



INTERIOR CONDITION ASSESSMENT REPORT

TUMACÁCORI NATIONAL HISTORICAL PARK

Drachman Institute | Heritage Conservation
College of Architecture, Planning, and Landscape Architecture
The University of Arizona

In conjunction with:
Tumacácori National Historical Park
DRAFT September 2014



COLLEGE OF ARCHITECTURE, PLANNING
& LANDSCAPE ARCHITECTURE

Drachman Institute

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PROJECT INFORMATION

This project was carried out between the National Park Service and the University of Arizona's Drachman Institute.

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Project References:

Cooperative Agreement No. H1200100001
Task Agreement Order No. P14AC00554
Project Number UAZDS-410
UA Account No. 300946

EXECUTIVE SUMMARY

Tumacácori Mission Church was designated a National Monument in 1908, prior to the formation of the National Park Service (NPS) in 1916. Soon after its inception, the NPS assigned as custodian famed early preservationist Frank “Boss” Pinkley, who immediately took rehabilitative action to the historic ruin. Over the subsequent decades under NPS supervision, Tumacácori underwent various phases of reconstruction and repair. As a consequence, the church structure embodies in microcosm the evolution of NPS preservation theory and action, demonstrating a range of conservation techniques. The interior in particular, featuring layers of plaster and painted surfaces over the adobe construction, poses a unique set of maintenance challenges. Natural forces of deterioration and mechanical responses to failing preservation techniques both affect the interior condition of the church. A comprehensive assessment and documentation of these factors was thus essential for the future application of treatment and maintenance at Tumacácori Mission Church.

Documentation was conducted by four graduate student investigators under the direction of the architectural conservator and exhibit specialist at Tumacácori, Alex Lim. Field documentation took place over a period of three weeks wherein the student investigation team recorded a defined set of conditions, repairs and materials present in the church’s interior. These data were then digitally rendered to create condition maps and materials from which the Tumacácori National Historical Park crew will be able to monitor change, archive a record of conditions and treatments, evaluate the performance of past treatments, and prepare an appropriate treatment plan.

PROJECT BACKGROUND AND NEED

The conservation of historic adobe buildings such as Tumacácori Mission Church represents an ongoing and adaptive process. As a formed-earth material, adobe is naturally inclined to degrade, requiring competent, cyclical maintenance to preserve its character and integrity. As a consequence, the preservation crew at Tumacácori National Historic Park engages in year-round conservation efforts, combining traditional knowledge with modern scientific techniques.

Documenting and assessing the current condition of the church interior walls and features is fundamental to both the continued treatment of the building, and the development of future preservation plans.

An additional layer of consideration in the assessment of the interior condition is the history of repair and reconstruction performed on the mission church. Designated a National Monument in 1908, Tumacácori Mission Church has undergone various preservation and restoration activities over the subsequent century, rendering the adobe structure a veritable laboratory for conservation techniques. These myriad repair actions contribute to the integrity of the structure and may have direct impacts on the adobe building's continued quality of preservation. An in depth identification and documentation of this chronology of efforts is critical to the understanding and treatment of both successful historic repairs and those that are failing.

The performance of this conditions assessment of the mission church interior sought also to address the critical lack of training opportunities in Southern Arizona for students to engage in the preparatory documentation process necessary for the planning and implementation of appropriate adobe treatment and maintenance. An important component of the project was thus to establish a connection between a pool of technically trained graduate students and the preservation specialists at the National Park Service in order to address the preservation needs at Tumacácori National Historical Park (TNHP).

R. Brooks Jeffery, Director of the University of Arizona's Drachman Institute, served as the Principal Investigator. Alex Lim, TNHP Architectural Conservator and Exhibit Specialist served as the project ATR. The interior condition assessment and documentation was performed by Mel Beggy, Rebecca Caroli, Starr Herr-Cardillo and Brianna Lehman, student employees of the University of Arizona's Drachman Institute. After the first two weeks of documentation, Mel Beggy left the team and the project continued with three student investigators. All photographs were taken by Starr Herr-Cardillo and Rebecca Caroli. Digitization was performed by Rebecca Caroli, Starr Herr-Cardillo and

Brianna Lehman, with the final conditions maps designed and produced by Rebecca Caroli and Starr Herr-Cardillo. All graphics rendered within this report were designed by Rebecca Caroli. The Illustrated Conditions Glossary was designed by Starr Herr-Cardillo, and the final report was prepared by Rebecca Caroli.

PART ONE

METHODOLOGY

METHODOLOGY

Documentation was conducted at Tumacácori Mission Church by four graduate student investigators, with backgrounds in fields including archaeology, heritage conservation, architecture and landscape architecture, under the direction of the Agreement Technical Representative (ATR), Alex Lim, who serves as the architectural conservator and exhibit specialist at Tumacácori National Historical Park. Field documentation took place over a period of three weeks, from July 14 to August 1, 2014. This window was afforded both by the summer availability of the student investigators and the generally lower park visitation rates that coincide with the exceedingly high temperatures and monsoonal rains of mid-late summer. Data collection predominantly took place on site between 9am and 4pm, three to four days per week. An additional work day was typically taken on a weekly basis to archive data and prepare progress reports. Prior to the project's start, the scope, duration and impact of the work were discussed with the park Director, Bob Love, and staff in order to familiarize the staff with the project, address any concerns and clear a schedule of work. Potential considerations raised during these conversations pertained to the visual and physical impediment that the necessary scaffolding would present to visitor experience, and the length of time for which the scaffolding would be in place. As a consequence, these concerns were considered in the scheduling and execution of the documentation process.

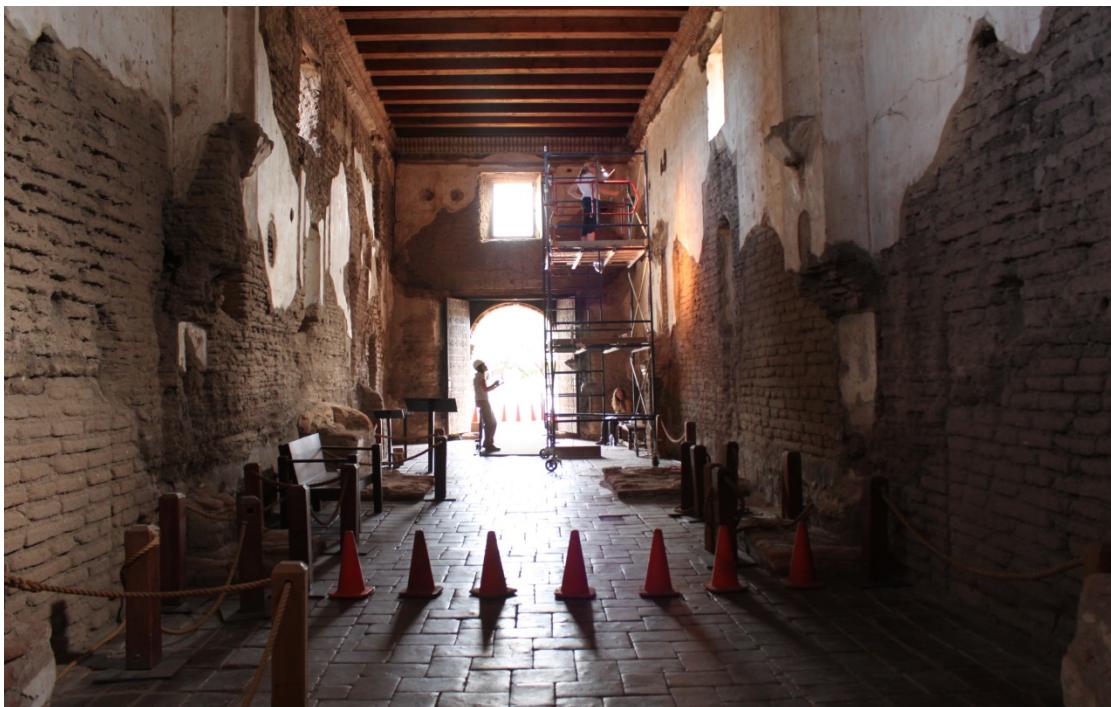


Figure 1: Scaffolding in south end of church nave, blocked off by construction cones during documentation process (S. Herr-Cardillo, photograph facing south, July 21, 2014).

The documentation team endeavored to work as expediently as possible in order to minimize the length of the documentation portion, and organized the use of the scaffolding in such a way that access to the mission church sanctuary was always available. When necessary, the times of highest obstruction took place before the opening of the park, or during non-peak hours. An explanatory poster was set up in the mission church nave describing the project, its significance and the joint participation of the NPS and Drachman Institute at the University of Arizona. Additionally the documentation team served as an interactive exhibit, discussing the project with interested visitors.

After the initial period of documentation, the team transitioned to the digitization phase, in which the recorded conditions were rendered in a digital format using AutoCAD, Adobe Photoshop and Adobe Illustrator. This process, undertaken over seven weeks, between August 1 and September 23, was carried out by three of the team members, before the formulation of the final report.

BACKGROUND AND PREPARATION

In preparation for the interior condition assessment, the investigators established and defined a list of conditions expected to be present at Tumacácori Mission Church, referencing the ICOMOS Glossary on Stone Deterioration Patterns (ICOMOS 2008), comparable analyses undertaken at the Spruce Tree House site (Lim 2010), and the expertise of ATR, Alex Lim. The documentation team members familiarized themselves with the terminology and recognition of relevant conditions through background research and a series of preliminary site inspections.



Figure 2: ATR Alex Lim demonstrating condition types at Tumacácori Mission Church (S. Herr-Cardillo, photograph facing northwest, July 15, 2014).

A list of conditions present at Tumacácori Mission Church was subsequently formulated and organized into three categories: Material Integrity, Historic Features and Conditions (For detailed Condition Glossary see Appendix A).

Category	Material Integrity	Historic Features	Conditions
Conditions	<ul style="list-style-type: none"> • Loss • Repair <ul style="list-style-type: none"> ○ Edging ○ Fill ○ Render ○ Reconstruction 	<ul style="list-style-type: none"> • Surface Decorations <ul style="list-style-type: none"> ○ Incisions ○ Painted Surfaces • Historic Graffiti • Construction Details <ul style="list-style-type: none"> ○ Pugholes 	<ul style="list-style-type: none"> • Structural Cracks • Superficial Cracks • Detachment (from substrate) • Delamination (from adjacent layer) • Holes/indentations • Disintegrations • Loose mortar • Voids • Surface deposits

Table 1: Condition assessment categories and condition features.

These conditions were then divided into manageable subsets, termed Assessment groups, based on the number of features that could legibly occupy a single page, and the comparable amounts of time estimated for each team member to complete the documentation of all assigned conditions in one tile unit (see Figure 3). Subject to the varying size of the tile units and complexity of the conditions affecting the corresponding wall space, the average goal length of documentation for each tile unit was 20 minutes per Assessment. These Assessment groups largely followed the categories outlined in Table 1, however the Conditions category, being the longest, was necessarily split among two investigators.

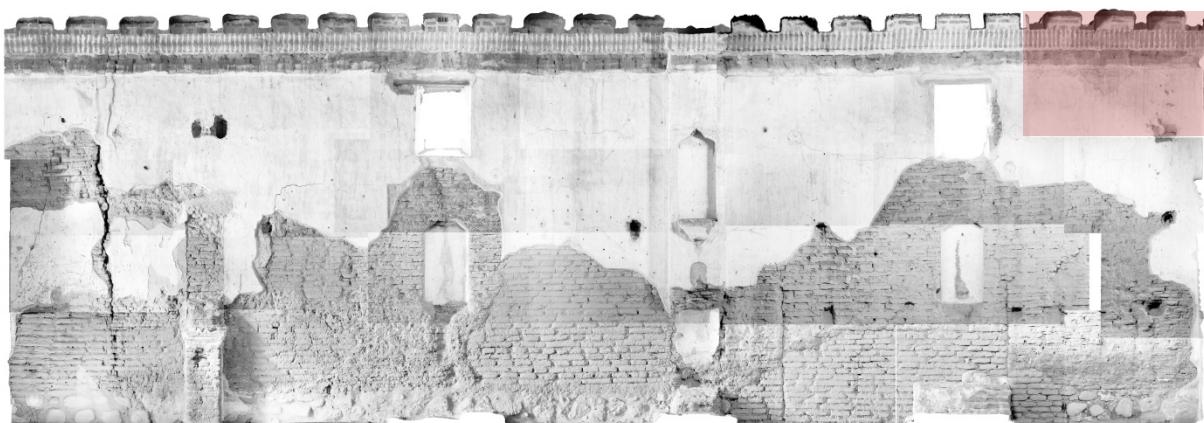


Figure 3: Composite image of SOAR 3D laser scanned orthophotographic tiles with highlight denoting size of one regular tile unit.

This division ultimately amounted to approximately five to six conditions per team member, generally oriented categorically and assigned as follows:

Assessment 1 (Material Integrity)	Assessment 2 (Conditions)	Assessment 3 (Conditions/Historic Features)	Assessment 4 (Material Integrity/Conditions)
Loss (Plaster)	Mortar Loss	Structural Cracks	Fill (Adobe)
Edging	Pugholes	Superficial Cracks	Reconstruction
Fill (Plaster)	Animal Holes	Detachment	(Adobe)
Render	Disintegration	Delamination	Droppings
Joints	Fragmentation	Incisions	Runneling
	Voids	Historic Graffiti	Discoloration

Table 2: Assessment groups and assigned condition features.

