

## Cultural and landscape aspects of the Acequia Real (Royal Water Channel) of the Alhambra. Towards the recovery of a historical hidro-environmental infrastructure

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### Abstract

From the 13<sup>th</sup> century onwards water has been an intrinsic part of the Cultural Landscape of the palatial city of the Alhambra, which was connected to the valley of the Darro River as a source of lasting supply. This was made possible through the construction of the Royal Canal, the Acequia Real, which today consists of two main canals, known as Acequia de los Dos Tercios and Acequia del Tercio. In the last section there is also a third lower water channel, that could obtain excess water from the ones above it, directing them to the farming terraces located on the northern slope of the Palace of the Generalife. Furthermore, exist other channel, the Acequia de los Arquillos ran above all of them, without reaching the Alhambra. The environment through which they flow has a huge environmental and cultural value, thus, the Patronato de la Alhambra y Generalife (PAG) is committed to the recovery and management of big parts of the two main branches of the Alhambra's royal water channels, as well as their heritage and environmental values. During this process, archaeological interventions are being carried out that provide valuable information for understanding the complex hydraulic system that was articulated around the Alhambra in Nasrid times. The maintenance of the original riverbed of the Acequia Real through an ecological flow, is done in parallel to the recovery of a series of paths that are part of the network of existing pedestrian itineraries in the surrounding area the "Dehesa del Generalife", very popular among visitors.

**Keywords:** Royal water channels, Cultural landscape, Monumental Complex of the Alhambra, Dehesa del Generalife

### 1. INTRODUCTION

The hydraulic system that supplied to the Alhambra and all the royals almunias, located in highest points, reached a high degree of sophistication, searching the adaptation to the orographic and geological characteristic of the crossing area. The Royal Water Channels of the Alhambra were made up of two main channeling systems known as the Acequia de los Dos Tercios and the Acequia del Tercio. Together they stretched over more than 8 km from the Royal Dam to their entrance to the Generalife, the main channel is about 5562 m long and the Tercio about 2686 m. On the last kilometre of the journey, there is a third lower water channel that may have carried the overflow from the higher channels. This excess water was channelled to the cultivated terraced fields on the north side of the hill below the Generalife Palace. There was another water-channel further upstream that never actually reached the Alhambra precinct. This channel, of which some archaeological remains survive today, was known as the Acequia de los Arquillos (Water-Channel of the Arches).

The land through which these channels passed was totally transformed by the presence of water, which endowed it with important cultural and environmental values. In this way it became a "cultural landscape", in which the joint influence of natural processes and the organization imposed by man are evident. Prior to the building of much of the Alhambra in the Middle Ages, certain parts of the hillsides had already been damaged by erosion due to the mining of the alluvial gold found in the "Conglomerado Alhambra", the geological substrate on which the Alhambra complex was later developed.

Muhammad I, the first monarch from the Nasrid Dynasty (r. 1238-1273), was responsible for the planning and construction of the Alhambra on a hill overlooking Granada called La Sabika. He was also responsible for the first system for channelling water to the hill. This system, which came into operation in 1238, was originally designed to water the sloping hillsides that would later form part of the Generalife Palace. With the creation of this first Royal Water-Channel, this area was converted into an agricultural ecosystem with a few scattered buildings with various different purposes. From there, it developed into a complex mosaic of irrigated

vegetable fields and gardens. There were also extensive areas of rainfed crops that did not require irrigation and *dehesas* that were used for silvopasture.

