From the Museum to the Archaeological Site: Virtual Reconstruction of the Sosandra Sector at the Baths of Baia (Naples)

Massimiliano Campi, Marica Camerino, Marika Falcone,
Víctor A. Lafuente Sánchez, Daniel López Bragado, David Marcos González

Abstract

The paper presents a virtual reconstruction of the Sosandra Sector within the Archaeological Park of the Baths of Baia, aimed at clarifying its architectural organization and proposing a hypothesis regarding the original placement of the Aphrodite Sosandra *statue. Located in the Campi Flegrei area, Baia was one of the most important centres of otium for the Roman elite between the late Republican period and the Early Empire, characterized by a complex architectural layout and the close integration of architecture, landscape, and water features.*
The research is based on a 3D survey carried out through dynamic LiDAR scanning, integrated with archaeological and typological analyses and the systematic comparison of coeval structures. The resulting point cloud provided the metric basis for developing a digital model of the sector, organized into four terraces interconnected on both functional and symbolic levels according to a coherent spatial logic. At the same time, the digitalization of the statue, currently housed at the Museo Archeologico Nazionale di Napoli, enabled the testing of different relocation hypotheses within its original context, assessing its visual impact and semantic value within a space likely functioning as a nymphaeum. From this perspective, virtual reconstruction emerges not only as a tool for documentation and critical analysis, but also as an interpretative device capable of restoring the spatial and symbolic complexity of archaeological contexts.

Keywords: Baia, virtual reconstruction, Sosandra sector, Aphrodite Sosandra, digital archaeological heritage.

Introduction

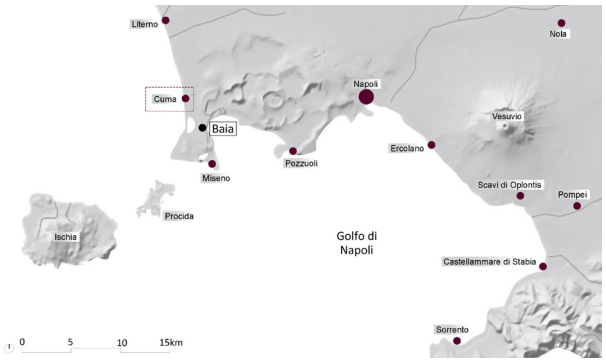
This paper aims to analyse the architectural organization of the Sosandra Sector within the Archaeological Park of the Baths of Baia, with the objective of virtually reconstructing its original configuration and verifying a plausible hypothesis regarding the placement of the *Aphrodite Sosandra* statue. In this context, the research seeks to demonstrate how digital technologies can not only support the documentation of cultural heritage, but also provide interpretative tools capable of restoring the spatial and symbolic complexity of ancient contexts.
The adopted methodology is based on an integrated approach that combines three-dimensional surveying through dynamic LiDAR technology with archaeological and bibliographic analysis. The results highlight how 3D reconstruction enables a more effective understanding of the relationships between architecture, landscape, and decorative apparatus, identifying the central niche of the axial hall as the most coherent location for the *Aphrodite Sosandra*. The research therefore confirms the value of virtual reconstruction as a critical and interpretative tool, capable of integrating material evidence and reconstructive hypotheses into a unified vision of the archaeological complex.

Historical framework

Geographical ccontext of Baia
Baia is located at the western end of the Gulf of Naples, within the volcanic area of the Campi Flegrei, a territory

characterized by intense geothermal activity and a highly unstable coastal morphology (fig. 1). Since antiquity, this environmental context, marked by the presence of thermal springs, fumaroles, and volcanic lagoons, has profoundly influenced settlement patterns and the architectural solutions adopted. Originally, the coastline took the form of a wide inlet opening toward the Gulf of Pozzuoli, protected from prevailing winds and favoured by a mild microclimate: conditions that early encouraged its residential and thermal vocation, making it a renowned place for leisure and retreat.
Over the centuries, bradyseismic phenomena, already documented in Roman times, significantly altered the original configuration of the coastline, causing the gradual subsidence of extensive coastal areas. A substantial part of the ancient urban and thermal complex is now submerged, while what remains visible today represents only a fragment of the original settlement. These transformations were compounded by the impact of the eruption of Monte Nuovo in 1538, which radically modified the topography of the area, as well as by extractive and industrial activities developed during the modern period. The archaeological site of Baia currently accessible to visitors thus appears as the result of a long stratification of natural processes and human interventions, which have fragmented and partially decontextualized a landscape once conceived as a unified system based on the close integration between architecture, water, and territory.

Fig. 1. Territorial framework of Baia within the Gulf of Naples and the Campi Flegrei area, with focus on the principal archaeological and urban centres. Image by the authors (graphic elaboration by the authors).



Importance of Baia as a recreational and social center
Beginning in the late Republican period and throughout the Early Empire, Baia established itself as one of the most important centres of *otium*, healing, and self-representation for the Roman elite. Rather than functioning as a city in the strict sense, it operated as a true aristocratic extension of Rome in Campania: a privileged space devoted to cultivated *otium*, where thermal practices, social relations, and symbolic display were integrated into a unified architectural and landscape system. Ancient sources repeatedly emphasize the exceptional character of the site, highlighting the combination of natural beauty, architectural luxury, and social prestige that made it a favoured destination for senators, high-ranking officials, and members of the imperial family.
The thermal facilities, enhanced through sophisticated hydraulic systems, constituted the functional core of this constructed landscape; however, their significance extended far beyond a merely therapeutic dimension. In Baia, bathing complexes, terraced villas, gardens, nymphaea, and monumental vaulted halls formed a continuous fabric conceived to structure a spatial experience that was simultaneously sensory, visual, and social. The scenographic use of water, the careful arrangement of sculptures, and the calibrated orchestration of views toward the sea and the volcanic landscape transformed these complexes into devices for the representation of rank and power. From this perspective, Baian architecture cannot be reduced to mere thermal infrastructure, but must instead be interpreted as a sophisticated cultural instrument capable of translating, through stone, water, and light, the values of refinement, authority, and imperial identity into material form.