Once assigned, the conditions were designated with a distinct colored Sharpie pen color. A preliminary glossary was created with photographs of the determined conditions and a documentation key denoting color and stroke or shading if applicable (Appendix B). A preliminary run of the documentation and digitizing process was taken for one unit of the interior west wall of the Tumacácori Mission church. Documentation then began on the northern interior end of the west wall of the church nave.

DOCUMENTATION



Figure 4: Investigator Brianna Lehman documenting Assessment group 3 conditions for tile unit A1 (S. Herr-Cardillo, photograph facing north, July 21, 2014).

Prior to the initiation of this project, laser scanner and photogrammetry documentation conducted by the National Park Service Southern Arizona Office (SOAR) was completed of the interior of the mission church, resulting in the creation of orthophotographic images of the interior surface (Degayner et al. 2014). These photographs were utilized as the base images over which condition documentation took place. Each tile unit represented approximately 50 sq. ft. of wall space, and generally corresponded to a seven by four tile grid for the long nave walls, and one by three tile grid for the choir loft and sanctuary walls. These tiles were subsequently labeled alphabetically and numerically; columns were denoted as A-O in the nave, with rows numbered one through four, beginning with the floor level and working upwards towards the ceiling. For the sanctuary and choir loft, each wall was divided into three tiers labeled one through three from bottom to top.

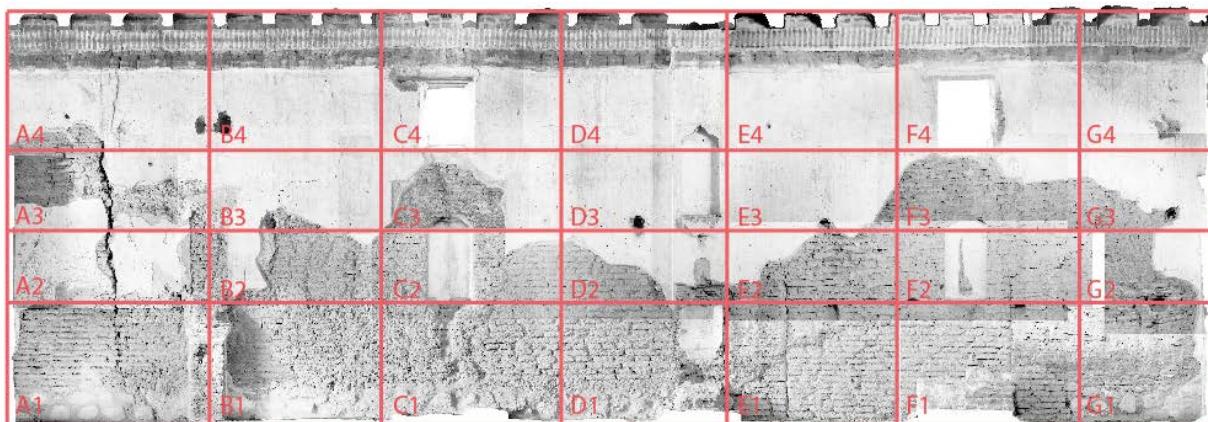


Figure 5: Composite image of SOAR 3D laser scanned orthophotographic tiles for the west wall of the church nave with approximate tile grid overlay denoting the labeling convention (SOAR, photographic facing west, November 2013).

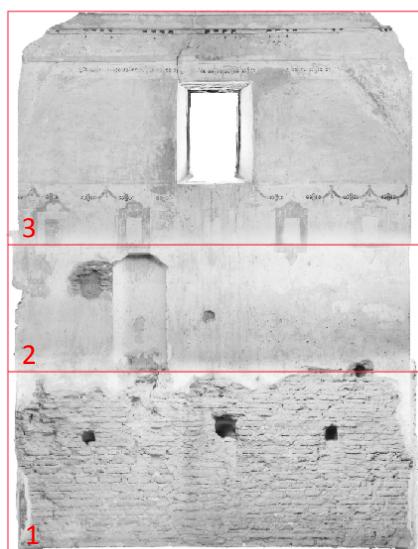


Figure 6: Composite image of SOAR 3D laser scanned orthophotographic tiles for the west wall of the sanctuary with grid denoting the tile units.

Despite the general outline of the grids presented above, the actual tiles provided were irregular in dimensions, some being larger and longer than others. This resulted in frequent overlap and, more significantly, the occasional gap in content where none of the tiles intersected. These areas were noted during the documentation process and, when possible, new photographs were printed so that the conditions within these areas could be accurately documented. Conditions otherwise occurring outside the parameters of the base photographs were addressed in annotations, although this occurrence was rare.

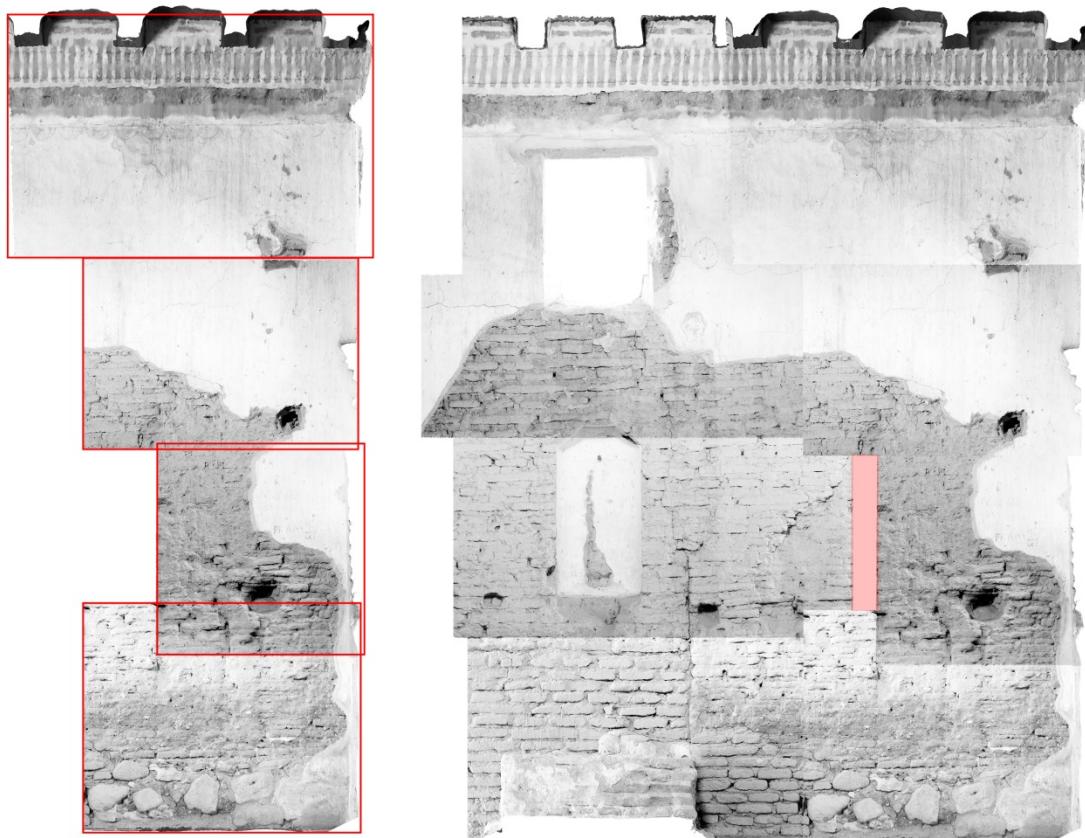


Figure 7: Demonstration of irregular photo tile size and shape, and consequent gap in base image data coverage, in pink.

The documentation process began with column G, located in the northwest corner of the nave and progressed tile column by column south towards the entrance of the nave (Column A). First the entire west wall was completed, along with the south face of the north end of the nave (columns and archway), followed by the south wall of the nave (columns and choir loft), then the entire east wall working by tile column from south to north (From Column O to Column H). After the nave was completed, the four walls of the sanctuary were recorded simultaneously by three investigators.

Multi-tiered scaffolding was erected within the nave and initially set up directly in front of the north corner of the west wall in the nave. The scaffolding contained two levels, the uppermost extending a little over halfway up the wall. One to two investigators occupied each level of the scaffolding, including the ground level beneath the scaffold. If an investigator finished the present column ahead of the rest of the group, said person would continue recording the floor level (Row One) of the subsequent columns.



Figure 8: Investigators recording conditions on top tier of scaffolding for the west wall of the church nave (S. Herr-Cardillo, photograph facing northwest, July 21, 2014).

For reasons of safety, while scaffolding was up, park visitors were allowed to enter the nave up to a certain point, delineated by construction cones, with a perimeter around the scaffolding roped off. To access the sanctuary, visitors were directed around the side of the church towards a second entrance through the sacristy. When work was not taking place, the scaffolding was positioned close against a wall and roped off with caution tape and signs, to permit passage through the nave to the sanctuary. While working on scaffolding, investigators wore hard hats, and scaffolding was always moved by trained staff members of Tumacácori NHP. In general, the intention was to place the scaffolding as close to the wall as possible, centered on the tile column being recorded. Obstructions occasionally prevented the scaffolding from being positioned right up against the walls. Because the scaffolding could only be moved by trained staff whose schedules did not always coincide with the flow of work inherent to the documentation process (thus resulting in a limited number of moves per day), the scaffolding was positioned as optimally as possible to record features, usually nearer to the middle of nave.

The process of recording involved the folding in half and placement of 11 by 17-inch orthophotographs into 8.5 by 11-inch transparent sheet protectors. These sheets were labeled according to the wall, column, row and Assessment number (e.g. A1_West_Int_Tuma_Assess.1; Sanct_North_Int_Tuma_Assess.3). Investigators drew registration marks on the sheet protectors corresponding to the corners of the photo tile. Assigned conditions were traced and broader or more ephemeral areas were outlined with a Sharpie pen. Conditions were represented either by lines or closed polygons to aid in the digitization process. As work progressed, the investigators consulted with each other on questionable features and checked in frequently during the day with the ATR.

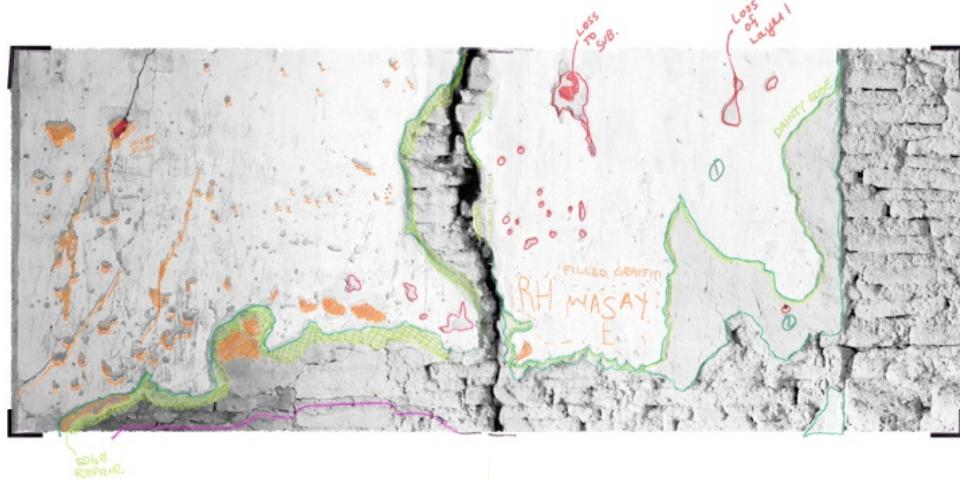


Figure 9: Sharpie pen documentation of Assessment 1 conditions for tile unit A2, west wall of nave.

After the nave was fully recorded, the scaffolding was brought back to its original position between columns G (west) and H (east) and moved down the center aisle of the nave so that each instance of historic graffiti could be photographed and documented in further detail. The photograph file information was recorded on the corresponding Assessment sheets, wherein the general area of the graffiti was recorded. In addition, throughout the process, areas of interest were photographed, including decorations and representative examples of all documented conditions. All photographs produced were raw image format files, captured with a digital camera (Canon Rebel; Canon 7d). Side altars were additionally photographed with a color card.

Within the sanctuary a new condition was added (recorded as part of Assessment 2), where painted surfaces were recorded. Owing to the much smaller nature of the sanctuary and higher level of historic detail still present on the walls, the scaffolding was moved twice during the documentation process. First the west wall and half of the north and south walls were recorded, then the east wall with the remaining halves of the north and south walls. At this point, three investigators were

responsible for recording the conditions, thus Assessments 1 and 4 were performed by one investigator following the conventions established at the onset. All historic graffiti was photographed in the sanctuary and the sacristy at this point.

Lastly, condition reports were recorded for each of the five extant side altars within the nave. Each side of the altars was recorded, including the exposed top face, generating four condition tiles for each Assessment group.

DIGITIZATION

After on site documentation was concluded, investigators scanned the transparent sheet protectors with a blank printer page inserted within to provide a white backdrop and clearer image of the drawn Sharpie lines. These scans were then imported to Photoshop where the background was eliminated and the scans were oriented and scaled on top of digital files of the orthophotographs using the registration marks. Each Assessment was placed on a different layer on top of the orthophotograph background. All of the individual photograph tiles were joined together in photograph to create a comprehensive base image of the walls.

