THE DRAWING OF A TERRITORIAL INFRASTRUCTURE. THE CASE STUDY OF THE 'CAROLINO' AQUEDUCT (ITALY)

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ABSTRACT:

The 'Carolino' Aqueduct, a territorial infrastructure, principally known to lead water to the park and the gardens of the Royal Palace of Caserta (Italy) is the main topic of tis paper. Specifically, presented here are some outcomes of research activities carried within the discipline of drawing with its different meanings (survey, representation, modeling, communication) and scalarities (architecture and territory). The activities have been fully systematized within a Geographical Information System (GIS) project with the aim not only to archive all the acquired and surveyed information but also to make it a communication tool - accessible through the web - to an expanded user that can enjoy this infrastructure, inscribed for its peculiarities in the UNESCO World Heritage List.

1. INTRODUCTION

This paper presents the research activity carried out as part of the survey, census, representation and communication activities of the 'Carolino' Aqueduct, inscribed together with the Royal Palace of Caserta and the San Leucio complex in the UNESCO World Heritage List since 1997 (Pisacane et al., 2011). Some of the described activities had been part of preparatory study aimed at updating the Management Plan of the UNESCO site.
The 'Carolino' Aqueduct -as a part of this site- is a territorial infrastructure closely connected to the realization of the Royal Palace of Caserta and its Park and, due to its relationship with the territory, is mostly underground, emerging in the territory through some elements such as vent or inspection towers, bridges and factories, but its importance is also related to productive sites close to the Royal Palace itself and to the necessity of the city of Caserta.
The research activities presented here are inherent to the census activities of the entire route of the aqueduct, the works adjacent to it and connected to it, the geometric survey of the emerging works of the imposing territorial infrastructure, the cataloging of information within an ad hoc Geographic Information System (GIS) designed and structured by the author and, finally, to the communication of information through sharing systems through the web for the enjoyment of the site to an expanded user base and especially to make visible what by its conformation and configuration is predominantly underground. The communication activities, in particular, are aimed to spread the knowledge of this site and as starting point for a touristic development of the area.

2. DATA ACQUISITION AND METHOD

2.1 Site survey

In 1752, when the construction of the Royal Palace of Caserta began, Luigi Vanvitelli, the architect and engineer who was commissioned by the King to design the Royal Palace, began the search for springs to capture water, an element that would further enrich his design idea that in water would find the end of the building and the park. The Park and the scenic appearance of the waterfalls and fountains that follow one another in the central area completely draw the architecture and the surrounding context. The necessity connected with the construction of an aqueduct also had functional needs for the palace itself and the surrounding area: a considerably large complex, such as the one in question, required a constant and adequate water supply to meet the needs of the area. The 'Carolino' Aqueduct, therefore, began as a service work for the palace but ended up decisively characterizing the territory it passes through by means of the emergent elements that signal its presence. In addition to a redesign of the territory, the Aqueduct also had a clear social function in perfect coherence with the spirit with which the Borbone Family had characterized and set up its reign. The will to increase production in that site -even to start a social rebirth of local population through productive site that take advantage of local resource- is strictly connected to the presence of water for productive activities.
The places crossed by the aqueduct along the 38-kilometer route, from the Fizzo springs to the falls in the Park, were, prior to the start of the works to build this infrastructure, largely areas of little social security belonging to a few feudal lords and partially uninhabited. In this regard, it is significant that already in letters to his brother Urbano, Luigi Vanvitelli tells of being accompanied by armed guards during inspections preliminary to the beginning of work on the aqueduct construction site. Such a work could have a substantial influence in social and economic terms with repercussions for both the city of Caserta and the territories crossed by the aqueduct. A transformation that was not limited to the construction period because of the interest of factories in supplying building materials but also because of the opening of new production facilities, as well as the increase in agriculture. All activities that found benefit from the systematization of water distribution through the aqueduct, also influencing the subsequent development of those areas. The path of the aqueduct did not only reach the Royal Palace but also continued its course, although in the years following its completion, to the Royal Site of San Leucio near Caserta with its silk processing factories and the Hunting Lodge of Carditello with large areas dedicated to agriculture and animal breeding (Serraglio, 2008; Serraglio 2012).
The start of construction was preceded by a long and laborious search for springs that would ensure an abundant water supply to the Royal Palace.