In the last third of the 14<sup>th</sup> century, Muḥammad V ordered the construction of another channel (Acequia de los Arquillos), as an extension of the existing water supply system. This enabled water to be supplied to other royal estates built at slightly higher altitudes than the Generalife. In the 15<sup>th</sup> century, the water system was radically altered by the loss of the Acequia de los Arquillos, and by the lax management of the Royal Water-Channel after 1492 by the Alhambra's new Christian rulers. The Dehesa near the Generalife was severely damaged at the end of the 1560s during the Morisco Uprising, as revealed by historical documents about the state of the Generalife and its adjoining land, which was severely overexploited during this period of unrest. Even before then, the Dehesa had been badly neglected due to uncontrolled communal use by the people of Granada, which led to numerous abuses and generalized deterioration. Although it was later restored to some extent and grazing of livestock was forbidden, this process of neglect seems to have continued until the first half of the 20<sup>th</sup> century, when the first aerial photos show a bare, practically treeless Dehesa del Generalife. Reforestation work began in the 1950s, with the planting above all of aleppo pines (*P. halepensis*), holm oaks (*Q. ilex*) and various species of cypress were also used (*Cupressus spp.*) in the driest and most degraded areas, while on the hillside along which the water-channels run. In the shade (north-facing and quite near the River Darro) the vegetation is wetter, dominated by holm oaks and scrub with a magnificent gall oak forest at the east sector.

The mediaeval water-channels were abandoned at various times in history. In 1955, important landslides at two points on the shaded slopes leading down to Jesús del Valle, led the Guadalquivir River Basin Authority (Confederación Hidrográfica del Guadalquivir) to draw up a project, the following year, for "Improvements in the Channelling of the Royal Water-Channel of the Alhambra". From the same point (i.e. the Royal Dam, which is still in use today), a new channel was built slightly higher up the hill than the mediaeval *acequias*. This new channel, which was made out of concrete and was mostly underground, was known as the *canal contemporáneo* or "modern channel". Even though part of its waters were diverted into the original channels, the original historic routes of the Royal Water-Channel gradually fell into disuse and were abandoned due to a lack of the maintenance required to keep them in working order. At present, water is carried along about 700 m of the Acequia del Tercio in the vicinity of the Generalife (entering service in the 1990s) and about 1 km of the Royal Water-Channel of the Alhambra between the Carmen de Peregrina or Divider of the Acequia de Axares and the steep gully known as the Barranco del Aljibe de la Lluvia (Figure 2).



**Figure 1.** Hypothesis on the development of the Alhambra and its grounds at the time of maximum expansion during the second half of the 14<sup>th</sup> century. (Drawing by Rocío Espín Piñar after sketch by the authors).



## 2. OBJETIVES

The Patronato de la Alhambra and Generalife (PAG) intends to recover the two main branches of the Royal Water-Channel of the Alhambra and the heritage and environmental values associated with them. The maintenance of the historic channel-bed by diverting a sufficiently large environmental flow of water from the modern water channel will enable the recovery and maintenance of the ecosystems associated with the presence of water, from aquatic ecosystems to the vegetation associated with damp soil due to seepage of the water flowing along the channels. This work will be accompanied by the restoration of various pleasant paths, so enhancing a network of walking paths and itineraries of great interest for the general public.

1. Restoration and recovery of heritage features of great value.
2. Identify and document all the small details of this complex system for the supply of water to the Alhambra and the nearby Nasrid-era estates.
3. Establish a clear methodology for our work, find solutions for structural problems and identify the maintenance tasks required to guarantee the long-term survival of the restored structures. The hydro-environmental restoration of the historical channels that carried water to the Alhambra and its associated ecosystems.
4. Extension of the network of walking paths in the area around the Alhambra and the city of Granada.
5. Stabilization and consolidation of the ecosystems associated with water. Inclusion of the work required for the maintenance and conservation of the historic water-channels within the general maintenance programme.
6. Dissemination of the importance in heritage terms of the restored infrastructures and their associated ecosystems.

