APPENDIX C – TOOL/SCRIPT SUMMARY

The objective of this project is to automate the process of creating rockfall shadow zone maps using a shadow angle of 27.5 degrees (determined by S.G. Evans & O. Hungr in 1993[10]) in Global Mapper. The Global Mapper script tool is utilized to automate this process and the code language reference can be found in the "Global Mapper Scripting Reference V 24.0" Book/ PDF[11]. The full automation code is shown in Appendix D. The general process involves the following steps (for full details on each step please see the comments in Appendix D):

1) Load Orthophotos and DEM Files from respective folders. (Only 1 DEM file can be processed at a time.)
2) Reclassification of DEM based on slope values. (Need to set default shader as "Slope Shader" first) (See Figure 48 for slope values) (See Figure 50 and Figure 51 for result output)
3) Creating equal value areas based on color palette to create polygons around talus slope and edge of rock. (Smoothing, Simplification and Island Deletion are applied) (See Figure 52 for result output)
4) Creating buffer zones around talus slope and edge of rock polygons. (Smoothing and Simplification are applied) (See Figure 53 for result output)
5) Using intersection spatial operation on the two buffer zones. (Smoothing and Simplification are applied) (See Figure 54 for result output)
6) Create skeleton lines on the resulting polygon from the intersection of the two buffer zones. The skeleton line created maps out the top of the talus slope. It is important to note that buffer zones are created in a way to shift the top of the talus slope 10 to 15 metres below its actual location to avoid problems in slope direction values for the viewshed analysis step. (See Figure 55 & Figure 57 for result output)
7) Combine all skeleton lines to carry out smoothing and simplification. (See Figure 55 & Figure 57 for result output)
8) Create points every 100 metres along the skeleton line and calculate elevation & slope values for all points. (See Figure 56 & Figure 58 for result output)
9) Create new attribute "SDN" (Slope Direction Numerical) by coping the values from "SLOPE_DIR" attribute.
10) Remove all non-numerical values from attribute "SDN" and use attribute "SDN" to calculate and store value of the start angle (taken by subtracting SDN value by 30 and if value is less than 0 then use SDN value minus 30 plus 360) to be used in viewshed analysis as an attribute "Start Angle".
11) Split layer which contains all the points (in this case "THE CHOOSEN ONES") by SDN number resulting in all points with same SDN value (& Start Angle value as SDN was used to calculate it) to be grouped into one layer. This will allow us to run a loop on the layers using a "VAR_LOOP" Command.
12) Apply viewshed analysis on the points created (See Appendix D for more details on VAR_LOOP Command)

Step 12 in the full automation code takes a long processing time; hence, step 12 has not been run yet but all other step's code work properly. However, there are currently two main drawbacks of the full automation code which are inaccuracy of mapping the top of the talus slope in certain topography (See Figure 49) and the lack of choice of selecting your own points of interest to carry out the viewshed analysis in Step 12. Therefore, two more tools are created which are the "Raster Reclassification Tool" and "Semi-Automation of Mapping Rockfall Shadow Zones in Global Mapper Tool" and their code and instructions on how to use are shown in Appendix E and Appendix F, respectively. "Raster Reclassification Tool" basically carries out step 2. The purpose of this tool is to help visualize the top of the talus slopes and edge of the rocks which can be helpful in addition to the orthophotos. "Semi-Automation of Mapping Rockfall Shadow Zones in Global Mapper Tool" basically carries out steps 9 to 12. The purpose of this tool is to allow the user to choose their own points of interests to map out the rockfall shadow zones (shown in Figure 59 to Figure 61) and in the process reduce the inaccuracy and the lack of choice in the points of interest. The result of this tool is shown in Figure 62. If the full automation code runs the 12th step the results will be quite similar to the results shown in Figure 62.

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[10] https://www.for.gov.bc.ca/hfd/library/ffip/Evans_SG1993CanGeotechJ.pdf
[11] https://www.bluemarblegeo.com/knowledgebase/global-mapper-24-1/GlobalMapper_ScriptingReference.pdf

In short, the results shown in Figure 62 are quite accurate. The full automation code has its limitation but the semi-automatic tool works correctly. Hence, this project has successfully automated the process of creating rockfall shadow zone maps in Global Mapper.

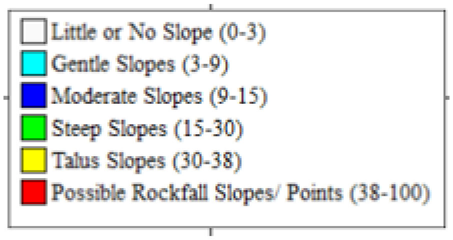

Figure 48: Key to the Slope Values for the Raster Reclassification

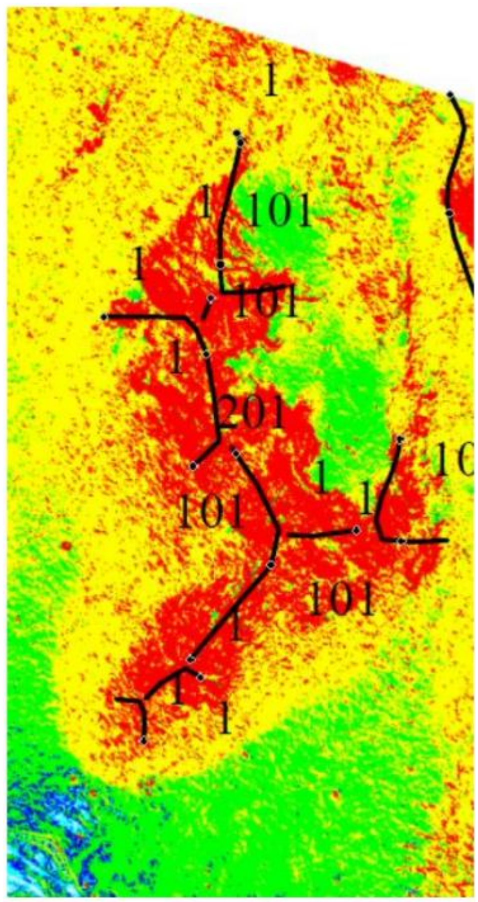

Figure 49: Example of Inaccurate Mapping of Top of Talus Slope

APPENDIX D – FULL AUTOMATION OF MAPPING ROCKFALL SHADOW ZONES IN GLOBAL MAPPER CODE

GLOBAL_MAPPER_SCRIPT VERSION=1.00

UNLOAD_ALL

// The following script/code is suited to only one dem file at the moment. Batch processing is a work in progress. So please keep only one DEM file in the folder //which will be used to import the DEM file. In addition, please name the DEM file as "DEM".

// Anything written after "//" is a comment and will not be processed. In addition, you will notice that there is a "\" at the end of few lines this means that the code //is continuing in the next line.

// In Global Mapper Script there is usually a command given which is followed by parameters. When stating the value of a parameter, it is important to put the //value in quotation.

// IMPORT_DIR_TREE is a command that allows you to import files into global mapper from a certain directory/folder. DIRECTORY is a parameter. Hence, change the directory to the folder where your files are located for the DIRECTORY parameter.

// The first folder being uploaded contains the orthophoto files

IMPORT_DIR_TREE DIRECTORY="H:\Project\ORTHOPHOTOS_DATA\" FILENAME_MASKS="*" RECURSE_DIR="YES" \

LAYER_GROUP="ORTHOPHOTOS"

// The second folder being uploaded contains the DEM file.

IMPORT_DIR_TREE DIRECTORY="H:\Project\DEM_DATA\" FILENAME_MASKS="*" RECURSE_DIR="YES" \

LAYER_GROUP="DEM"

// You can change the initial shader as required using the command "SET_VERT_DISP_OPTS". In this case, Slope Shader is selected as we are going to use raster //reclassification on the DEM file based on slope values.

SET_VERT_DISP_OPTS SHADER_NAME="SLOPE SHADER"

// The following code of line runs a command to carry out raster reclassification on the DEM file. In addition, this command requires you to set the rules using a //gmr file. The rules are basically how do you want to carry out the raster reclassification. For this code, the gmr file has been created and will be shared with the //code. Please update the parameter "RULES_FILENAME" with the directory of the gmr file where you have placed it. To know the details of what rules have //been set, you can open global mapper then go to raster reclassification tool and then load the already created gmr file to see the rules. In case anyone wants to //create a new set of rules from scratch, you can create one by scratch by going to global mapper then go to raster reclassification tool and then defining the rules //that you want and save the rules as a gmr file.

```
RASTER_RECLASSIFY LAYER_DESC="DEM RECLASSIFIED" FILENAME="DEM" \

OUTPUT_LAYER_TYPE="PALETTE" RULES_FILENAME="H:\Project\RASTER RECLASIFICATION FOR SCRIPTING DATA\RRS_2.gmr"

// "GENERATE_EQUAL_VAL_AREAS" command is being used to create polygons around the talus slope and edge of rocks using the colors defined in the gmr
//file in the previous command.

GENERATE_EQUAL_VAL_AREAS FILENAME="DEM RECLASSIFIED" LAYER_DESC="TALUS" ATTR_NAME="COLOR" \

    AREA_TYPE="Unknown Area Type" \

    COLOR_DIST="0" ELEV_DIST="0" SLOPE_DIST="1" FORCE_RGB="NO" FIX_INVALID="NO" EQUAL_COLORS="RGB(255,255,0)"

GENERATE_EQUAL_VAL_AREAS FILENAME="DEM RECLASSIFIED" LAYER_DESC="POSSIBLE ROCKFALL EDGE" ATTR_NAME="COLOR" \

    AREA_TYPE="Unknown Area Type" COLOR_DIST="0" ELEV_DIST="0" SLOPE_DIST="1" FORCE_RGB="NO" \

    FIX_INVALID="NO" EQUAL_COLORS="RGB(255,0,0)"

//The following command is setting the units of area and distance for this global mapper file.

ADD_MEASURE_ATTRS FILENAME="TALUS" AREA_UNITS="SQUARE METERS" DISTANCE_UNITS="METRIC" \

MEASURE_UNIT_TYPE="BASE"

ADD_MEASURE_ATTRS FILENAME="POSSIBLE ROCKFALL EDGE" AREA_UNITS="SQUARE METERS" DISTANCE_UNITS="METRIC" \

MEASURE_UNIT_TYPE="BASE"

// "EDIT_VECTOR" command is an important command to edit vector features such as polygons. The following line of code, selects all polygons greater than
//5000 meters squared and copies them to a new layer.

EDIT_VECTOR FILENAME="TALUS" COMPARE_NUM="YES" SHAPE_TYPE="AREA" COMPARE_STR="ENCLOSED_AREA>5000" \
COPY_TO_NEW_LAYER="YES" NEW_LAYER_NAME="TALUS > 0.5 Hectares"

EDIT_VECTOR FILENAME="POSSIBLE ROCKFALL EDGE" COMPARE_NUM="YES" SHAPE_TYPE="AREA" \
COMPARE_STR="ENCLOSED_AREA>5000" COPY_TO_NEW_LAYER="YES" NEW_LAYER_NAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares"

// The following line of code is smoothing and simplifying the features. USE DELETE_ISLAND="YES", If you want to remove holes/islands from the polygons

EDIT_VECTOR FILENAME="TALUS > 0.5 Hectares" DELETE_ISLANDS="YES" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="3"
```