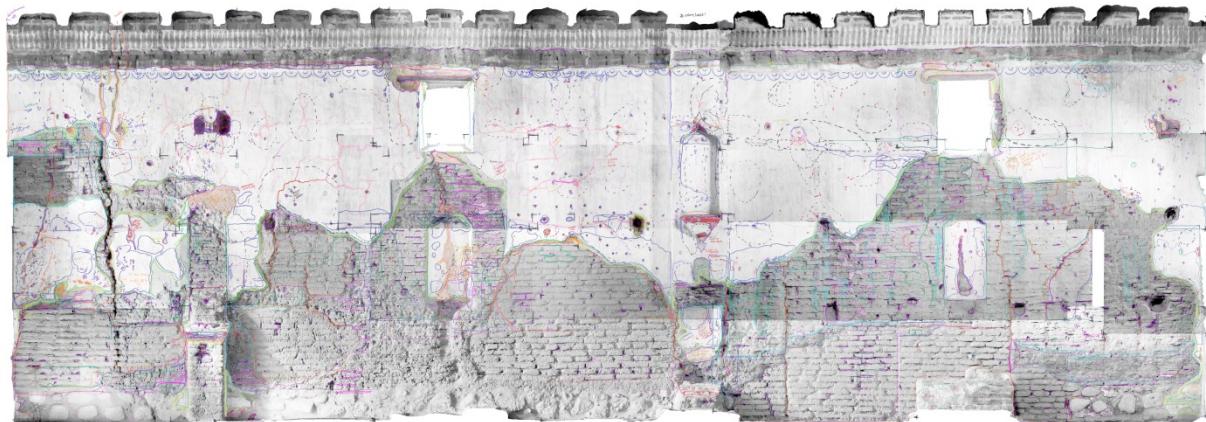


Figure 10: Composite background with all scanned Sharpie pen Assessment groups, imported into and assembled in Adobe Photoshop, ready for digitization using AutoCAD.

The Photoshop files were then imported into AutoCAD with one Assessment layer rendered visible at a time, and digitized by the investigator who was responsible for recording the particular Assessment group in the field, except Assessment group 1, whose original recorder had since left the project. Refinements were made to colors of the recorded conditions, designed to be intuitive and legible (reds for loss, blues for repair). The glossary was subsequently revised to reflect clarifying changes in terminology and final color selections.

All graffiti was logged and keyed to the AutoCAD files. A database was assembled in Microsoft Excel, documenting each instance of historic graffiti with a photograph (labeled according to the tile and key number), a description of the graffiti and a record of all legible information, including dates and names (Appendix E). Initially this was performed for the graffiti in the nave and sanctuary, but was later expanded to include the sacristy.

PART Two

PRODUCTS AND RESULTS

PRODUCTS AND RESULTS

PRODUCT CATALOG

Layered Interior Wall Conditions Maps

These include a set of interactive maps of the interior walls of the church demonstrating the presence of various sets of phenomena. The maps consist of black and white orthophotographic background images onto which CAD layers indicating various surface conditions are applied. These recorded features are categorized into the Assessment groups: Material Integrity, Historic Features, and Conditions. The interior of the mission church is divided into wall sections including: the east wall of the nave, the west wall of the nave, the choir loft, and the sanctuary. Columns on the north and south end of the nave, and the south face of the archway separating the nave from the sanctuary were individually recorded and mapped. Each wall section has four corresponding maps, three demonstrating the Assessment groups and their corresponding features, and one that includes all recorded conditions. This information is provided in AutoCAD files and interactive PDF files for broader distribution and access. Layers within these files can be turned on and off so that the reader may choose which conditions they wish to view and to better highlight the connections between multiple conditions. Additionally, non-interactive versions of the maps have been produced for paper and web distribution, subdivided by the Assessment groups for greater legibility (Appendix D).

Illustrated Conditions Glossary

The Illustrated Conditions Glossary describes and defines each condition recorded and provides an image demonstrating the feature as it appears both on the physical walls of the mission church and as it is represented on the final map (Appendix A).

Historic Graffiti Photo Documentation

All historic graffiti was documented with raw photographs keyed to the digital maps for easy reference. An Excel database was formulated to record all legible information ascertained from the historic present in the nave and sanctuary (Appendix E).

AutoCAD files of Conditions Layers of Interior Walls

These are digitized AutoCAD files of the interior wall conditions of the church include the orthophotographic base image which can be adjusted to display aligned scans of the original recorded conditions. The walls are divided into sections: the west wall of the nave, the east wall of

the nave, the choir loft, and the four walls of the sanctuary. Files for each section contain digitized layers of all conditions present. The files are compatible with 2000 to 2014 versions of AutoCAD software.

Hard Copy of Recorded Conditions

All of the organized binders of base images in sleeves with recorded conditions and original glossary have been submitted with this report.

DOCUMENTATION RESULTS

General observations and discoveries were made by the investigators during the documentation process. These data and correlations were clearly rendered in the documentation products for further interpretation. In general the interior condition of the mission church was highly stable, with few observable threats either from age and wear, or failing/incompatible repairs. A few isolated instances of severe detachment are thought to warrant attention, as well as areas where detachment has resulted in subsurface voids. Of note were striking patterns of overlapping conditions which suggested, in certain cases, potential causality. In all areas where discoloration of the adobe was noted, extensive disintegration was also present. These areas of discoloration and disintegration occurred almost exclusively along the joints of modern (reconstructed) adobe wall sections and the original material. Other areas that demonstrated discoloration and disintegration occurred along structural cracks. Consequently these zones represent important areas of consideration in the continued maintenance and conservation of the mission church, as they potentially represent areas of incompatible repair. An unexpected discovery was the evidence of recent termite activity in the adobe of the east wall of the nave, however the impact, pending further investigation, appears superficial.

REFERENCES

DeGayner, Jake, Tylia Varilek and Alex Lim

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Lim, Alex B.

2010 Conservation of Architectural Surface Finishes at Spruce Tree House, Mesa Verde National Park. The Architectural Conservation Laboratory, University of Pennsylvania.

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APPENDIX A

TUMACÁCORI NATIONAL HISTORIC PARK ILLUSTRATED CONDITIONS GLOSSARY



MISSION SAN JOSE DE TUMACÁCORI



INTERIOR CONDITION ASSESSMENT GLOSSARY

Drachman Institute | Heritage Conservation
College of Architecture, Planning, and Landscape Architecture
The University of Arizona

In conjunction with:
Tumacácori National Historical Park
September 2014

SUMMARY OF CONDITIONS

MATERIAL INTEGRITY {	MATERIALS		LOSS		REPAIR	
	PLASTER	p 1	PLASTER LAYERS	p 2	EDGING (PLASTER)	p 3
	ADOBE	p 1	ADOBE SUBSTRATE LOSS	p 2	FILL (PLASTER)	p 4
						FILL (ADOBE) p 4
HISTORIC FEATURES {	DECORATIVE FEATURES		ARCHITECTURAL FEATURES		GRAFFITI	
	INCISIONS	p 5	PUGHOLES	p 7	HISTORIC GRAFFITI	p 7
	PAINTED SURFACE	p 6				
CONDITIONS {	ADOB E		PLASTER		SURFACE DEPOSITS/ ANIMAL ACTIVITY	
	DISINTEGRATION	p 8	VOIDS	p 10	RUNNELING	p 12
	FRAGMENTATION	p 8	DETACHMENT	p 11	SMALL HOLES	p 13
	DISCOLORATION	p 9	DELAMINATION	p 10	TERMITE ACTIVITY	p 12
	STRUCTURAL CRACK	p 9	SURFICIAL CRACK	p 11	DROPPINGS	p 12
				PITTING	p 11	



PLASTER

Area of remaining historic plaster layer (gypsum, lime, mud plaster).



Indicates the presence of any original layers of plaster: mud plaster, lime, or gypsum.



ADOBE

Indicates areas of exposed original adobe wall.





Loss of top layer of plaster on column on west side of the nave.

PLASTER

Denotes any loss beyond the top layer of gypsum plaster.



Loss of historic features in the sanctuary.



ADOBE

Denotes loss to adobe layers.

Loss occurring in mortar joints between adobe bricks.



Larger scale loss of entire segments of adobe bricks.



EDGING (PLASTER)

Stabilizing treatment applied to the edges of original plaster.

Edge treatments varied in material and application. They were observed as adjoining to both adobe and plaster, or between plaster layers.



RECONSTRUCTION (ADOBE)

Portions of the adobe walls that have been completely reconstructed with new adobe bricks.

Reconstructed portions of wall can be recognized by the size, integrity and texture of the newer adobe and are clearly differentiated from the original wall material.

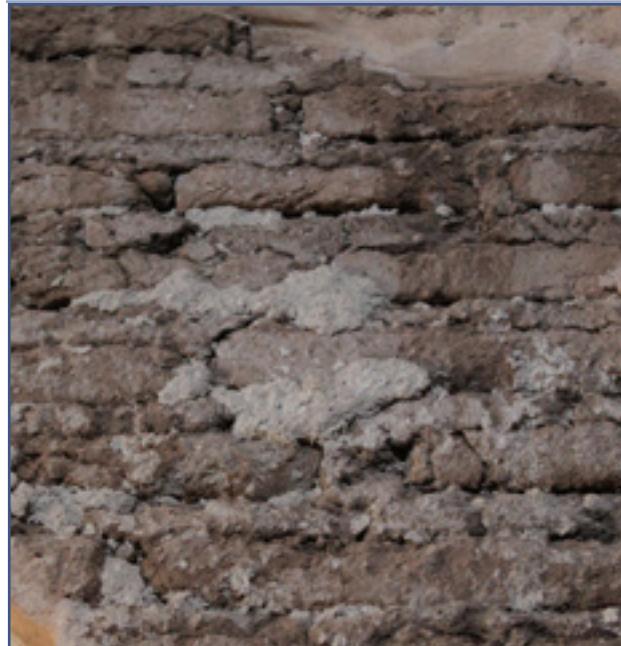
Clear edges between reconstructed and original segments of adobe walls.





FILL (PLASTER)

Patching and fill repairs applied to plaster surfaces.



FILL (ADOBE)

Areas where fill repairs have been applied to adobe substrate.



INCISIONS

Original incised decorations on plaster



An incised semi-circular border runs along the top of the nave walls.



Two incised birds were observed in the upper left corner of the Choir Loft.



Etching was recorded along features, such as niches and columns.





PAINTED SURFACE

Areas of original Pigment on plaster



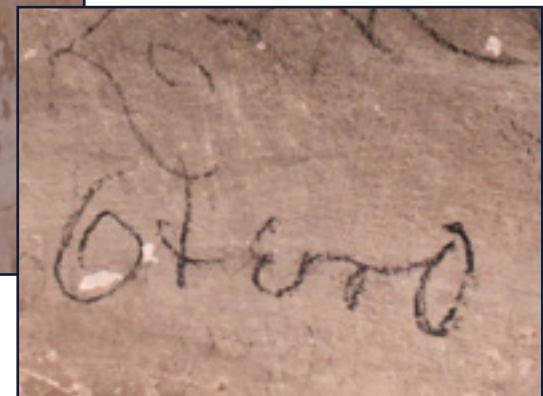


PUGHOLES

Historic structural support holes.

HISTORIC GRAFFITI

Areas containing historic graffiti (etched or drawn in charcoal) keyed to corresponding photograph of detail.



CONDITIONS

ADOBE

PLASTER

SURFACE DEPOSITS/ANIMAL ACTIVITY



DISINTEGRATION

Areas where adobe surface has deteriorated and exhibits active granular breakdown (surface loss occurs when touched).

Often observed in conjunction with discoloration and a general deformation of adobe brick (outline of individual bricks obscured due to breakdown).



FRAGMENTATION

Areas where individual adobe bricks exhibit visible structural cracks due to stress or pressure.



CONDITIONS

ADOBE

PLASTER

SURFACE DEPOSITS/ANIMAL ACTIVITY

DISCOLORATION

Areas in which adobe is visibly darker than surrounding material.



STRUCTURAL CRACK

Structural crack that penetrates the adobe substrate.



CONDITIONS

ADOBE

PLASTER

SURFACE DEPOSITS/ANIMAL ACTIVITY



VOID

Areas in which plaster has visibly bulged or pulled away from substrate creating a gap between the plaster and the adobe, often found in conjunction with significant cracking or holes. Voids were identified by knocking when possible, or when a visible bulge in the plaster was present.

Asterisks within polygons denote areas of concern.



DELAMINATION

Areas in which visible detachment has occurred between adjacent layers of plaster.



CONDITIONS

ADOBE

PLASTER

SURFACE DEPOSITS/ANIMAL ACTIVITY

**DETACHMENT**

Areas in which plaster has visibly detached from adobe substrate.

**SURFICIAL CRACK**

Smaller surface cracks occurring only in the top layer of material.

PITTING

Areas of concentrated loss in top layer of plaster caused by "lime pops." Recorded only in upper corners of Sanctuary.



CONDITIONS

ADOBE

PLASTER

SURFACE DEPOSITS/ANIMAL ACTIVITY

**RUNNELING**

Muddy surface deposits or channels along adobe caused by rivulets of water.

**TERMITE ACTIVITY**

Areas of visible surface deposits indicative of termite activity within the adobe.