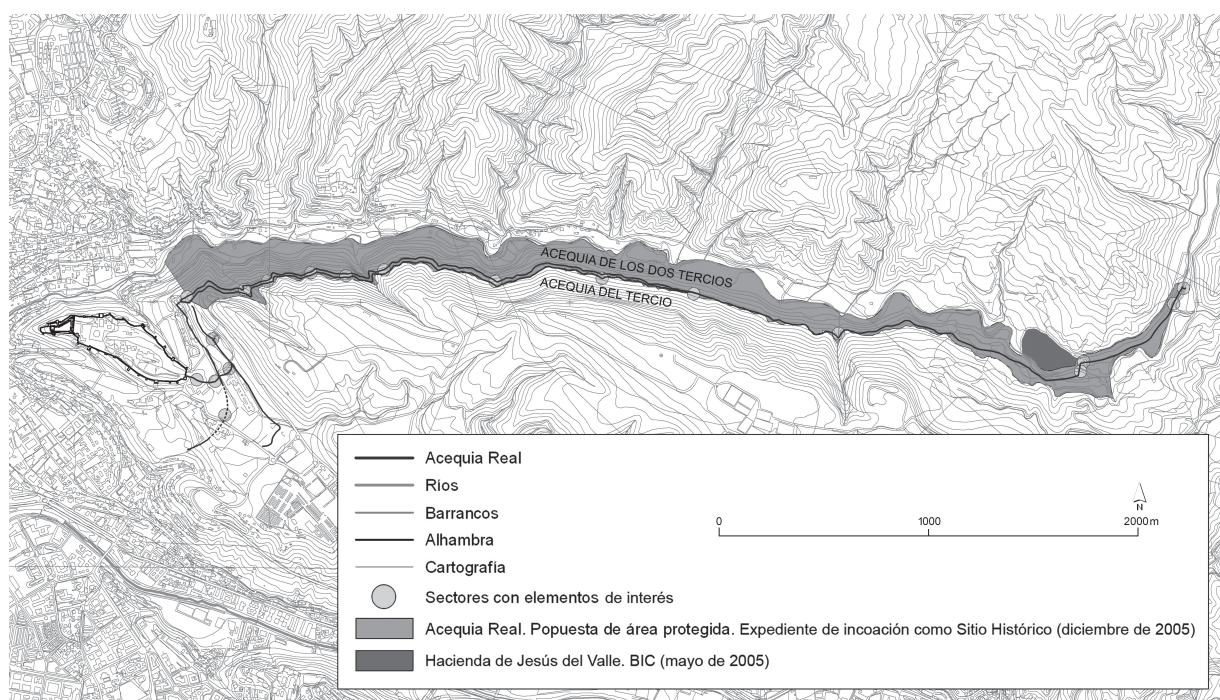
## 3. METHODOLOGY

The methodology followed to restore the water-channels centred around the following actions:

1. Topographic survey of the state of each structure prior to beginning work.
2. Cleaning and clearing out of the debris that has accumulated in each water channel over the course of time. This process was monitored by archaeologists and supervised by technical staff from the Conservation Department of the Patronato de la Alhambra and Generalife. Every single item that appeared was registered and the whole process was documented in writing and with photographs.
3. Taking samples for analysis.
4. Photogrammetric survey of the water channel prior to and after cleaning, removal of rubble and/or archaeological excavation. Taking of ground-level and aerial photographs.
5. Consolidation of the remains when necessary and protection of each one of the water structures.
6. Enhancement and adaptation of the archaeological sites to prepare them for visits.
7. Planting of vegetation to help stabilize the hillside below the water-channel and improve the habitat in the surrounding area.
8. Dissemination of the results obtained. Design and assembly of explanatory information panels to be installed in each water channel and at different points in the Alhambra precinct.
9. Loading the channels with water, by diverting a permanent flow of water to the restored water channel, once the question of how to discharge the water at the end of the circuit had been resolved.
10. Include maintenance the channels within the regular maintenance work carried out at the Monumental Complex.

## 4. PROCESS OF RESTORATION OF WATER HERITAGE

The surrounding area defined by the Royal Water-Channel of the Alhambra and its associated infrastructure was initially the subject of an application for its registration as a *Historical Site* in the *General Catalogue of Andalusian Historical Heritage*<sup>3</sup>. The application was drawn up by Luis Ignacio Fernández-Aragón and José Javier Álvarez García, and presented at the Delegation in Granada of the Department of Culture of the Regional Government of Andalusia in December 2005. The area affected by this application covered a total of 767,857 m<sup>2</sup> and had a perimeter of 12,046 m (Figure 2).



