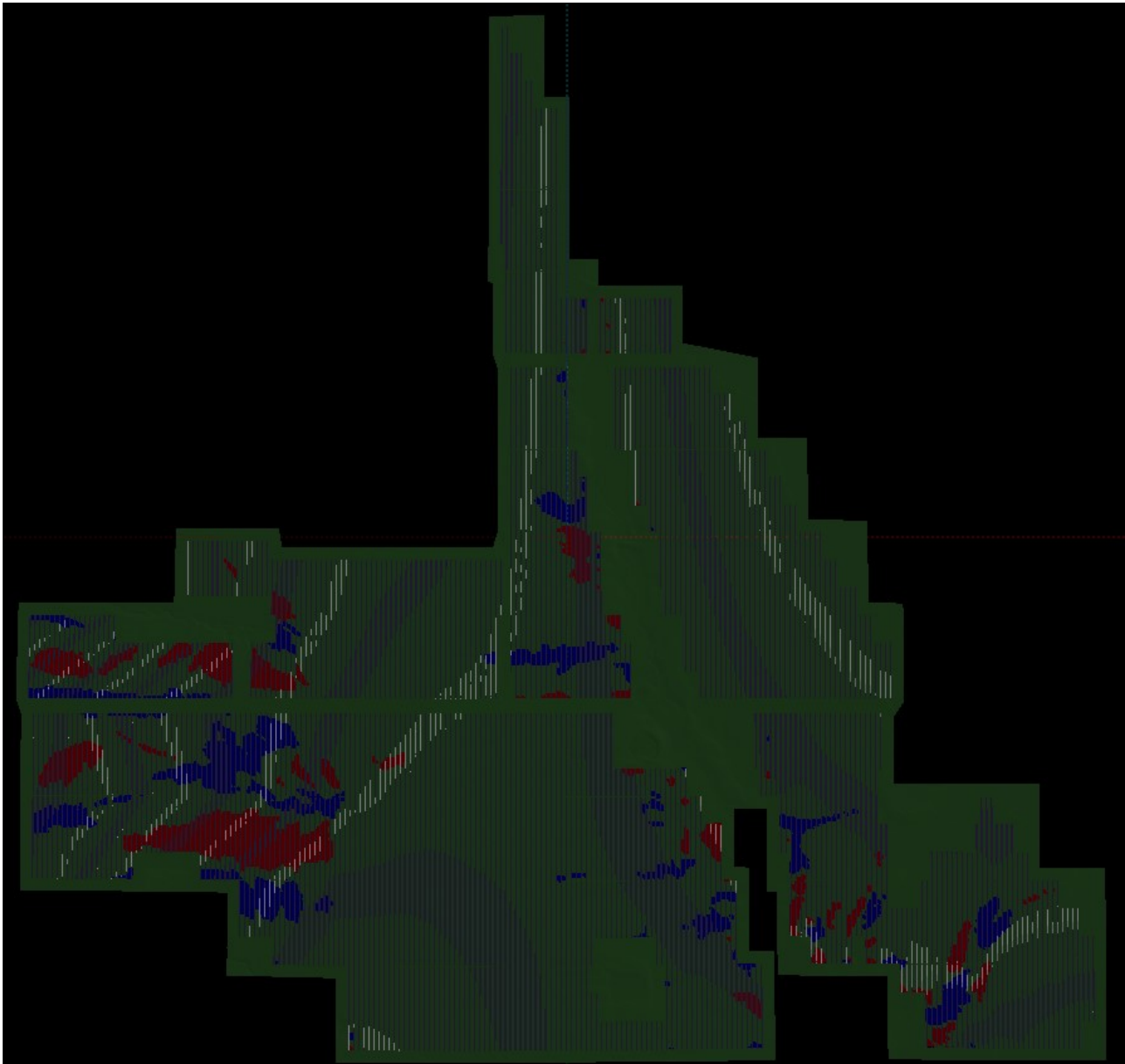


Figure 20: Earthwork - Group 1A

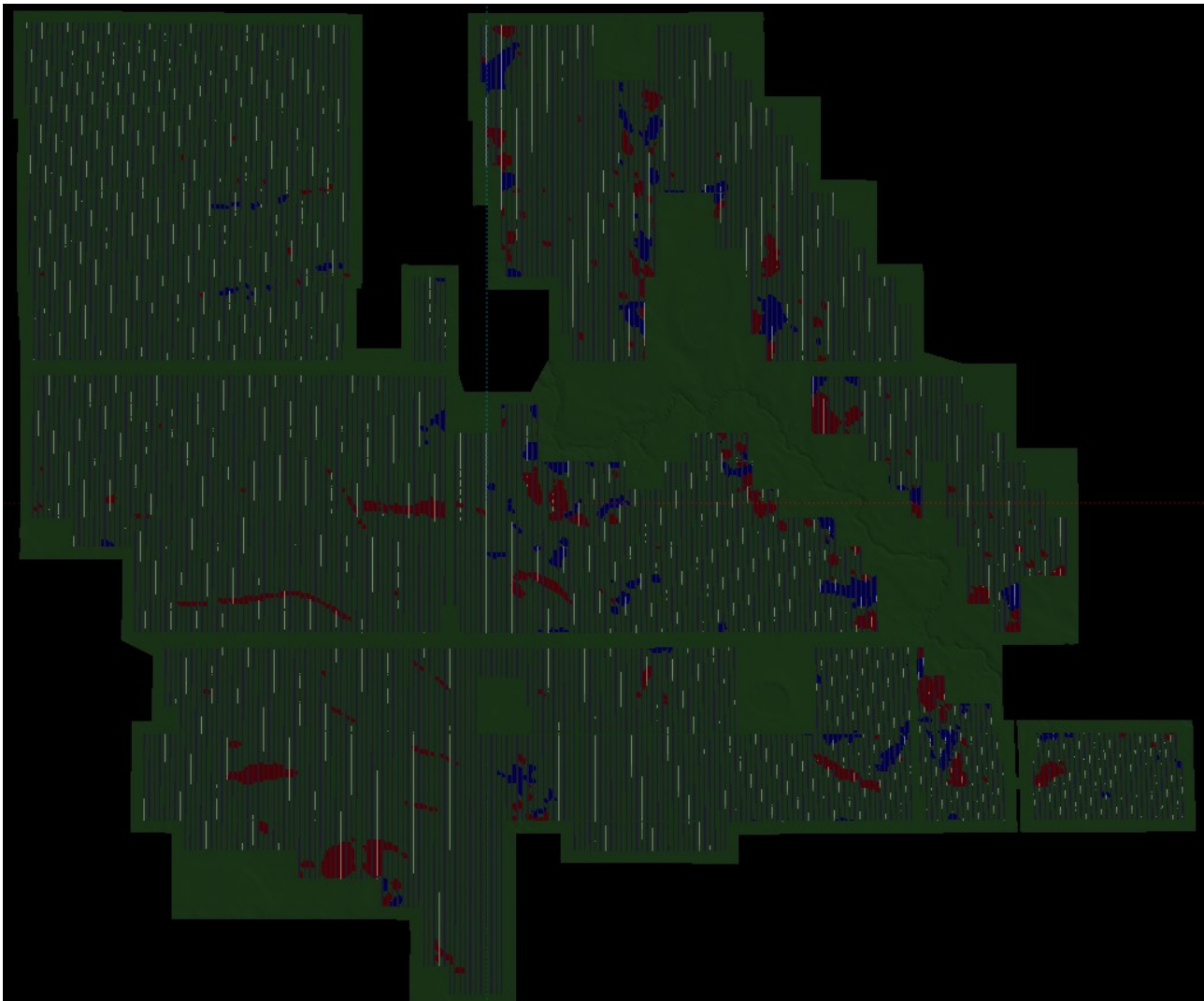


Figure 21: Earthwork - Group 1B

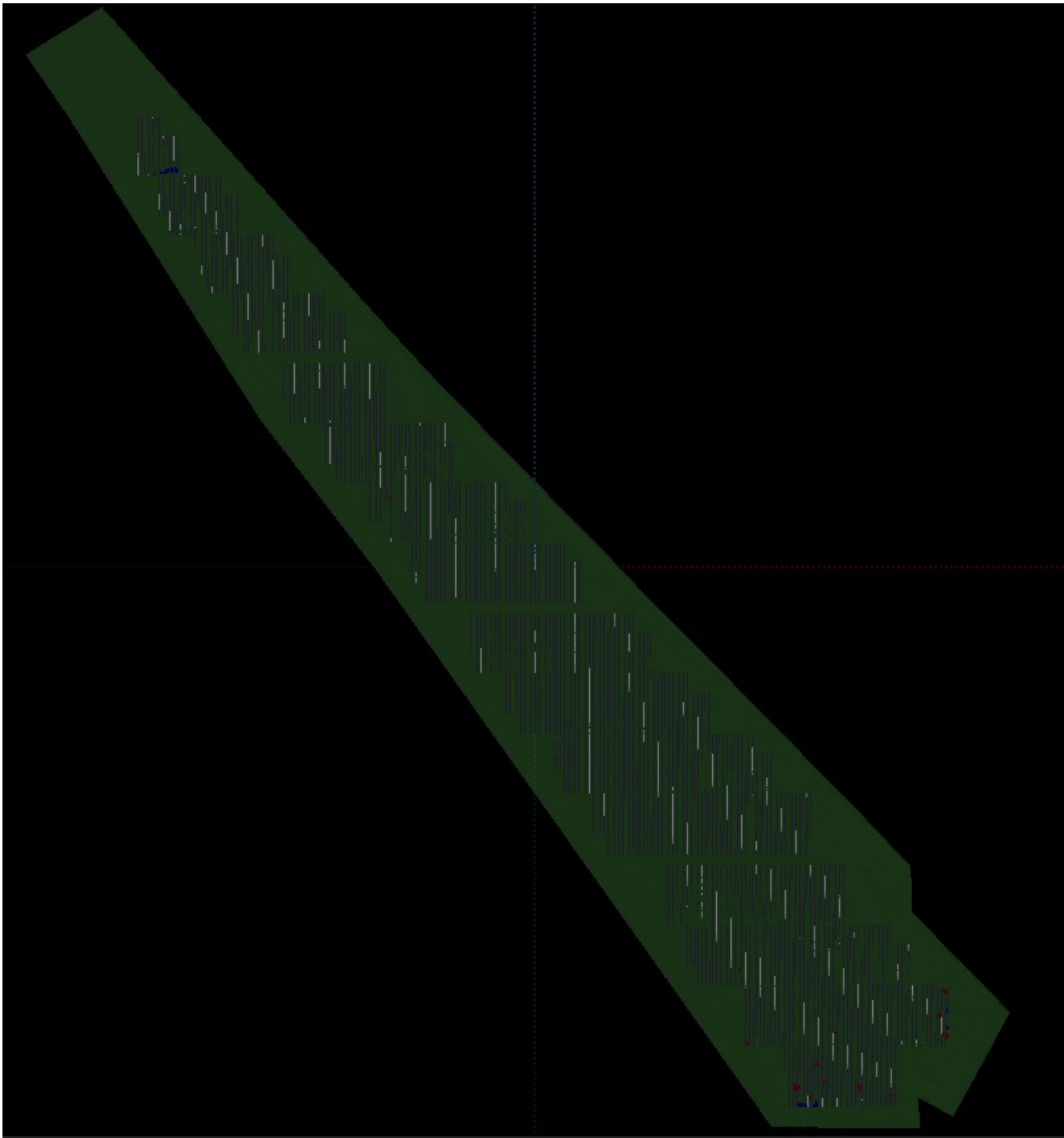


Figure 22: Earthwork - Group 2

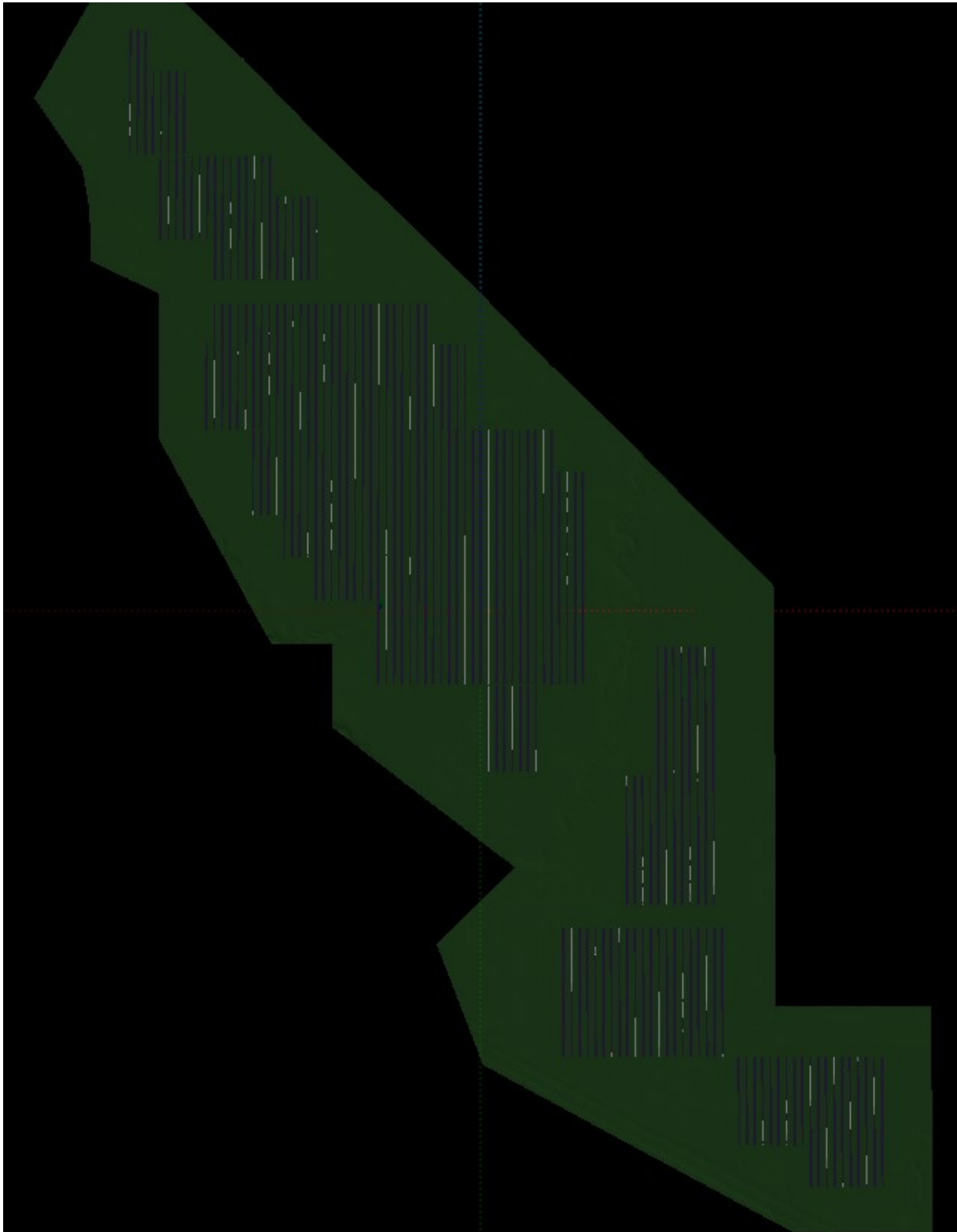


Figure 23: Earthwork - Group 3

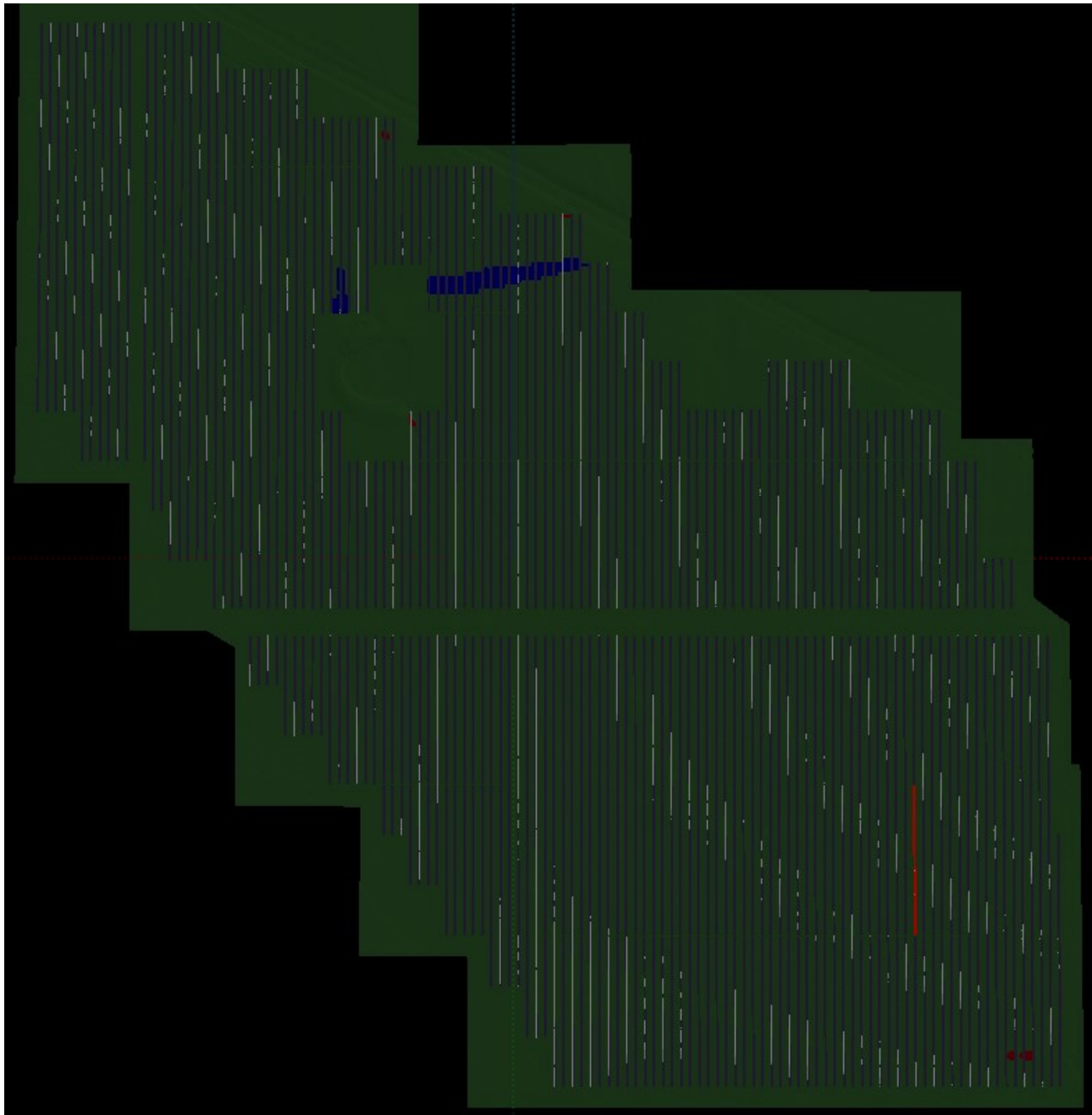


Figure 24: Earthwork - Group 4

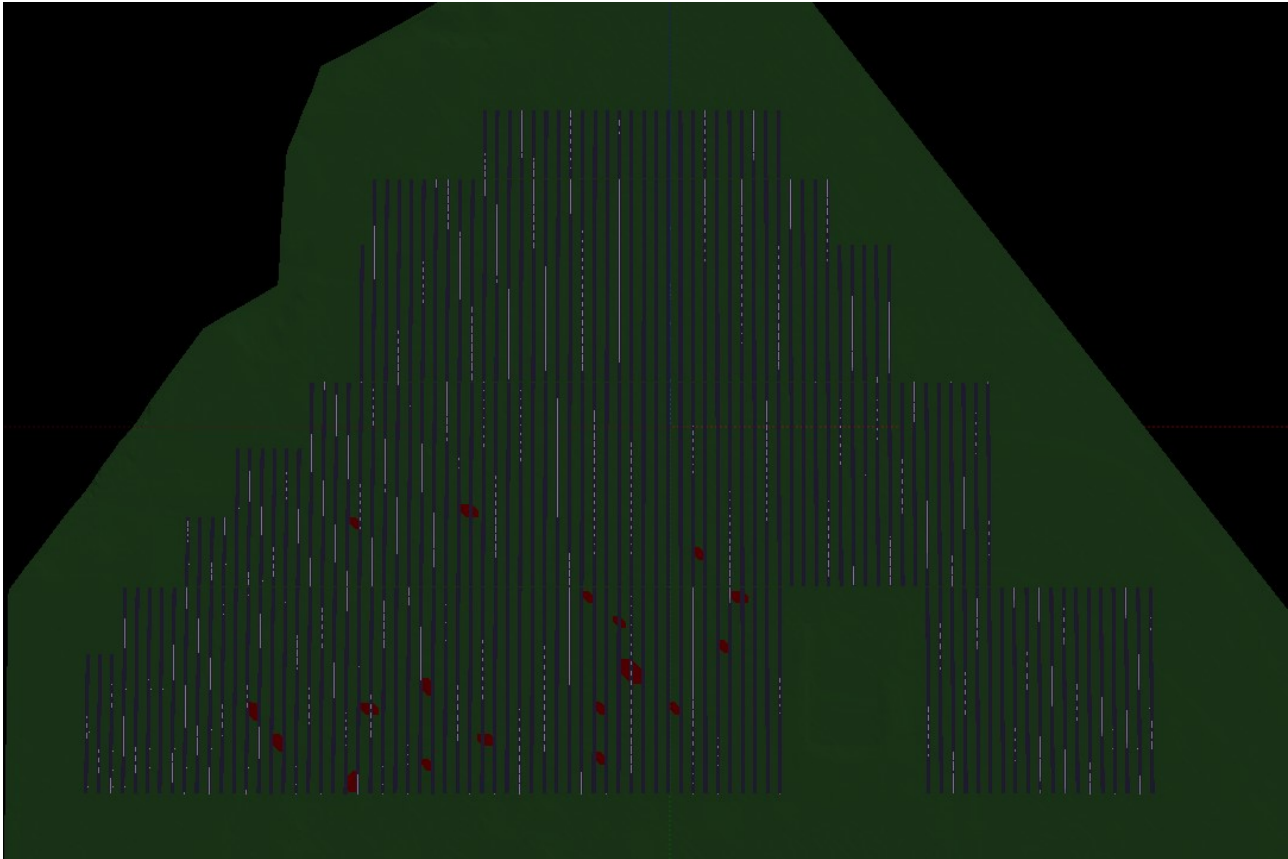


Figure 25: Earthwork - Group 5

The following table (Table 2), shows the compilation of the volumes of the analysis, with an optimum offset of 0. Top soil is considered per the geotechnical investigation under Earthwork section on page 13, performed by Terracon, dated Septmeber 5, 2023, report number 94235249-R3. The table also describes the following:

1. Area: it is the Surface that presents changes due to earth movement adjustment.
 - Total Volume of Clearing: is the total amount of material that will come from cuts in the natural terrain, considering the removal of topsoil.
2. Volume of topsoil in the clearing zone: the topsoil that will be removed and cannot be used in embankment construction purposes. This value is approximate and is based on the geotechnical study findings. Refer to the geotechnical report to verify is topsoil is suitable for construction (Geotechnical Report by Kleinfelder Feb 11,2022 & Tolunary-Wong Sept 21, 2022), in addition to the site conditions as observed by the construction team.
3. Volume of Usable Waste: is the material that can be used for embankment construction purposes.

