

# GEOMORPHIC AND HABITATS RECONSTRUCTION AT THE RECLAMATION PLAN OF THE 'LOS QUEBRADEROS DE LA SERRANA QUARRY' (TOLEDO, SPAIN)

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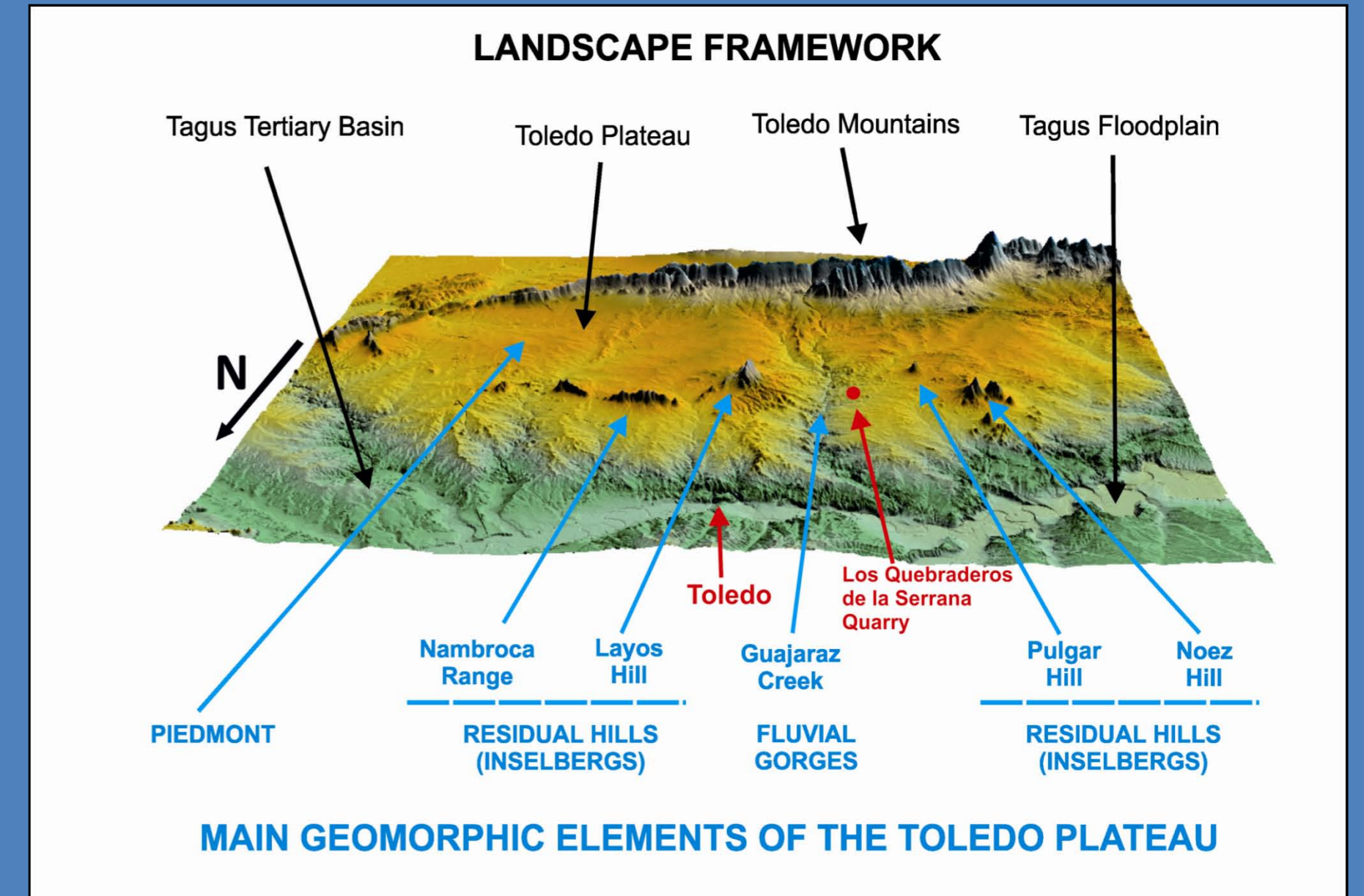
## 1 Introduction

This work is part of the *Environmental Impact Assessment and Restoration Plan for the Quarry "Los Quebrados de la Serrana"*, located in the municipality of Noez (Toledo, Spain), developed in the framework of a research contract between the Complutense University of Madrid and the construction company Construcciones Lozoya S.A.