DROPPINGS

Areas of visible surface deposits indicative of termite activity within the adobe.



CONDITIONS

ADOBE

PLASTER

SURFACE DEPOSITS/ANIMAL ACTIVITY



SMALL HOLES

Holes created by insect or small animal activity in both adobe and plaster surfaces.

Small, deep holes observed in lower half of plastered portion of sanctuary walls.



APPENDIX B

PRELIMINARY CONDITIONS ASSESSMENT FIELD GUIDE

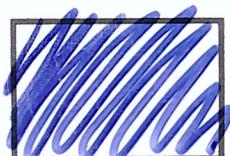
TUMA CONDITION ASSESSMENT GUIDE

HISTORIC FEATURES

SURFACE DECORATIONS

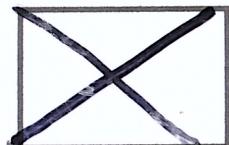


HISTORIC GRAFITTI



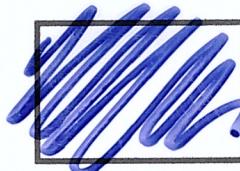
INCISIONS

etched decorations (eg. The semi-circle border around the top of each wall)



PAINTED SURFACE

not recorded in this investigation



GRAFITTI AREA



ASSESSMENTS 3

TUMA CONDITION ASSESSMENT GUIDE

CONDITIONS PART ONE

CRACKS



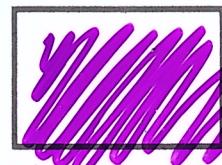
DETACHMENT



STRUCTURAL
penetrate substrate (adobe)



SURFICIAL
penetrate stucco surface



DETACHMENT
from substrate

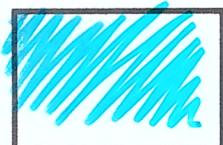


DELAMINATION
separation between adjacent layers of surface (gypsum and mud stucco)

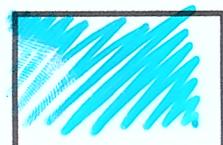
TUMA CONDITION ASSESSMENT GUIDE

ENVIRONMENTAL MONITORS

WATER

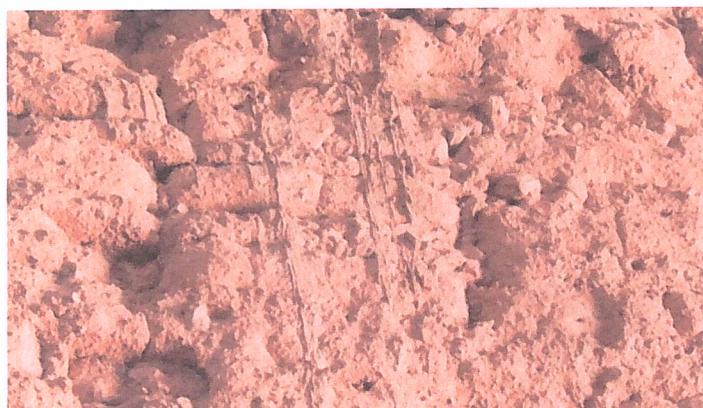


WETNESS/DAMP



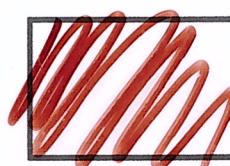
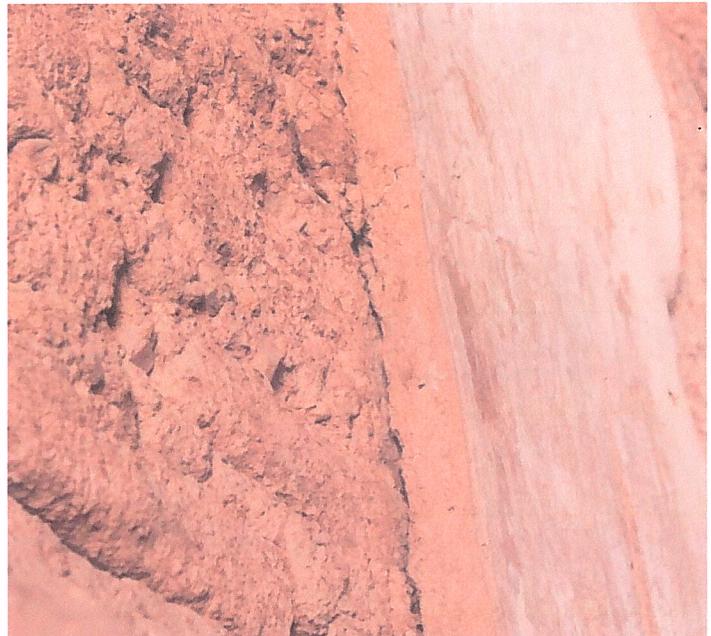
RUNNELING
ON
ADOBE

BIOOPENETRATION



PLANT GROWTH

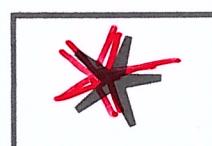
SURFACE DEPOSITS



SUR. DEPOSITS

Goal is to mark items that need cleaning with poultice brush or scalpel. *(over)*

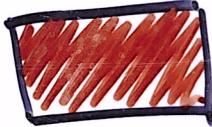
ELECTRICAL SENSORS



SENSORS

short red/black wires penetrating walls

SURFACE DEPOSITS

- 1  - DROPPINGS
(animal or bird)
- 2  - TUNNELING
(mud deposits on top)
PLASTER

Repair

Fill 
grout + patching added to void
space where loss occurred

Reconstruction

 replacement of
loss - adobe
(structural)

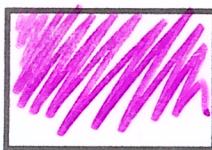
TUMA CONDITION ASSESSMENT GUIDE

CONDITIONS PART TWO

HOLES/INDENTATIONS



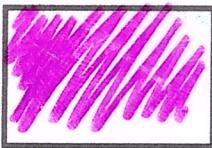
A



~~SMALL LOSS~~

adobe fragment, lost mortar gaps
(smaller than a fist)

B



PUGHOLES

historic scaffolding supports

C



ANIMAL HOLES

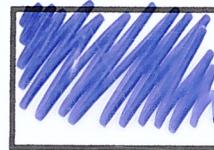
insect, squirrel, bird burrows

DISINTEGRATIONS



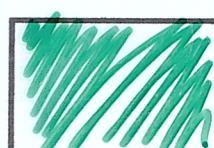
~~DISINTEGRATION~~

surface of substrate has deteriorated and become susceptible to granular breakdown.



~~FRAGMENTATION~~

brick level resolution (mark with lines), a potential subset of disintegration where a loss of structural stability has occurred. Will be evident by presence of many substrate cracks through a single adobe brick.



~~VOID~~ - - - - -

(mark areas) subsurface cavity, generally invisible but can be tested with a light tapping on the surface to listen for hollow spaces. Most interested in spaces where stucco appears fatigued and indicate imminent failure. Make special note of cases where "bulging" is occurring.



TUMA CONDITION ASSESSMENT GUIDE

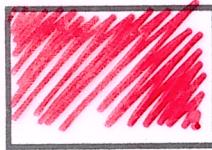
MATERIAL INTEGRITY

Analysis of the composition of structure to evaluate the present condition with regard to deterioration and repair conditions. Summary overview that primarily focuses on recording remaining stucco surface and the repair/reinforcement conditions.

LOSS



REPAIR



LOSS

Observed missing material down to the substrate as classified utilizing Part 3. Condition codes. All loss will be shown in RED for documentation summary, but will be further color coded by condition. Since majority of wall surfaces is a "loss" only the areas within the stucco will be circled red (ie: a hole through stucco down to substrate). During digitizing, large surface areas will be created tracing stucco and then utilizing the inverse space to create closed polygons for area calculations.

MATERIAL CODES

1. Gypsum-Lime Stucco
2. Mud Stucco/
3. Concrete/Portland Cement
4. Fire Baked Red Brick



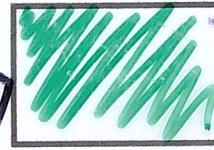
EDGING

reinforcement to border of render surface

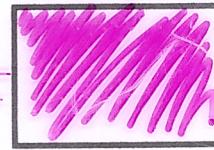


FILL (Becky)

grout and patching added to void space where loss occurred



~~RENDER PLASTER~~ AREA
stucco surface cover



JOINTS (Pattern change)

where reconstruction sections meet historic walls. Newer adobe will be identified



RECONSTRUCTION

replacement of loss, generally for structural reinforcement since TUMA is a preservation not restoration site

APPENDIX C

INTERIOR CONDITIONS ASSESSMENT MAPS

TABLE OF CONTENTS

Section One: Mission Church Nave

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Historic Features.....	2
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EAST WALL

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CHOIR LOFT

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Section Two: Mission Church Sanctuary

WEST WALL

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NORTH WALL

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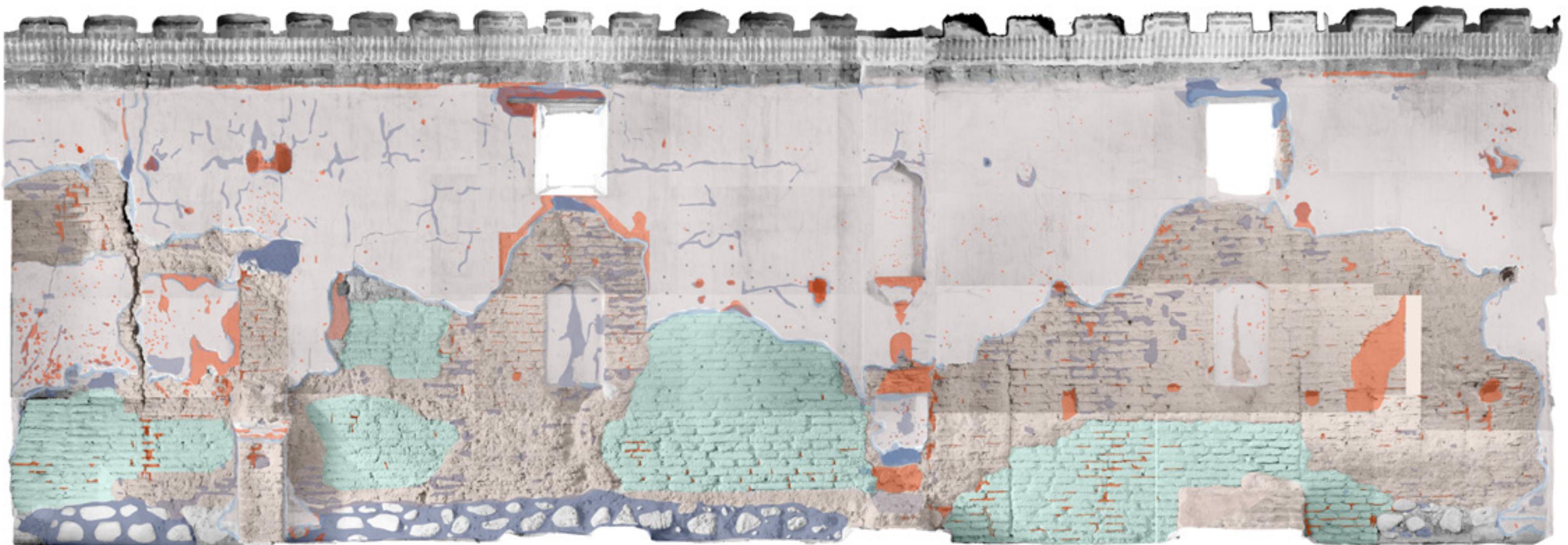
EAST WALL