Figure 1. 'Carolino' Aqueduct. Turret n.1 close Fizzo Spring area.

Figure 2. 'Carolino' Aqueduct. Turret n.9.

Figure 3. 'Carolino' Aqueduct. Turret n.40.

The suitable source was found well away from the Palace at 254 m above sea level at the foot of Mount Taburno in the territory of the present-day municipality of Airola, in the district of Benevento. The project that Vanvitelli presented to the King, who approved it without opposing any constraints, envisaged an infrastructure over 38 km long that would cross an area of articulated orography (Canestrini et al., 2007).

From an executive point of view, the work was divided into three lots along which to build a 1.20 m wide and 1.30 m high water conduit almost completely excavated in the rock and covered with a barrel vault, largely underground and marked on the surface by 66 square towers with a pyramidal roofing, serving as vents and inspection for the water conduit itself (Figure 1, Figure 2, Figure 3).

Work began in 1753 and was completed in 1770. During these years there were quite a few difficulties encountered in the execution of the works, related to the drilling of hills and mountains, the presence of marshes to be consolidated, as well as the capture and intersection with other springs along the route that could enhance the water flow of the work. Not least, numerous problems were encountered related to the morphology of the places and the engineering works that had to be built to overcome the differences in elevation. In particular, a number of bridges needed to overcome valleys and differences in elevation were built along the route. Among these, the best known but also most complex in terms of execution is the so-called 'Ponti della Valle' (Valley Bridges) intervention (Figure 4, Figure 5). This work is 529 meters long, over 95 meters high and built according to three orders of arches, topped by a convenient passage at the top that can be traveled by carriage. The grandeur of the work, which still represents the emblem of the entire 'Carolino' Aqueduct, perhaps because it is the most visible part, has always intrigued everyone. The Grand Tour travelers themselves in their travel chronicles expressed their wonder at such a structure. The design and construction expertise of this work testifies to the

great attention paid to the knowledge and survey of the area. In fact, only by starting from a careful surveying of the places using optical instruments and tools available at the time could it be possible to build an infrastructure as complex as it was precise. Chronicles of the time document every step in the execution of the work available today as archival records.

Figure 4. 'Carolino' Aqueduct. 'Ponti della Valle' (Credit: Luca Canonici)

Figure 5. 'Carolino' Aqueduct. 'Ponti della Valle' (Credit: Luca Canonici)

The surveying activities involved the entire site of the aqueduct in which, mainly through leveling measures, it was possible to built the work in three sections with extreme precision of connection between the different parts, also ensuring the necessary slope for the water to reach the Royal Palace Park after a long distance. Attention to leveling activities is also documented in Vanvitelli's drawings themselves. In the *Dichiarazione dei disegni del Reale Palazzo di Caserta*, precisely in the plates devoted to the aqueduct and specifically in the one relating to the *Prospetto degli Archi della Valle* in the lower part next to the two tombstones adorned with a laurel festoon is depicted a topographical instrument for leveling in the countryside complete with graduated rod (Figure 6) (Cundari et al., 2012).

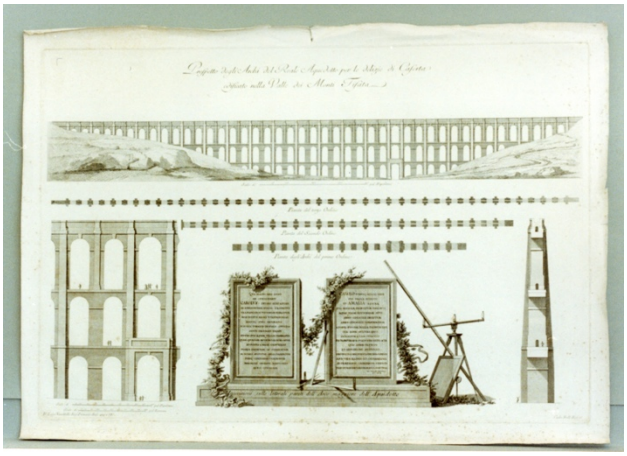

Figure 6. Carlo Nolli, *prospetto degli archi del Reale Acquedotto per le delizie di Caserta edificato nella valle dei monti Tifata*, 18th century.