4. Backfill Volume: is the volume necessary for embankment construction, but without considering the volume of material to cover the excavations due to the removal of topsoil in embankment areas.
5. Volume Topsoil in Embankment: is the material necessary to cover the excavations made by the extraction of topsoil.
6. Required Backfill Volume: the total amount of material needed to cover all embankment areas. It is the sum of the volume of fill and volume of topsoil in the embankment.

Table 2: Volumes Obtained from Earthwork Analysis

Group	Analysis Type	Total Cut (CU.YD.)	Total Fill (CU.YD.)	Net (CU.YD.)	Cut Area (SQ.YD.)	Fill Area (SQ.YD.)	Disturbed Area (SQ.YD.)
1A	10%	4,750	4,723	27 (cut)	48,006	49,421	97,427
1B	10%	2,540	2,377	163 (cut)	42,275	25,441	67,716
2	10%	20	31	11 (fill)	756	667	1,423
3	10%	0	0	0	0	0	0
4	10%	2	157	155 (fill)	147	1,823	1,970
5	10%	21	0	21 (cut)	885	0	885
Grand Total	---	7,333	7,288	45 (cut)	92,069	77,352	169,421

The table shows the balance resulting from the earthwork, and with which the excavation of topsoil in cut and embankment would be balanced in the volume of fill required.

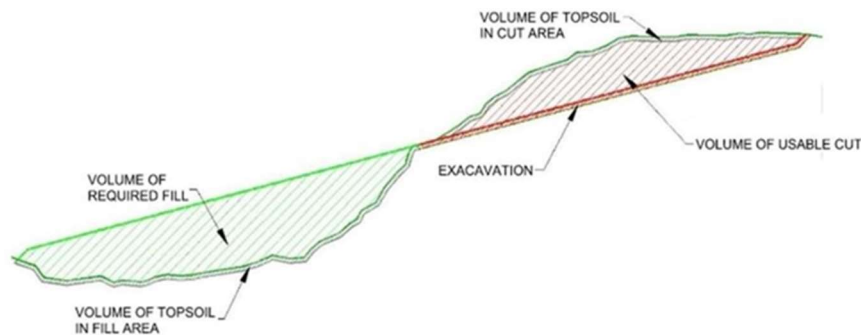


Figure 26: Scheme of Volumes

In the following images (Figure 27- 31), the zones with the highest cut and fill heights are represented. These values are found in intervals of 1 foot, starting with the lowest part in the cut zones and ending in the highest fill zones. This range of heights is shown in the accompanying table.