**Mining and Environment:** Mining is an essential activity to our wellbeing, to such an extent that we are totally dependent on it. On the other hand, mining is an activity that generates a strong environmental impact, because it affects to all the compartments of the ecosystem. Therefore it is necessary to reconcile this activity as essential as transforming for the environment, with the environment in which it takes place.

**The quarry "Los Quebrados de la Serrana":** The Project of quarry *Los Quebrados de la Serrana*, promoted by Construcciones Lozoya S.A., is located on the so-called Plateau of Toledo (see **Figure 1**). It is expected to extract high quality slates of high value for its use as asphalt mixtures. At the same time, this site is a *Distribution and Importance Area for the Imperial Eagle*. Inevitably, the extraction activities will alter of the relief which support various ecosystems where the rabbit lives. Rabbit is the main prey of the imperial eagle, a bird listed as Endangered Species. So the objective of this work is to combine the extraction of slate with the maintenance of the *Distribution and Importance Area for the Imperial Eagle* through a Restoration Plan based on Ecological Restoration.

The core of the Restoration Plan is a geomorphological restoration design. This design, along with replacement of soils and revegetation, will create a series of habitats capable of supporting optimal rabbit densities.



**Figure 1:** Location of the Project of quarry *Los Quebrados de la Serrana*, on the plateau of Toledo (Central Spain).

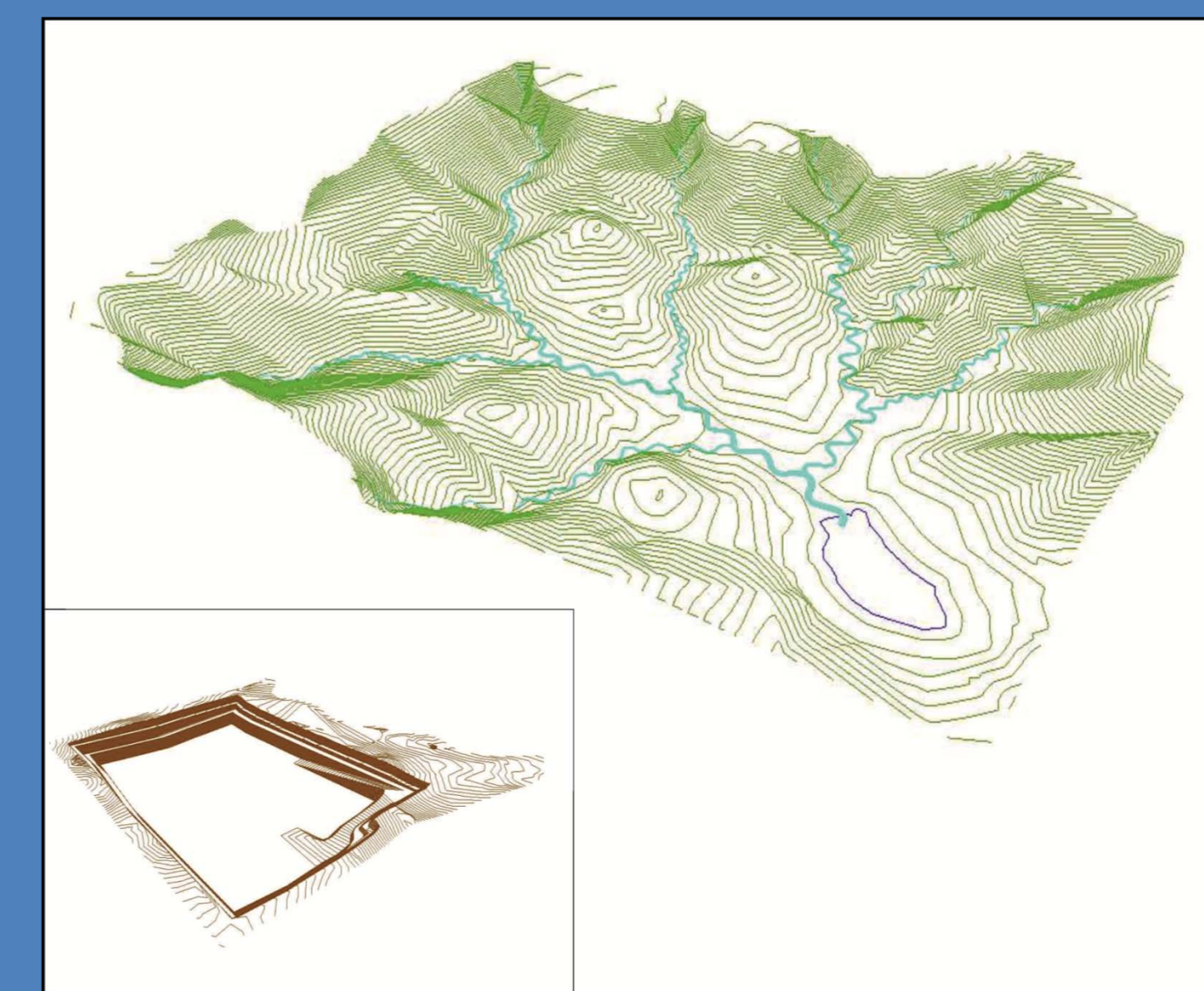
## 2 The GeoFluv™ methodology and the Natural Regrade software