EDIT_VECTOR FILENAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares" DELETE_ISLANDS="YES" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="3"

EDIT_VECTOR FILENAME="TALUS > 0.5 Hectares" DELETE_ISLANDS="YES" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="2"

EDIT_VECTOR FILENAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares" DELETE_ISLANDS="YES" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="2"

EDIT_VECTOR FILENAME="TALUS > 0.5 Hectares" DELETE_ISLANDS="YES" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="1"

EDIT_VECTOR FILENAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares" DELETE_ISLANDS="YES" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="1"

// Creating a buffer zone around the polygons created for the talus slope and edge of rock. This is done to shift the edge of the talus slope around 5 to 10 meters
//below its actual position to avoid any problems related to getting slope values for the viewshed analysis

EDIT_VECTOR FILENAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares" BUFFER_DIST="45 m" \

NEW_LAYER_NAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone"

EDIT_VECTOR FILENAME="TALUS > 0.5 Hectares" BUFFER_DIST="5 m" NEW_LAYER_NAME="TALUS > 0.5 Hectares with 20 Meters Buffer Zone"

// Smoothing and simplifying the features.

EDIT_VECTOR FILENAME="TALUS > 0.5 Hectares with 20 Meters Buffer Zone" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="100" SIMPLIFICATION="1"

EDIT_VECTOR FILENAME="POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone" SMOOTH_FEATURES="YES" \
COVERAGE_SMOOTHING_FACTOR="100" SIMPLIFICATION="1"

// “DEFINE_SPATIAL_OPERATION” command helps you to define spatial operations such as intersection between polygons. In this case, we are going to find the intersection between the two buffer zones created previously.

DEFINE_SPATIAL_OPERATION

SPATIAL_OPERATION_NAME="INTERSECTION OF TALUS > 0.5 Hectares with 20 Meters Buffer Zone AND POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone"

LAYER "INTERSECTION OF TALUS > 0.5 Hectares with 20 Meters Buffer Zone AND POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone" = INTERSECTION("POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone","TALUS > 0.5 Hectares with 20 Meters Buffer Zone")

END_DEFINE_SPATIAL_OPERATION

// Running the spatial operation

RUN_SPATIAL_OPERATION SPATIAL_OPERATION_NAME="INTERSECTION OF TALUS > 0.5 Hectares with 20 Meters Buffer Zone AND POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone"

// Smoothing and simplifying the features.

EDIT_VECTOR FILENAME="INTERSECTION OF TALUS > 0.5 Hectares with 20 Meters Buffer Zone AND POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone" SMOOTH_FEATURES="YES" COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="1"

// CREATE_SKELETON_LINES parameter is used to create a line in the middle of the polygon created by the intersection of the two buffer zones. This line will be roughly at the top of the talus slope (roughly 10 to 15 m below it).

EDIT_VECTOR \

FILENAME="INTERSECTION OF TALUS > 0.5 Hectares with 20 Meters Buffer Zone AND POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone" \
CREATE_SKELETON_LINES="YES"

// It is important to combine the lines created from the previous command so that we can smooth and simplify the top of the talus line.

COMBINE_LINES \

FILENAME="INTERSECTION OF TALUS > 0.5 Hectares with 20 Meters Buffer Zone AND POSSIBLE ROCKFALL EDGE > 0.5 Hectares with 40 Meters Buffer Zone Skeleton Lines" \
LAYER_DESC="ONE LINE THAT RULES THEM ALL" MAX_DIST="2"

// Smoothing and simplifying the features.

EDIT_VECTOR FILENAME="ONE LINE THAT RULES THEM ALL" SMOOTH_FEATURES="YES" COVERAGE_SMOOTHING_FACTOR="200" SIMPLIFICATION="1"

// Creating points along the top of the talus line at a distance of 100 m so that we can apply the viewshed analysis on those points (viewshed analysis works only //on points)

EDIT_VECTOR FILENAME="ONE LINE THAT RULES THEM ALL" CREATE_POINTS_ALONG_FEATURES="100" \
KEEP_ORIGINAL_VERTICES="NO"

// Calculating elevation and slope values at all the points that were created.

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" CALC_ELEV_SLOPE_STATS IGNORE_LINE_VERTICES

// Copying the slope direction values created from previous command to a new attribute named as SDN which stands for “Slope Direction Numerical”. Important //to note that for this DEM when slope stats are calculated the slope direction attribute is named as SLOPE_DIR and this might differ for another DEM hence you //may face an error for this and may have to edit the "SLOPE_DIR" in the “ATTR_TO_COPY” parameter.

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_TO_COPY="SDN=SLOPE_DIR"

// Removing non-numerical values from the SDN attribute (this code is removing the non-numerical values based on what I saw are being generated). You may //have to add another line of code if any non-numerical values are not removed which can simply be done by copy pasting one line of the code below and //changing the following part "SDN=*Input the non numerical value*="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=(="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=)="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN= ="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=°="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=N="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=S="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=W="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=E="

// “CALC_ATTR_FORMULA” command allows carrying out calculation on attributes. In this case I am creating a new attribute called "Start Angle" (which is //going to be used as an input for the viewshed analysis) using the SDN attribute. I want the start angle of the viewshed analysis to be less than 30 degrees than the //slope direction at the point feature. If you do not wish to use 30 then simply just replace 30 with number you want in the “FORMULA” parameter.

CALC_ATTR_FORMULA FILENAME="THE CHOOSEN ONES" NEW_ATTR="START ANGLE" CALC_MODE="NUMERIC" \

FORMULA=IF(SDN-30<0,SDN-30+360,SDN-30)

// Splitting the layer by the value of the SDN attribute so that we can run a loop. Important to note that, all points with same SDN value will be in one layer and //will also have the same start angle as start angle is calculated based on SDN value

SPLIT_LAYER FILENAME="THE CHOOSEN ONES" SPLIT_BY_ATTR="SDN" LAYER_DESC_ATTR_ONLY

// Running a loop using a variable loop. %Counter% is a predefined variable that counts which loop step is ongoing and we are using it to run the view shed analysis //on the layers created in the previous command. All the layers created are based on the SDN values which are basically numbers. So, we are using the counter //variable in the filename parameter which will go from 0 to 360 to run the viewshed analysis on the layers created based on the SDN number. In addition, we also //defined an additional variable named Start Angle which will have the value of the attribute named start angle for each layer and all points in each layer will have

//the same start angle since each layer was created based on the SDN values (meaning all points which have same SDN value are in one layer and hence have same
//start angle as well). In short, going to go layer by layer (from 0 to 360) and carry out view shed analysis for all points for each layer

```
VAR_LOOP_START VAL_START="0" VAL_STOP="360" VAL_STEP="1"

DEFINE_VAR NAME="START ANGLE" VALUE_ATTR="START ANGLE" FILENAME="%COUNTER%"

GENERATE_VIEWSHED LAYER_DESC="%COUNTER%" FILENAME="%COUNTER%" \

        XMIT_HEIGHT="10.4886004748 m" XMIT_HEIGHT_ABOVE_SEA_LEVEL="NO" RECEIVER_ELEV_TYPE="XMIT_ANGLE_RANGE" \

            RECEIVER_ANGLE="-28.5"    RECEIVER_ANGLE_END="-26.5"    RECEIVER_HEIGHT_ANGLE="0"
RECEIVER_HEIGHT_ABOVE_SEA_LEVEL="NO" \

  RADIUS="5 km" RADIUS_MIN="0 km" START_ANGLE="%START ANGLE%" SWEPT_ANGLE="60" USE_EARTH_CURVATURE="YES" \

  ATMOSPHERIC_CORRECTION="1.33333" CREATE_COVERAGE_AREAS="YES" SHOW_HIDDEN_AREAS="NO" \

  TREAT_INVALID_AS_ZERO="YES" COLOR="RGB(255,0,0)" GEN_POWER_GRID="NO" USE_VECTOR_HEIGHTS="NO" \

  FIX_INVALID="NO" SPATIAL_RES="1.528785126,1.5331757"

VAR_LOOP_END
```