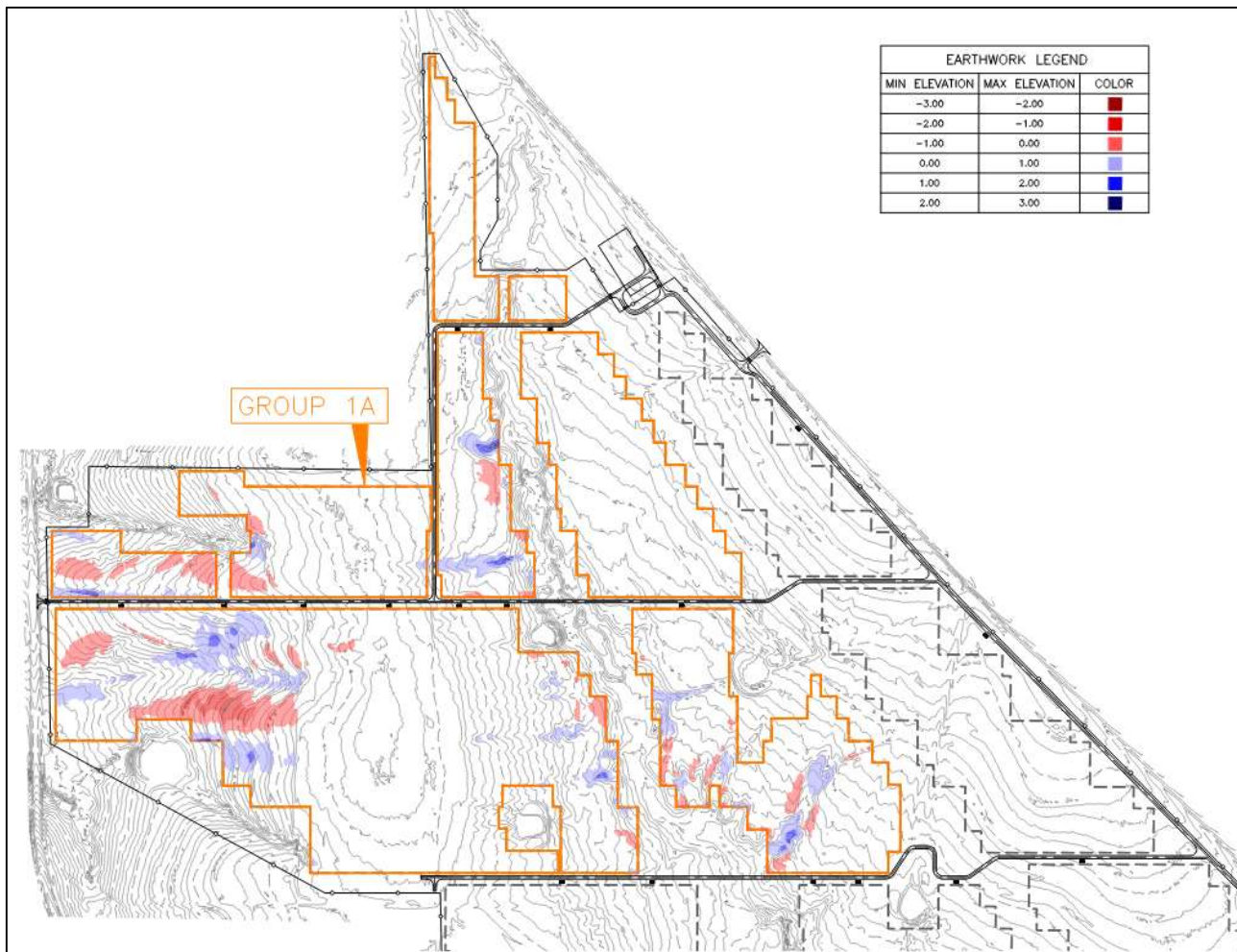


Figure 27: Cut and Fill Depths - Group 1A

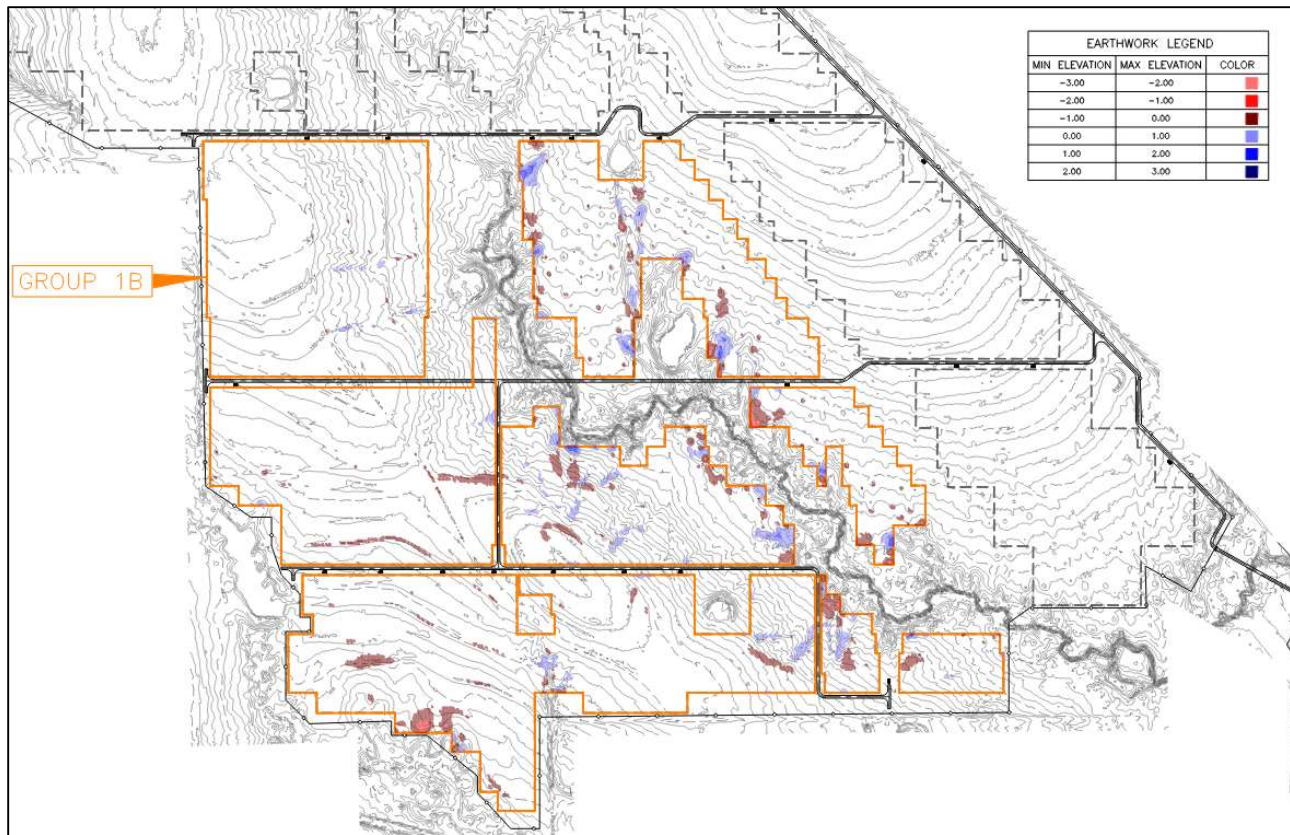


Figure 28: Cut and Fill Depths - Group 1B

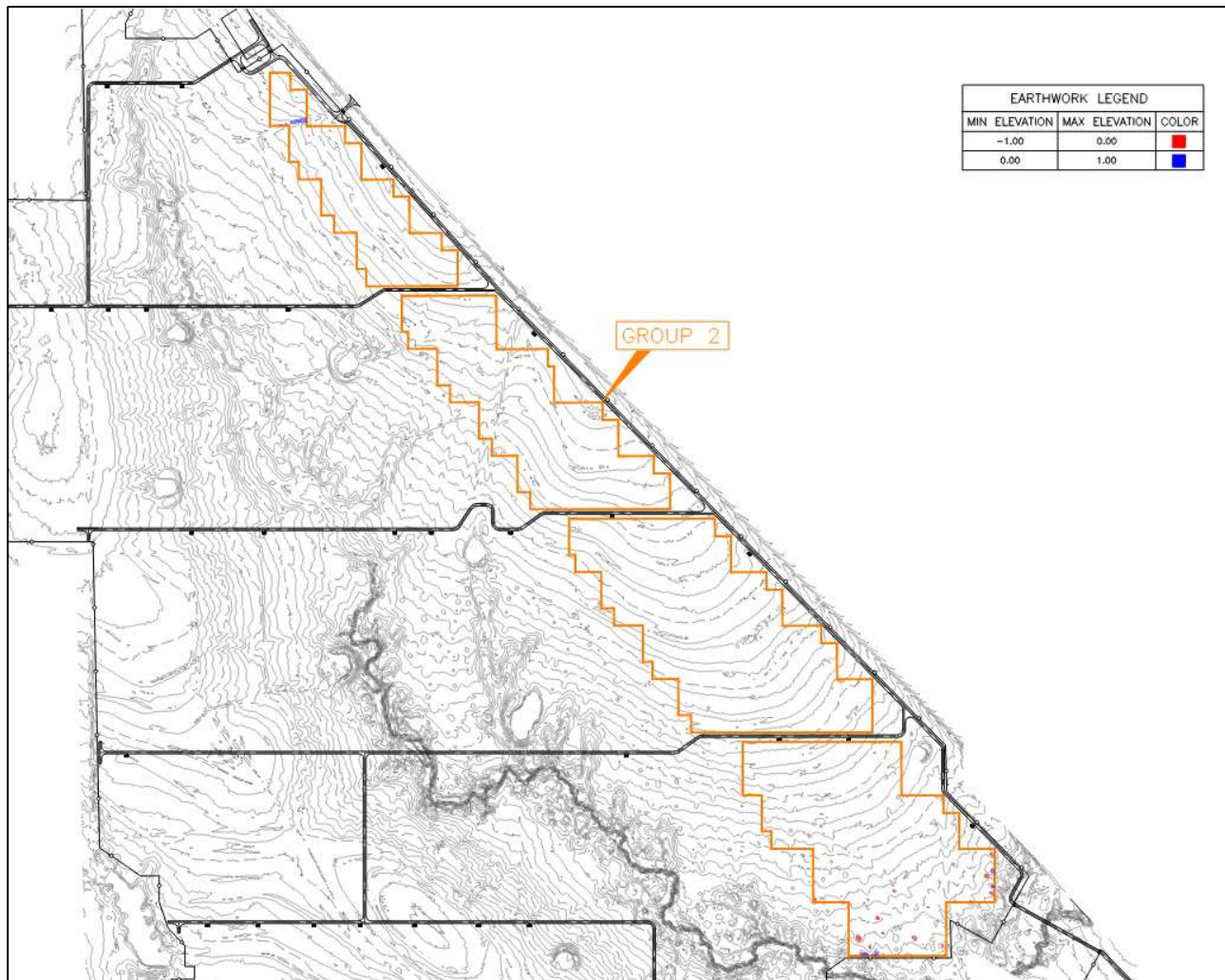


Figure 29: Cut and Fill Depths - Group 2

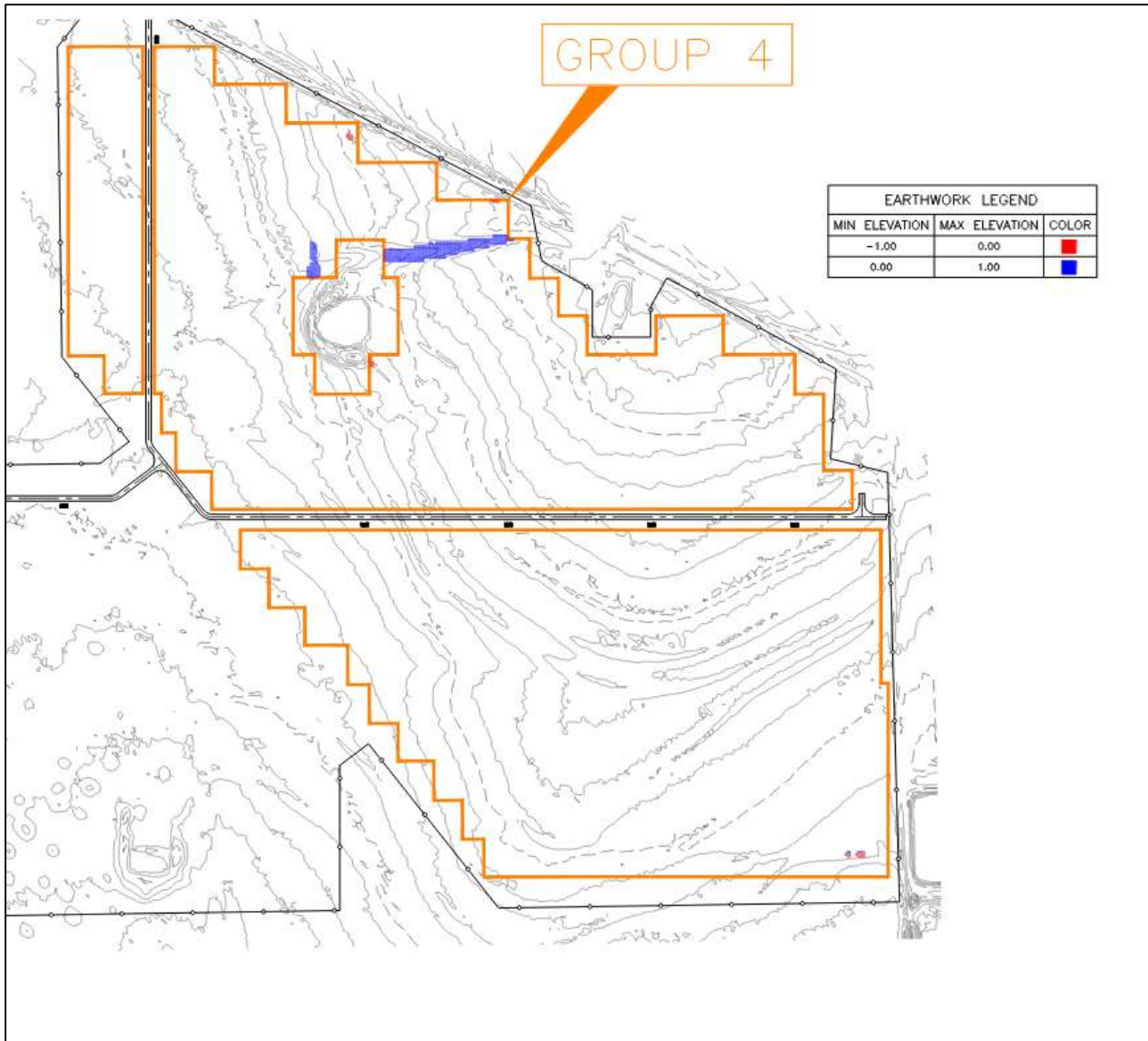


Figure 30: Cut and Fill Depths - Group 4



Figure 31: Cut and Fill Heights - Group 5

6 SLOPE ORIENTATION N-S

Based on the proposed earthworks, the N-S angular distribution of trackers for the project is obtained for each zone in a representative manner, which presents a color scale according to the slope ranges determined between $\pm 8.53^\circ$ ($\pm 15\%$) and the orientation of the trackers after the earth movements in the area (Figure 32-37).