**Figure 2.** Protected area proposed for registration as a *Historical Site* in the *General Catalogue of Andalusian Historical Heritage*.

Two years later the Master Plan for the Alhambra (*Plan Director de la Alhambra* 2007) in its programme on water set out various measures for the revitalisation of traditional irrigation systems and the restoration of the channel-beds in the deteriorated sections of the water channels. For this it was necessary to carry out a detailed study/diagnosis of the state of the surviving material remains, a compilation of bibliographical sources, an investigation of the exact routes followed by the water channels, an archaeological prospection and a detailed, geo-referenced, topographic survey. Individualized solutions for each element were also identified and detailed in the projects for restoration of the different stages of the channels. Among other benefits, the recovery of the functionality and of the landscape and environmental values of these historic water channels can help mitigate the risks set out in the *Risk of Desertification Schedule*. They can also sustain habitats for numerous species of flora and fauna. Amphibians are particularly important because of their rarity due to the lack of suitable habitats and their often endemic nature in the arid south-eastern part of Andalusia in which we find ourselves.

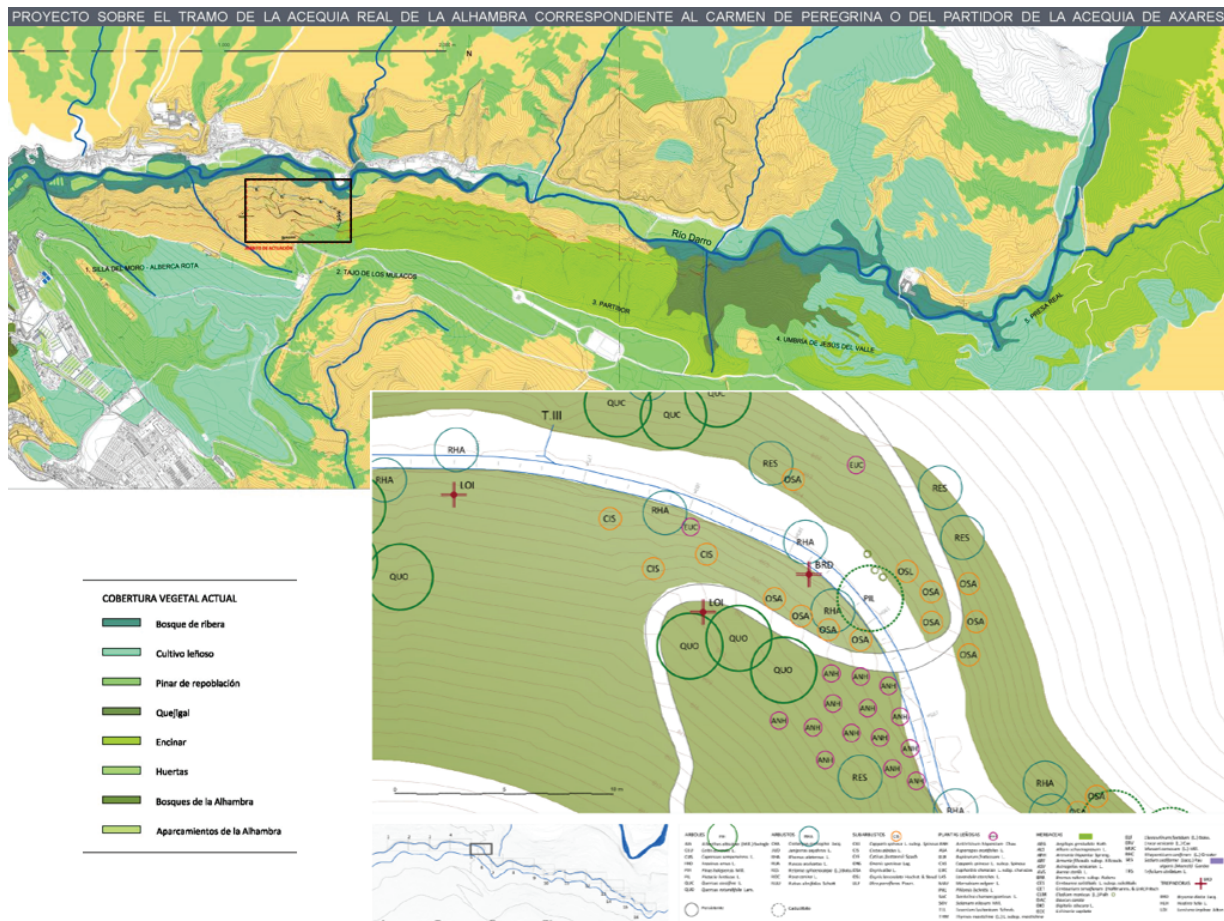
In 2008, a new project was drafted entitled “Programme of actions for the recovery and enhancement of the Royal Water-Channel of the Alhambra”. Just like the documents that followed it, this project was drawn up by Luis José García-Pulido with the collaboration of Virginie Brazille Naulet and the participation of Luca Mattei in the archaeological interventions, all under the management and supervision of the PAG. One year later, a general catalogue/inventory of the Royal Water-Channels of the Alhambra was created. This was a first attempt at a valuation of the rich legacy of different items or features of historic, heritage and ethnological interest. This document contains details regarding the identification, description, chronology, state of conservation, causes of decay, etc. These details were then set down in a technical fact sheet for each different part of the water system.