APPENDIX E – RASTER RECLASSIFICATION TOOL

```
// This code will generate a colorful map where the talus slope is colored using yellow and lump of rocks as red. In addition to the orthophotos the map generated from this tool helps visualize the top of the talus //slope and potential points of interests where you would like to know the rockfall shadow zone.

// You can change the initial shader as required using the command “SET_VERT_DISP_OPTS”. In this case, Slope Shader is selected as we are going to use raster //reclassification on the DEM file based on slope values.

SET_VERT_DISP_OPTS SHADER_NAME="SLOPE SHADER"

// The following code of line runs a command to carry out raster reclassification on the DEM file. In addition, this command requires you to set the rules using a //gmr file. The rules are basically how do you want to carry out the raster reclassification. For this code, the gmr file has been created and will be shared with the //code. Please update the parameter “RULES_FILENAME” with the directory of the gmr file where you have placed it. To know the details of what rules have //been set, you can open global mapper then go to raster reclassification tool and then load the already created gmr file to see the rules. In case anyone wants to //create a new set of rules from scratch, you can create one by scratch by going to global mapper then go to raster reclassification tool and then defining the rules //that you want and save the rules as a gmr file.

RASTER_RECLASSIFY LAYER_DESC="DEM RECLASSIFIED" FILENAME="DEM" \

OUTPUT_LAYER_TYPE="PALETTE" RULES_FILENAME="H:\Project\RASTER RECLASIFICATION FOR SCRIPTING DATA\RRS_2.gmr"
```

APPENDIX F – SEMI-AUTOMATION OF MAPPING ROCKFALL SHADOW ZONES IN GLOBAL MAPPER TOOL

//INSTRUCTIONS ON HOW TO USE THIS. LOAD YOUR ORTHOPHOTO AND DEM FILE ONTO GLOBAL MAPPER. SELECT THE CREATE //POINT/TEXT FEATURE AND CREATE ONE POINT FEATURE AT THE POINT OF INTEREST. WHEN CREATING THE FIRST POINT FEATURE A //POP-UP BOX WILL APPEAR WHERE YOU HAVE TO NAME THE LAYER AS "THE CHOOSEN ONES", SPECIFY THE STYLE OF THE POINT AS //YOU WANT (E.G, ORANGE DOT) AND, MOST IMPORTANTLY, TICK THE BOX NEAR "AUTOMATICALLY APPLY THESE SETTINGS TO NEW //FEATURES OF THE SAME TYPE" THIS WILL SAVE THE SETTINGS FOR THIS LAYER AND WILL ALLOW YOU TO CREATE MULTIPLE POINT //FEATURES AT MULTIPLE POINT OF INTERESTS EASILY WITHOUT THE POP-UP BOX POPPING UP.

// Use the orthophoto or (DEM RECLASSIFIED if generated from the code in Appendix E) to identify the point of interests

// Calculating elevation and slope values at all the points that were created.

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" CALC_ELEV_SLOPE_STATS IGNORE_LINE_VERTICES

// Copying the slope direction values created from previous command to a new attribute named as SDN which stands for "Slope Direction Numerical". Important //to note that for this DEM when slope stats are calculated the slope direction attribute is named as SLOPE_DIR and this might differ for another DEM hence you //may face an error for this and may have to edit the "SLOPE_DIR" in the "ATTR_TO_COPY" parameter.

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_TO_COPY="SDN=SLOPE_DIR"

// Removing non-numerical values from the SDN attribute (this code is removing the non-numerical values based on what I saw are being generated). You may //have to add another line of code if any non-numerical values are not removed which can simply be done by copy pasting one line of the code below and //changing the following part "SDN=*Input the non numerical value*="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=(="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=)="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN= ="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=°="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=N="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=S="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=W="

EDIT_VECTOR FILENAME="THE CHOOSEN ONES" ATTR_REPLACE_STR="SDN=E="

// “CALC_ATTR_FORMULA” command allows carrying out calculation on attributes. In this case I am creating a new attribute called "Start Angle" (which is //going to be used as an input for the viewshed analysis) using the SDN attribute. I want the start angle of the viewshed analysis to be less than 30 degrees than the //slope direction at the point feature. If you do not wish to use 30 then simply just replace 30 with number you want in the “FORMULA” parameter.

CALC_ATTR_FORMULA FILENAME="THE CHOOSEN ONES" NEW_ATTR="START ANGLE" CALC_MODE="NUMERIC" \

FORMULA=IF(SDN-30<0,SDN-30+360,SDN-30)

// Splitting the layer by the value of the SDN attribute so that we can run a loop. Important to note that, all points with same SDN value will be in one layer and //will also have the same start angle as start angle is calculated based on SDN value

SPLIT_LAYER FILENAME="THE CHOOSEN ONES" SPLIT_BY_ATTR="SDN" LAYER_DESC_ATTR_ONLY

// Running a loop using a variable loop. %Counter% is a predefined variable that counts which loop step is ongoing and we are using it to run the view shed analysis //on the layers created in the previous command. All the layers created are based on the SDN values which are basically numbers. So, we are using the counter //variable in the filename parameter which will go from 0 to 360 to run the viewshed analysis on the layers created based on the SDN number. In addition, we also //defined an additional variable named Start Angle which will have the value of the attribute named start angle for each layer and all points in each layer will have //the same start angle since each layer was created based on the SDN values (meaning all points which have same SDN value are in one layer and hence have same //start angle as well). In short, going to go layer by layer (from 0 to 360) and carry out view shed analysis for all points for each layer

VAR_LOOP_START VAL_START="0" VAL_STOP="360" VAL_STEP="1"

DEFINE_VAR NAME="START ANGLE" VALUE_ATTR="START ANGLE" FILENAME="%COUNTER%"

GENERATE_VIEWSHED LAYER_DESC="%COUNTER%" FILENAME="%COUNTER%" \

XMIT_HEIGHT="10.4886004748 m" XMIT_HEIGHT_ABOVE_SEA_LEVEL="NO" RECEIVER_ELEV_TYPE="XMIT_ANGLE_RANGE" \

RECEIVER_ANGLE="-28.5" RECEIVER_ANGLE_END="-26.5" RECEIVER_HEIGHT_ANGLE="0" RECEIVER_HEIGHT_ABOVE_SEA_LEVEL="NO" \

RADIUS="5 km" RADIUS_MIN="0 km" START_ANGLE="%START ANGLE%" SWEPT_ANGLE="60" USE_EARTH_CURVATURE="YES" \

ATMOSPHERIC_CORRECTION="1.33333" CREATE_COVERAGE_AREAS="YES" SHOW_HIDDEN_AREAS="NO" \

TREAT_INVALID_AS_ZERO="YES" COLOR="RGB(255,0,0)" GEN_POWER_GRID="NO" USE_VECTOR_HEIGHTS="NO" \

FIX_INVALID="NO" SPATIAL_RES="1.528785126,1.5331757"