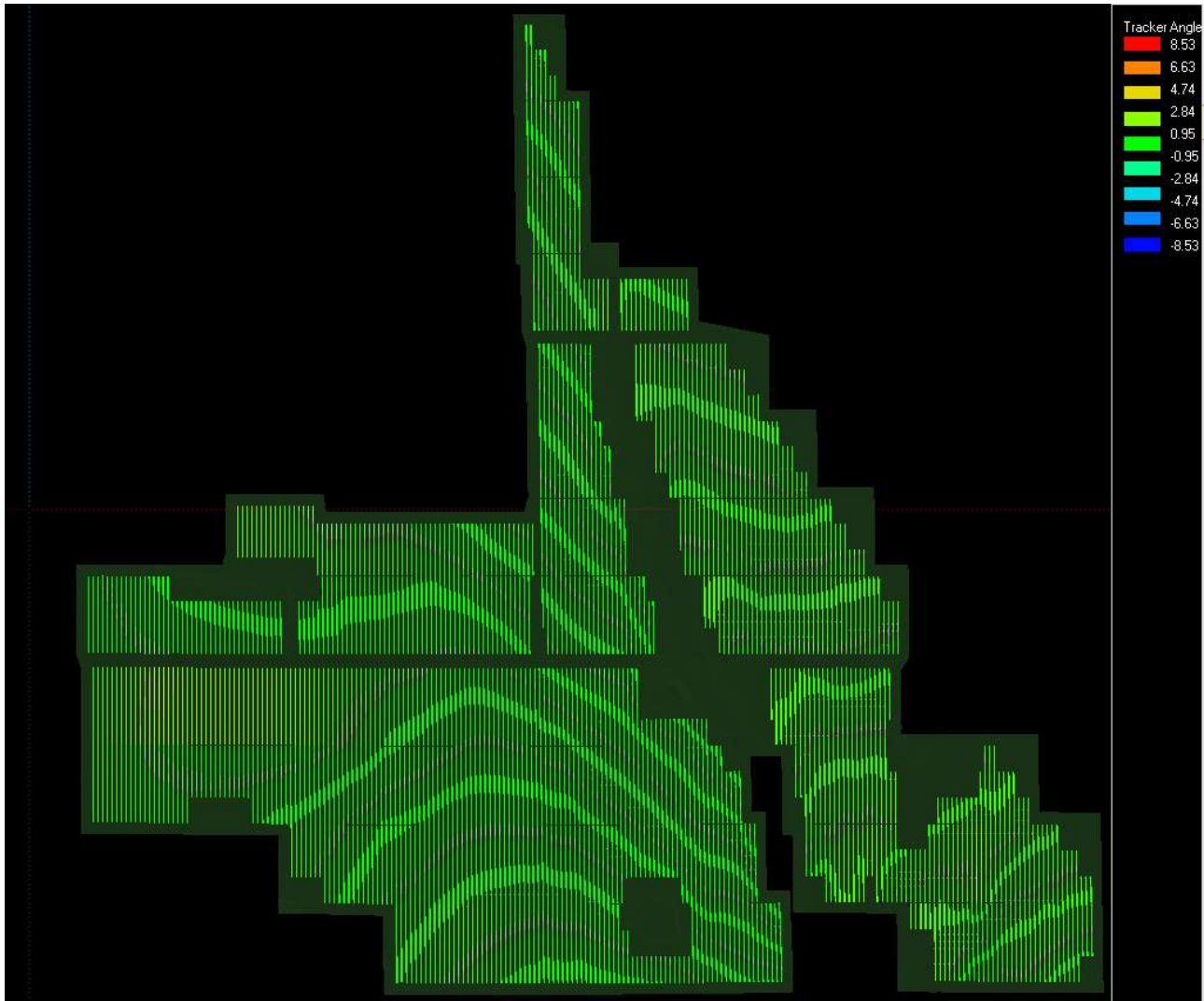


Figure 32: Tracker Slope Analysis - Group 1A

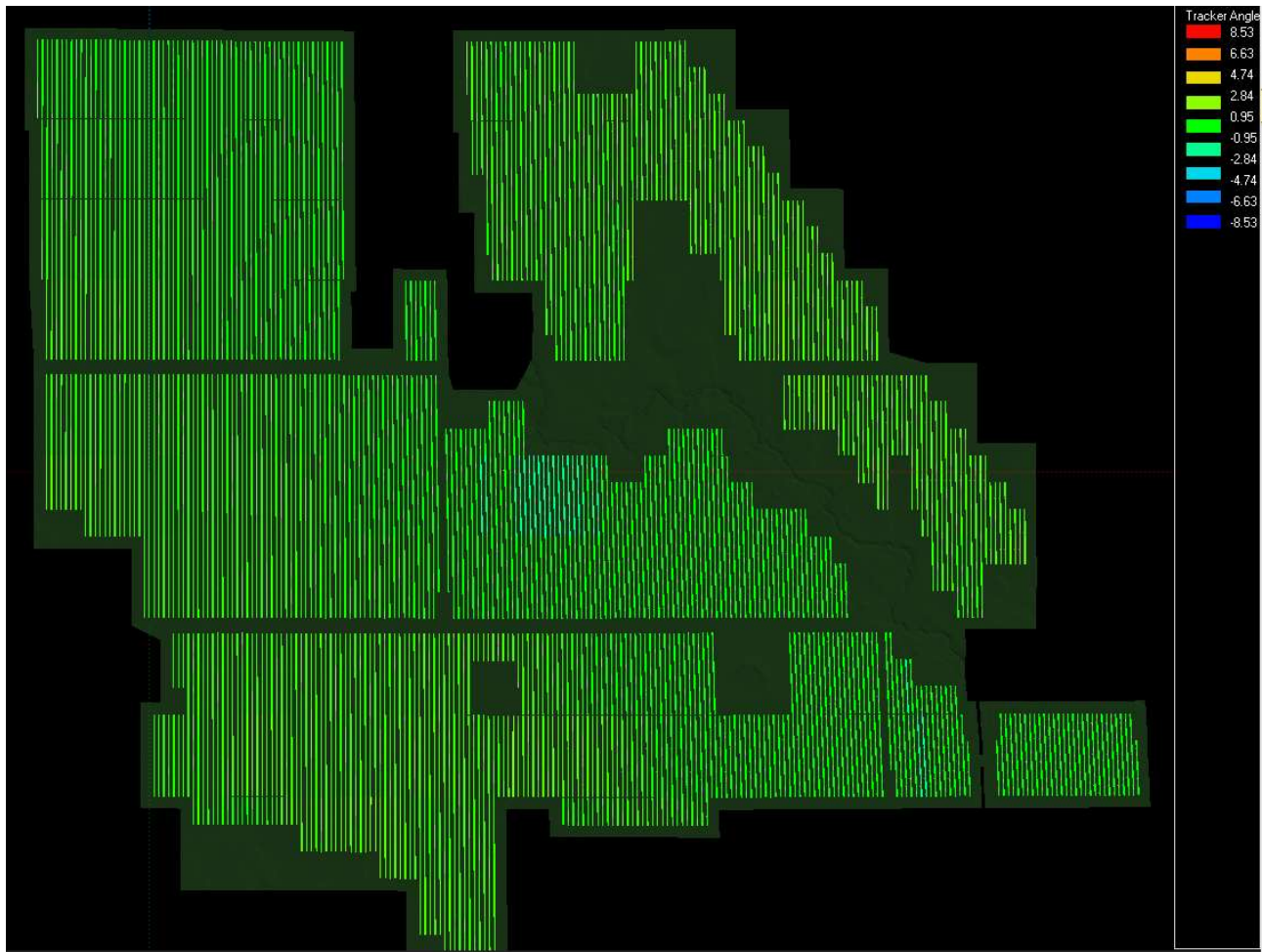


Figure 33: Tracker Slope Analysis - Group 1B

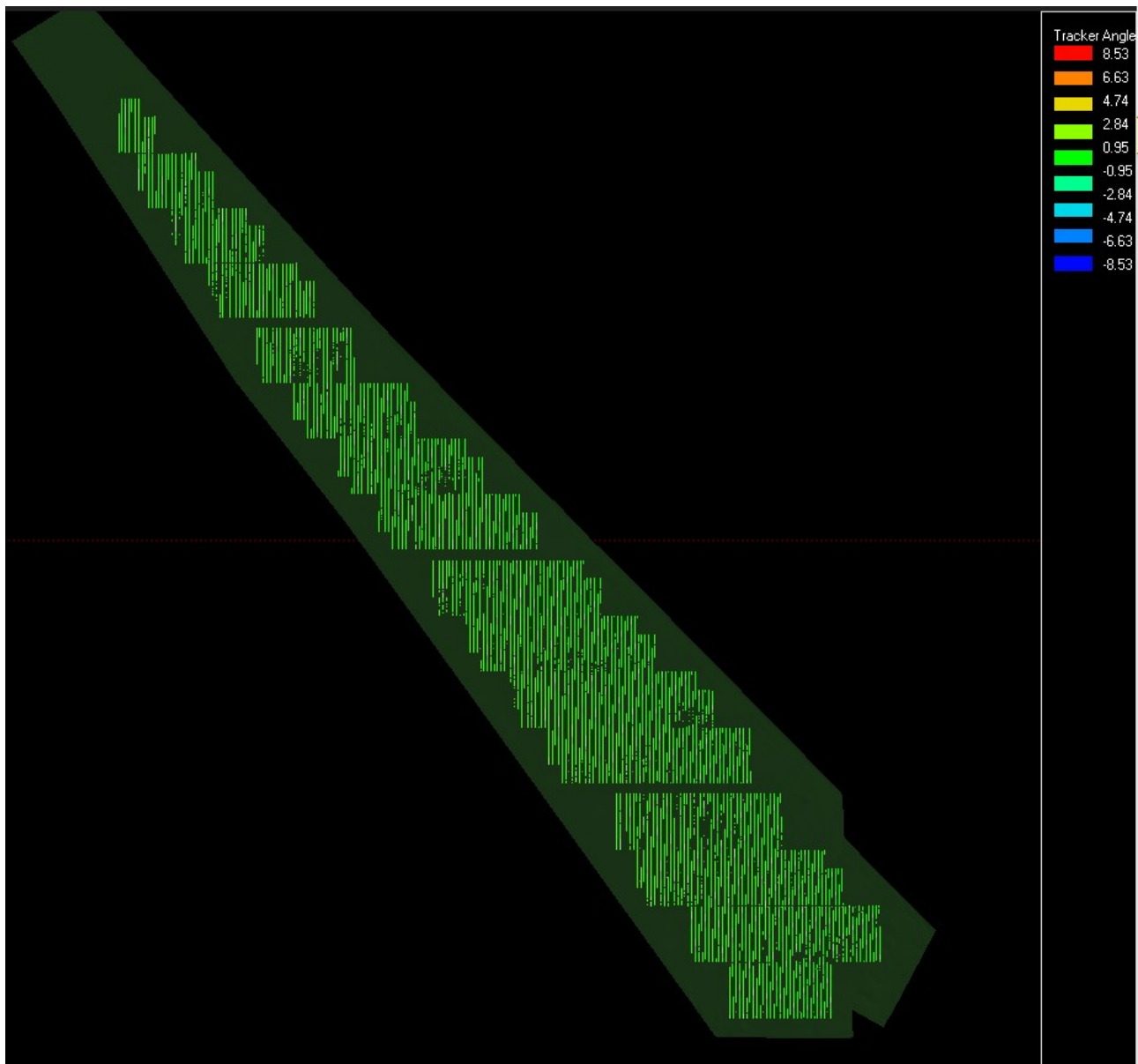


Figure 34: Tracker Slope Analysis - Group 2

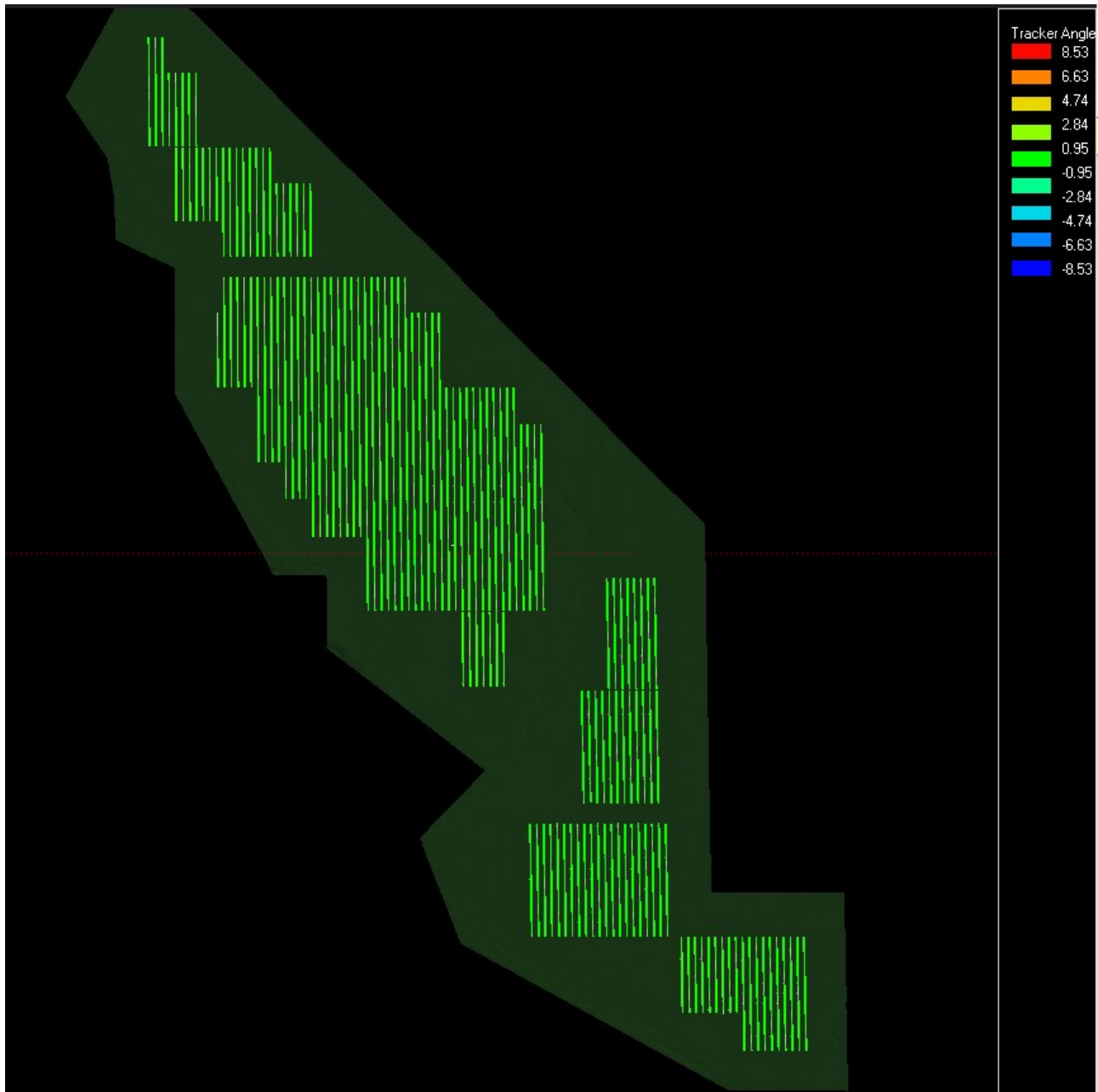


Figure 35: Tracker Slope Analysis - Group 3

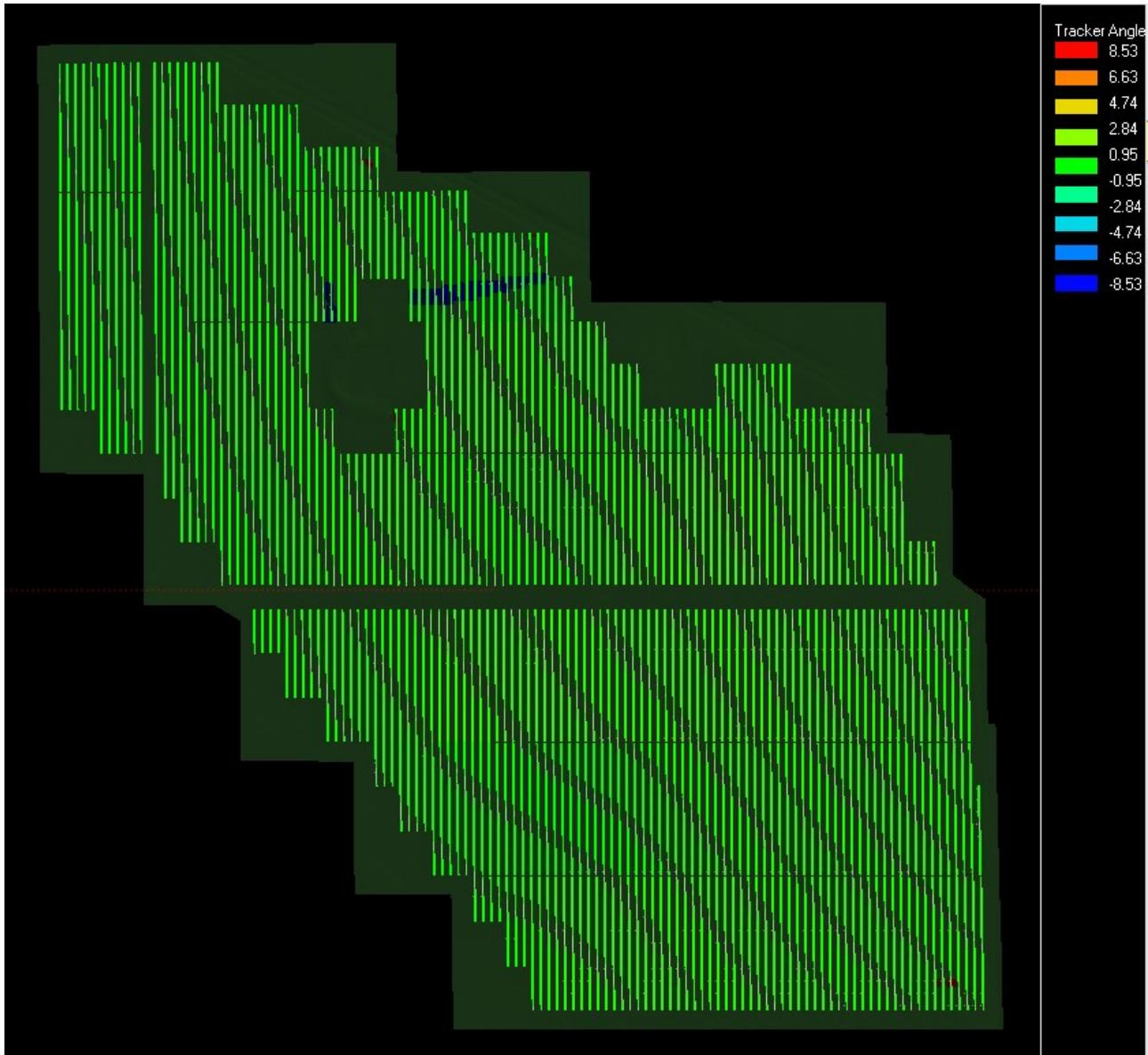


Figure 36: Tracker Slope Analysis - Group 4