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SOUTH WALL

Material Integrity.....	39
Historic Features.....	40
Conditions.....	41

TUMACACORI MISSION CHURCH
WEST WALL: MATERIAL INTEGRITY



MATERIALS

- PLASTER
- ADOBE

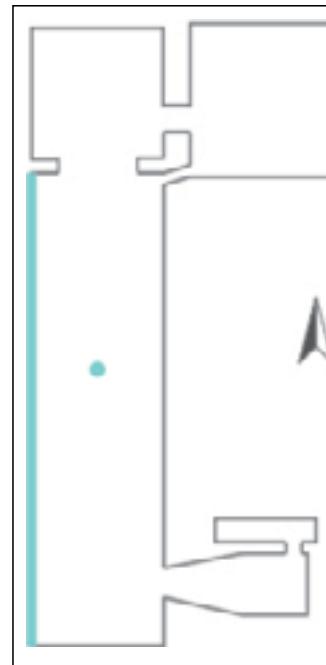
LOSS

- PLASTER LAYERS
- ADOBE SUBSTRATE

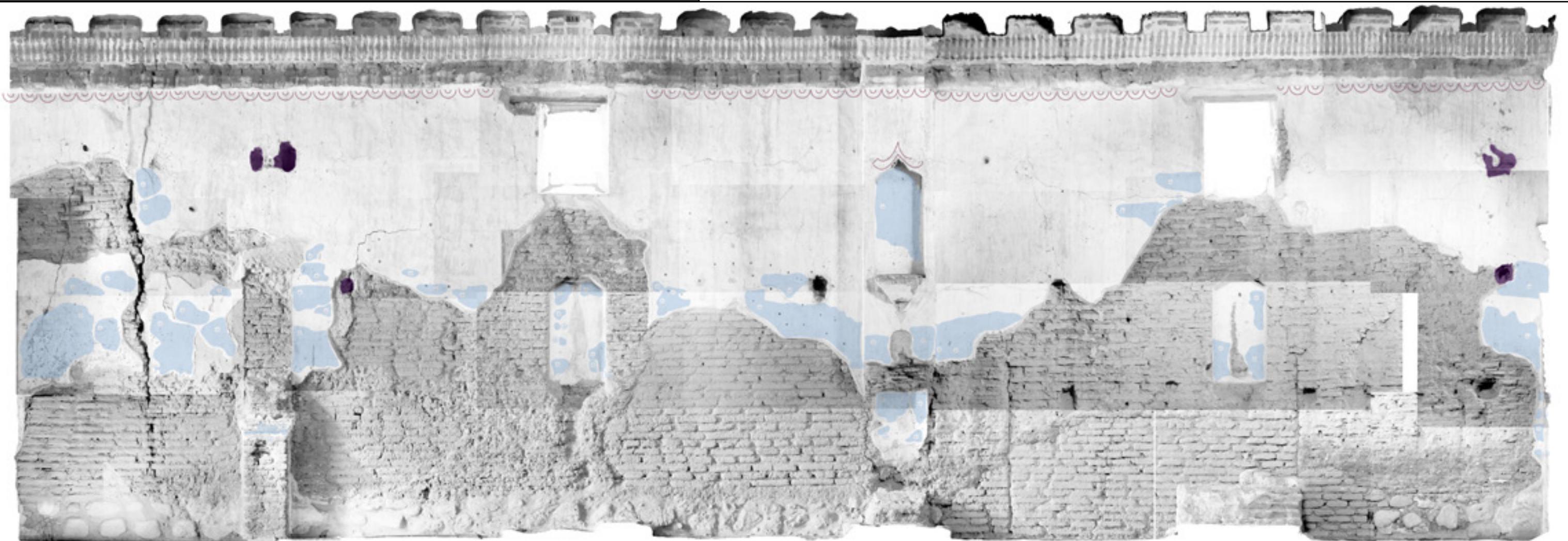
REPAIR

- EDGING
- RECONSTRUCTION
- FILL (ADOBE)
- FILL (PLASTER)

COMMENTS:



TUMACACORI MISSION CHURCH
WEST WALL: HISTORIC FEATURES



DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE

ARCHITECTURAL FEATURES

- PUGHOLES

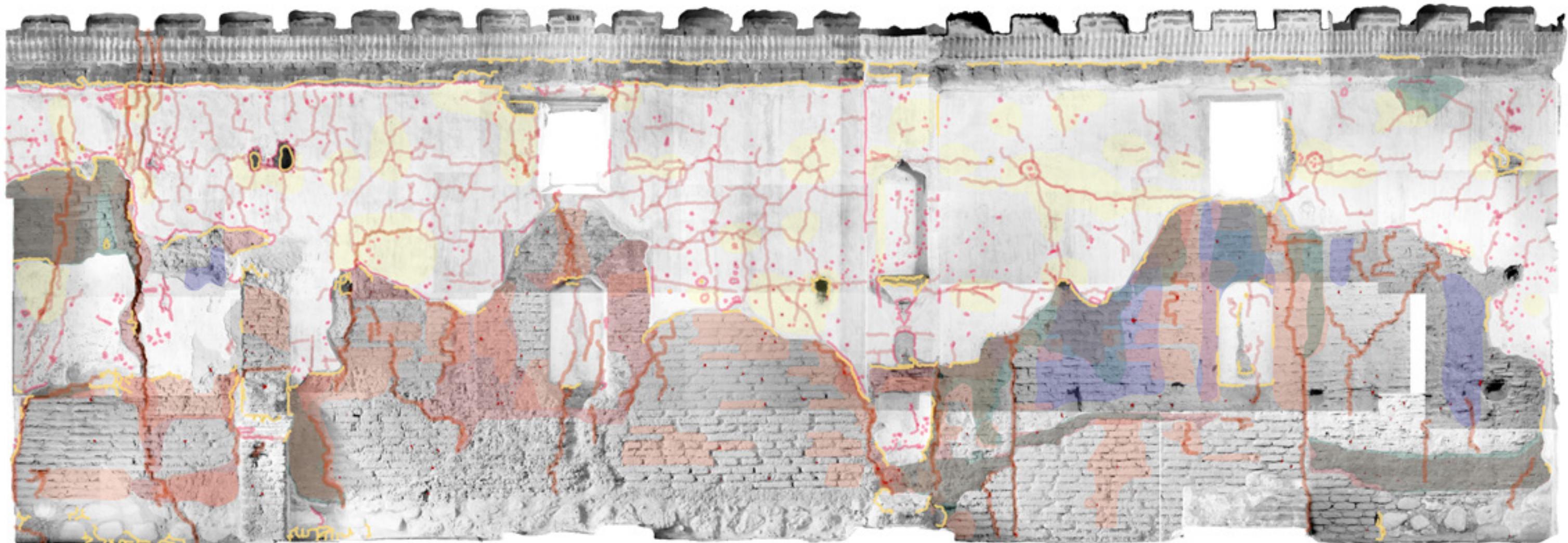
GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH
WEST WALL: CONDITIONS



ADOBE

- █ DISINTEGRATION
- █ FRAGMENTATION
- █ DISCOLORATION
- / STRUCTURAL CRACK

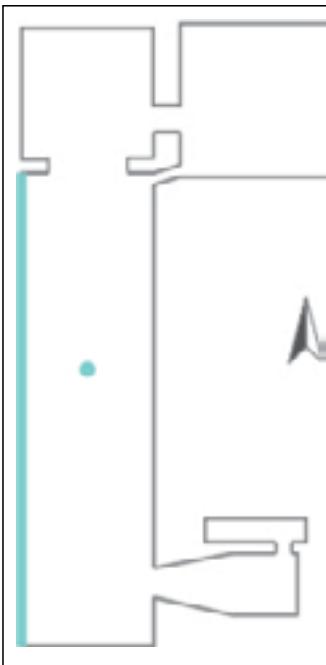
PLASTER

- █ VOID
- / DELAMINATION
- / DETACHMENT
- / SURFICIAL CRACK

SURFACE DEPOSITS/
ANIMAL ACTIVITY

- █ RUNNELING
- █ TERMITE ACTIVITY
- █ DROPPINGS
- █ SMALL HOLES

COMMENTS:



TUMACACORI MISSION CHURCH
EAST WALL: MATERIAL INTEGRITY



MATERIALS

- PLASTER
- ADOBE

LOSS

- PLASTER LAYERS
- ADOBE SUBSTRATE

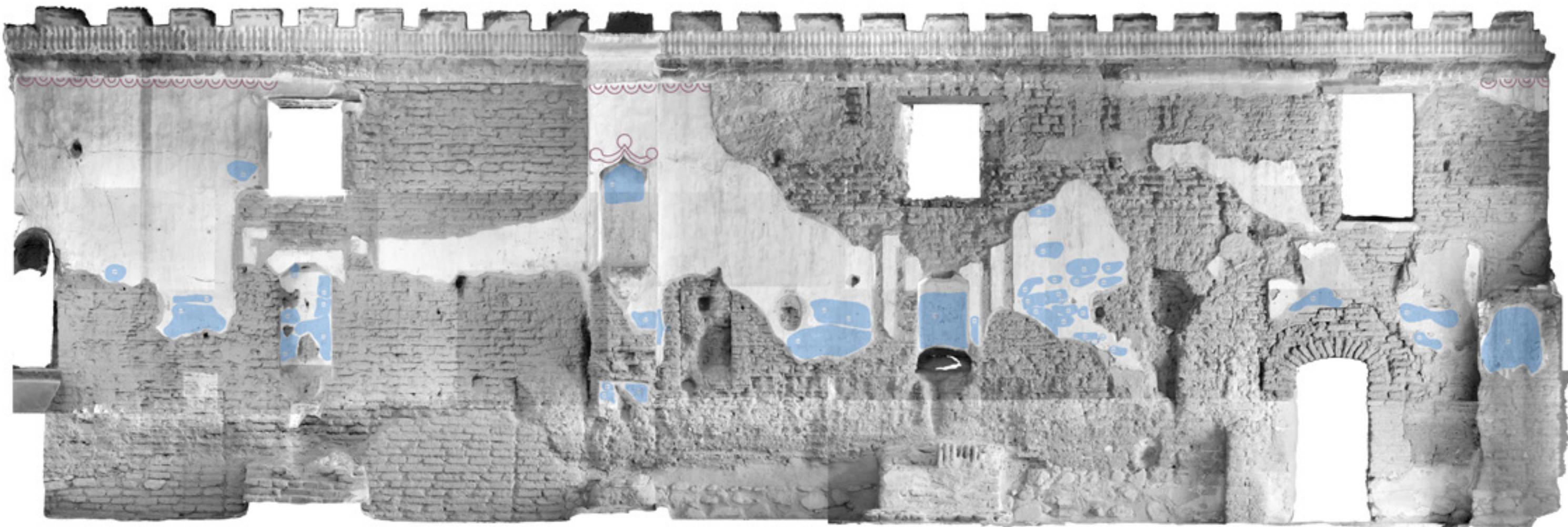
REPAIR

- EDGING
- RECONSTRUCTION
- FILL (ADOBE)
- FILL (PLASTER)

COMMENTS:



TUMACACORI MISSION CHURCH EAST WALL: HISTORIC FEATURES



DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE

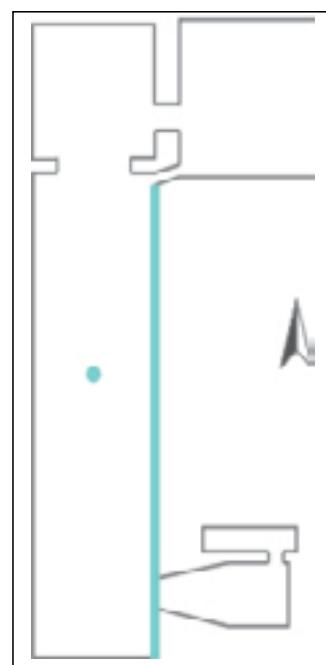
ARCHITECTURAL FEATURES

- PUGHOLES

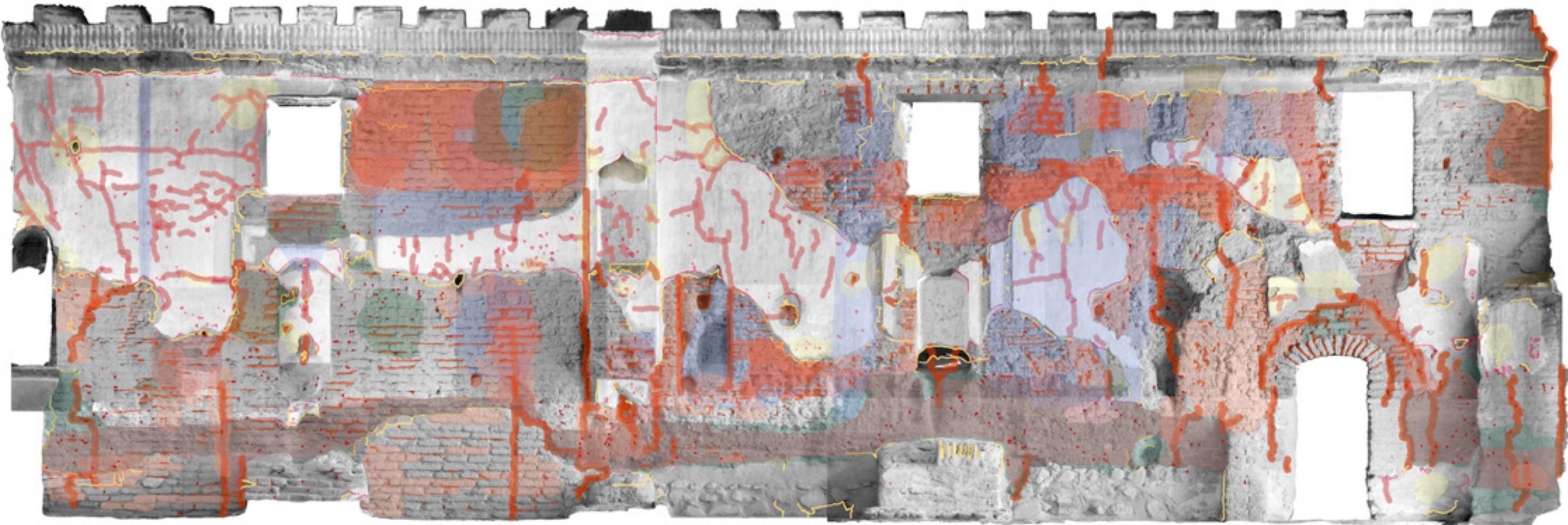
GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH
EAST WALL: CONDITIONS