VAR_LOOP_END

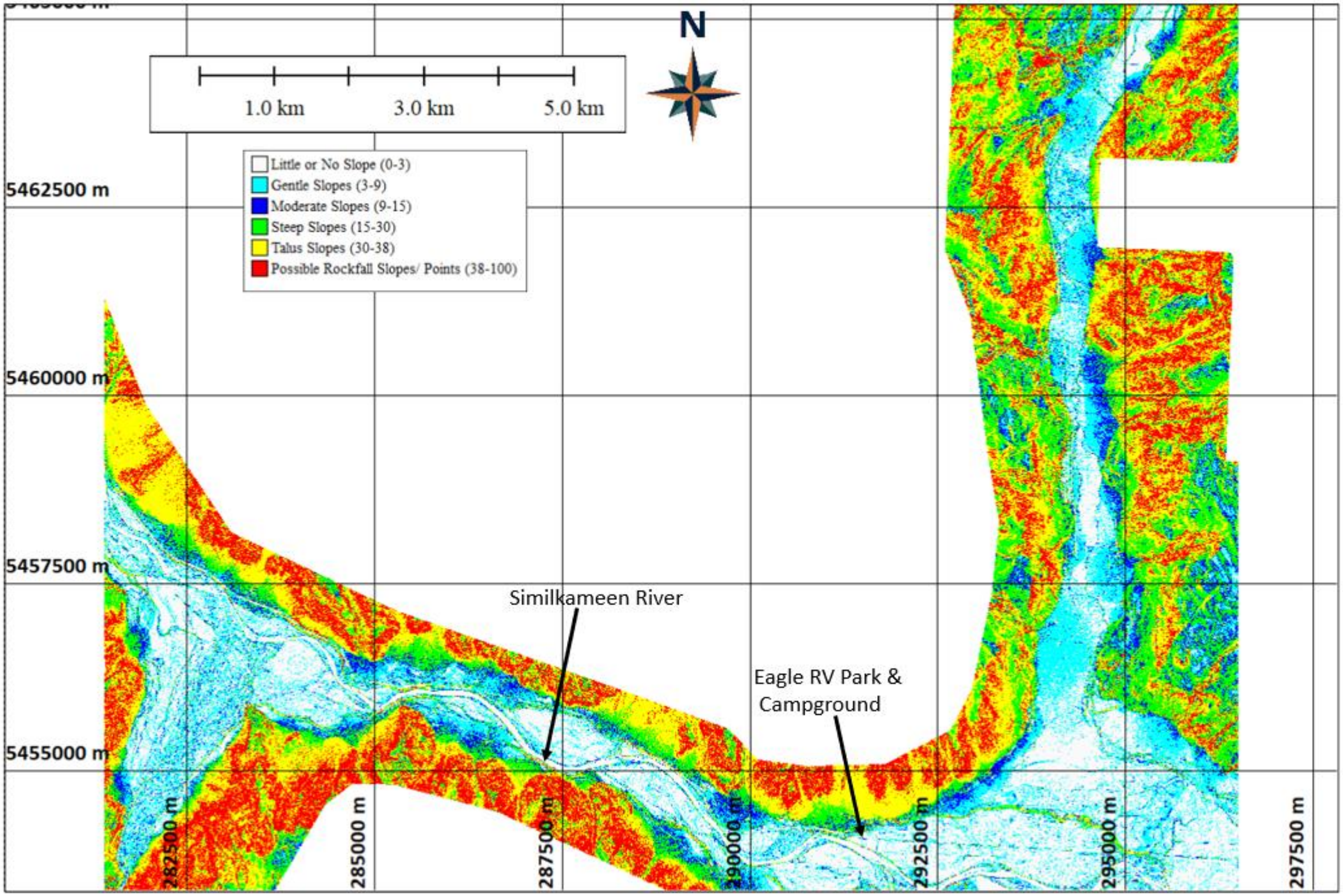

Figure 50: DEM Reclassified Based on Slope Values

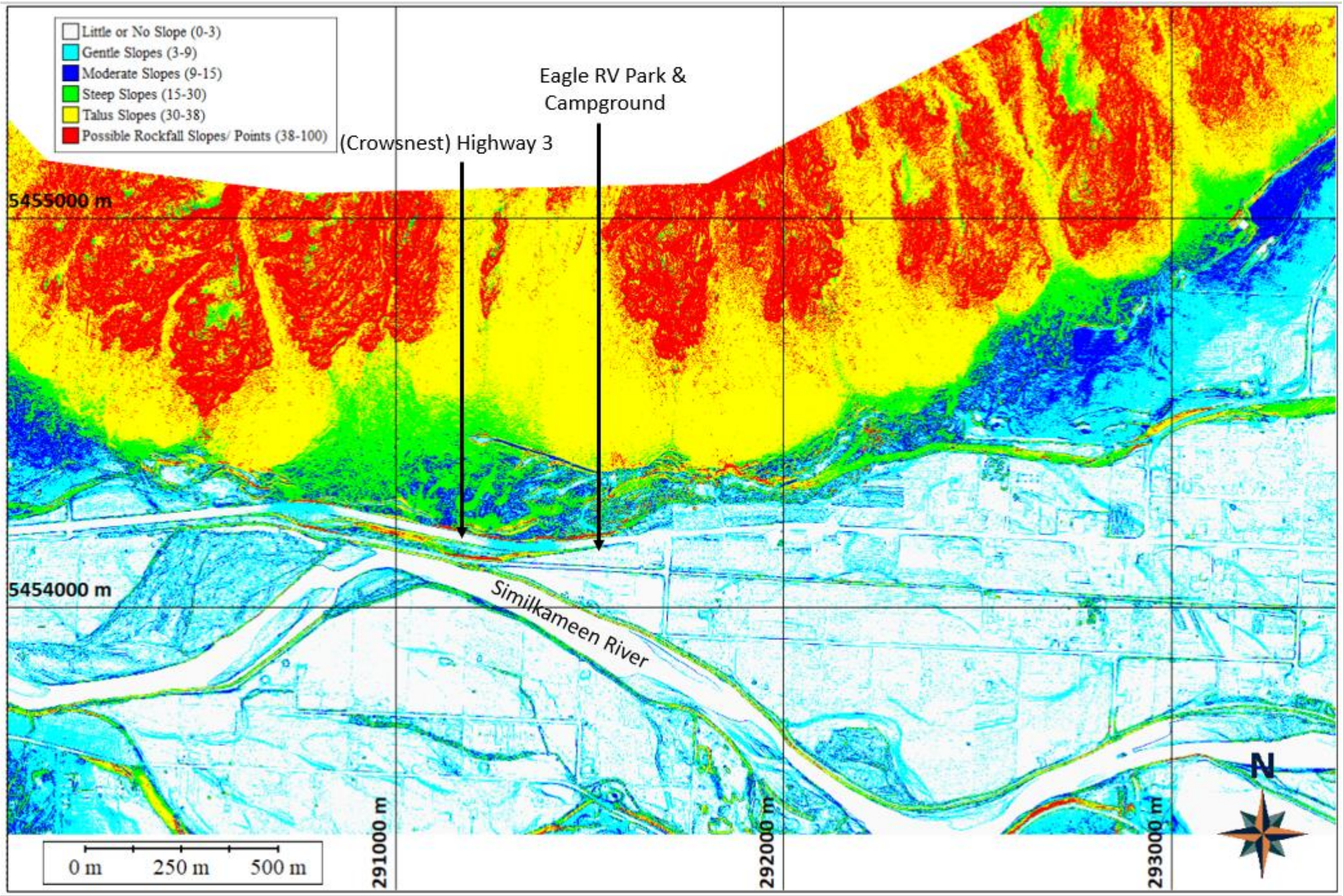

Figure 51: DEM Reclassified Based on Slope Values (Zoomed into Area of Interest)

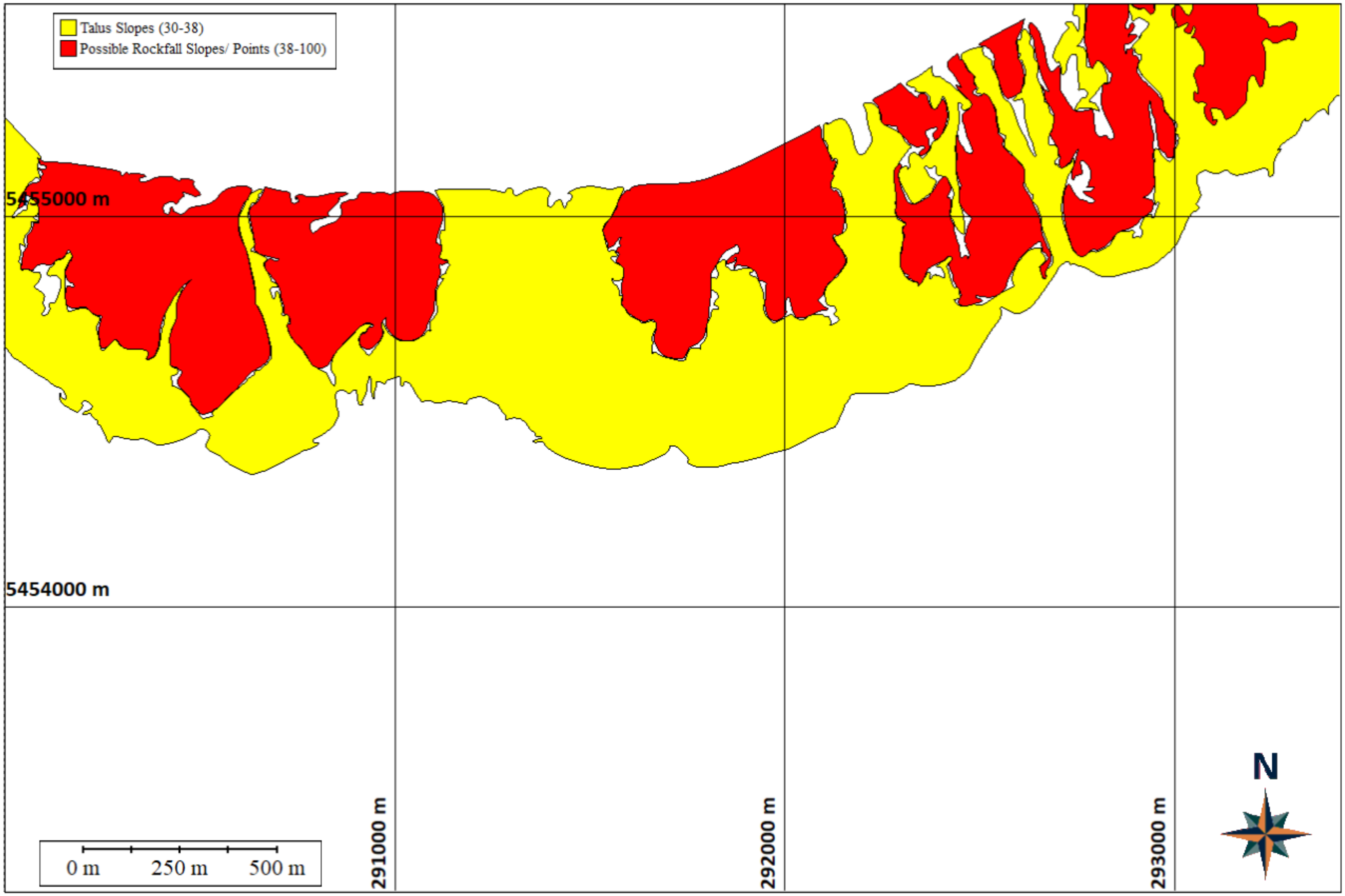

Figure 52: Using the Generate Equal Value Areas Tool to Generate Polygons Based on Color Palette (Smoothing, Simplification and Islands Deleted)