Architectural description

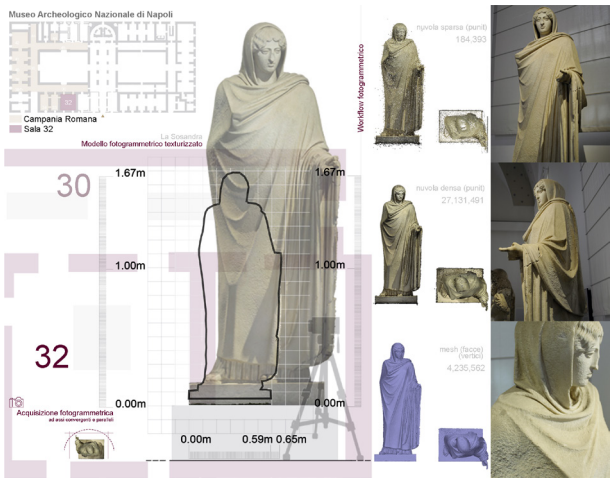
The Baths of Baia complex
The archaeological complex of the Baths of Baia constitutes one of the most extensive and complex architectural systems of the Roman world, both in terms of its surface development and its vertical articulation into a series of superimposed terraces. Far from corresponding to a single unified design, the complex is the result of a long process of growth and transformation extending from the late Republican period to the advanced Imperial age, during which private residences, thermal spaces, gardens,

nymphaea, and large representational halls were progressively integrated into an architectural continuum adapted to the rugged volcanic topography [Veronese 2018].
The complex is arranged along the slope of an ancient crater, exploiting the natural gradients to create a terraced system of platforms connected by ramps, stairways, and vaulted passageways. This layout enabled not only functional circulation between the different levels, but also a sophisticated choreography of visual and spatial sequences, in which the relationship between interior and exterior, architecture and landscape, played a central role [Maiuri 1951]. The large domed halls traditionally known as the "Temples" of Mercury, Venus, and Diana, which for centuries constituted the only visible remains of the complex, must be understood within this system as specialized thermal environments embedded in a much broader network of spaces dedicated to *otium* and representation (fig. 2).
From a technical and constructive perspective, Baia occupies a leading position in the history of Roman architecture. The early use of opus caementicium for the construction of large vaulted structures, the experimentation with wide-span domed forms, and the integration of complex hydraulic systems anticipated technological solutions that would later be codified in the great imperial baths of Rome. At the same time, the continuous adaptation of the complex to the geological phenomena characteristic of the Campi Flegrei and to the successive phases of use and renovation gives the ensemble a strongly stratified character, in which residential, bathing, and landscape functions overlap [Cennamo et al. 2024].

Fig. 2. The Archaeological Park of the Baths of Baia in Bacoli, including the layout of the principal sectors in plan and a focus on the current configuration of the Sosandra Sector (graphic elaboration by the authors).

The Sosandra sector
Within this vast system, the Sosandra Sector occupies a central and strategically articulated position. Located between the Mercury complex and the *Villa dell'Ambulatio*, the sector develops across four large terraced levels that exploit the natural slope of the volcanic terrain to organize an ascending sequence of residential spaces, gardens, porticoes, representational halls, and hydraulic devices. Such an arrangement does not merely respond to topographical adaptability, but rather to an architectural conception in which verticality, the superimposition of terraces, and the visual articulation between different levels play a fundamental role in constructing a hierarchically organized spatial experience.
The organization of the sector is structured around one or more compositional axes that regulate the succession of terraces and define the relationship between open and enclosed spaces. Along these axes are arranged peristyles, exedrae, and large vaulted halls conceived as transitional spaces between the external landscape and the internal architecture. The circulation system, based on ramps, stairways, and vaulted corridors, allows a continuous traversal of the complex, generating a spatial choreography in which the visitor progressively experiences the relationship between architecture, water, and landscape.

Fig. 3. Photogrammetric survey of the Aphrodite Sosandra statue in Room 32 of the Roman Campania section (graphic elaboration by the authors).