ADOBE

- █ DISINTEGRATION
- █ FRAGMENTATION
- █ DISCOLORATION
- / STRUCTURAL CRACK

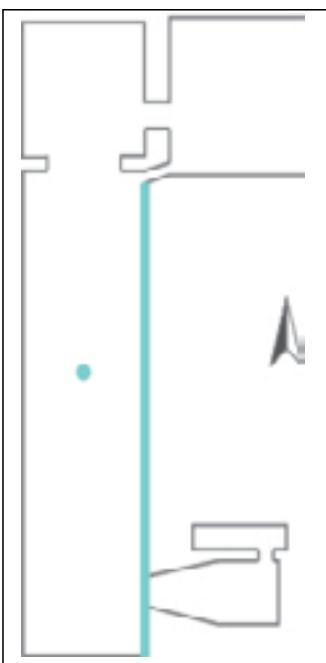
PLASTER

- VOID
- / DELAMINATION
- / DETACHMENT
- / SURFICIAL CRACK

SURFACE DEPOSITS/
ANIMAL ACTIVITY

- █ RUNNELING
- █ TERMITE ACTIVITY
- █ DROPPINGS
- █ SMALL HOLES

COMMENTS:



TUMACACORI MISSION CHURCH: CHOIR LOFT: MATERIAL INTEGRITY

MATERIALS

- PLASTER
- ADOBE

LOSS

- PLASTER LAYERS
- ADOBE SUBSTRATE

REPAIR

- EDGING
- RECONSTRUCTION
- FILL (ADOBE)
- FILL (PLASTER)

COMMENTS:



TUMACACORI MISSION CHURCH: CHOIR LOFT: HISTORIC FEATURES

DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE

ARCHITECTURAL FEATURES

- PUGHOLES

GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH: CHOIR LOFT: CONDITIONS

ADOBE

- DISINTEGRATION
- FRAGMENTATION
- DISCOLORATION
- STRUCTURAL CRACK

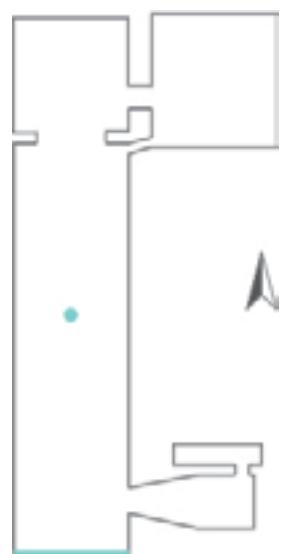
PLASTER

- VOID
- DELAMINATION
- DETACHMENT
- SURFICIAL CRACK

SURFACE DEPOSITS/ANIMAL ACTIVITY

- RUNNELING
- DROPPINGS
- SMALL HOLES

COMMENTS:



TUMACACORI MISSION CHURCH

SIDE ALTARS

WEST WALL, ALTAR ONE, WEST VIEW

MATERIALS

PLASTER
FIRED BRICK

LOSS

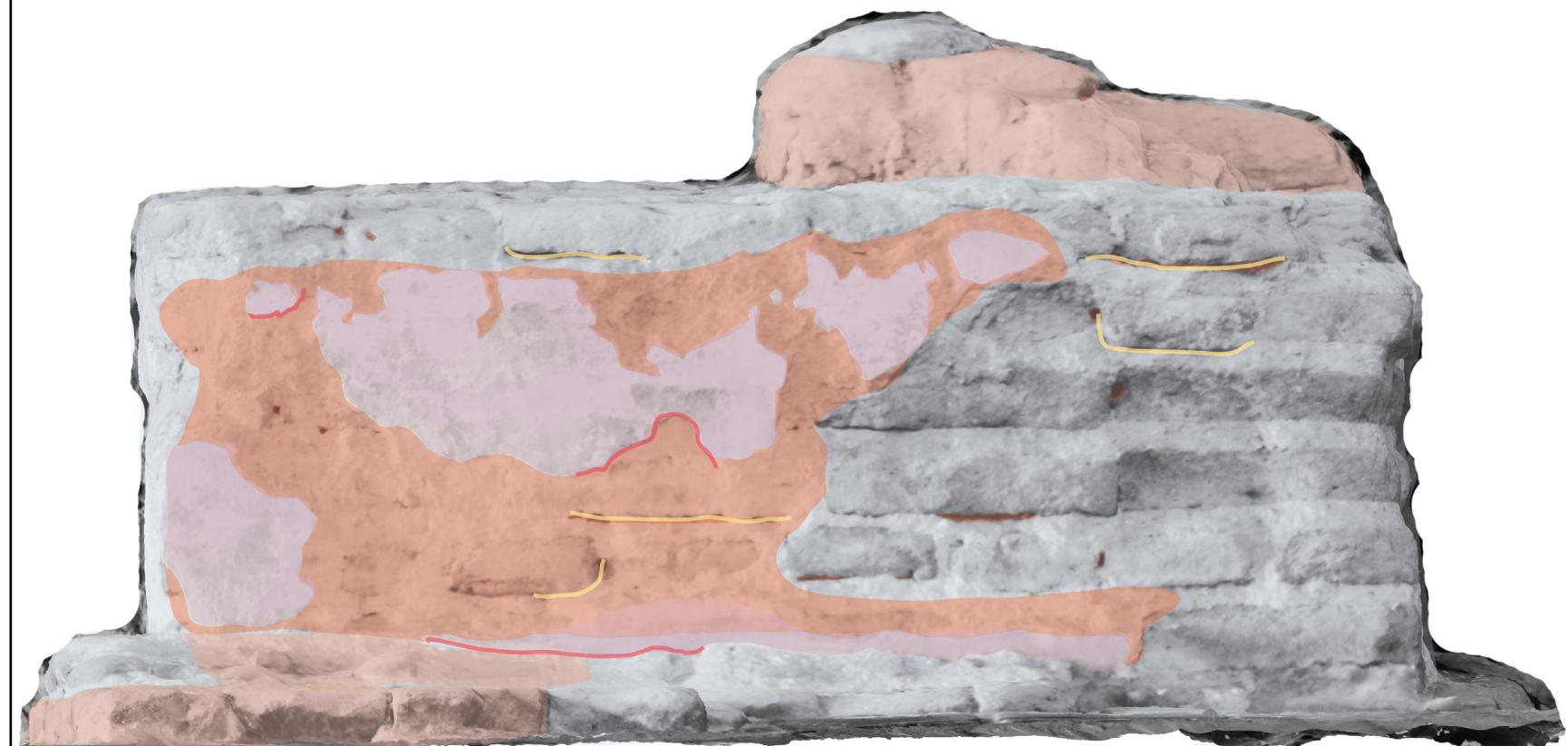
PLASTER LAYERS
BRICK SUBSTRATE

HISTORIC FEATURES

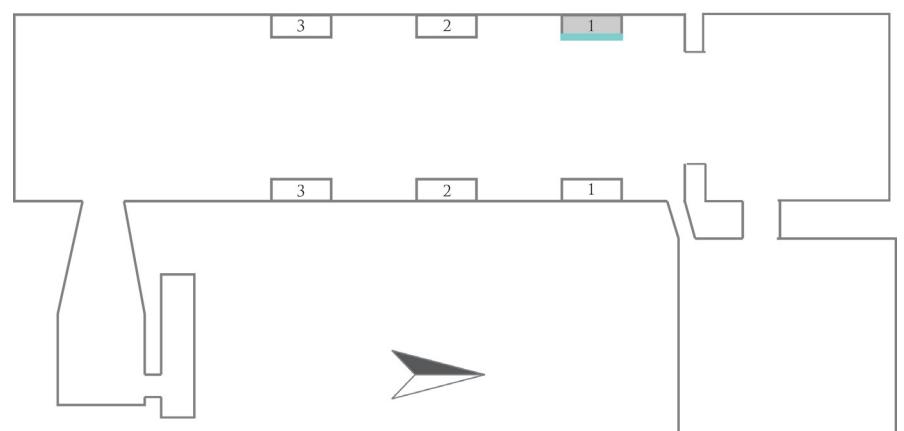
PAINTED SURFACES

CONDITIONS

FRAGMENTATION
DETACHMENT
DELAMINATION
ANIMAL HOLES



PLAN VIEW, KEY



WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

WEST WALL, ALTAR ONE, NORTH VIEW

MATERIALS

- PLASTER
- FIRED BRICK

CONDITIONS

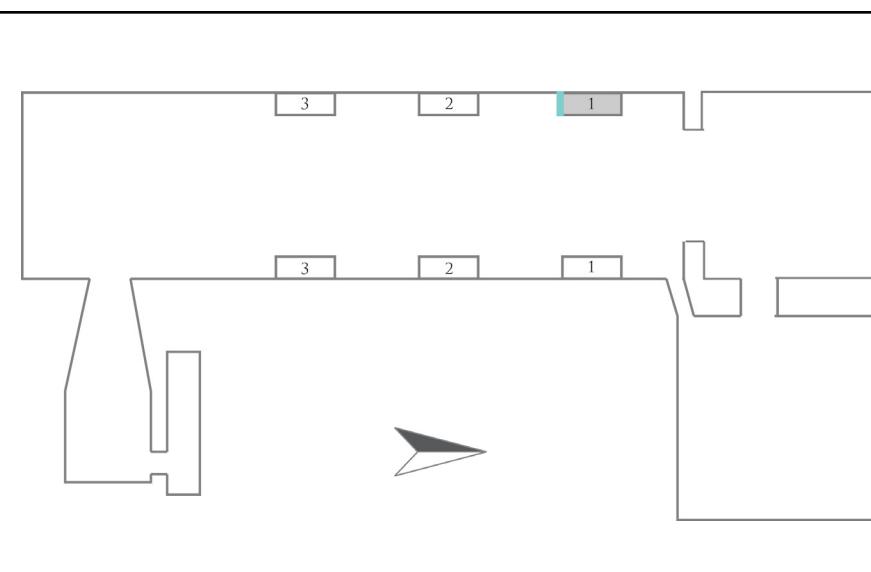
- FRAGMENTATION
- DETACHMENT
- DELAMINATION