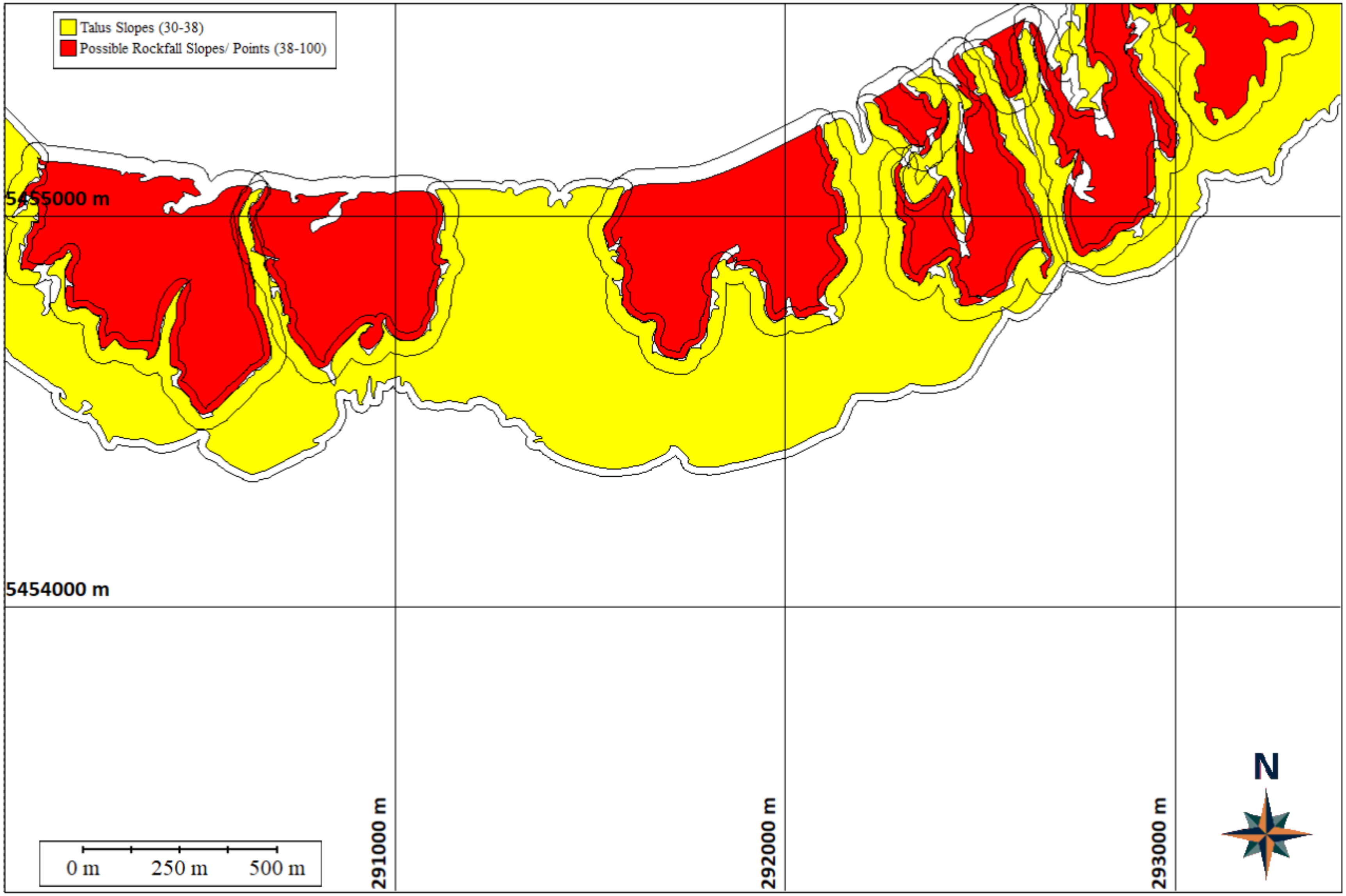

Figure 53: Buffer Zones Created Around Talus Slope and Edge of Bedrock

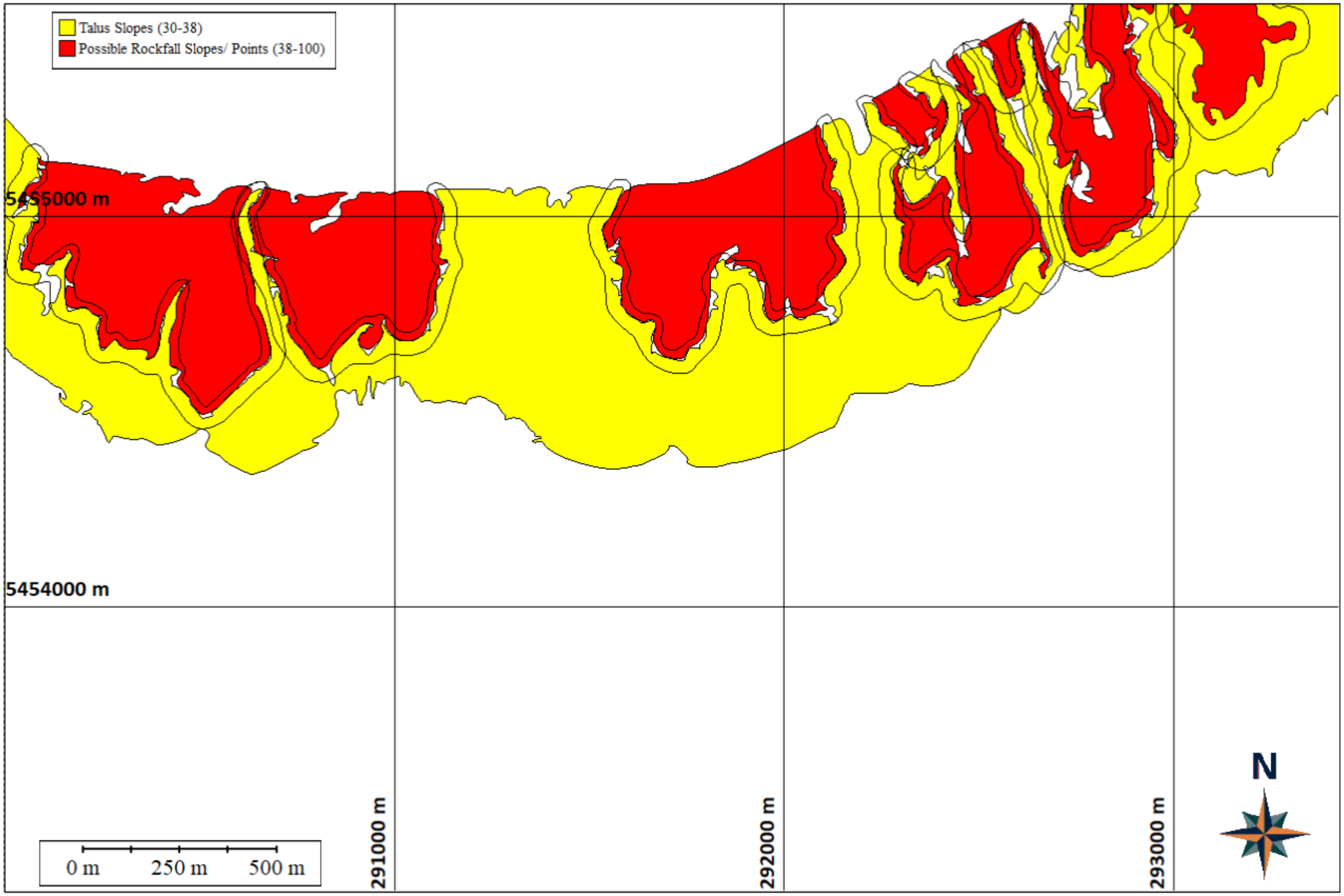

Figure 54: Intersection Between the Buffer Zones Created Around Talus Slope and Edge of Bedrock