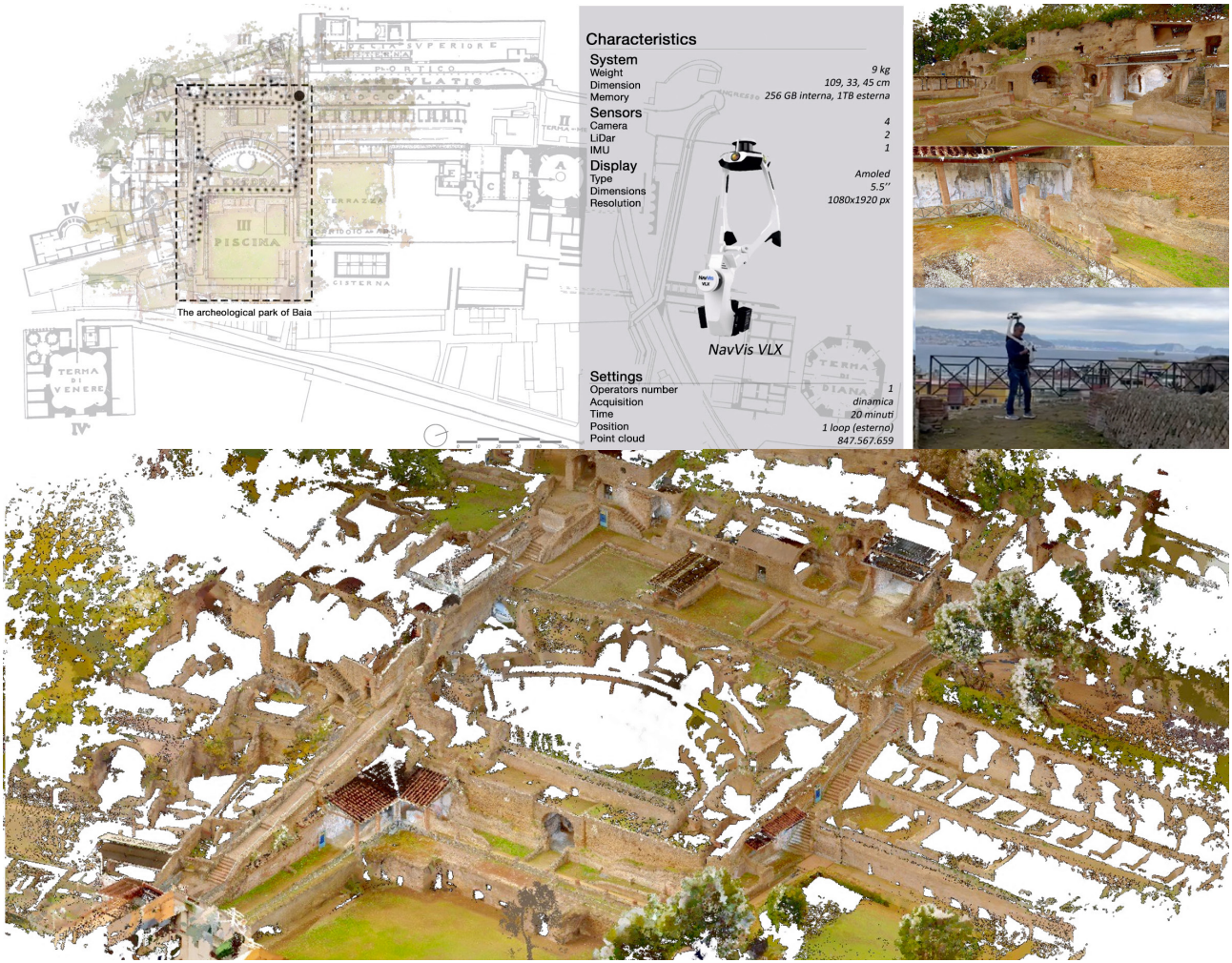


Water constitutes one of the structuring elements of the Sosandra Sector. Fountains, basins, and nymphaea contributed not only to climatic comfort and ornamentation, but were also integrated into a complex scenographic program intended to intensify the visual, acoustic, and symbolic effects of space. The presence of reflective surfaces, the movement of water, and its association with vegetation and sculpture reinforced the perception of this sector as a carefully constructed artificial landscape, in which nature was dominated and sublimated by architecture.
Within this system stands out a large axial hall equipped with three monumental niches, identified as the environment in which the *Aphrodite Sosandra* statue was discovered. Its dominant position within the complex, the direct relationship with the gardens and circulation axes, and its connection with the hydraulic devices suggest that this space played a central role within the representative program of the sector. It was not a secondary or transitional hall, but rather a true scenographic nucleus conceived for the display of sculptural images of high symbolic and aesthetic value.
Consequently, the Sosandra Sector must be interpreted as a unified architectural organism in which residence, *otium*, representation, and landscape are integrated into a single spatial device. The articulation of the terraces, the sequence of open and enclosed spaces, the control of visual perspectives, and the strategic placement of sculpture reveal a profoundly scenographic conception of space, aimed at producing a sensory and socially codified experience coherent with the elitist and symbolic character of Baia as a place of imperial *otium*.

The sculpture of *Aphrodite Sosandra*

Aphrodite Sosandra between semantic fulcrum of the Thermal Complex and contemporary device of cultural mediation
The *Aphrodite Sosandra* statue represents one of the principal interpretative nodes for understanding the sector of the same name within the Baths of Baia complex, both because of its historical-artistic significance and because of the symbolic and spatial value it must originally have possessed. The sculpture is a second-century AD Roman marble copy derived from a Greek bronze original attributed to Kalamis and datable to the mid-fifth century BC, belonging to an iconographic type that clearly differs from the more familiar representations of the goddess [Ridgway 1981].