The design of the geomorphological reconstruction of the quarry *Los Quebrados de la Serrana* is based on the creation of a topography that mimics the natural forms of a geomorphological referent of the local environment, characterized by convex-concave slopes and drainage networks. To do this, the methodology GeoFluv™ and the Natural Regrade software have been used, because these are the only tools in the market which can design mining restorations on the basis of geomorphological principles. The whole process is carried out taking into account four aspects:

- **Identification of a geomorphological referent:** Since the sterile materials generated for the mining operation will be similar to the colluvium deposits of metamorphic rocks, the base of two nearby hills of similar characteristics, called Layos and Pulgar, were chosen as the geomorphological referents. Parameters such as drainage density and the shape of channels were extracted from these referents.
- **Weather conditions-climate:** They are taken into account to dimensioning the channels. It is calculated based on the precipitation values for different return periods.
- **Type of sterile:** In this case are slate blocks and calcoschists of different sizes. Its nature, besides the soil which will be replaced, will determine the run-off coefficient.
- **Quantity of sterile and topography:** the software also considers the characteristics of the quarry: hollow of operation, method of extraction and volume of sterile.

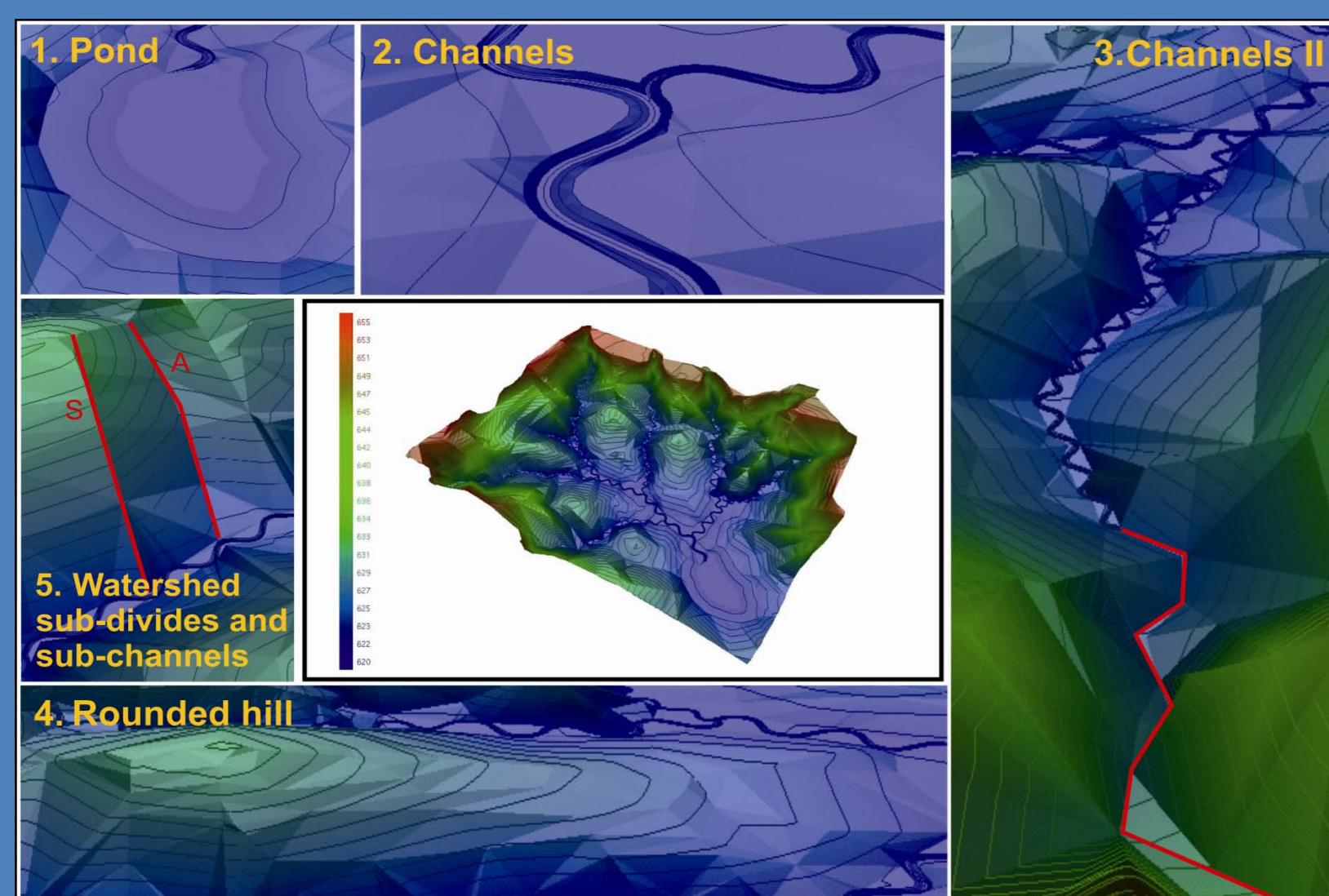
## 3 Geomorphological reconstruction

With these four elements (geomorphological referent, climate, type of sterile and quantity of sterile and topography) it has been done the first design in Europe using the Natural Regrade software (1) (see **Figure 2**).