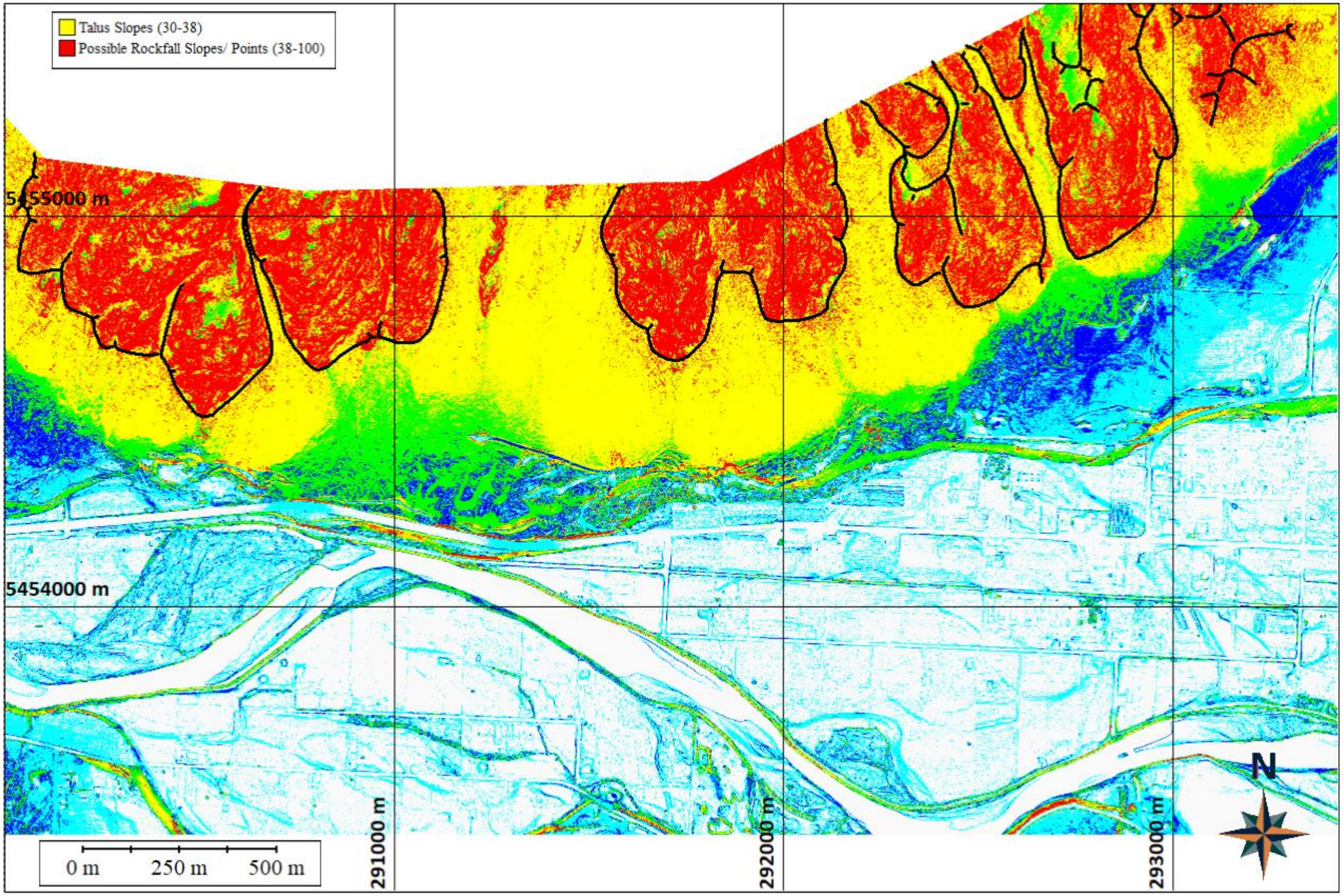

Figure 55: Line Created which Maps Out the Top of the Talus Slope

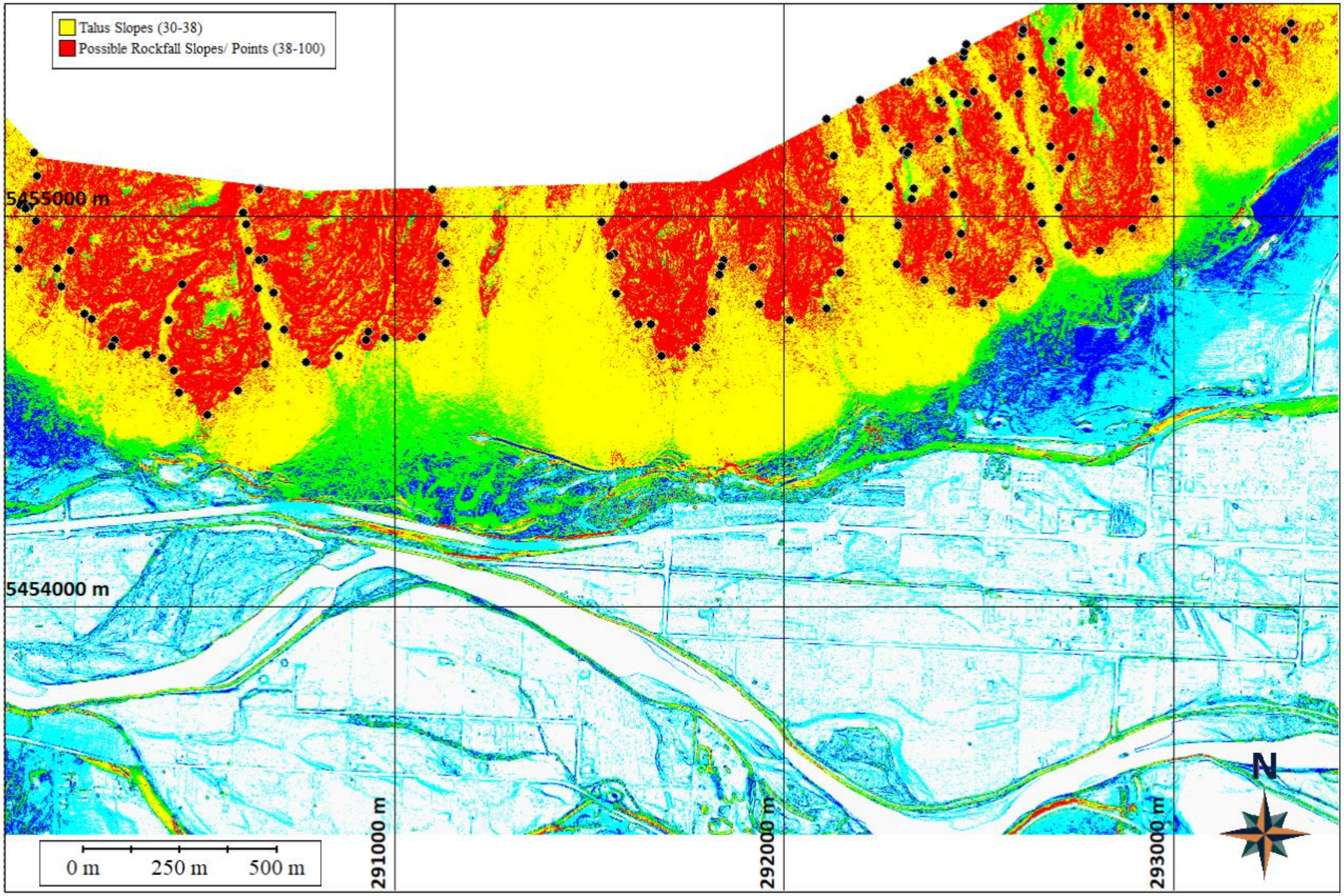

Figure 56: Points Created at Every 100 Metres Along the Line which Maps out the Top of the Talus Slope

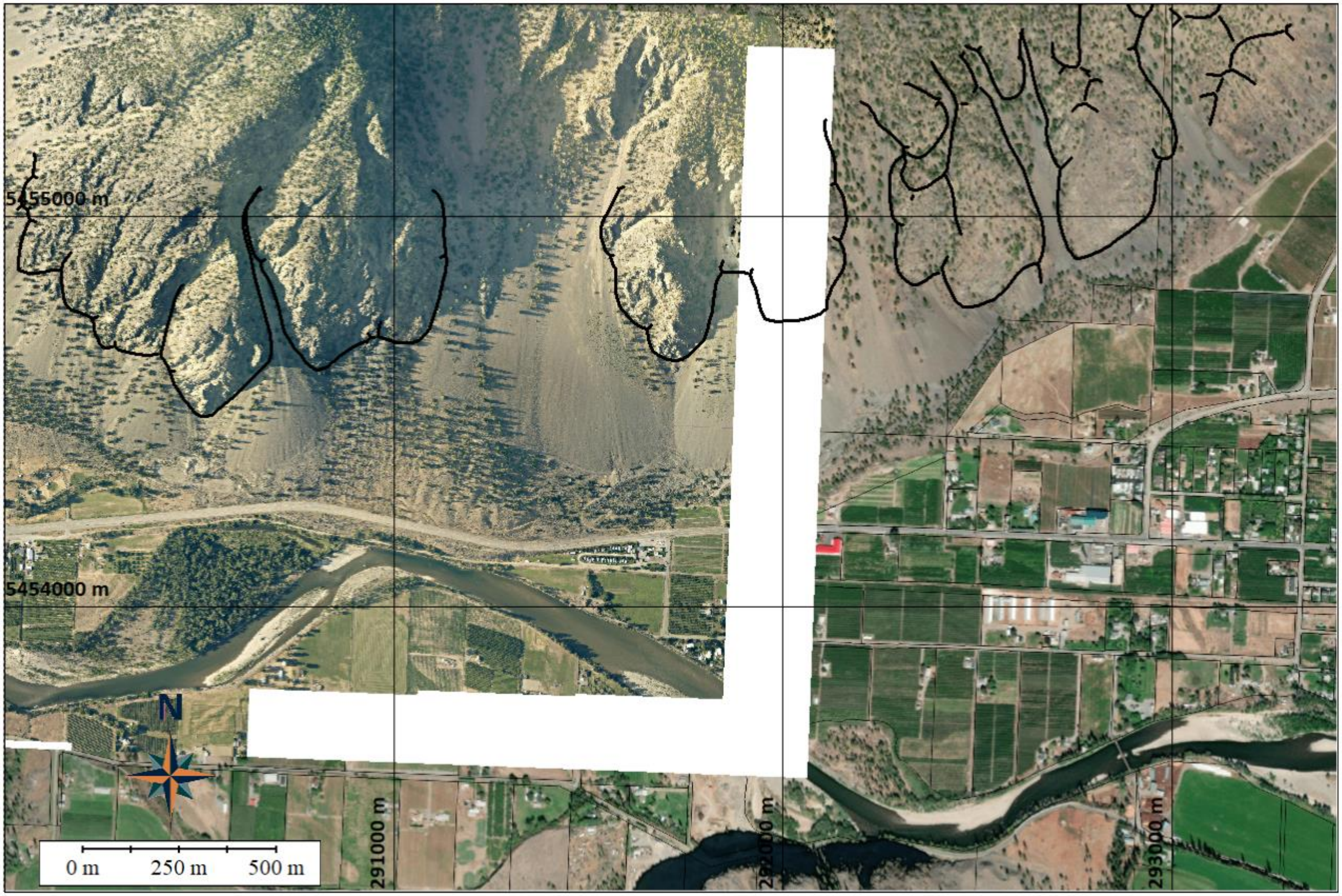

Figure 57: Line Created which Maps out the Top of the Talus Slope Shown on the Orthophoto