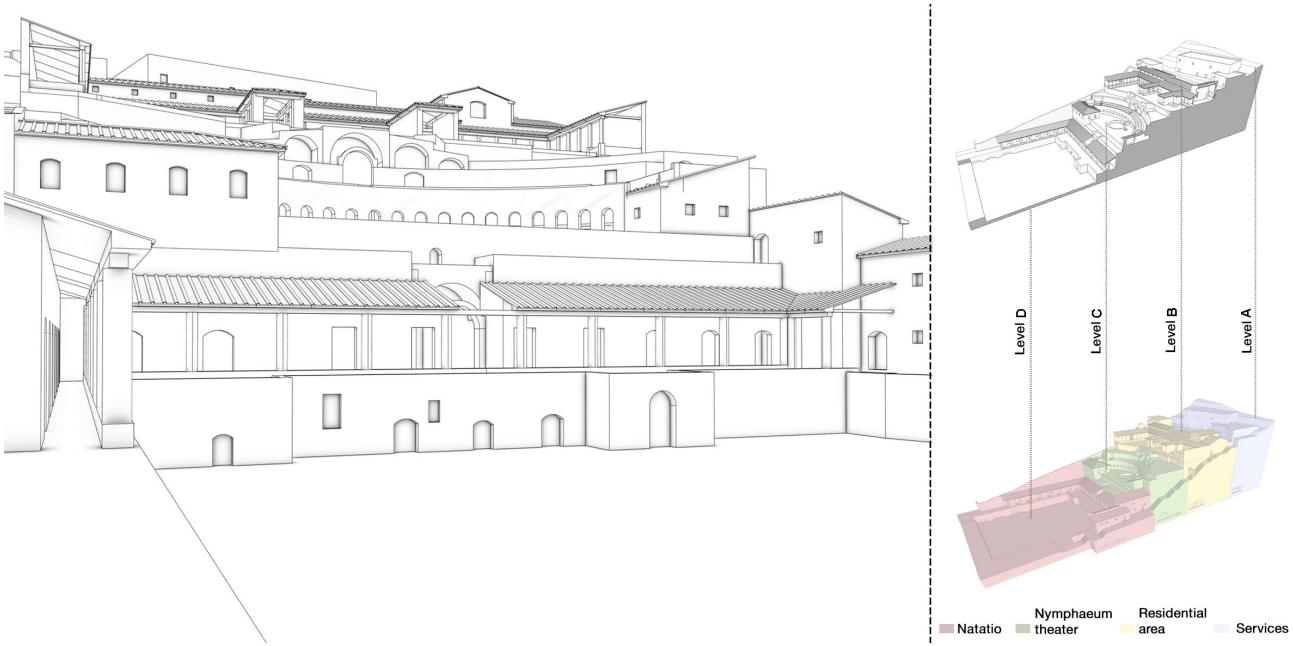
Fig. 4. SLAM survey of the Sosandra Sector using NavVis VLX instrumentation, including views of the point cloud (graphic elaboration by the authors).



The *Aphrodite Sosandra* embodies an ideal of femininity marked by composure and restraint: the enveloping drapery, controlled posture, and introspective attitude refer to the concept of sophrosyne, presenting the divinity as a guarantor of balance and order, far removed from more overtly sensual interpretations. Precisely this "moderate" dimension –the Sōsándra, "she who saves men"– makes her presence particularly coherent within spaces associated with bodily care and the thermal practices that defined the Baian landscape. From this perspective, the statue cannot be regarded as a mere ornamental element, but rather as an authentic visual and conceptual fulcrum capable of semantically qualifying the surrounding environment.
Within the framework of the valorization project linked to the new Baia railway station, the three-dimensional reproduction of the work assumed a paradigmatic role, configuring itself as an emblematic case of integration between archaeological research, digital technologies, and heritage mediation strategies. Through the combined use of 3D acquisition, digital modelling, and additive manufacturing, the research translated specialist knowledge into accessible forms, returning a cultural heritage to the wider community beyond the confines of the museum.
The 1:1 scale replica of the *Aphrodite Sosandra* –together with the Dioscuri, the imperial busts, and the head of Apollo– forms part of a broader reflection on the epistemological value of the copy, understood not as a substitute for the original, but as an autonomous device capable of conveying meanings, proportions, and modes of adaptation of ancient space within a contemporary context [Jeffrey 2015]. In this way, an infrastructure of mobility is transformed into a place of diffuse cultural narration, fostering a daily encounter with antiquity and contributing to the configuration of Baia as a landscape of heritage integrated into public space [Pinna 2011; Bonacini 2014].

Discovery of the statue
The *Aphrodite Sosandra* statue was discovered in 1946

Fig. 5. Virtual reconstruction of the Sosandra Sector showing the terraced articulation and functional distribution of the different levels (graphic elaboration by the authors).



during one of the most significant excavation campaigns conducted in the eastern sector of the Baths of Baia, within an environment characterized by the presence of niches and an articulated decorative pavement apparatus [De Franciscis 1965]. The context of discovery, situated along the terraced system structuring the so-called Sosandra Sector, suggests for the sculpture an original placement of strong scenographic value, likely associated with a representational space or an environment involved in ceremonial circulation routes. The insertion of the statue within an architecturally qualified and hierarchically significant hall directed scholarly interpretation toward recognizing a function that was not merely ornamental, but rather central within a complex visual and symbolic apparatus, in which the sculpture established a calibrated dialogue with both the architecture and the surrounding landscape [Caruso 2001]. From this perspective, the Sosandra functioned as an ordering element within a spatial experience aimed at constructing a process of harmonization between body, architecture, and the thermal environment.
The profound transformations that affected the site over the centuries, particularly the phenomena of bradyseism and the progressive loss of decorative apparatuses, have however compromised the legibility of the original relationships between the statue and its architectural context. In response to this condition of fragmentation, virtual reconstruction assumes a methodologically central role, as it makes it possible to reconstruct, in hypothetical yet scientifically grounded form, the placement and significance of the work within the terraced system. The digital model thus emerges not only as a visualization tool, but also as a device for critical analysis and interpretative verification, capable of integrating archaeological data and reconstructive hypotheses into a coherent framework [Dell'Unto et al. 2013; Forte 2010].