As mentioned above, the mastery of construction in the realization of this work, the executive accuracy shown by Vanvitelli in the design and execution of the works allowed that it was not merely related to the need to provide water for the waterfall and water features for the fountains of the Royal Park, for the functional needs of the Palace or to feed the tanks and fishponds for the sovereigns' pleasure, but was also conceived in anticipation of a rational urban and territorial development and so that it could also be employed for productive activities (Cundari, 2005). The possibility of employing waterpower for other productive activities is evidenced not only by the better-known San Leucio complex and the textile and silk processing connected with it, but also by other factories close to the aqueduct path established for the handling of agricultural products such as, for example, the mills driven by the waters of the 'Carolino' Aqueduct that arose near Airola, Bucciano, Paolisi and Maddaloni. Alongside the activities just described, within the territory of the 'Ponti della Valle', the presence of a steep slope already used for mills for grinding grain was also used for ironworking and to design a branch mill. Likewise, in the territory of Caserta, sometimes not even at a great distance from the Royal Palace and Park, a number of mills were installed, such as those at San Benedetto, Ercole and those in the Aldifreda locality, all modern buildings also equipped with attached service facilities.

2.2 The cartographic analysis and the GIS Project.

The research activity here presented is carried out within the principle, methodology and tools of the discipline of Drawing and specifically in surveying at the architectural and territorial scale and in representation and modelling methods of the land and the built environment. The application to the case study was divided into several phases -each linked to the following ones- that in different ways could be declined at different scales, from the territorial to the building scale.