LOSS

- PLASTER LAYERS
- BRICK SUBSTRATE

HISTORIC FEATURES

- PAINTED SURFACES



PLAN VIEW, KEY

WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

WEST WALL, ALTAR ONE, SOUTH VIEW

MATERIALS

PLASTER
FIRED BRICK

LOSS

BRICK SUBSTRATE

HISTORIC FEATURES

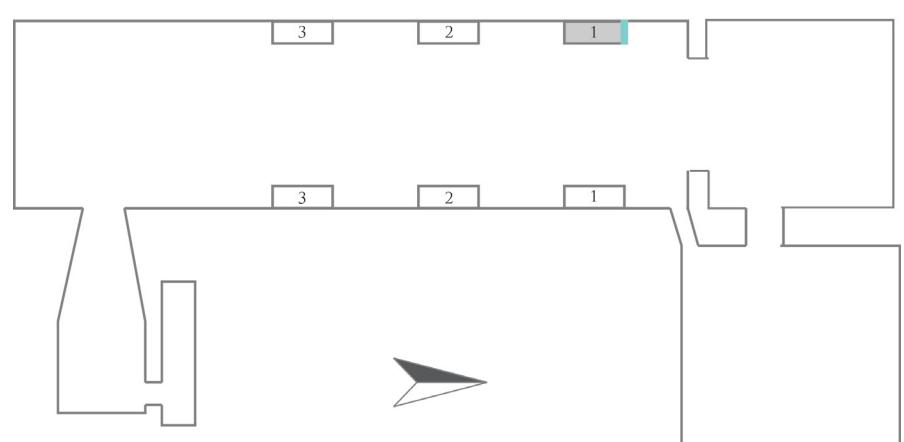
PAINTED SURFACES

CONDITIONS

FRAGMENTATION
DETACHMENT
DELAMINATION
ANIMAL HOLES



PLAN VIEW, KEY



WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

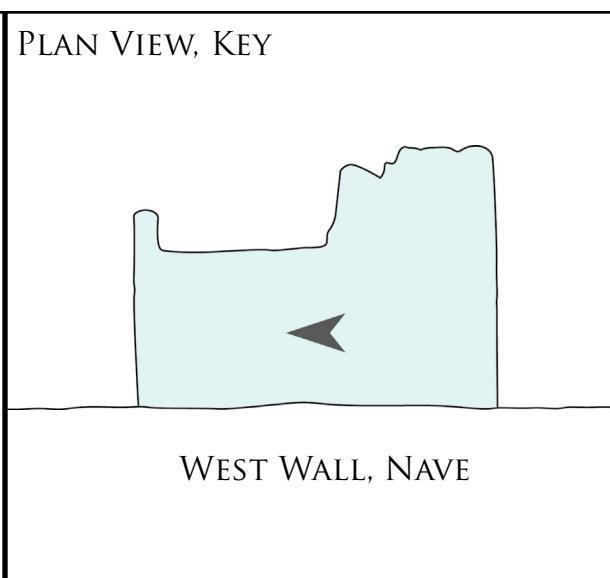
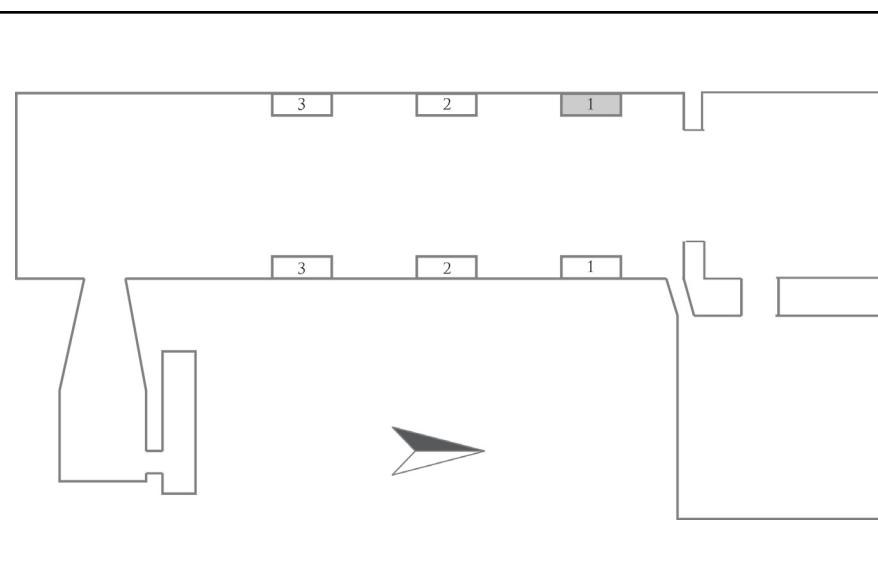
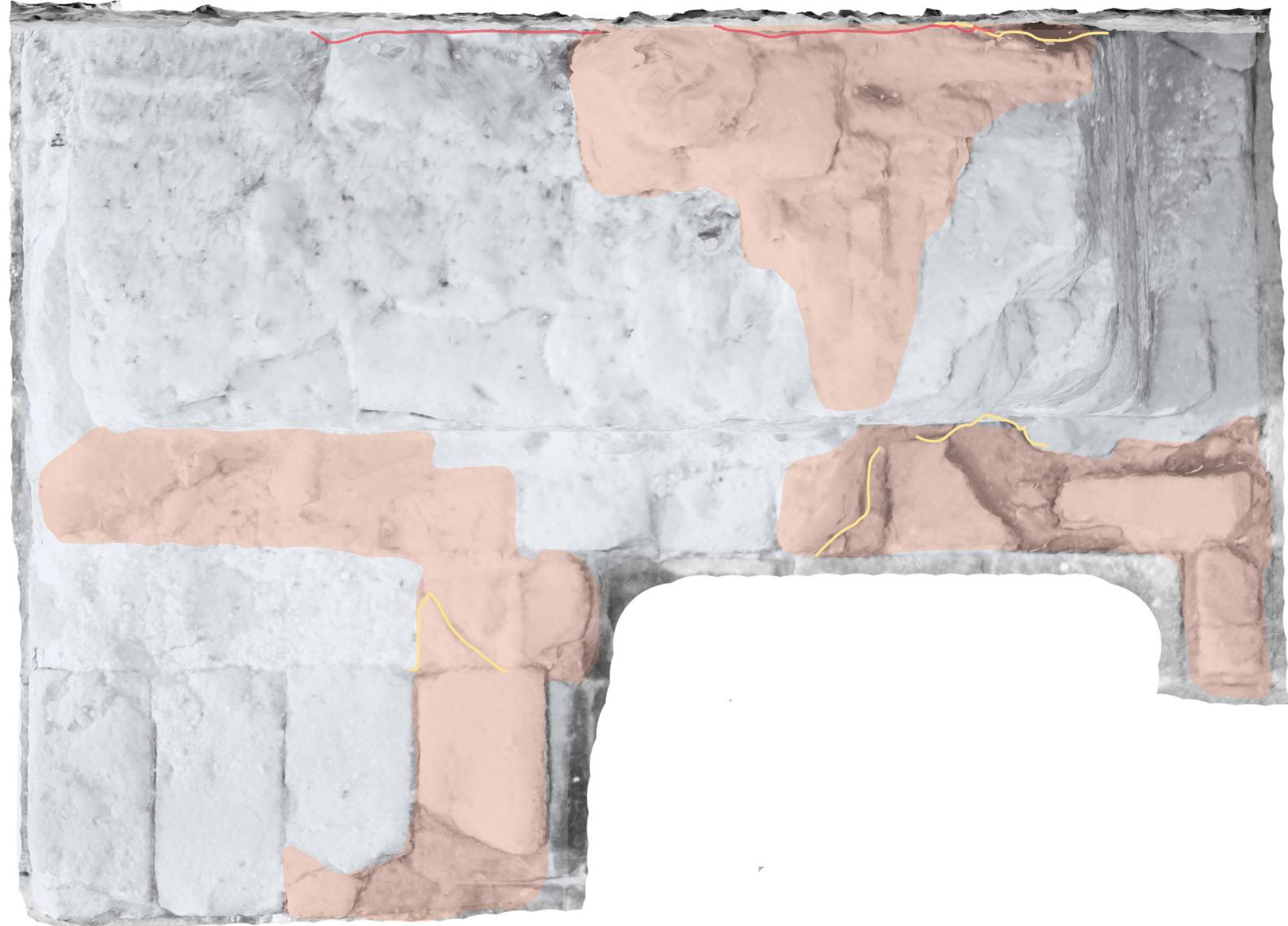
WEST WALL, ALTAR ONE, PLAN VIEW

MATERIALS

 FIRED BRICK

CONDITIONS

-  FRAGMENTATION
-  DETACHMENT
-  DELAMINATION



COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

WEST WALL, ALTAR TWO, WEST VIEW

MATERIALS

- PLASTER
- FIRED BRICK
- ADOBE

LOSS

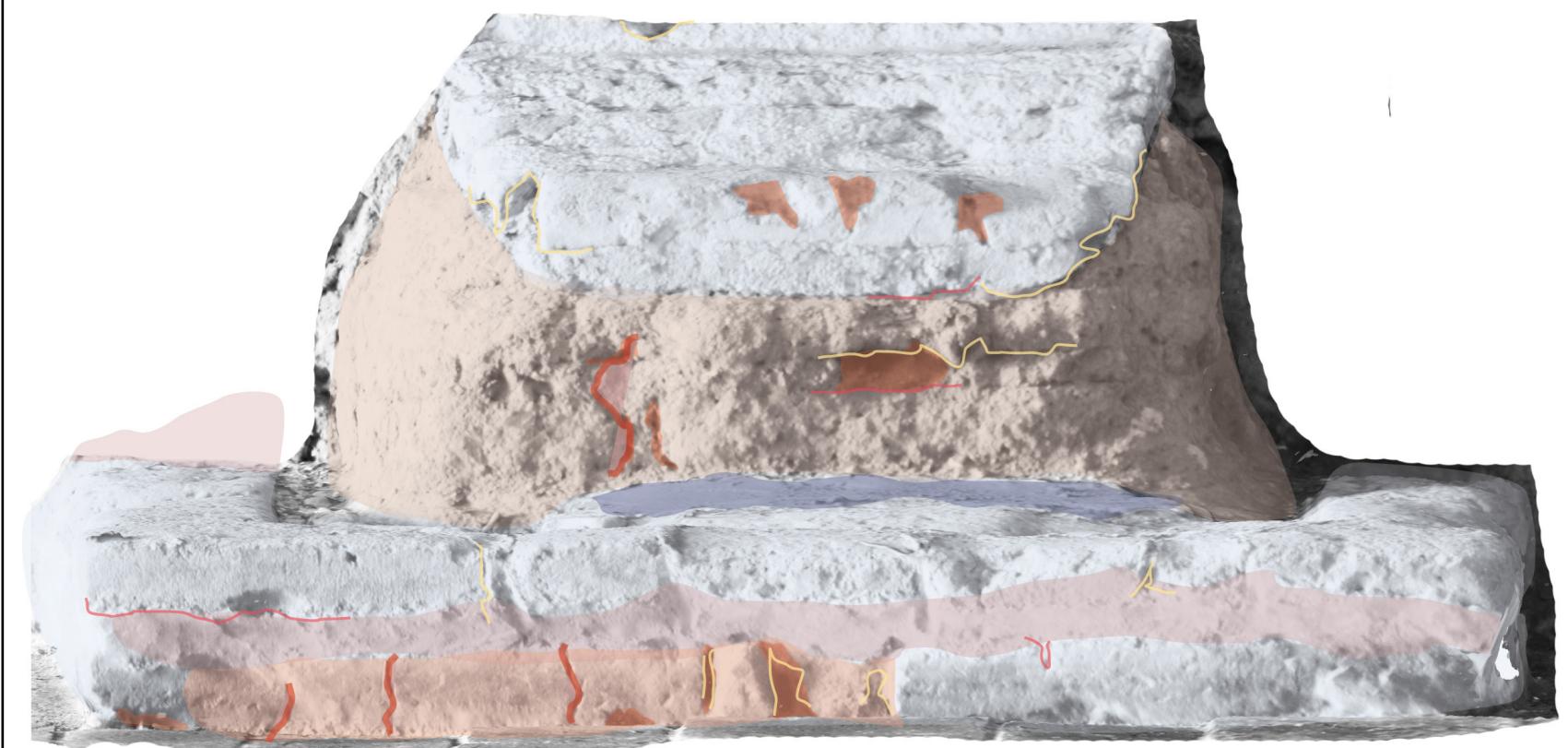
- BRICK SUBSTRATE
- ADOBE SUBSTRATE

REPAIR

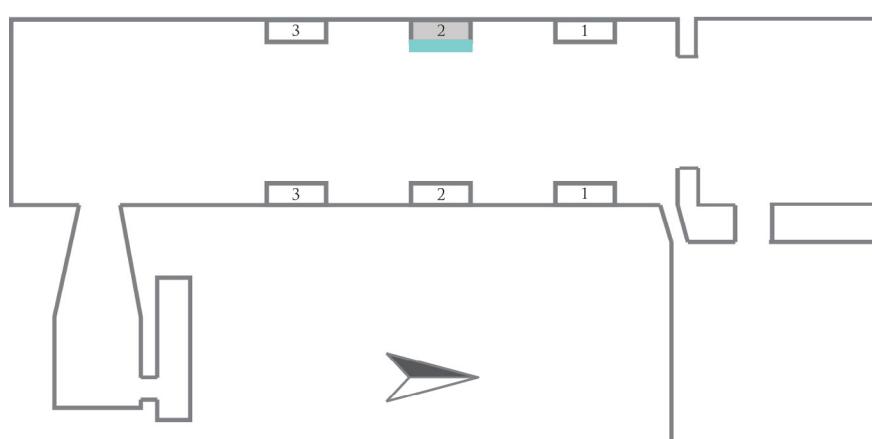
- FILL (BRICK)

CONDITIONS

- FRAGMENTATION
- DETACHMENT
- DELAMINATION
- STRUCTURAL CRACKS



PLAN VIEW, KEY



WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS WEST WALL, ALTAR TWO, NORTH VIEW

MATERIALS

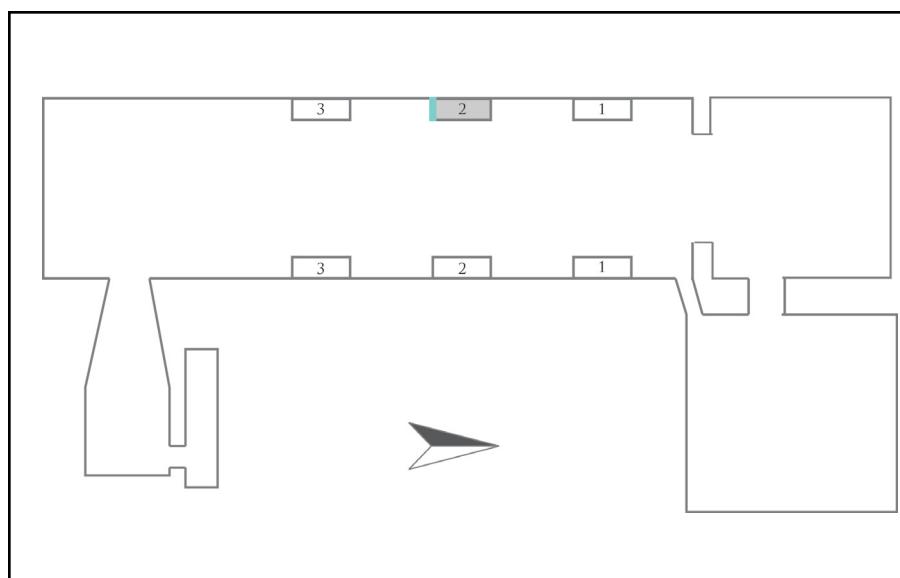
- FIRED BRICK
- ADOBE

LOSS

- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DETACHMENT
- DELAMINATION
- ANIMAL HOLES



PLAN VIEW, KEY

WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS WEST WALL, ALTAR TWO, SOUTH VIEW