In February 2012, work to clear out the channel and cut back the vegetation began on a branch of the Acequia de Dos Tercios. This first stage ran from the steep valley of the Carmen del Barranquillo (809.45 m.a.s.l.) to a point 557 m away from the start, and at a slightly lower altitude (802.50 m.a.s.l.). After this initial clear out, a topographic survey was conducted on the bed of the channel, with which we obtained an accurate planimetric map with contour lines at an equidistance of 10 cm and transversal sections every 5 m.

At the same time, a study was conducted on the historic documents and maps relating to this area, from which written descriptions and images of its state at different times in the past were obtained. This demonstrated the existence of seven outlets or spouts. Results were set out in the report on the stage of the Royal Water-Channel of the Alhambra “Informe sobre el tramo de la Acequia Real de la Alhambra correspondiente al Carmen de Peregrina o del Partidor de la Acequia de Axares”, issued in December 2012. The information obtained was also included in the database of the catalogue started in 2009.



A survey was also conducted of the most representative plant species along this stage of the water channel. These were represented on a map with an alphabetical code and proportions relating to the size of each individual, indicating if they were arboreal, shrub, sub-shrub, woody, herbaceous or climbing plant strata (Figure 3).



**Figure 3.** Sample of survey of plant species along the Royal Water-Channels.

The next stage was to draw up the “Project on the stage of the Royal Water-Channel of the Alhambra corresponding to the Carmen de Peregrina” (Figure 3). The restoration work set out in this project was carried out between April 2014 and March 2015 and was accompanied throughout by archaeological supervision work led by Luca Mattei. These special precautions to protect a water channel of great heritage and symbolic value also enabled to investigate how it has evolved over the years and the transformations it has undergone. The project was part of the restoration work scheduled in the Programme for Intervention on the Royal Water-Channel of the Alhambra, as a first step on the road to restoration of this channel and to ensure effective protection of the water heritage associated with the Alhambra as a whole. In order to achieve this objective, it is fundamentally important to obtain an exhaustive knowledge of this channel.

Within this project a series of works were performed which could be grouped together under the following headings:

- Maintenance of the bed of the water channel, without altering the material deposited over the centuries, which may be of archaeological interest.
- Transfer of water from the Modern Channel of the Alhambra to the Royal Water-Channel. The water is transferred through a tube measuring 200 mm in diameter. The water is drawn at an altitude of 837 m.a.s.l. from the service gallery in the gully of the Carmen del Barranquillo.
- Reinforcement and repair of containment structures and construction of drains to enable run-off waters to pass over the water channel.
- Maintenance of existing subterranean galleries with the minimum possible alteration.

- Archaeological study of the outlets along the route and of key points for the identification of any additional structures and of the route and section of the original water channel.