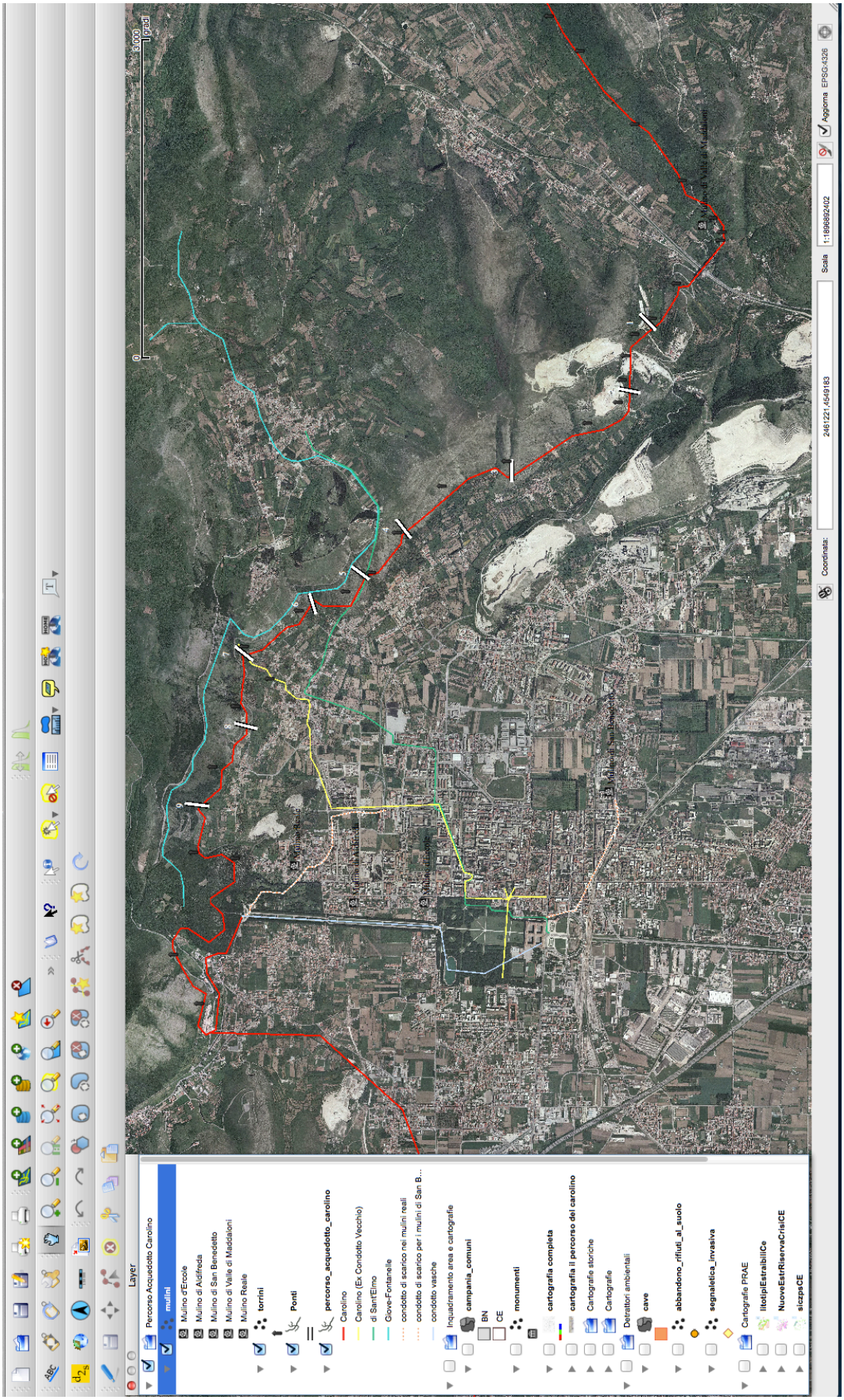

Figure 7. 'Carolino' Aqueduct. GIS project (Credit Valeria Di Salvatore).