**Figure 2:** 3D view of the contour line (green) of the relief designed with Natural Regrade. In blue is the network of main channels. The bottom left image shows the state of the operating hollow without restoration. Approximately 650,000 m<sup>3</sup> will be extracted of this hollow in its 13 years of activity, this is the volume of sterile used to design the restoration. The hollow to be operated will have 16 hectares and a depth of 30 meters.

## 4 Geomorphological reconstruction details



- 1. Pond:** the mining hollow left after the mining operation will be endorreic (not pour water out of it). So the main channel ends in a pond which is going to give rise to a wetland.
- 2. Channels:** the channels are prepared to evacuate water of rains of different duration and return period. All this through its bankfull and a floodplain.
- 3. Channels II:** the general pattern of the fluvial networks shows that for channels slope greater than 4%, the channels are dug into the substrate (ie, are not alluvial rivers), and its predominant pattern is in zig-zag (red line in the **Figure 3**). When the slope is less than 4%, the vast majority of the rivers become alluvial, and their channels are meandering type (2). The software reproduce these details.
- 4. Rounded hill:** There are stable hillocks between the channels, devoid of geometric shapes, unlike what happens in conventional restorations (berm-slope model) (3) (4).
- 5. Watershed sub-divides and sub-channels:** each one of the main hillock is subdivided into smaller ones, represented by secondary subdivides. Between these subdivides, there is going to be small sub-watershed channels, which will lead the water to the main channels. This will ensure that all the run-off generated in the restored area is directed and managed.

**Figure 3:** Details of the geomorphological design developed with Natural Regrade software and the methodology GeoFluv™. Where: "S" refers to subdivide; "A" to stream; the red line of box 3 refers to the part of the channel with a slope greater than 4% and thus with a zig-zag shape; this pattern is very common in nature. The color scale of the central image corresponds to the different heights reached by the designed relief.