This last intervention involved the investigation and loading with water of a stage of the Royal Water-Channel of the Alhambra measuring 455 m long, situated between the place where the channel comes out to the east of gallery G.9 (810.30 m.a.s.l.) and outlet T.III (803.70 m.a.s.l.) (Figure 4).



**Figure 4.** Different sectors of the Royal Water-Channel after the intervention carried out in 2014-2015.

After the detailed study and the work conducted on this stage, various different features associated with the water channel were analysed in depth. Amongst these different features, we should highlight in particular up to 11 stages in which the channel ran through galleries/tunnels, grouped into four main sectors. It was discovered that these stages must originally have been longer than those surviving today. The continual process of landslips and cave-ins in these galleries has undermined their stability and reduced their size. They normally contain openings to the outside in the form of skylights or breathe-holes, which in some cases get larger and larger until the whole roof collapses, leaving the water channel in the open air.

The curves along the route of the water channel which coincided with small gullies had drains or vaults to enable run-off waters to circumvent them, so preventing the materials washed down the hillside by the rain from accumulating in the channel. After the cleaning operation in July 2012, it was noted how quickly the channel filled up again at these points, given that the structures that once existed for controlling run-off waters had long since disappeared. The remains of these structures were documented in the archaeological intervention carried out at these points. The bricks associated with the drains appear to have been reused on several occasions, as a result of the level of deterioration and consequent destruction to which these structures are subject. A fragment from a wooden board located in one of the surveys in the gully of the Carmen de Barranquillo provided a C 14 dating from the Nasrid era. In the study conducted by Dr Elena Villafranca Sánchez, the person responsible for the C 14 dating unit at the Scientific Instruments Centre of the University of Granada, the calibration at 2 sigma (95.4 %) dated the fragment from between 1299 and 1415 and at 1 sigma (68.3 %), between 1305 and 1355 (Figure 5).





**Figure 5.** C 14 dating of a fragment from a wooden board located in one of the surveys in the gully of the Carmen de Barranquillo, dated to Nasrid times.