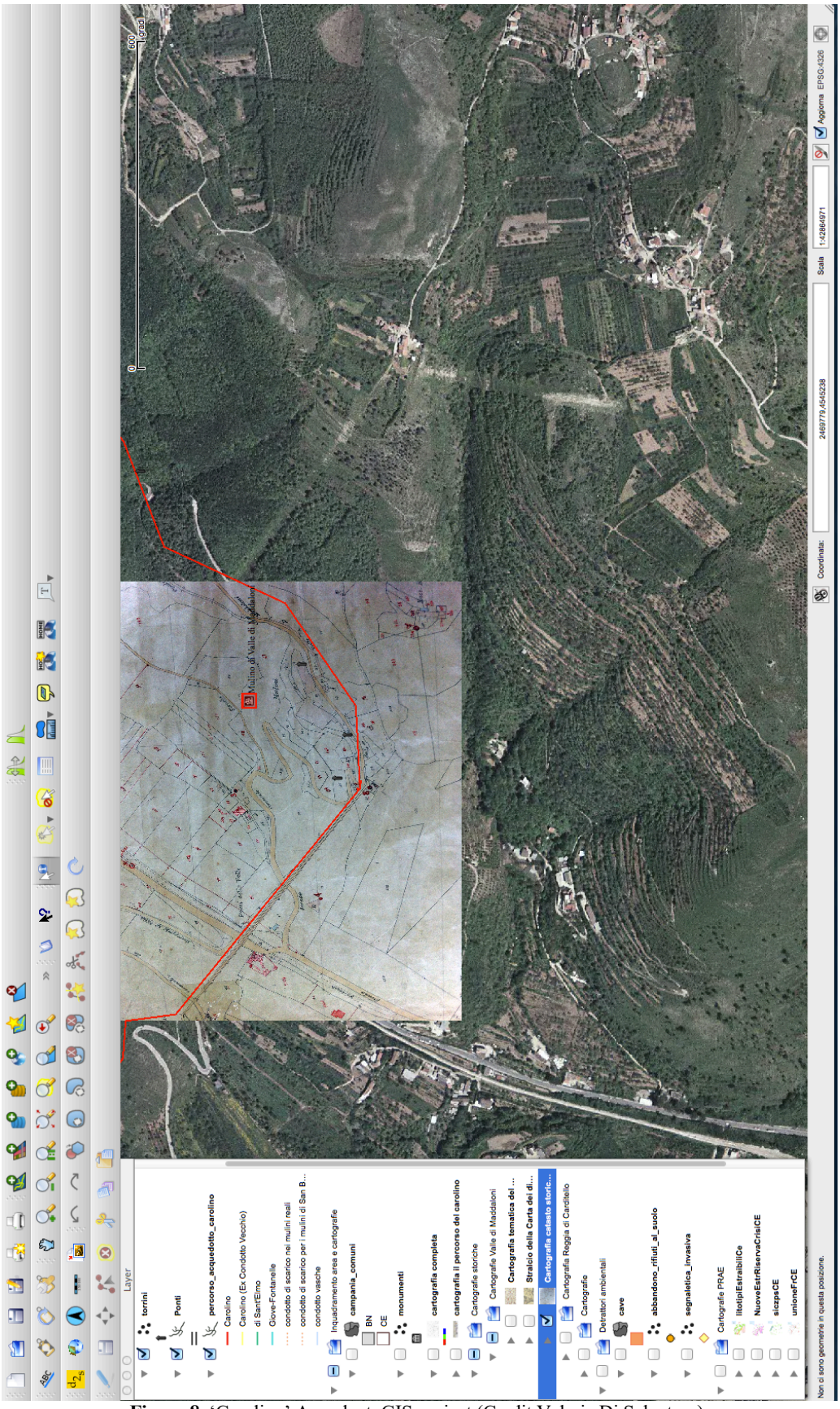

Figure 8. 'Carolino' Aqueduct. GIS project (Credit Valeria Di Salvatore).