Digitalization of the Statues at the MANN Museum
The original sculptures discovered at Baia are today preserved in Rooms 30 and 32 of the Roman Campania section of the Museo Archeologico Nazionale di Napoli. It is from this museum context that the digitalization process began, aimed both at the virtual relocation of the statues within their original environment and at the production of physical replicas destined for the Baia railway station.
The digitalization was carried out through an integrated approach: laser-scanner surveying of the museum spaces was combined with digital photogrammetry of the individual sculptures. This approach made it possible to establish an operational workflow capable of generating high-resolution 3D models able to reproduce with great precision both the overall geometry of the works and the surface and material details fundamental for their study and faithful reproduction [Forte, Pescarin 2013; Pescarin 2020] (fig. 3).
Particular attention was devoted to the digitalization of the *Aphrodite Sosandra*, whose formal complexity required highly accurate acquisition procedures followed by a subsequent phase of editing and optimization of the models. The digital model made it possible to test hypotheses regarding the relocation of the statue within the Sosandra Sector, verifying the spatial relationships between sculpture, architecture, and landscape, and contributing to the reconstruction of the scenographic organization of the complex [Campi et al. 2025].
For the statue, the acquisition workflow combined close-range photogrammetry (300 acquisitions using a full-frame sensor) to obtain a highly detailed morphology, with a Faro Focus 3D scan used exclusively for validating the scale and metric accuracy of the digital model. The digital prototyping of the elements was performed using the non-decimated photogrammetric mesh, ensuring maximum resolution in the final integration.

Virtual reconstruction of the Sosandra sector

Methodology
The virtual reconstruction of the Sosandra Sector was based on the integration of geometric data obtained through SLAM LiDAR scanning with archaeological, planimetric, and bibliographic information deriving also from historical excavation campaigns and more recent surveys. The use of a dynamic scanning system enabled the generation of a continuous and georeferenced three-dimensional point cloud capable of reproducing the current morphology of the complex and constituting the reliable metric basis for the entire reconstruction process [Remondino, Campana 2014]. The modelling methodology adhered to high-fidelity metric criteria, establishing a positional tolerance of ±8 mm for the archaeological complex through data acquisition using the NavVis VLX 3 scanner.
Starting from this point cloud, the data underwent cleaning, segmentation, and classification processes, identifying the different masonry bodies, vaulted structures, platforms, and preserved hydraulic elements. The morphometric model was subsequently imported into a three-dimensional

modelling environment, within which an interpretative reconstruction of the lost volumes was developed, based on criteria of constructive coherence, typological analogy, and structural compatibility [Fernández Ruiz 2002] (fig. 4).
Throughout this process, a clear distinction was explicitly established between documented elements, those reconstructed through analogy, and those of a purely hypothetical nature, thereby ensuring the traceability of reconstructive choices. The principal objective of the model was not the production of a final image, but rather the construction of a spatial analysis tool capable of testing hypotheses, evaluating visual relationships, and verifying the architectural plausibility of the proposed reconstructions [Ortega-Vidal et al. 2011]. From this perspective, virtual reconstruction was conceived as an open process, susceptible to revision and updating according to the acquisition of new archaeological or interpretative data.

Formulation of the Hypotheses Aaross the four levels
The Sosandra Sector was interpreted as an architectural system articulated into four major levels, corresponding to the terraces archaeologically documented and represented within the geometric model. Each level was subjected to a specific reconstruction process, taking into account both its hypothesized function and its relationships with the other areas of the complex.
The lower level, situated closest to the hydraulic systems and service areas, was interpreted as a zone of access and distribution, from which the ascending route toward the more representative spaces originated. The second level, characterized by the presence of porticoes and open areas, was reconstructed as a transitional environment in which gardens and basins articulated the relationship between interior and exterior spaces. The third level concentrated the large

Fig. 6. View of the virtual model with the hypothetical placement of the Sosandra statue within the central niche (graphic elaboration by the authors).