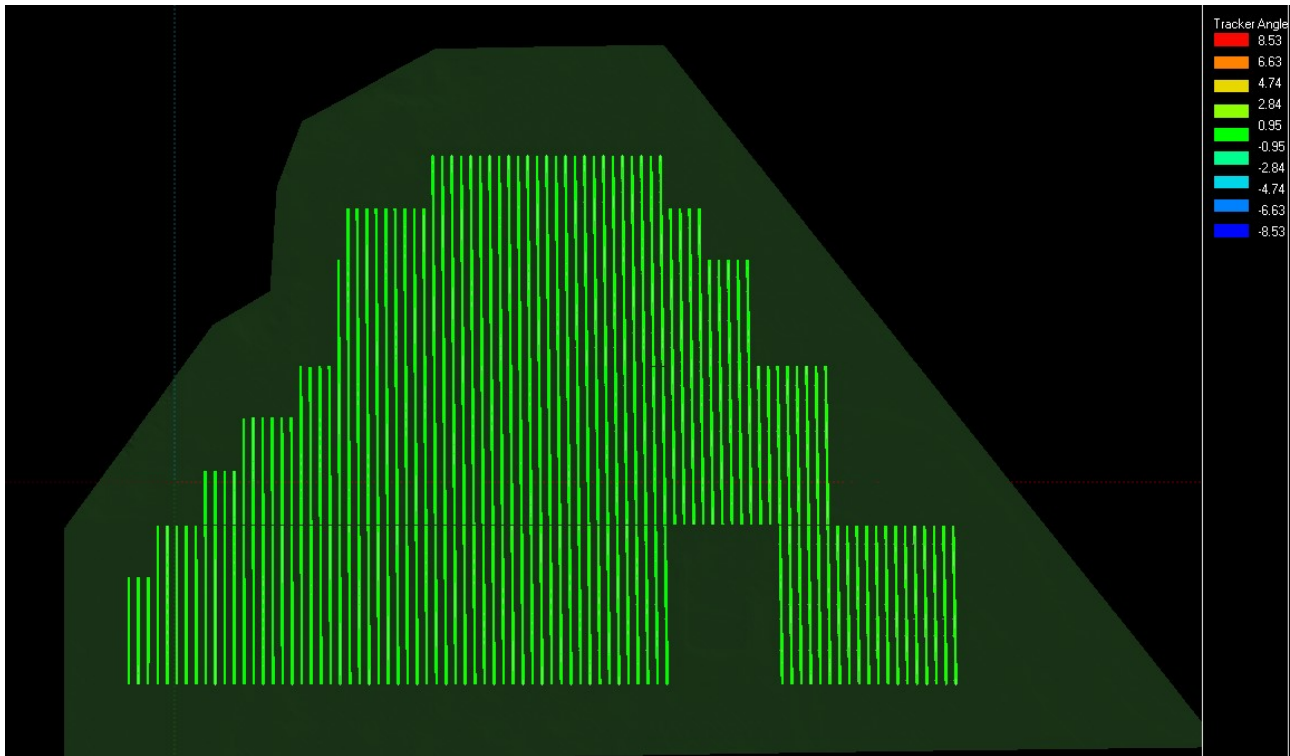


Figure 37: Tracker Slope Analysis - Group 5

In all cases, the trackers do not exceed the angle limitation of $\pm 8.53^\circ$ ($\pm 15\%$).

The frequency distribution of the north-south angular deviations of the trackers on site, is relevant in order to evaluate the production capacities of the site. So, Figures 38-43 summarize the tracker slope distributions per:

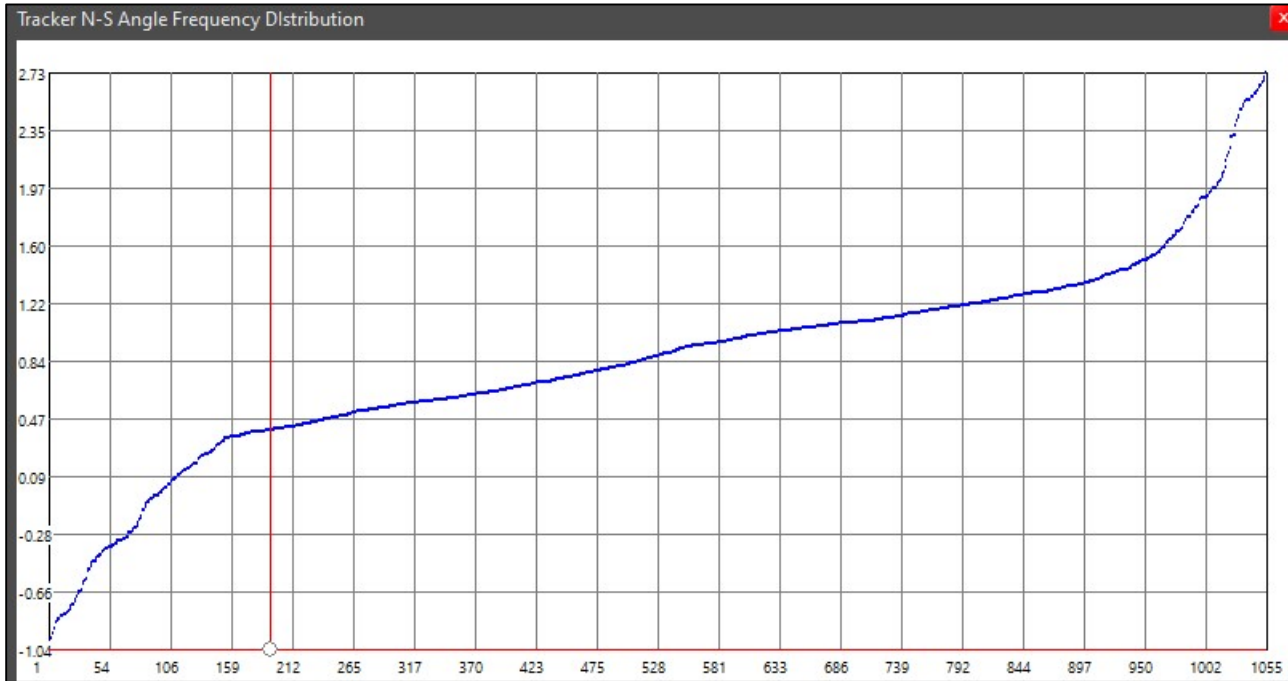


Figure 38: Tracker Distribution by Slope - Group 1A

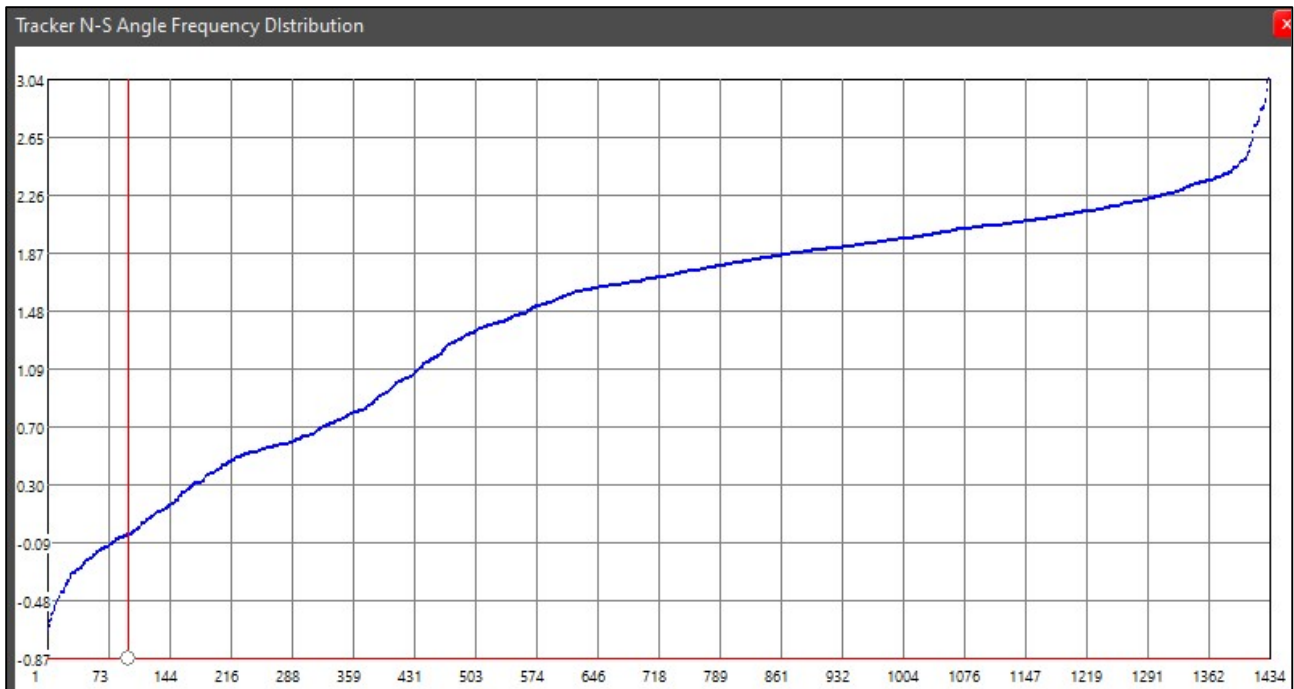


Figure 39: Tracker Distribution by Slope - Group 1B

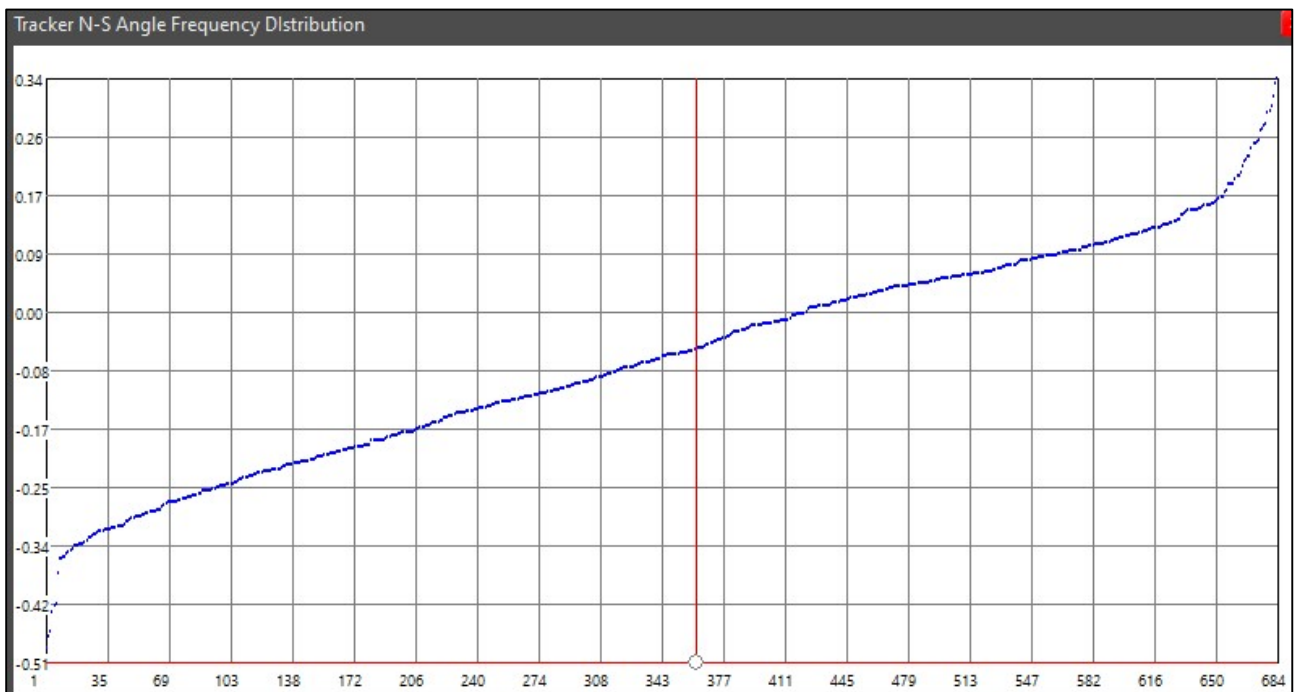


Figure 40: Tracker Distribution by Slope - Group 2

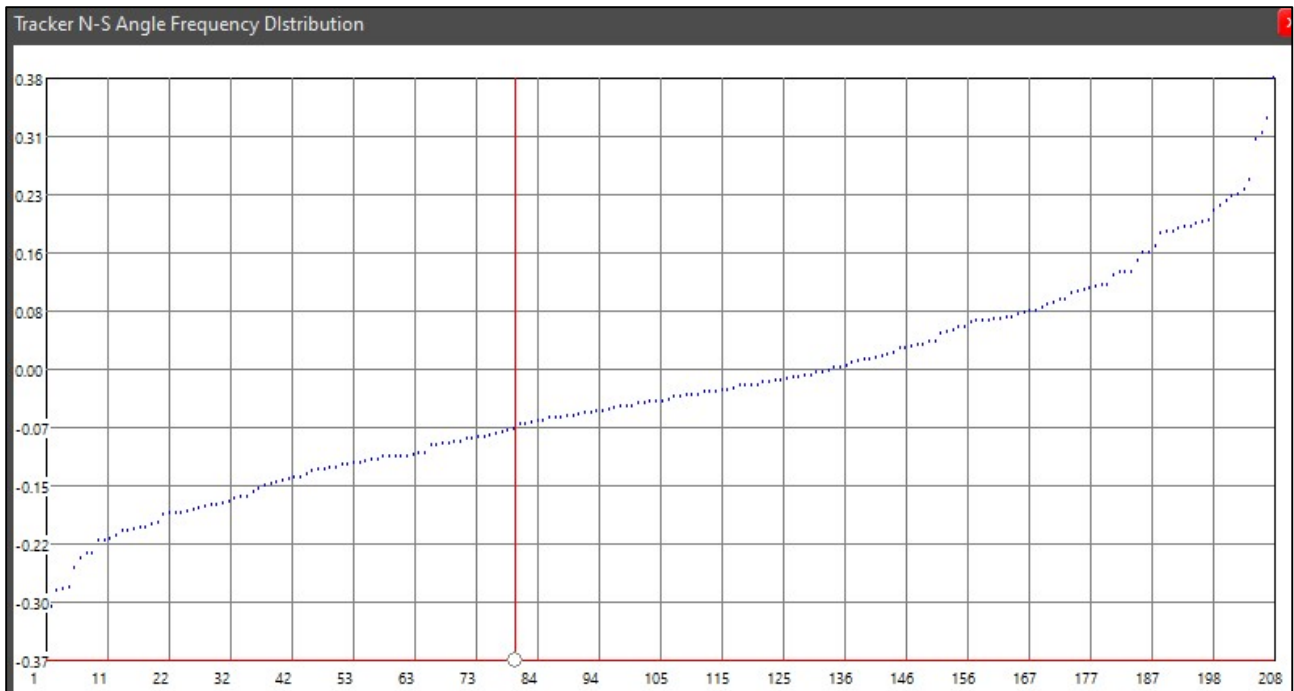


Figure 41: Tracker Distribution by Slope - Group 3

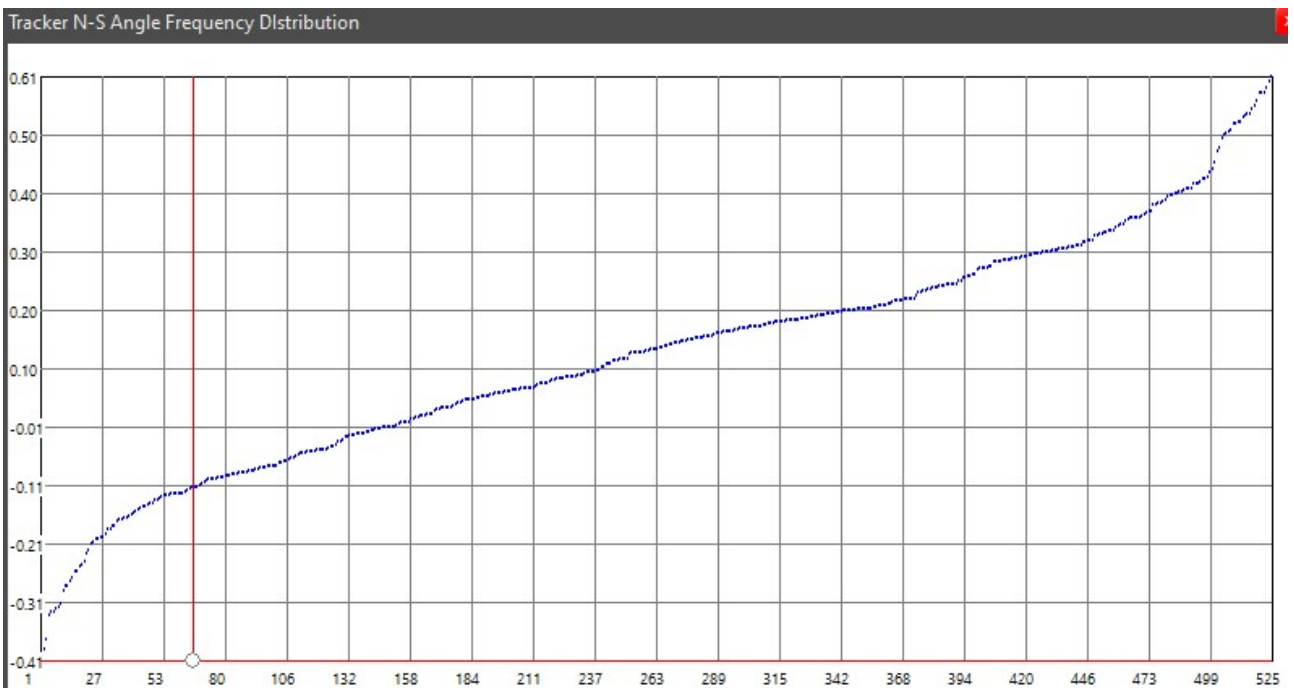


Figure 42: Tracker Distribution by Slope - Group 4

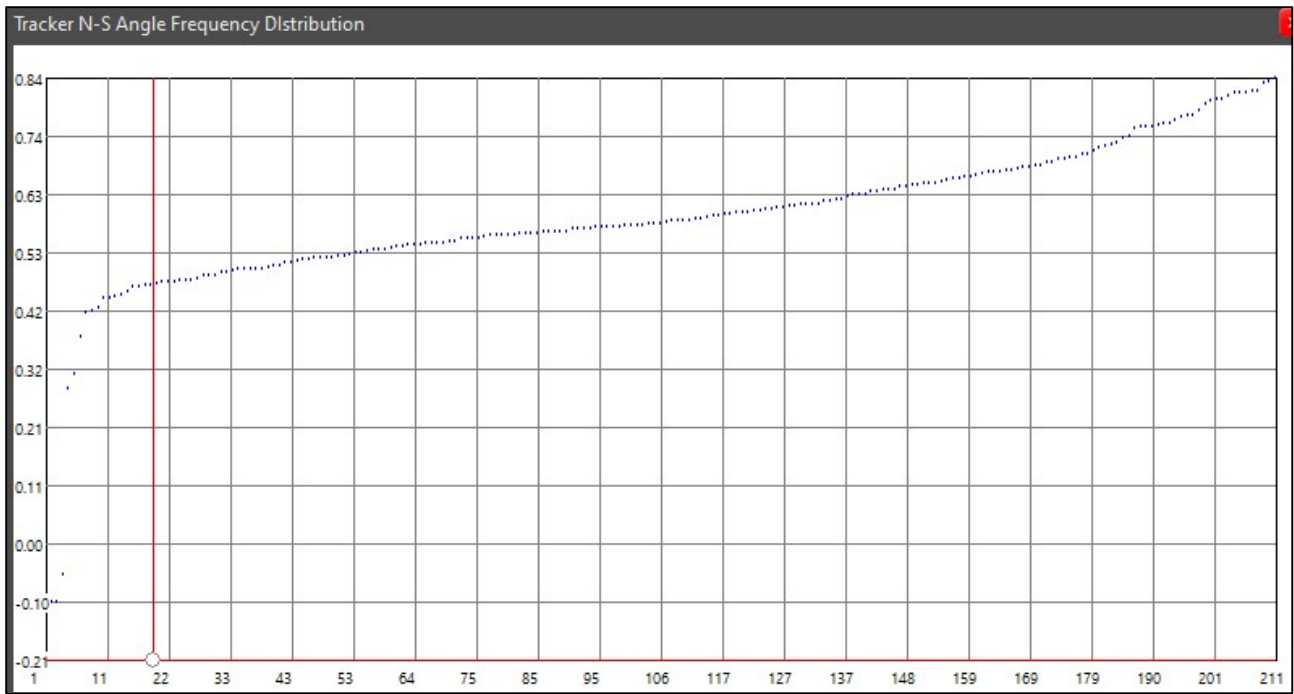


Figure 43: Tracker Distribution by Slope - Group 5

7 HYDRAULIC PATTERNS

The following figures (Figure 44-54) show the drainage patterns (runoff direction) before and after the proposed earthworks, within the analyzed area. Differences are observed between one situation and the other to determine if the proposed grading severely impacts the natural flow of water. Also, this hydraulic analysis was performed with the help of PVGRad software, so it is considered a representative analysis and should not be considered or used as a design.