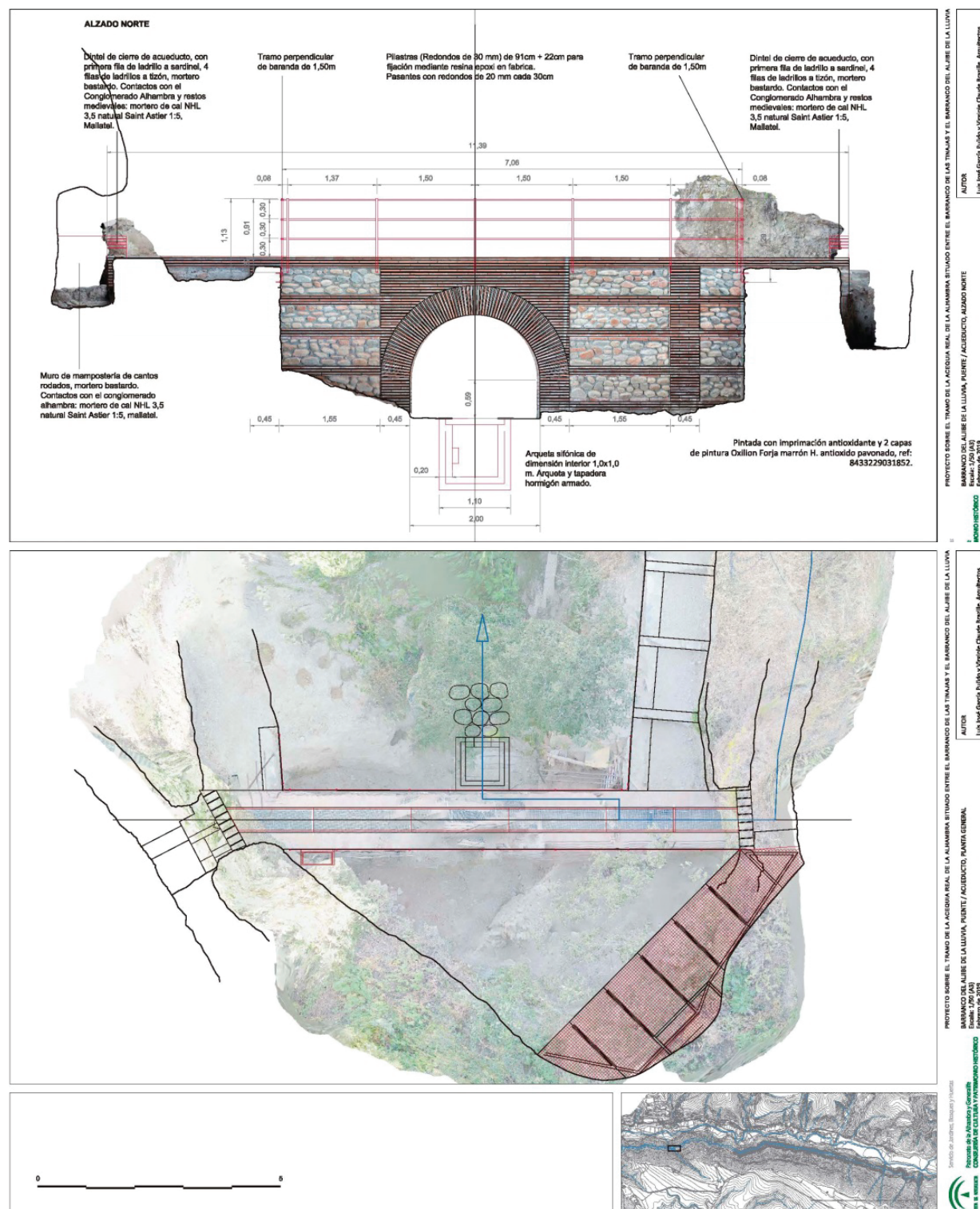
Archaeological surveys were conducted in 14 points linked to 11 sectors of this stage of the Royal Water-Channel, together with one more in the higher branch of the Acequia del Tercio (Figure 4). In 12 of these surveys, remains of brick and/or masonry structures were found associated with small bridges for run-off, outlets, overflow controls and reinforcements made at different times in history. The original level of the water channel was also documented. It was dug out of a natural geological substrate made up of the Conglomerates from the spurs of the Sierra Nevada mountains in this area. The full results of the archaeological investigation can be consulted in the “Final report on the archaeological intervention in the Royal Water-Channel of the Alhambra. Stage corresponding to the Carmen de Peregrina”, presented by Luca Mattei.

In 2015 a new report was issued entitled “Report on the stage of the Royal Water-Channel of the Alhambra between the Gully of las Tinajas and the Carmen de los Granados”, which included maps showing the Royal Water-Channel. A topographic survey of this stage of the Royal Water-Channel was also conducted together with a catalogue/inventory of the structures associated with it.

This was followed, one year later, by the “Project for the recovery of the Royal Water-Channel of the Alhambra in the stage between the gully of las Tinajas and the gully of Aljibe de la Lluvia”, together with the phases for the restoration of the last, remaining stage to reach the Generalife. These were set out in an extensive document in which the various stages for restoration work were analysed in general and in detail together with the possibilities of recovering the original bed of the Royal Water-Channel of the Alhambra in each stage. It also analysed the situation of the hydrographical network on the nearby hill, Cerro del Sol, together with the geology and instability of the hillsides, and the flora and fauna in the area. Finally, it analysed the infrastructures and their uses and the synthesis between the cultural and landscape heritage.

Execution of the project began in May 2018. The information arising from the archaeological monitoring of this process was set out in the “Final report on the temporary archaeological intervention by means of the analysis of emerging structures and the monitoring of any digging or movement of earth in the Royal Water-Channel of the Alhambra. Stage running between the Carmen de Peregrina and the gully of the Aljibe de la Lluvia”, in July 2019.