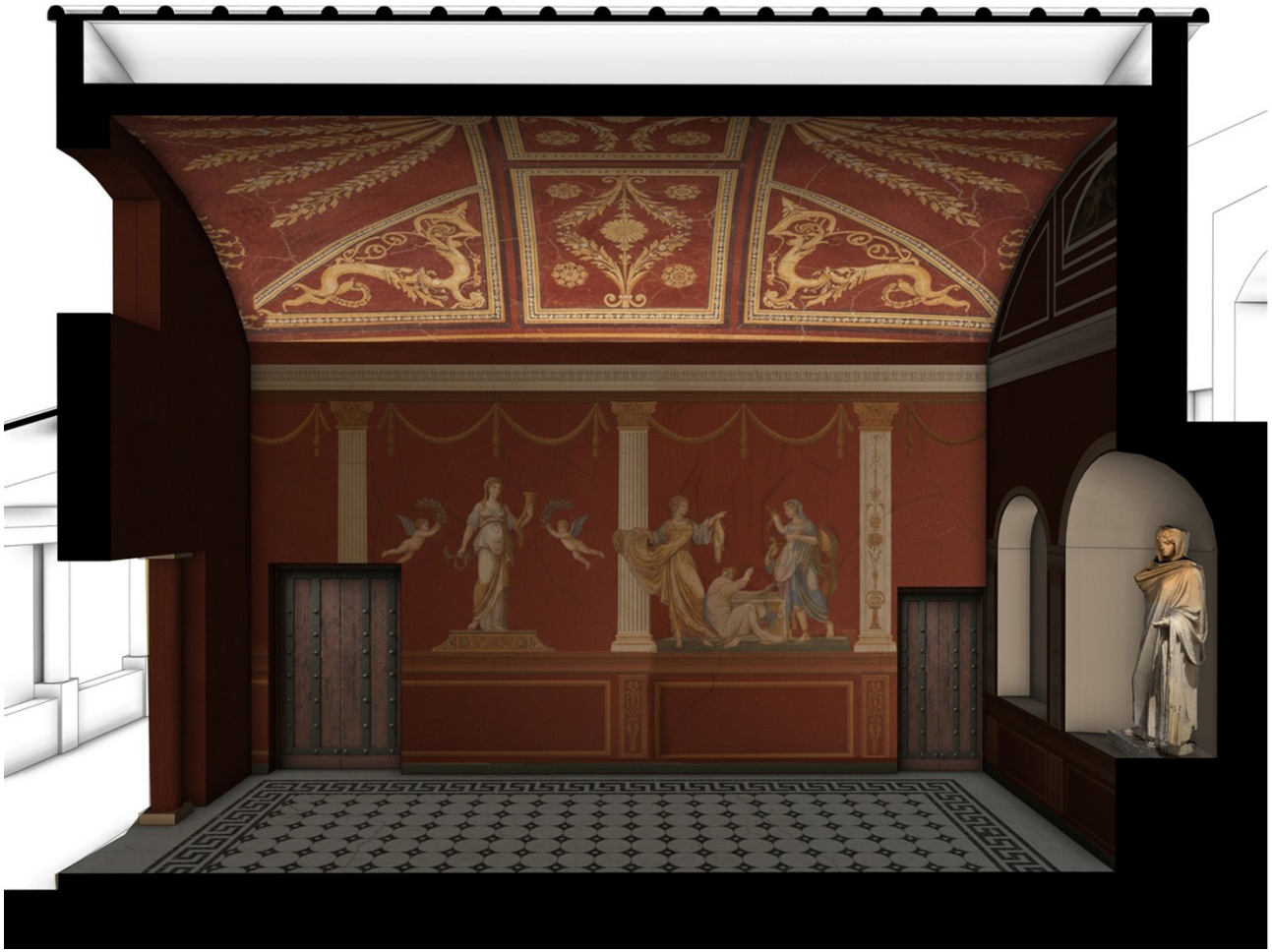
vaulted halls and representational spaces, organized according to compositional axes and carefully controlled visual relationships. Finally, the upper level, associated with panoramic terraces, was related to residential and contemplative spaces overlooking the entire gulf and the gardens below (fig. 5).
The modelling of these four levels made it possible to verify the coherence of the Sosandra Sector as a unified scenographic architecture, in which the superimposition of terraces does not respond exclusively to topographical requirements, but rather to an explicit intention of spatial hierarchization and the progressive construction of the experience of place.
The virtual reconstruction of the Sosandra Sector was carried out through CAD modelling based on the point cloud. The verifiability of the hypotheses relies on in situ archaeological evidence for the site plans, while for the volumetric reconstruction and the placement of the sculptures, criteria of historical analogy were applied, based on typological parallels from the same period and on the consulted bibliographic documentation.
Therefore, the virtual reconstruction of the Sosandra Sector was carried out through a systematic and traceable workflow grounded in historical evidence. This process combines critical documentary analysis, parametric digital modelling, the application of rendering textures, and the use of real-time visualization technologies. The applied methodology adheres to the principles established by the London Charter (2009) and the Seville Principles (ICOMOS, 2017), ensuring transparency, scientific traceability, and critical rigour in the digital reconstruction of cultural heritage (Table 1).

The Sosandra hall and the placement hypothesis
The three-dimensional digitalization of the *Aphrodite Sosandra*, carried out at the Museo Archeologico Nazionale di Napoli, made it possible to integrate the sculpture within the virtual model of the Sosandra Sector. Starting from the actual dimensions of the statue and the reconstructed geometry of the niche hall, several placement hypotheses were tested by evaluating their visibility along the principal circulation axes, their relationship with the gardens and hydraulic devices, and their perceptual impact within the architectural ensemble (fig. 6).
The analysis demonstrated that positioning the statue within the central niche of the axial hall maximizes both the formal legibility and the symbolic effectiveness of the composition (fig. 7). From this location, the Aphrodite becomes the visual fulcrum of the space, dominating the compositional axis that articulates the different levels of the sector and establishing a direct dialogue with the landscape and water. Such a configuration reinforces the interpretation of the environment as a representational nymphaeum, in which the sculpture does not function merely as an ornamental element, but as a structural component in the construction of the spatial meaning of the environment [Gómez Robles 2013, p. 62].

Table 1. Levels of evidence in the virtual restitution.

Level of Evidence	Description	Applied Criteria	Examples of Restitution
Direct evidence (documented/certain)	Elements whose form, proportions, and position are demonstrated by primary sources or preserved physical remains	Partial or total preservation of the material Verifiable historical graphic documentation Precise documentary sources	Arrangement of the different buildings and their related access routes (stairs/ramps) Height of most buildings, as demonstrated by the traces of the stairways
Indirect evidence (deduced/probable)	Elements not fully preserved, but whose form can be deduced from coherent material or documentation	Partial remains or archaeological evidence Incomplete textual or graphic references Typological correspondence with verified coeval buildings	Relationship between the hydraulic channels of the different levels of the sector Plan layout of all buildings Arrangement of the vaults according to their state of preservation
Well-founded hypothesis (plausible reconstruction)	Elements not preserved or directly described, reconstructed through scientific criteria based on historical, typological, and constructive analogies	Comparative analysis with analogous buildings Structural and stylistic coherence Explicit architectural justification	Arrangement of elements such as columns and roof slopes (with a non-preserved wooden structure) Junctions between some of the buildings Interior finishes of the environments

Fig. 7. Perspective section of the virtual reconstruction of the Sosandra Sector, with focus on the positioning of the statue (graphic elaboration by the authors).



The virtual reconstruction also made it possible to evaluate the relative scale between the figure, the architecture, and the surrounding environment (fig. 8), an operation that would have been impossible either from the isolated statue within the museum context or from the fragmentary remains preserved in situ. In this way, the three-dimensional model emerges as a tool for the archaeological validation of the proposed placement hypothesis (figs. 9, 10).

Social impact and the 'pop-effect' action

The opening of the new Baia station along the Cumana railway line, enriched by the presence of 3D reproductions of the statues originating from the Baths of Baia, represents a significant case of integration between contemporary infrastructure and archaeological heritage (fig. 11). The research does not limit itself to a traditional operation of cultural enhancement, but rather takes shape as a device capable of generating a concrete social impact, activating a return effect on the territory and, in particular, on the Archaeological Park of the Baths of Baia.