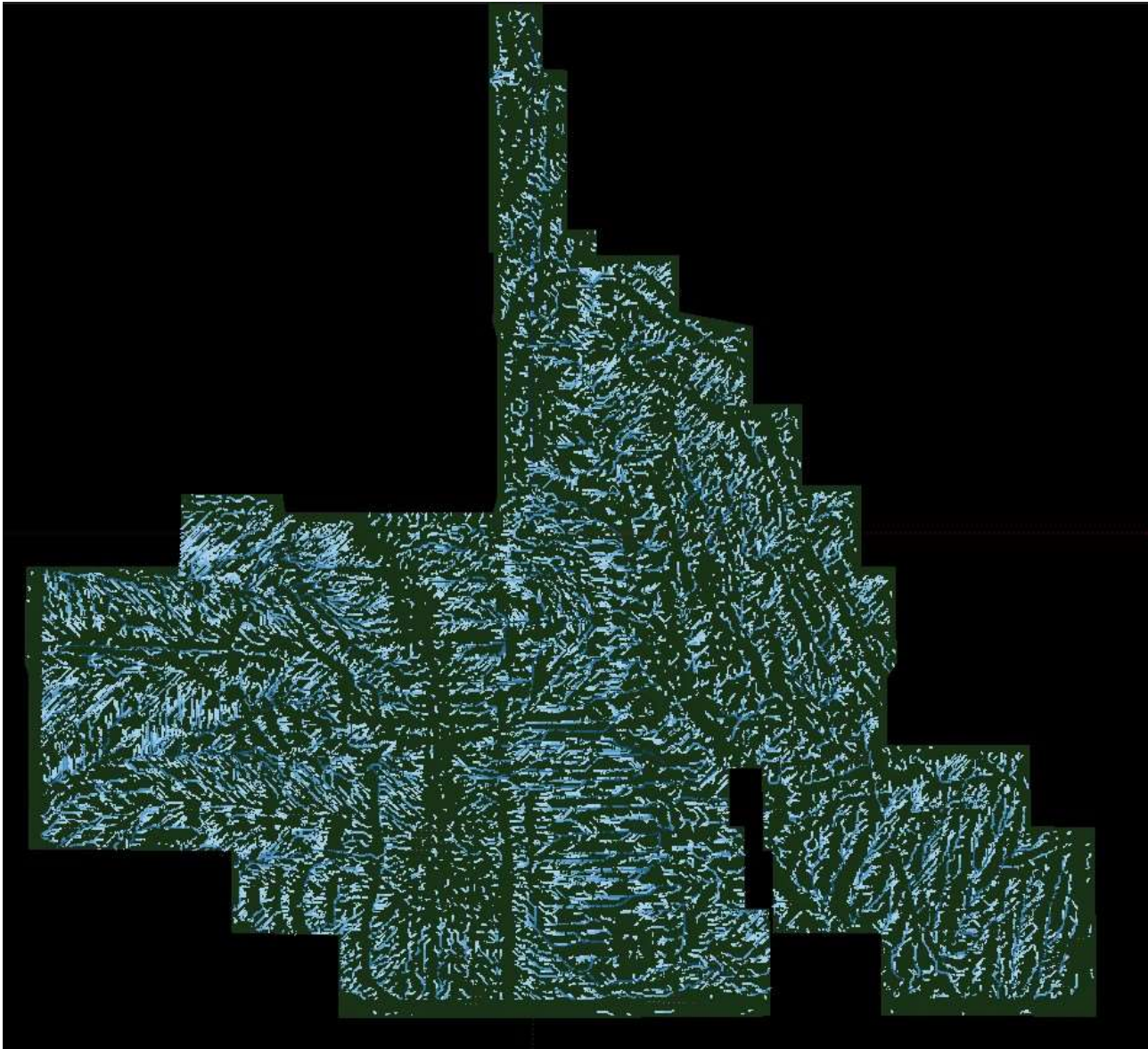


Figure 44: Drainage Pattern Before Earthwork - Group 1A



Figure 45: Drainage Pattern After Earthwork - Group 1A

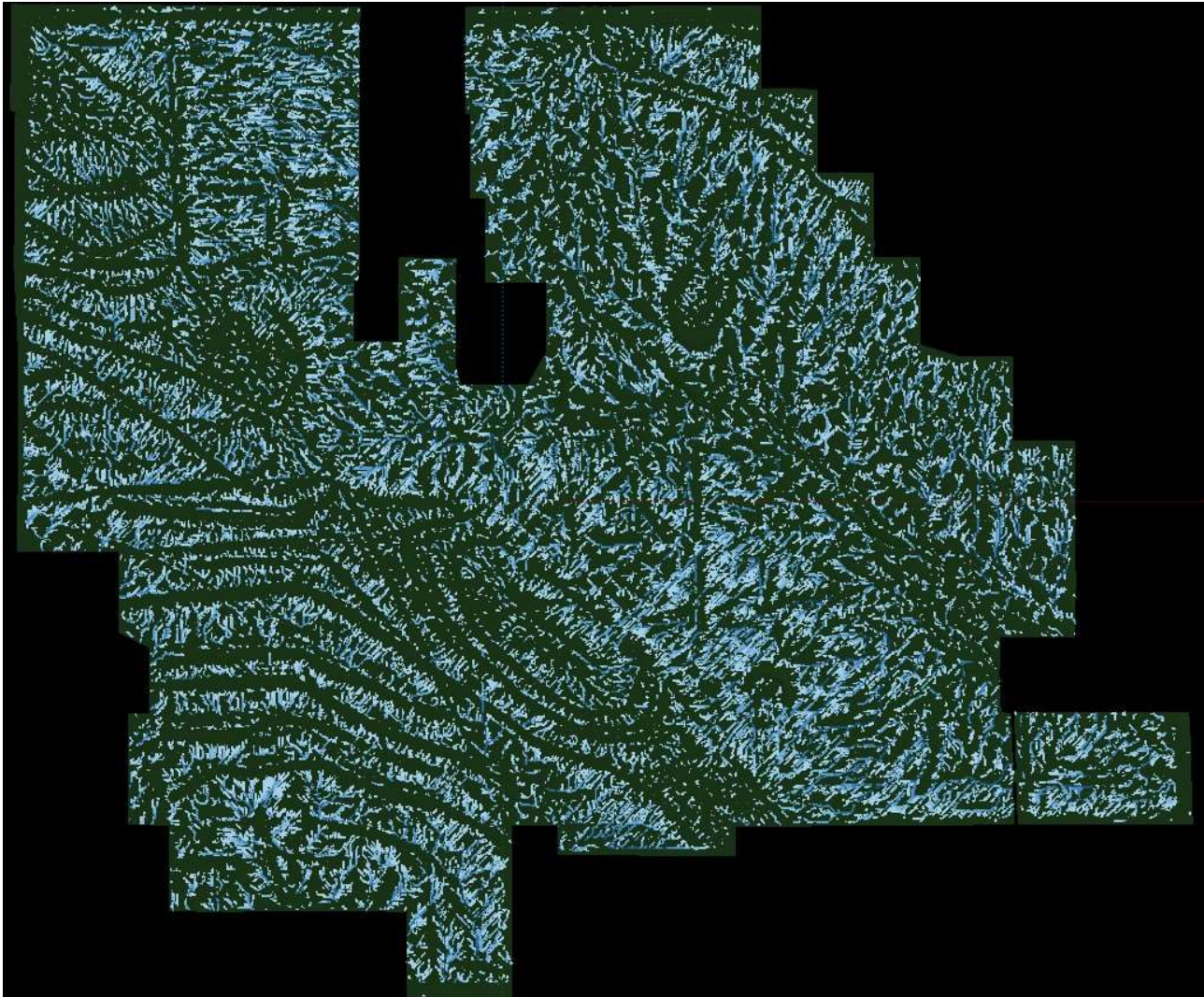


Figure 46: Drainage Pattern Before Earthwork - Group 1B



Figure 47: Drainage Pattern After Earthwork - Group 1B

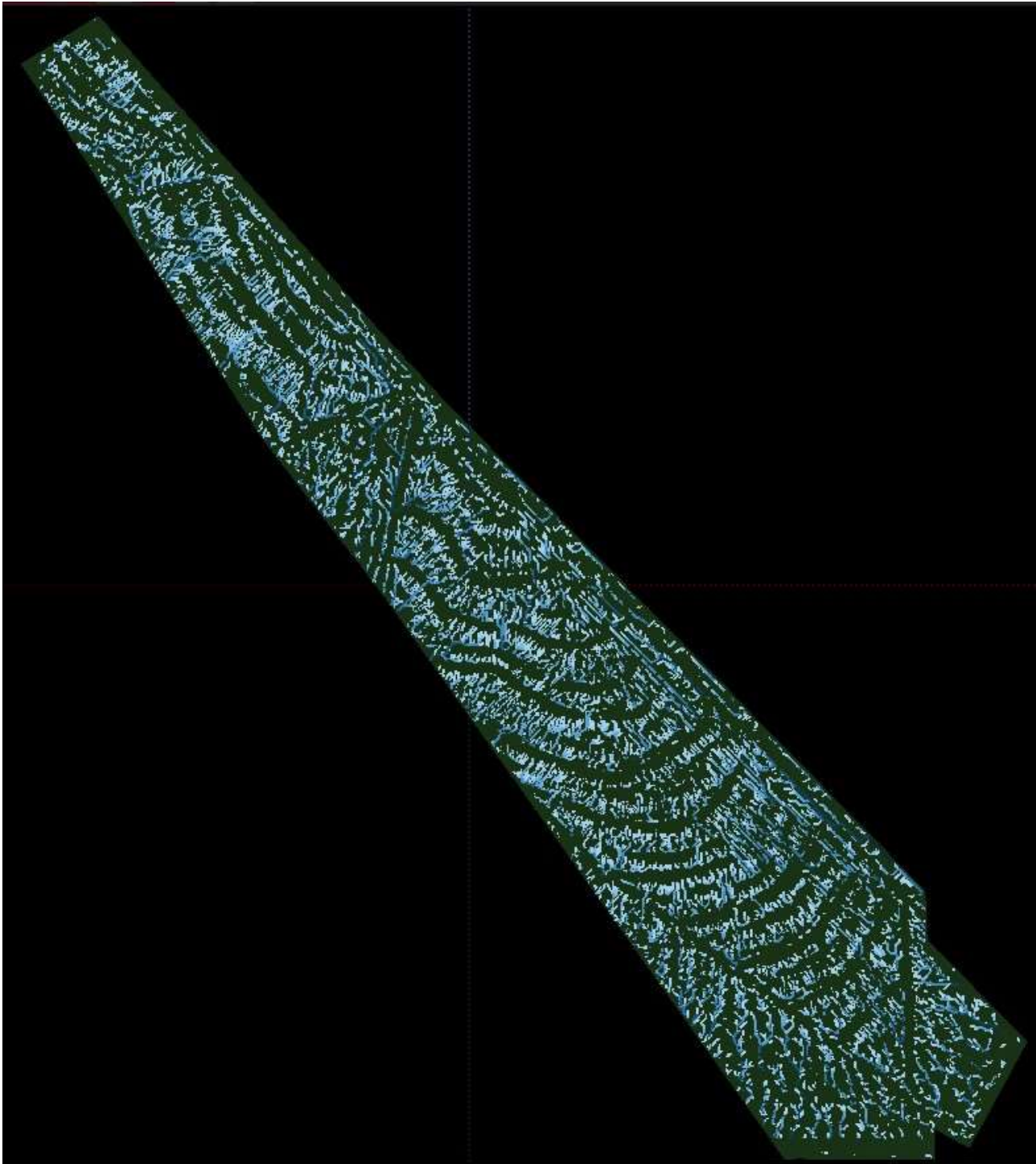


Figure 48: Drainage Pattern Before Earthwork - Group 2

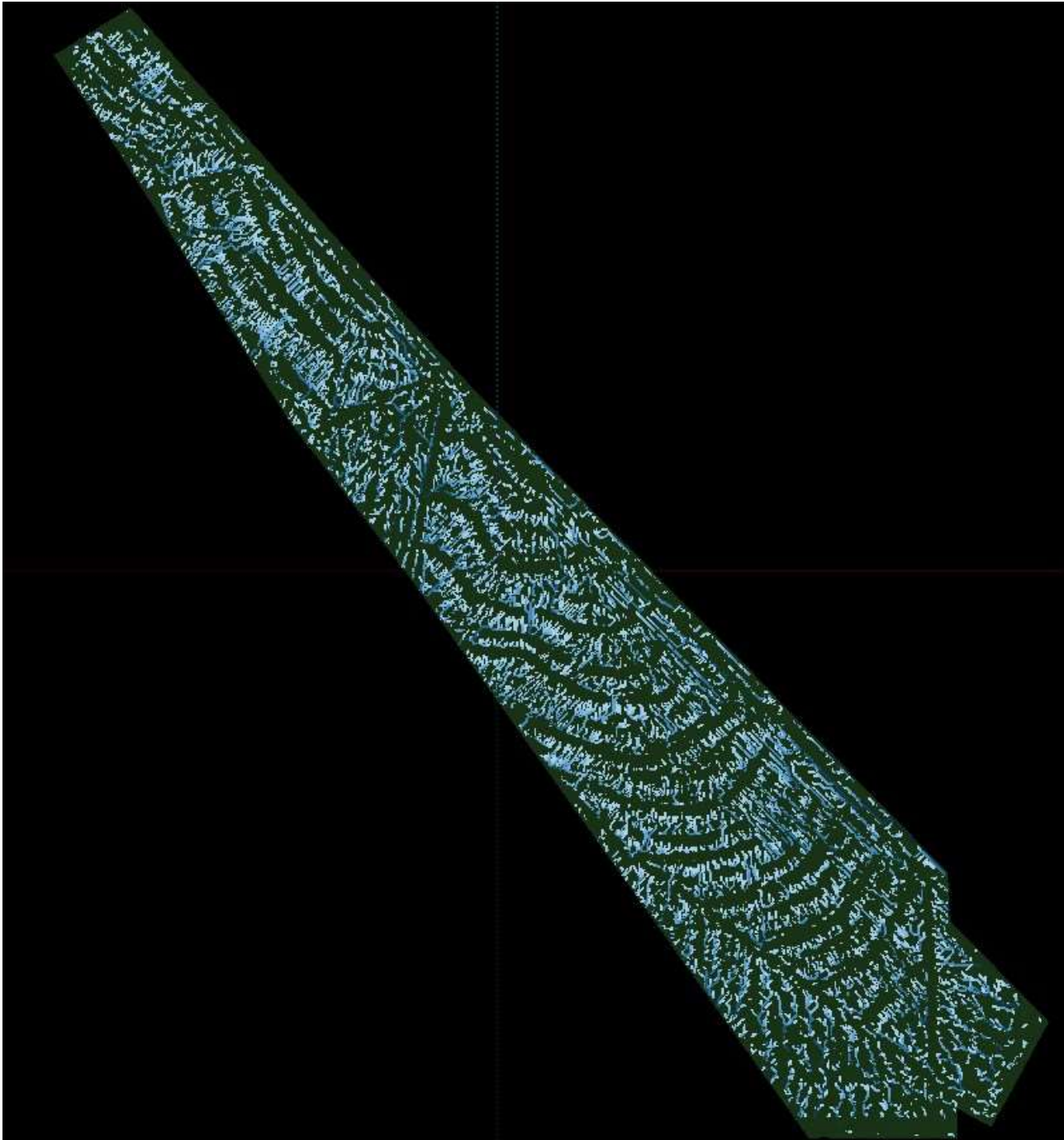


Figure 49: Drainage Pattern After Earthwork - Group 2

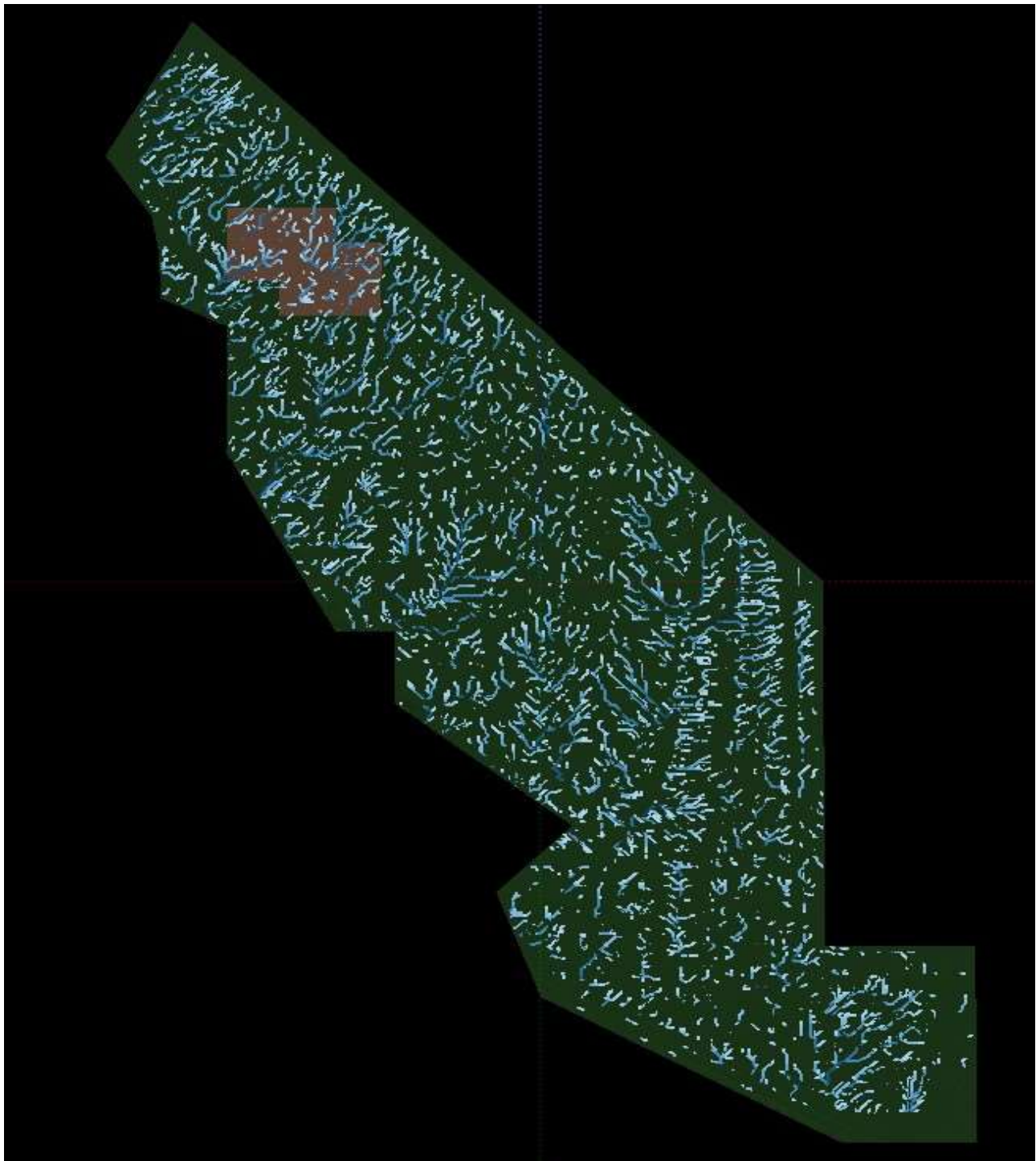


Figure 50: Drainage Pattern Before Earthwork (no grading proposed) - Group 3

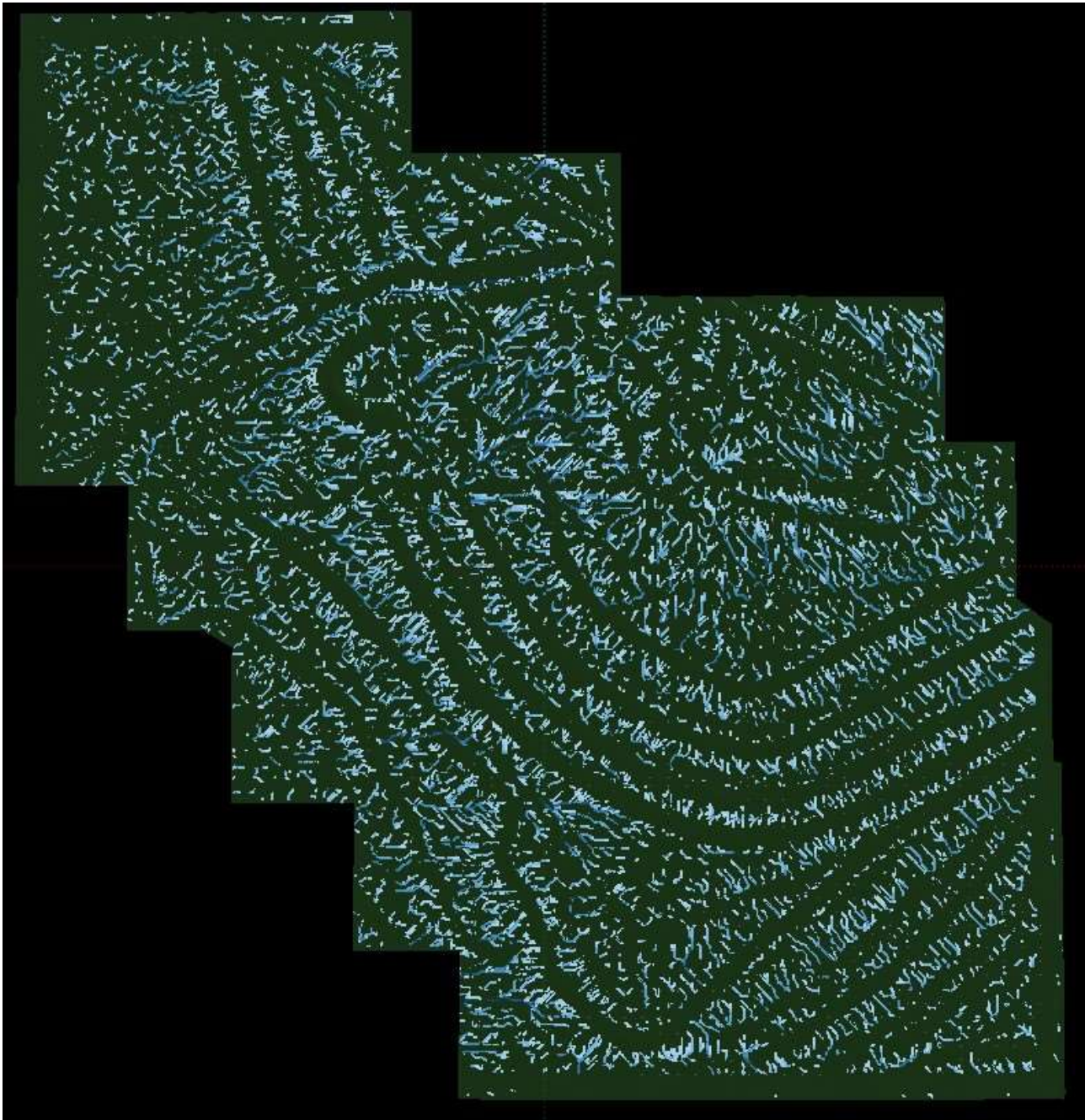


Figure 51: Drainage Pattern Before Earthwork - Group 4

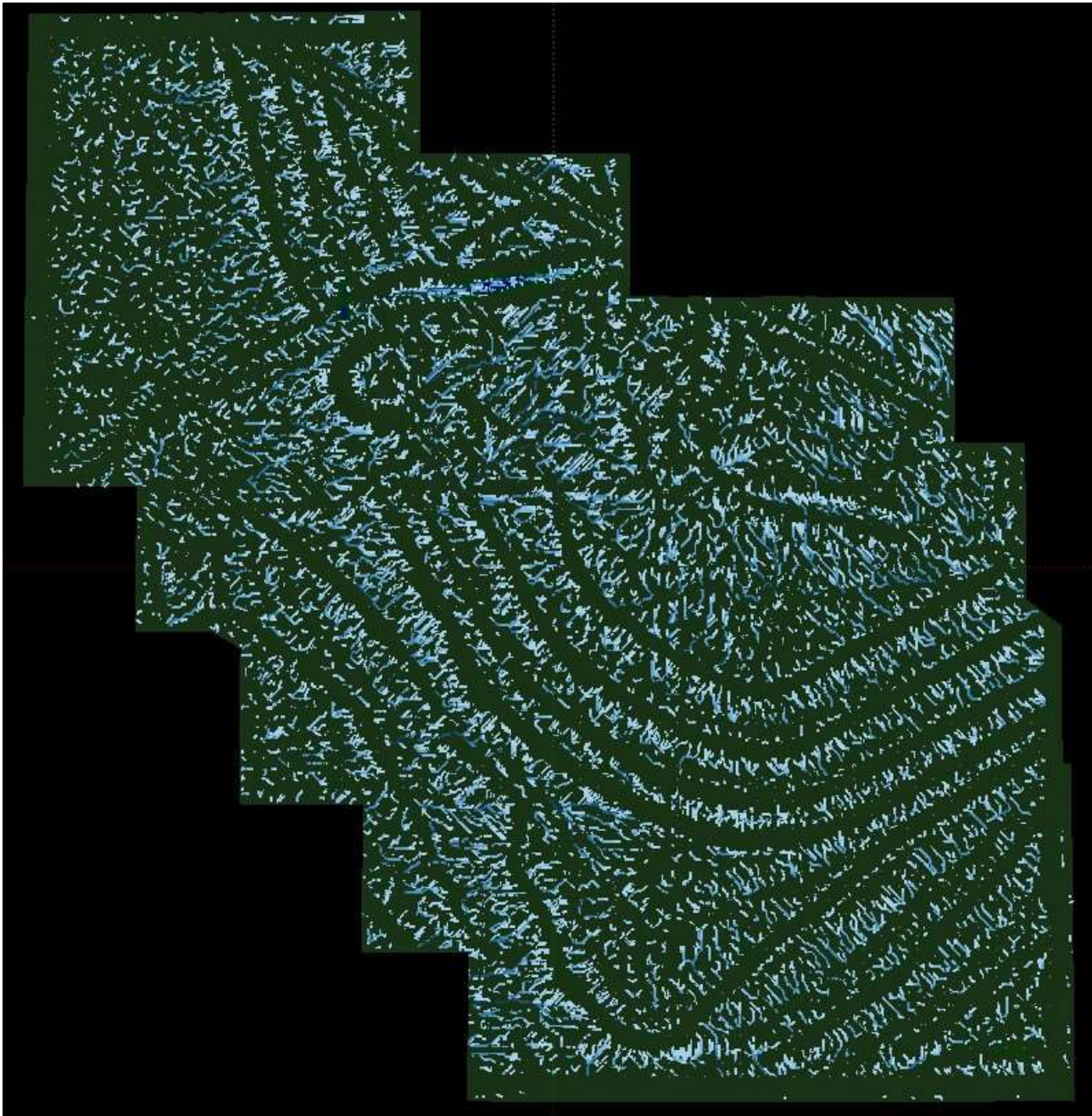