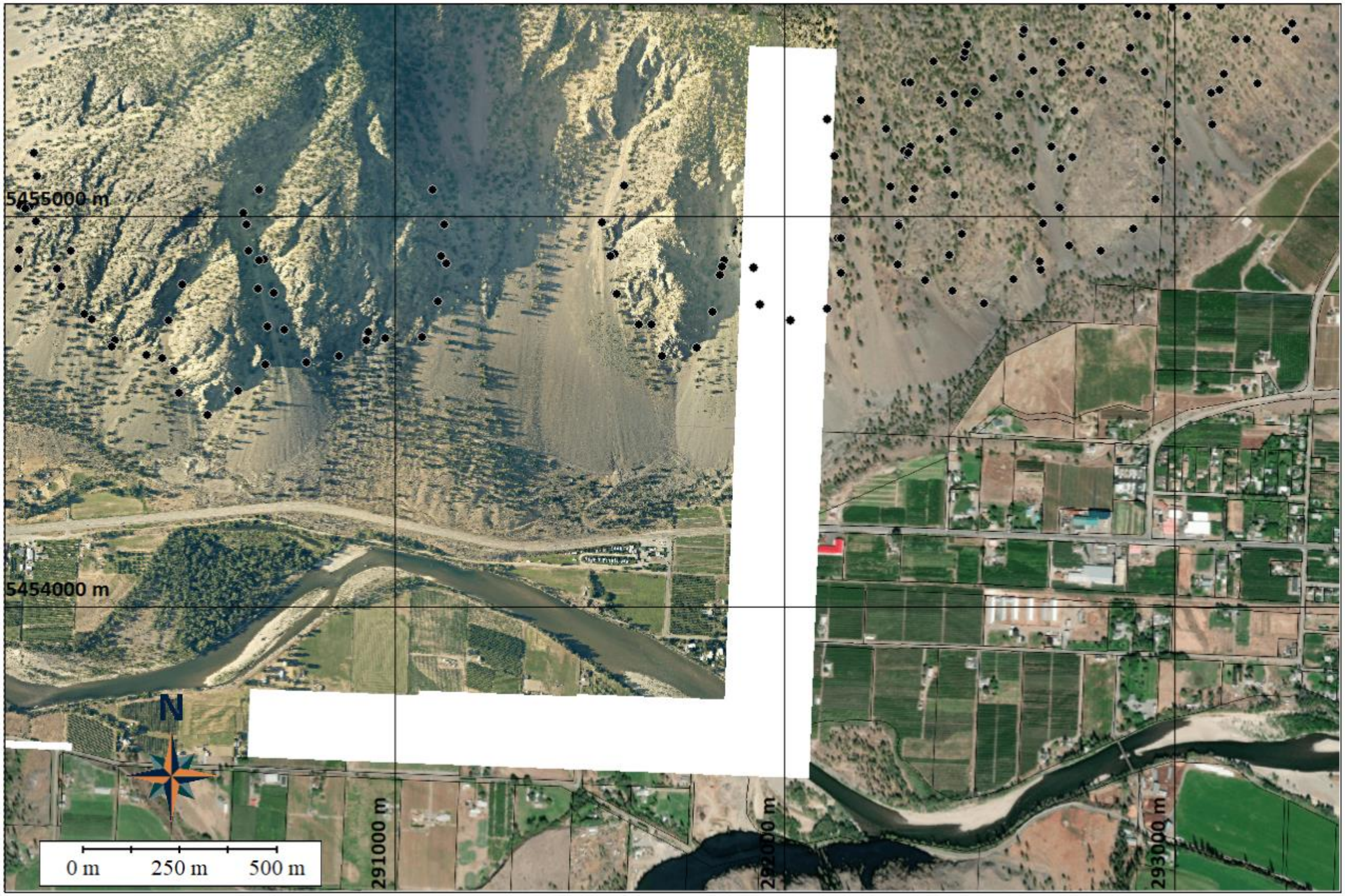

Figure 58: Points Created at Every 100 Metres Along the Line which Maps out the Top of the Talus Slope Shown on the Orthophoto

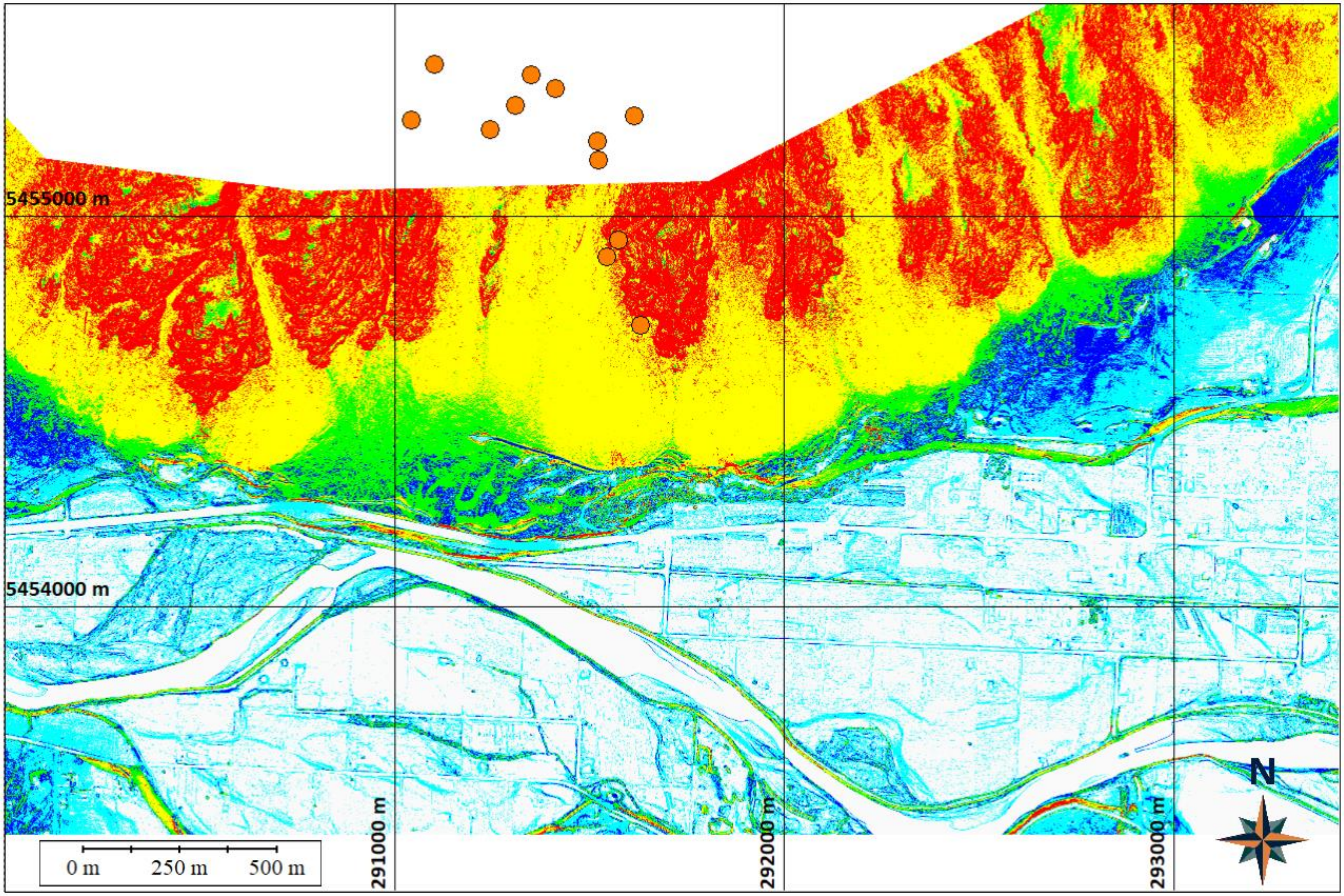

Figure 59: Points Created Manually Shown on the DEM (Fine) Reclassified Based on the Slope Values