Although the thermal complex constitutes one of the most imposing and significant architectural ensembles of the Roman world, it has long suffered from a condition of marginality due to critical issues related to accessibility and transport efficiency. The difficulty of reaching the site has progressively reduced its perception as a central component of Campanian heritage, limiting its full public use despite its exceptional historical, architectural, and landscape value.

Within this framework, the new Baia station assumes a strategic role, positioning itself as an infrastructure capable of directly influencing the relationship between the archaeological site and the mobility network. The station becomes a threshold of access not only in a physical sense, but also in a symbolic one, to the archaeological heritage. It is precisely in this context that the 'pop-effect' action of the intervention emerges. The presence of the statues within a space traversed daily by commuters and visitors makes the heritage immediately visible, recognizable, and accessible, reducing the symbolic distance between the public and the archaeological asset.

Fig. 8. Virtual reconstruction of the Sosandra Sector (graphic elaboration by the authors).

Fig. 9. Detail of Level C of the Sosandra Sector - the theatre-nymphaeum (graphic elaboration by the authors).

Fig. 10. View of the virtual model of the Sosandra Sector (graphic elaboration by the authors).

Fig. 11. The new Baia metro station (graphic elaboration by the authors).

The informal experience of the replicas stimulates curiosity and interest, encouraging an initial encounter with the heritage that may subsequently develop into a desire for deeper understanding and direct visitation. In this sense, the station is capable of anticipating the archaeological experience, orienting visitors toward the Park and strengthening the relationship between infrastructure and site.
This mechanism proves particularly effective within the Phlegraean area, characterized by a strong historical stratification but also by infrastructural and environmental fragilities. The placement of heritage within a space of everyday life contributes to redefining the relationship between community and territory. The Baia station therefore does not merely improve physical accessibility to the archaeological park, but also redefines its image, restoring its centrality within the urban and metropolitan system.
The effect generated by this operation may thus be considered strategic and functional, insofar as it possesses the capacity to activate a virtuous relationship between mobility, public space, and archaeological heritage. The sculptural replica, inserted within an infrastructural context, acts both as a catalyst of attention and as a tool of diffuse narration, contributing to the reactivation of the social and cultural potential of a complex that, despite its monumentality, has long remained undervalued. In this way, cultural mediation and technological innovation become strategic instruments for overcoming accessibility challenges and strengthening the relationship between archaeological heritage and contemporary society.

Conclusions

This paper has examined the role of virtual reconstruction within archaeological heritage studies through the case study of the Sosandra Sector at the Baths of Baia. Through the integration of architectural, topographical, and sculptural data, the research demonstrates how digital technologies are not only tools for documentation and preservation, but also instruments for critical interpretation and for the reactivation of ancient contexts within contemporary space. The virtual reconstruction of the Sosandra Sector restored legibility to a heavily compromised archaeological complex, clarifying the spatial and symbolic relationships between architecture, landscape, and sculpture. The *Aphrodite Sosandra* emerges as a key element whose digitalization and virtual relocation make it possible to interpret the ideological and representational function of the sector within a systemic framework.
A decisive role in the reconstruction process was played by the topographical data provided by Dr. Paola Miniero and Dr. Enrico Gallocchio of the Archaeological Park of the Baths of Baia. Direct collaboration with them, together with the analysis of previously conducted surveys, represented a valuable contribution to understanding the historical evolution of the site and made it possible to verify and integrate the reconstructive hypotheses, relating the current condition of the complex to its past configurations.
At the same time, the production of 1:1 scale additive-manufactured replicas of the statues and their placement within the new Baia station along the Cumana railway line highlight the social and communicative potential of digital technologies: the copies do not replace the originals, but rather become autonomous artefacts capable of generating new forms of use and mediation, inserting heritage into everyday public space. The experience demonstrates how the integration of digital surveying, 3D modelling, and additive manufacturing overcomes the traditional separation between museum, archaeological site, and urban space, promoting a vision of heritage as a dynamic and relational system.
The project opens the way for future developments, both in terms of immersive virtual environments and in the application of the model to other contexts characterized by similar critical conditions, demonstrating how scientific research, cultural design, and technological innovation can support the enhancement and informed use of cultural heritage.

Credits

The research group is composed of: Massimiliano Campi, Marica Camerino, and Marika Falcone for the Department of Architecture of the University of Naple Federico II, Italy; Víctor A. Lafuente Sánchez, Daniel López Bragado, and David Marcos González for the Department of Urbanism and Representation of Architecture, University of Valladolid, Spain.

Although the research is the result of joint work, Massimiliano Campi, Marica Camerino and Marika Falcone are the authors of: *Architectural description; Virtual reconstruction of the Sosandra Sector, Digitalization of the Statues at the MANN Museum;* Víctor A. Lafuente Sánchez, Daniel López Bragado and David Marcos González are the authors of: *Introduction*; *Historical framework*; *The sculpture of Aphrodite Sosandra*.

Acknowledgements

The authors would like to express their sincere gratitude to Dr. Paola Miniero and Dr. Enrico Gallocchio of the Archaeological Park of the Baths of Baia for their valuable contribution to the understanding of the historical evolution of the site. They also wish to thank the company Medaarch for its contribution to the additive manufacturing process, and the studio Od'A Officina d'Architettura for the design of the Baia metro station. Furthermore, the authors would like to thank architect Sergio Sabbatini of the company 3DScan - Smart Surveying for the technological and operational support provided to the research, particularly for the extensive application expertise demonstrated in the use of the NAVVIS VLX instrumentation.