## 5 Replacement of soils, revegetation and habitats

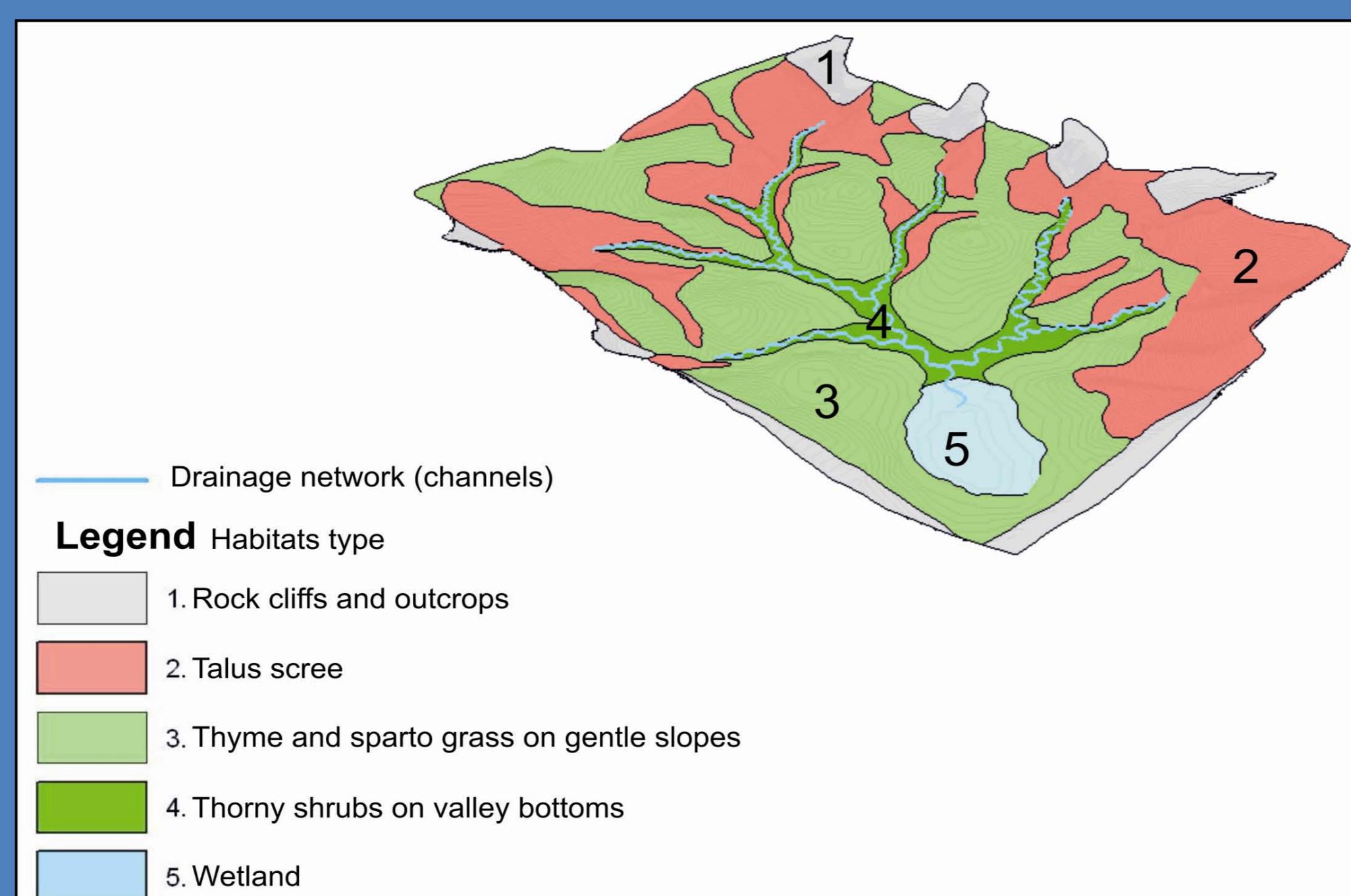
### Replacement of soils

During the operation process, original soils are going to be removed and stocked, including a layer of clay located beneath the edaphic soil. These soils will be spread on the new relief, with a thickness close to 40 cm.

### Revegetation and habitat

Revegetation is fully directed to the reconstruction of habitats for the rabbit. Currently, the surface on which the quarry in projected is

characterized for a dominant and homogeneous habitat of grasslands slightly ridged. The new relief designed with Natural Regrade, along with replacement of soils and revegetation will allow creating five new habitats (see **Figure 4**): 1, rocky cliffs and outcrops; 2, talus screens; 3, thyme and esparto grass on gentle slopes; 4, thorny shrubs on valley bottoms; and 5, wetland.



**Figure 4:** 3D view showing the distribution of habitats on the future surface restores of the quarry *Los Quebrados de la Serrana*.

## 6 Conclusions

The restoration design achieved considering geomorphological criteria: 1) *increase the number and diversity of habitat compared to the situation before the activity*; 2) *ensures the long term stability of the substrate, which contrasts with the instability of many conventional models of berm-slope*; 3) *reduces or eliminates maintenance costs*; 4) *achieve a greater visual appeal than conventional model of berm-slope*. In short, this is a reclamation solution which allows to restore habitats that will support the rabbit, and will make compatible mining and imperial eagle conservation.

## 7 References

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## 8 Acknowledgments

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