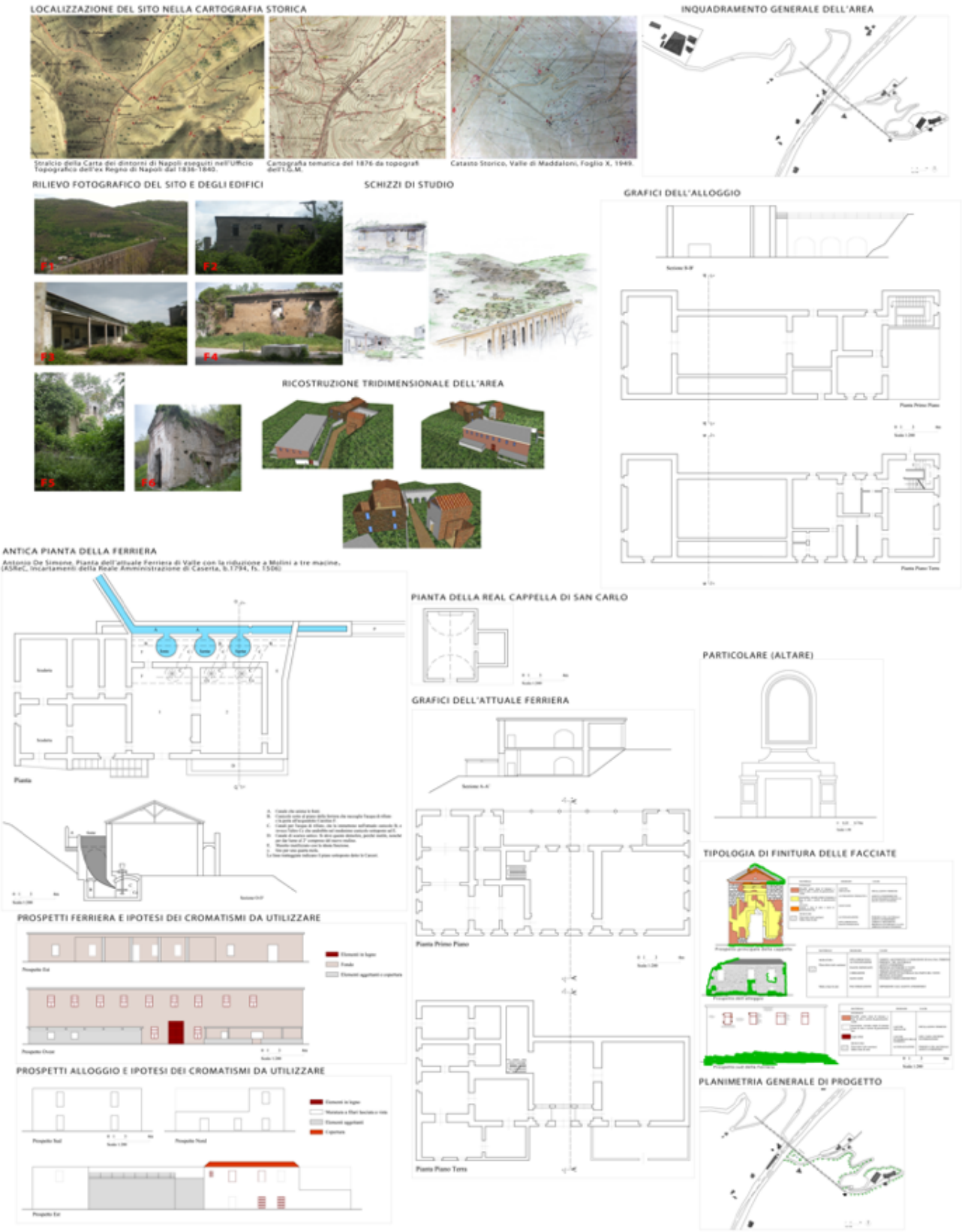

Figure 9. 'Carolino' Aqueduct. Survey of San Carlo Chapel and Ironworks. (Credit Valeria Di Salvatore)

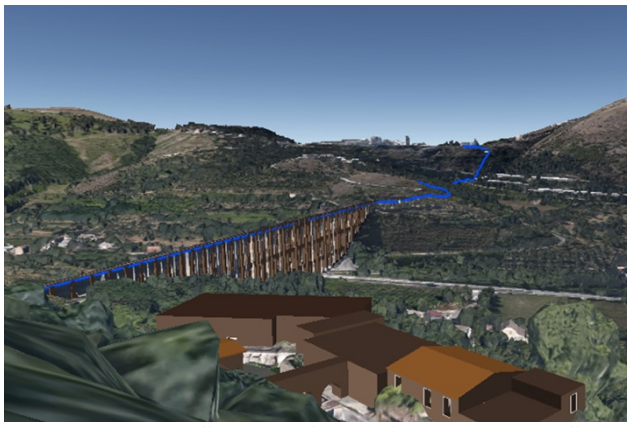

Figure 10. 'Carolino' Aqueduct. WebGIS system (Credit: Vincenzo Migliaccio).

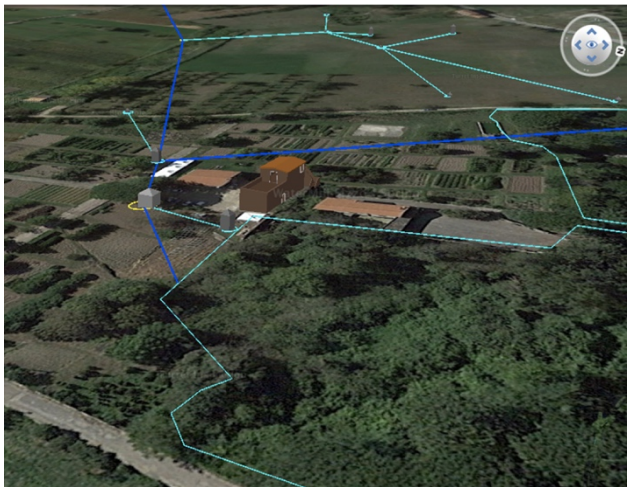

Figure 11. 'Carolino' Aqueduct. WebGIS system (Credit: Vincenzo Migliaccio).