Figure 52: Drainage Pattern After Earthwork - Group 4

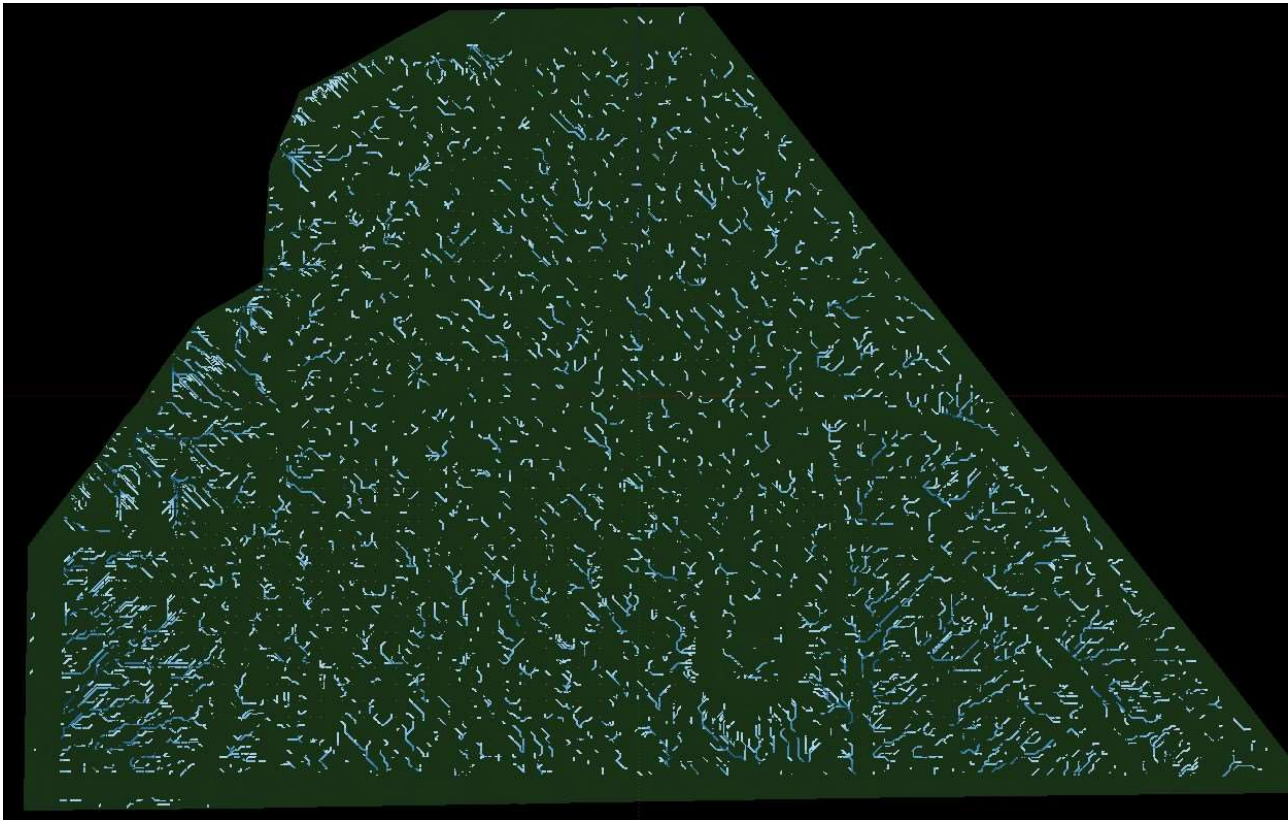


Figure 53: Drainage Pattern Before Earthwork - Group 5

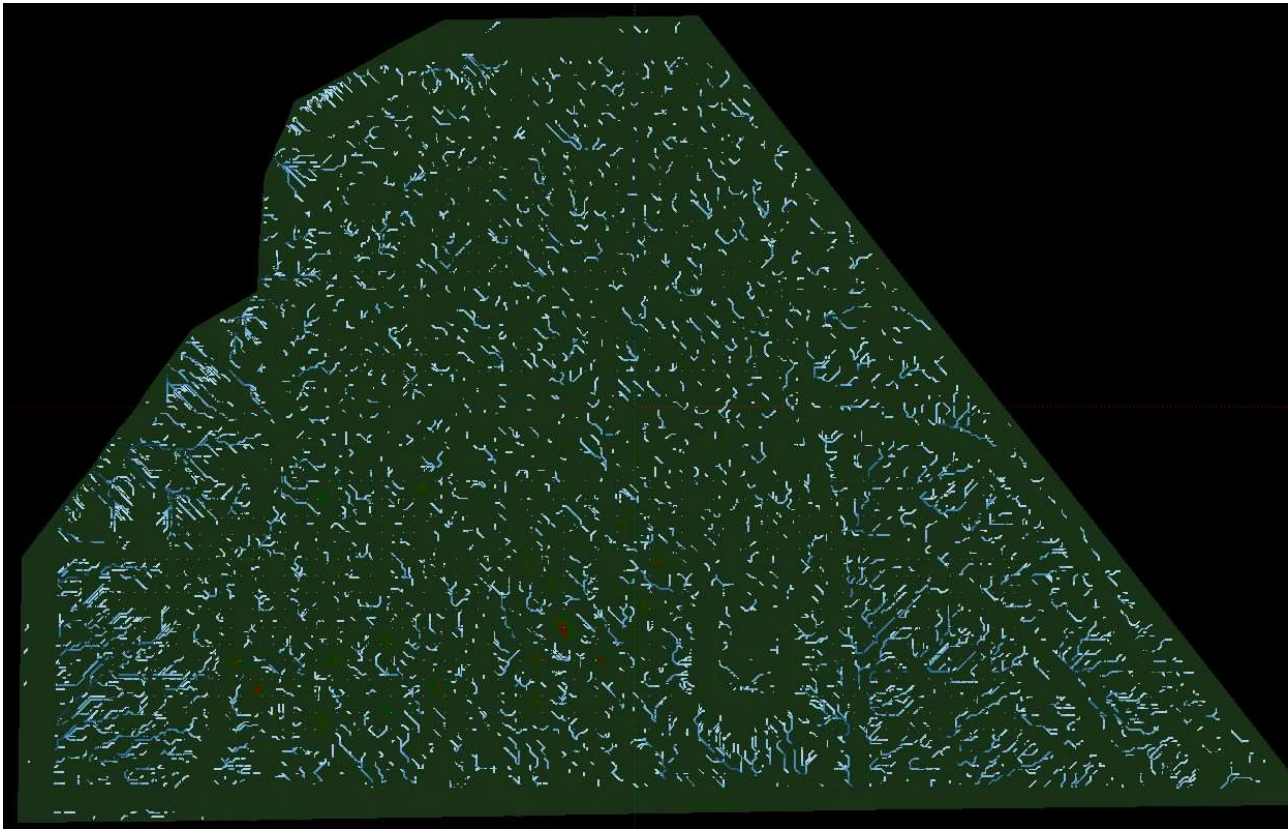


Figure 54: Drainage Pattern After Earthwork - Group 5

8 CONSTRUCTION TOLERANCES

Construction tolerances are allowable variations from the dimensions specified in the design.

The Array Earthwork Analysis was performed for a 10% design. The results in this study (Table 2 & Figures 27-31) should not be used for the final design phase of development. This analysis was performed to obtain a reliable estimate of the required earthworks for the project. Result values shall be considered as estimates and not final values. No construction tolerances were considered during this analysis.