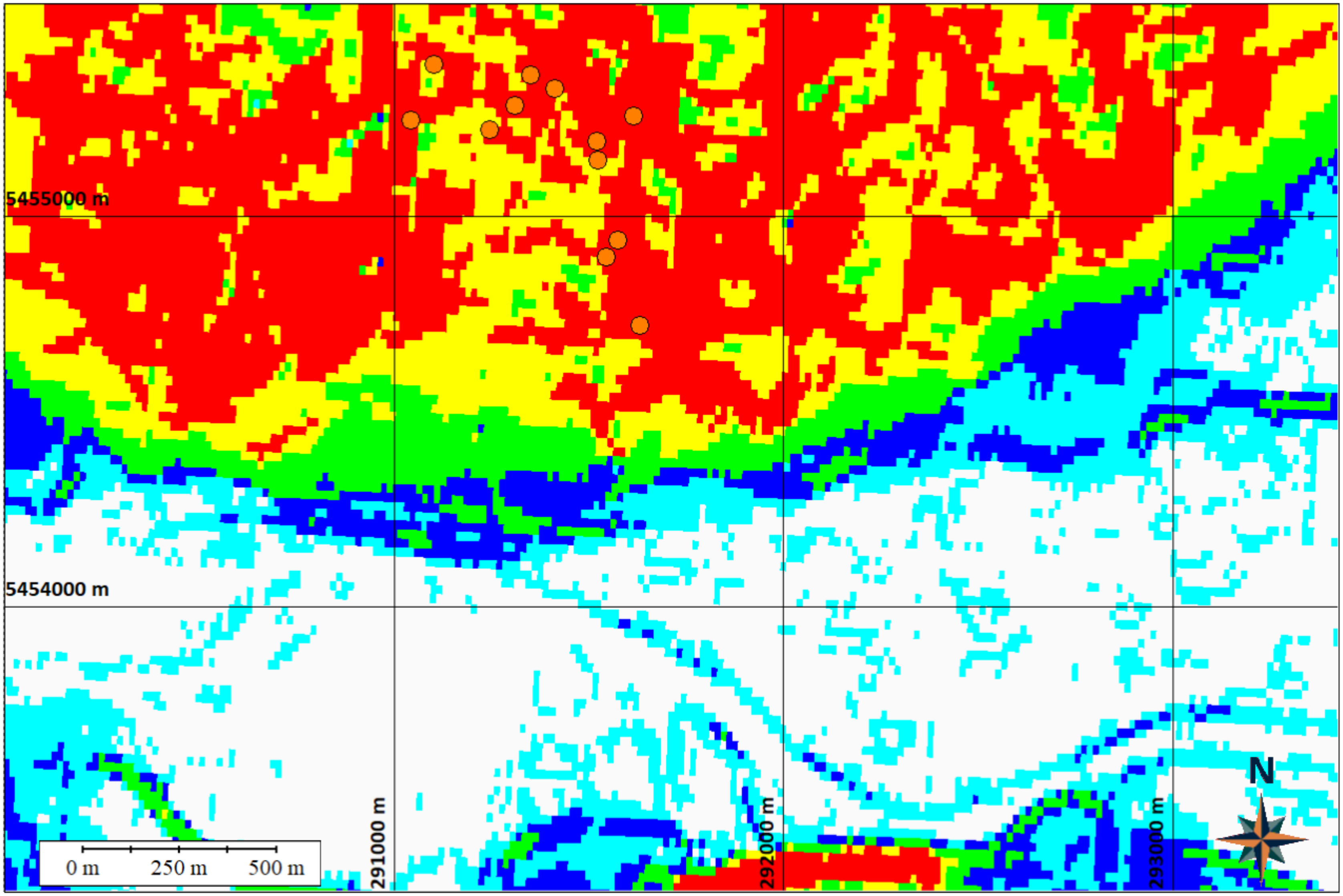

Figure 60: Points Created Manually Shown on the DEM (Coarse) Reclassified Based on the Slope Values (Used for Points which are not on the Fine DEM)

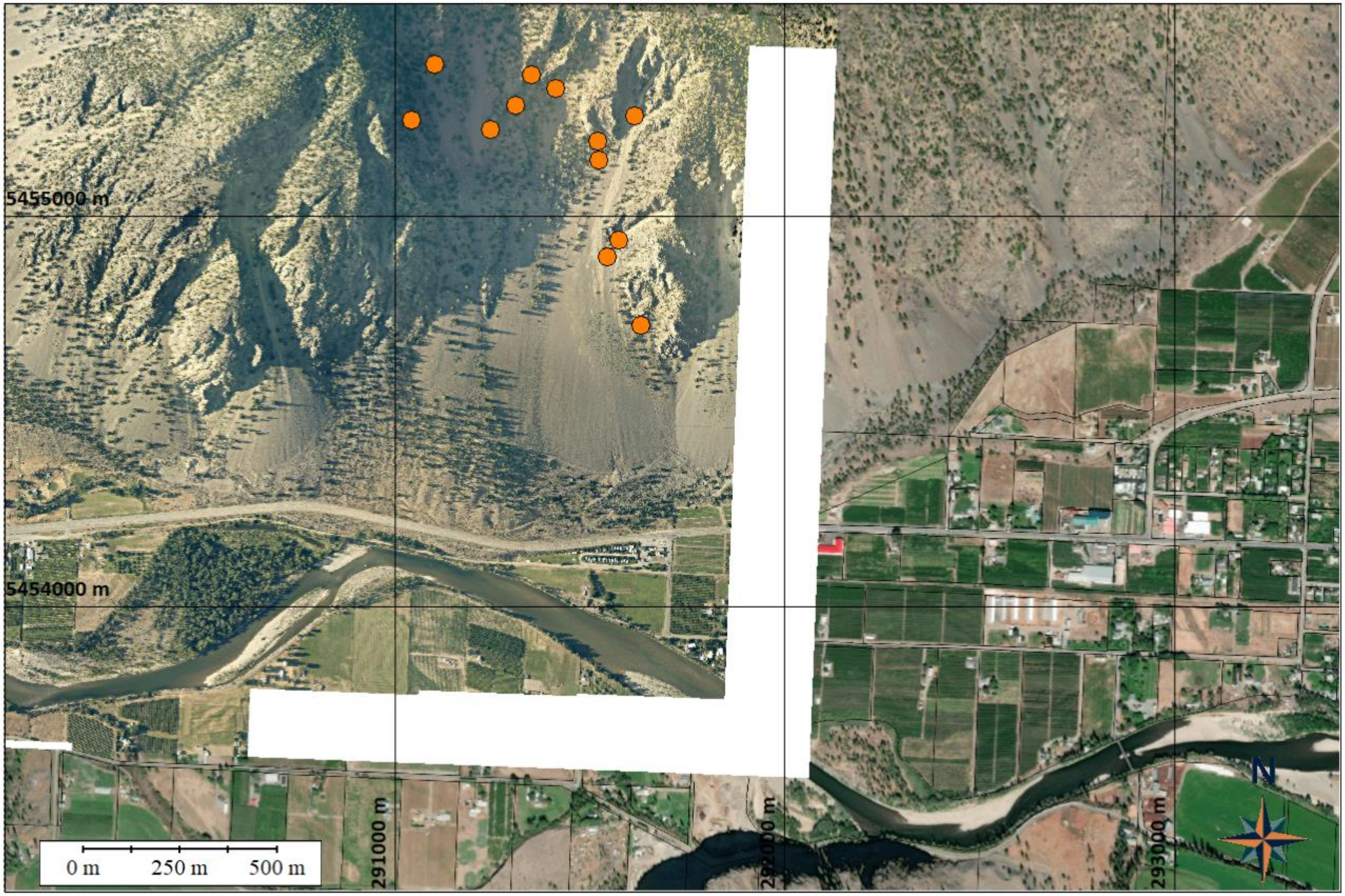

Figure 61: Points of Interests Created Manually Shown on the Orthophoto

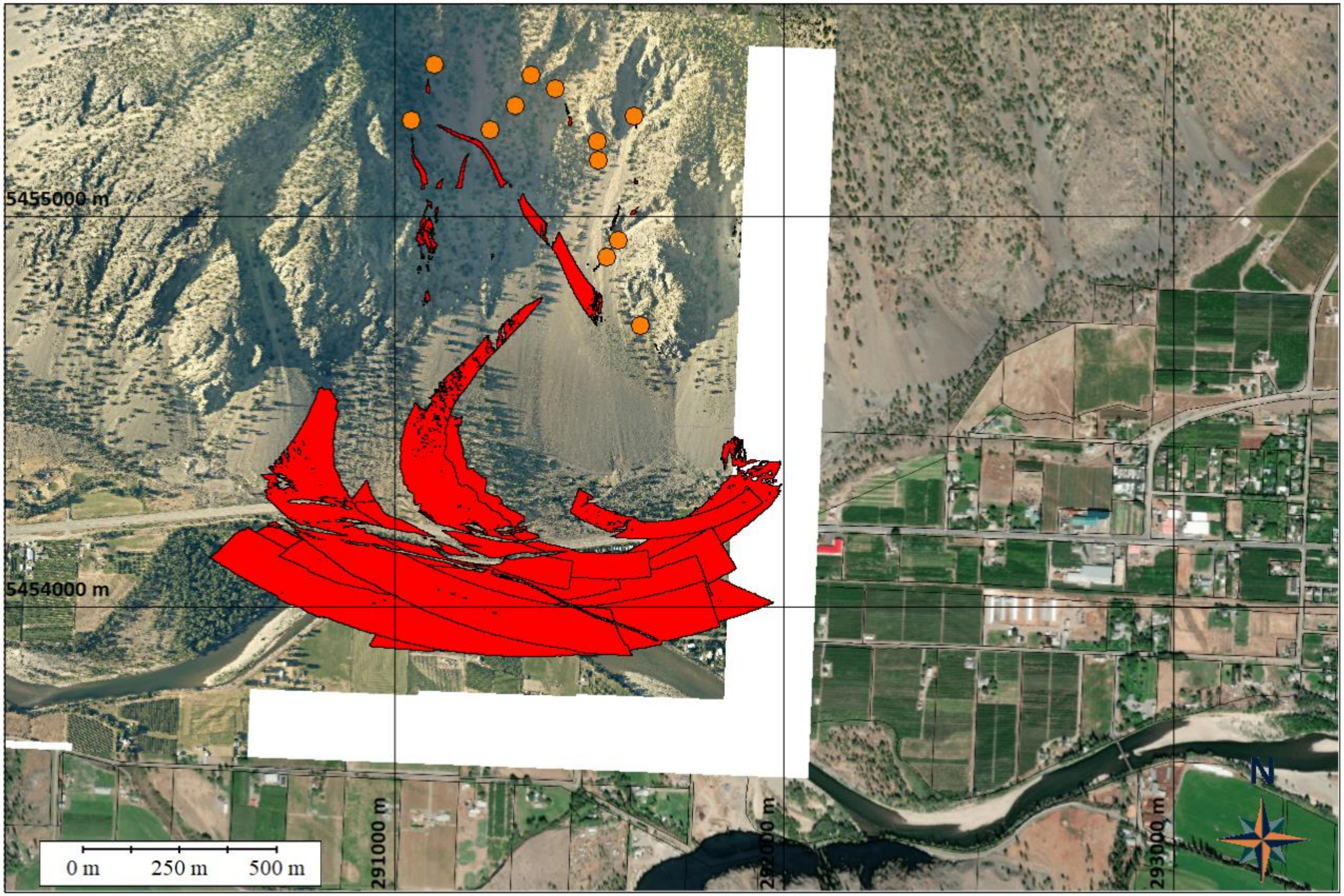

Figure 62: Viewshed Analysis Results for Points of Interest Created Manually