The synthesis of all the documentation acquired and produced is archived within a Geographic Information System (GIS) of the Aqueduct that on the contemporary map base overlays and integrates the different information in a synchronic and diachronic way (Longley et al., 2015).
The survey, census activity, from data acquisition to processing, was carried out through the use of an open GIS platform that could collect through a geographic data base all the data acquired from different sources and surveyed 'in situ'. The GIS project elaborated for the present research was executed through the use of both open data geographic information and open-source software and apps, with a view to future and following developments and continuous implementation of the information and its sharing to other users, possibly through the web also to encourage a tourist enjoyment of an asset that is difficult to reach and visible in many of its parts.
In addition, the need to acquire and survey a great deal of information in the field, such as the geolocation of turrets and springs, which required the identification of platforms that would premise not only the recording of data but also their geolocation and their immediate interface with the constructed information database. All information was acquired from the survey, associating with the alphanumeric data, also photographic images of the building or infrastructure (general and detailed), as well as the exact geographic position automatically measured by the GPS/GNSS (Global Position System/Global Navigation Satellite System) antenna internal to the smartphone device used for the acquisition and recorded by the app and the date of the survey. The acquired information allowed the populating of the attribute table data associated with specific layers of the GIS project, in which the thematic layers referred to the infrastructure and related works, representative through the geometric primitive that can best describe such data. In addition, within the aforementioned platform, archival cartographic information acquired digitally for research was georeferenced and projected into the reference cartographic system in order to superimpose the historical datum on the contemporary datum.
The GIS Project enabled the systematization of open geographic data from different sources, survey data and processing of these. The thematic layer containing the information acquired is compared with data on the complex orography of the area represented through a digital elevation model (DEM) with 25 meters ground resolution, road systems, hydrography, as well as specific data on the aqueduct path, service buildings (towers, vents, washers, wells), architecture and productive factories connected to the aqueduct (processing sites, mills), as well as highlighting any degradation phenomena related to the emerging works (Figure 7, Figure 8).
Cartographic data acquired from libraries, archives and in the extensive bibliography present on the subject have been georeferenced in the platform, as well as the surveys carried out related to both the entire infrastructure and all the service works, as well as information related to the presence of landscape elements that alter its perception and functionality (von Lünen et al., 2013). The geographical platform thus becomes not only the tool for collecting and integrating data related to the infrastructure and the site, but also a support for the activities of protection, management and planning of interventions to safeguard this engineering masterpiece.
The activities developed were also integrated with the survey and modeling of some works, specifically the mills in the aqueduct area, integrating historical-archival data with direct metric survey data (Figure 9).
The geographic data, the entire GIS project, and the modeling of some of the architecture present along the path were processed in order to be able to export the data for a webGIS platform in order to make this information usable to an expanded user base through easily accessible channels on the web (Figure 10, Figure 11) (Taylor et al., 2006).

3. CONCLUSIONS

The knowledge activities of the World Heritage UNESCO site of the Royal Palace of Caserta with the complex of San Leucio and the 'Carolino' Aqueduct offered the possibility for the experimentation and application of the new ways of representation of the territory, aimed mainly at the dissemination of the richness of this heritage in order to systematize the knowledge activities but also to provide technological support for the increase of tourism and thus the economic revitalization of the territory. This model can become the prototype of a method to be tested and applied in similar contexts. In particular, for the aforementioned site the aim was to experiment with the production of a multimedia map that, starting with the realization of a Geographic Information System, would well represent the complexity, at different levels, of the territorial infrastructure of the 'Carolino' Aqueduct, strongly related to the realization of the Royal Palace of Caserta and its Park.
The experimental model created for the 'Carolino' Aqueduct wants, however, to be not only an opportunity to offer through the web a multimedia tool of fruition, but also an opportunity to deepen the knowledge of the asset in relation to the UNESCO site, its buffer zone and the wider territorial reality that surrounds it (Gambardella et al., 2015). In fact, moving from what were the same intentions of the Borbone Family when they conceived and

wanted the realization of such an infrastructure not only for the scenography of the park, but rather for the implementation of a territorial design that would include the Royal Palace, but also the surrounding urban area, San Leucio with its village and the Site of Carditello with its production sites.

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