Authors

Massimiliano Campi, Department of Architecture, University of Naples Napoli Federico II, campi@unina.it
Marica Camerino, Department of Architecture, University of Naples Napoli Federico II, marica.camerino@unina.it
Marika Falcone, Department of Architecture, University of Naples Napoli Federico II, marika.falcone@unina.it
Víctor A. Lafuente Sánchez, Departament of Urbanism and Representation of Architecture, University of Valladolid, victorantonio.lafuente@uva.es
Daniel López Bragado, Departament of Urbanism and Representation of Architecture, University of Valladolid, daniel.lopez.bragado@uva.es
David Marcos González, Departament of Urbanism and Representation of Architecture, University of Valladolid, david.marcos.gonzalez@uva.es

Reference List

Bonacini, E. (2014). *Nuove tecnologie per la fruizione e valorizzazione del patrimonio culturale*. Roma: Aracne.

Campi, M., Cera, V., Falcone, M., Camerino, M. (2025). Frontiere del rilievo dell'architettura e sistemi di conoscenza mobile mapping per una candidatura alla Rete delle Città Creative UNESCO / Frontiers of surveying from architecture and knowledge systems for a candidacy to the UNESCO Creative Cities Network. In *Graphic Thinking. Proceedings of the XVII International Conference on Graphic Expression Applied to Building - APEGA 2025*. Cartagena, 2-4 October 2025, pp. 954-965. Cartagena: Ediciones UPCT.

Caruso, G. (2001). *Baia. Il parco archeologico*. Napoli: Electa Napoli.

Cennamo, P., De Rosa, A., Scielzo, R., Rippa, M., Trojsi, G., Chianese, E. (2024). Diagnostic investigation of the wall paints conservative state in a hypogeal room of the archaeological park of Baia (Italy). In *ACTA IMEKO*, vol. 13 (3), pp. 1-8. DOI: 10.21014/actaimeko.v13i3.1807. <https://acta.imeko.org/index.php/acta-imeko/article/view/1807> (accessed 25 June 2026).

De Franciscis, A. (1965). *Baia. Storia e topografia dei Campi Flegrei in età romana*. Roma: L'Erma di Bretschneider.

Dell'Unto, N., Leander Touati, A.M., Ferdani, D., Dellepiane, M., Callieri, M., Lindgren, S. (2013). Digital reconstruction and visualization in archaeology Case-study drawn from the work of the Swedish Pompeii Project. In A.C. Addison, G. Guidi, L. De Luca, S. Pescarin (Eds.). *2013 Digital Heritage International Congress (DigitalHeritage)*. Marseille, France, 2013, pp. 621-628. DOI: 10.1109/DigitalHeritage.2013.6743804. <https://ieeexplore.ieee.org/document/6743804> (accessed 25 June 2026).

Fernández Ruiz, J.A. (2002). Criterios y método para la modelación digital del Patrimonio Arquitectónico. In *EGA. Revista de Expresión Gráfica Arquitectónica*, No. 7, pp. 73-78.

Forte, M. (2010). *Cyber-Archaeology*. Oxford: Archaeopress.

Forte, M., Pescarin, S. (2013). The virtual museum: reconstructing cultural heritage in the digital age. In M. Forte (Ed.). *Virtual Archaeology*, pp. 71-90. Oxford: Archaeopress.

Gómez Robles, L. (2013). *El ninfeo romano, tipologías y características. Aplicación de un método de análisis procedente de la conservación*. Tesis doctoral Inédita, Universidad de Granada.

Jeffrey, S. (2015). Challenging heritage visualisation: beauty, aura and democratisation. In *Open Archaeology*, 1, pp. 144-152 DOI: 10.1515/opar-2015-0009.

Maiuri A. (1951). Terme di Baia: scavi, restauri e lavori di sistemazione. In *Bollettino d'Arte*, No. 36, pp. 359-364.

Moreno Alcaide, M., Román Punzón, J. M., Valdivia García, M. (2024). Application of digital technologies for virtual reconstruction of the Roman Villa of Salar (Granada, Spain): an example of archaeological heritage transfer. In *Virtual Archaeology Review*, vol. 16 No. 32, pp. 130-143. DOI: 10.4995/var.2024.22364.

Ortega-Vidal, J., Martínez-Díaz, A., Muñoz de Pablo, M.J. (2011). El dibujo y las vidas de los edificios. In *EGA. Revista de Expresión Gráfica Arquitectónica*, No. 18, pp. 50-63. DOI: 10.4995/ega.2011.1335.

Pescarin, S. (2020). Digital applications and accessibility in cultural heritage. In *Journal of Cultural Heritage*, No. 43, pp. 234-241. DOI: 10.1016/j.culher.2019.12.006.

Pietroni, E., Ferdani, D. (2021). Virtual Restoration and Virtual Reconstruction in Cultural Heritage: Terminology, Methodologies, Visual Representation Techniques and Cognitive Models. In *Information*, 12(4), 167. DOI: 10.3390/info12040167.

Pinna, G. (2011). *Il museo contemporaneo*. Roma: Carocci.

Remondino, F., Campana, S. (2014). 3D surveying and modeling in archaeology and cultural heritage. In *Theory and best practices. British Archaeological Reports*, Int. Ser. 2598. Oxford: BAR Publishing.

Ridgway, B. S. (1981). *Fifth Century Styles in Greek Sculpture*. Princeton: Princeton University Press.

Veronese, L. (2018). Alle origini di una difficile tutela: Amedeo Maiuri e i restauri al Parco archeologico delle Terme di Baia. In *RA-Restauro archeologico*, pp. 20-43. Firenze: University Press. DOI: 10.13128/RA-23459.