In February 2020, protective features were installed to protect the structures leading the run-off over the Royal Water-Channel (Figure 6). In addition, vegetation was planted to help sustain the steep slopes. The structures for channelling the run-off in the gully of Las Cañas were cleaned and mapped. This stage will be repaired in the last phase of the restoration work, which will connect the Royal Water-Channel to the Generalife Palace.



**Figure 6.** Bridge-aqueduct built in order to by-pass archaeological structures of the Royal Water-Channel, that have been restored and protected.



Currently, annual repair and maintenance work is being performed on the restored sections, repairing faults in the structure and the damage caused by wild boars, who enjoy rolling around in the mud if the water channel is not kept constantly within its pre-established course and the surrounding vegetation is not properly managed.

## 5. RESULTS

About 1700 m of water channel have now been restored and put into service. Water is now circulating along the same channels as it did seven centuries ago. The channels are being conserved and maintained and are used for transporting water, so contributing to the preservation of the cultural landscape.

A great deal of knowledge has been generated, together with a methodology for the planning of the work involved in the restoration of water systems and their enhancement in preparation for public visits. The next phases have already been scheduled (pending drafting of the projects), so that the water can reach the Generalife via the original channel.

Suitable procedures for the restoration of the structures and the associated ecosystems have been tried and tested and the different tasks required for their maintenance and conservation have been identified.

A path along the Royal Water-Channel has been linked up with another walking path in the area, so creating a network of itineraries of great cultural and natural interest, especially given that this is an area with a beautiful landscape that is very popular with the public.

## 6. CONCLUSIONS

As compared to other water landscapes in the Granada area, where the water systems dating from the al-Andalus era are either endangered or becoming extinct, the unrestored stages of the Royal Water-Channel of the Alhambra are still relatively intact and its full restoration is considered feasible. The PAG is currently promoting the restoration and enhancement of water features in the monument and in its surrounding area. To this end in the Master Plan for the Alhambra, there is a specific line of action entitled “Full incorporation of the Royal Water-Channel (course and dam) into the Alhambra area” and within the sub-programme of conservation and restoration, its enhancement appears as an objective together with a programme of actions for the recovery of traditional irrigation systems. In addition, it has been proposed that priority should be given to the inclusion of the Landscape Unit formed by the Royal Water-Channel in the Atlas of Landscapes of the Alhambra.

The restoration of the stage of the Royal Water-Channel that runs from the Carmen del Partidor to the gully of the Aljibe de la Lluvia has served as an experimental laboratory for analysing the problems and the possible solutions that could be applied in the improvement of the cultural ecosystem of the Royal Water-Channels of the Alhambra. The experience acquired during this intervention is an excellent starting point for the gradual recovery of the unique water system of the Alhambra in forthcoming restoration projects.

The various different projects that have been carried out on this water system together total over 20 extensive documents, a sign of the importance of the restoration work on this delicate and important piece of heritage that forms part of the water system of the Alhambra.

The increased humidity on the hillside produced by seepages of water from the channels will enable the surrounding vegetation to better resist the increasingly harsh climate, with years that are getting drier, with longer periods without rain and more intense heat waves. This will provide the following environmental benefits: stabilizing hillsides against erosion, reduction of the temperature, shelter for fauna, etc, so acting to safeguard the conservation of an important cultural landscape in the face of climate change.

The enhancement and putting into service of these waterways also helps emphasise the many excellent qualities of this remarkable space. In addition to its landscape and ethnological values, these also include the recovery of a range of different archaeological remains of historic water supply systems within this ancient cultural landscape.

The interventions carried out have provided new perspectives when it comes to our increasing appreciation of the importance of the valley of the River Darro and the Cerro del Sol as an adjoining area that is inextricably linked with the Alhambra and on which the Alhambra depends for its survival.

These interventions have enabled these structures to become part of the circuits followed on the visits to the area surrounding the Nasrid Citadel, which in 2007 were included within the “water itineraries” in the Master Plan for the Alhambra. In this way, they are becoming an additional new attraction offered by the Council of the Alhambra and Generalife in a bid to diversify the cultural potential of the monument.

## 7. ACKNOWLEDGEMENTS

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