MATERIALS

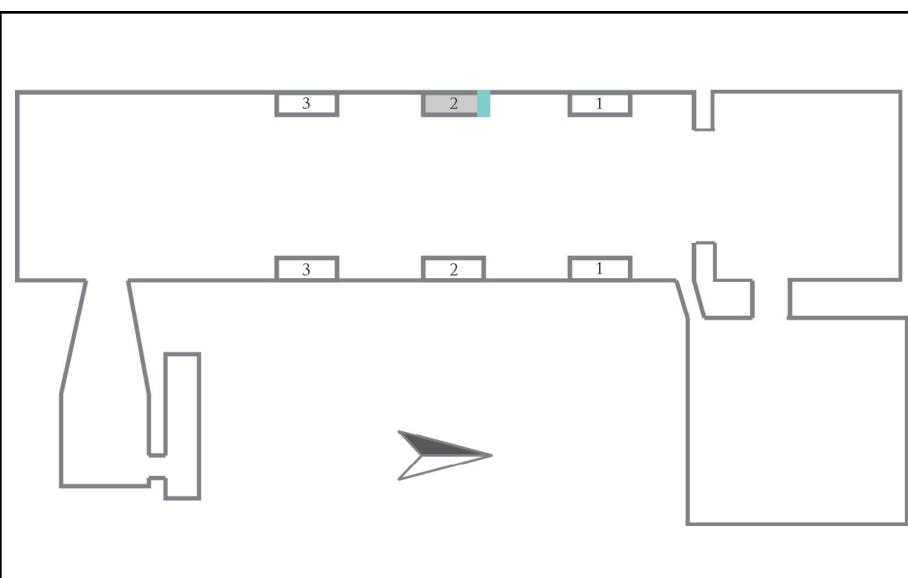
-  FIRED BRICK
-  ADOBE

LOSS

-  ADOBE SUBSTRATE

CONDITIONS

-  DETACHMENT
-  DELAMINATION
-  ANIMAL HOLES



PLAN VIEW, KEY

WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS WEST WALL, ALTAR TWO, PLAN VIEW

MATERIALS

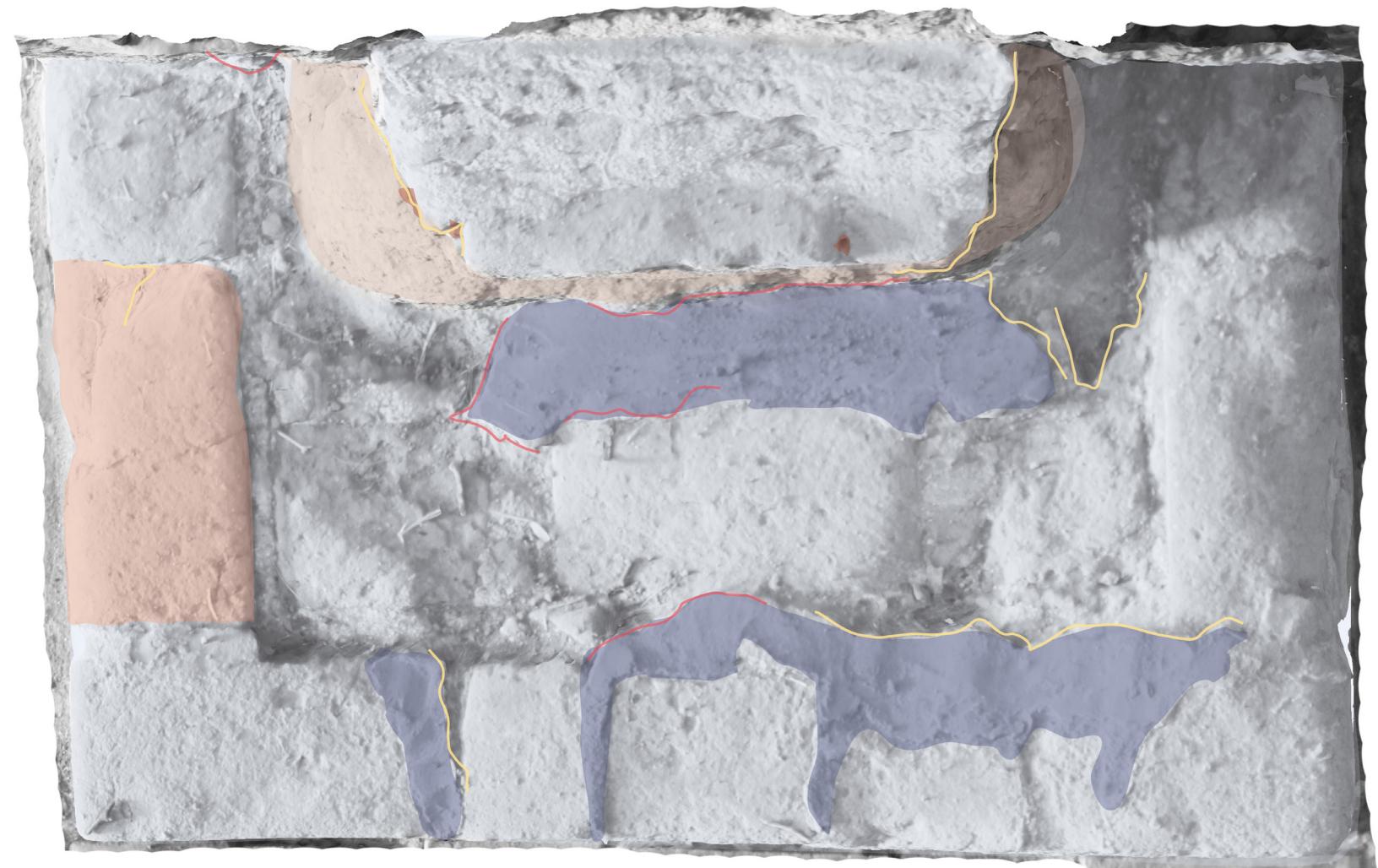
- FIRED BRICK
- ADOBE

REPAIR

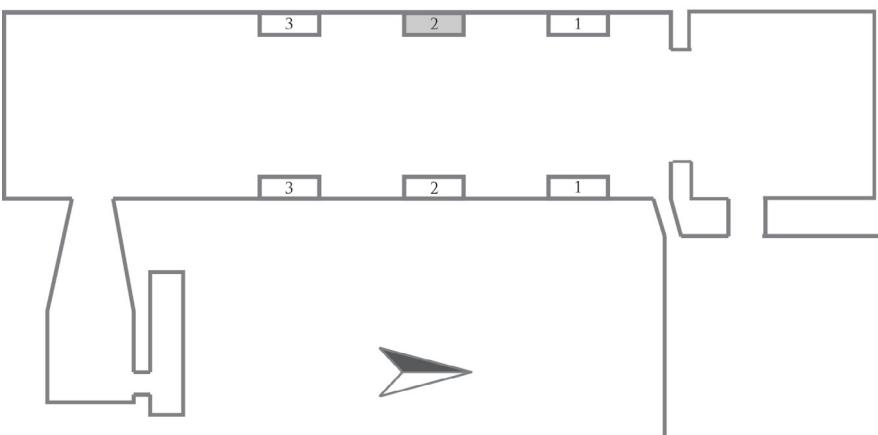
- FILL (BRICK)

CONDITIONS

- FRAGMENTATION
- DETACHMENT
- DELAMINATION
- ANIMAL HOLES



PLAN VIEW, KEY



WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS WEST WALL, ALTAR THREE, PLAN VIEW

MATERIALS

 FIRED BRICK

LOSS

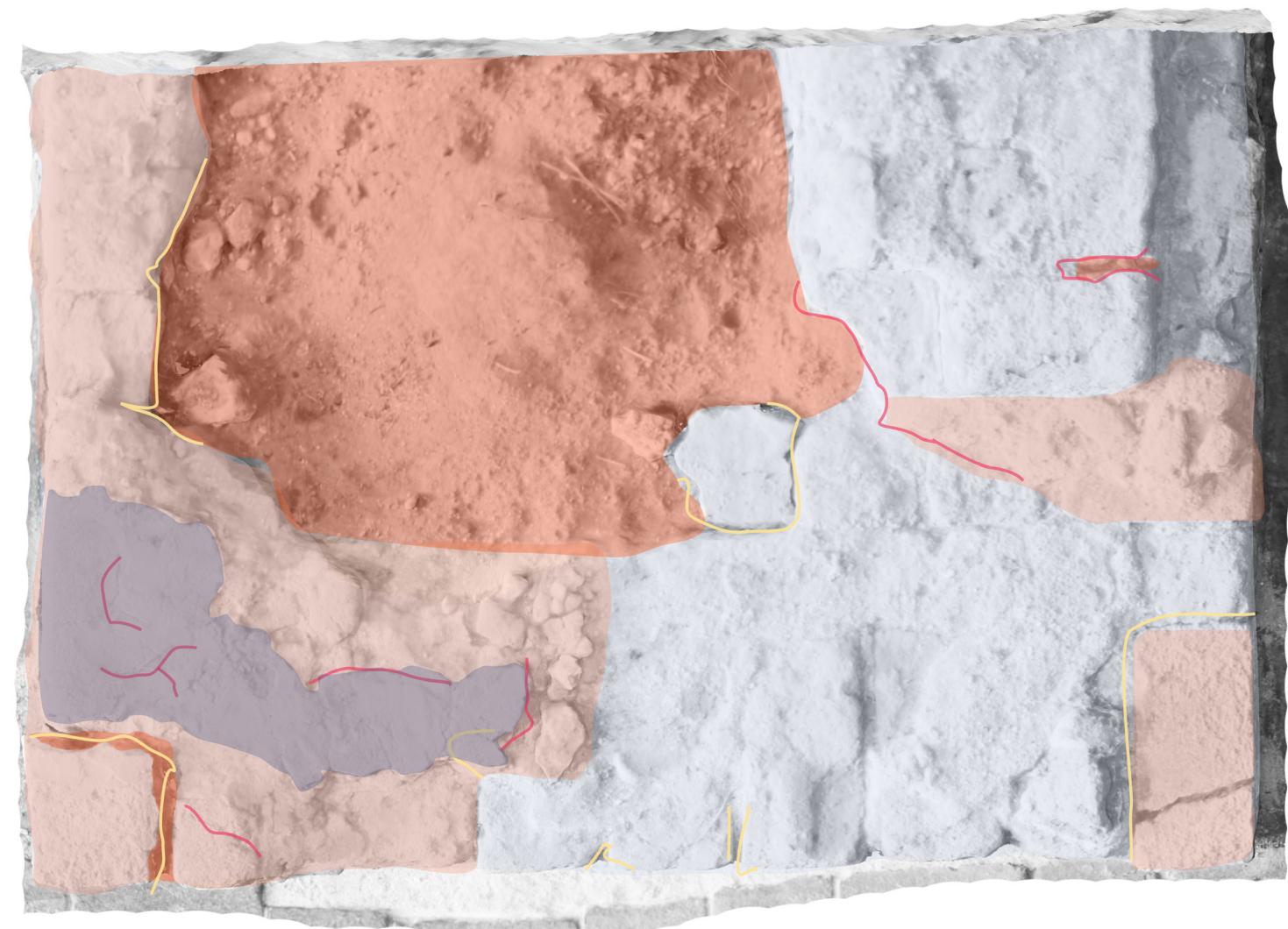
 BRICK SUBSTRATE

REPAIR

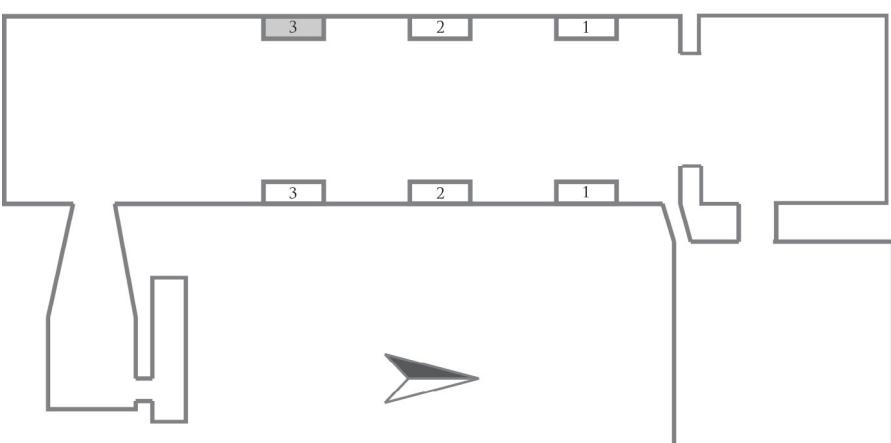
 FILL (BRICK)

CONDITIONS

-  FRAGMENTATION
-  DETACHMENT
-  DELAMINATION



PLAN VIEW, KEY



WEST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

EAST WALL, ALTAR ONE, EAST VIEW

MATERIALS

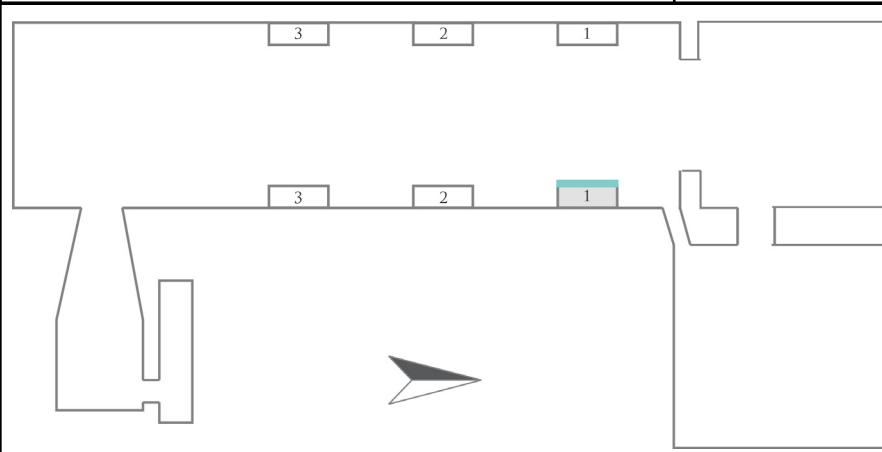
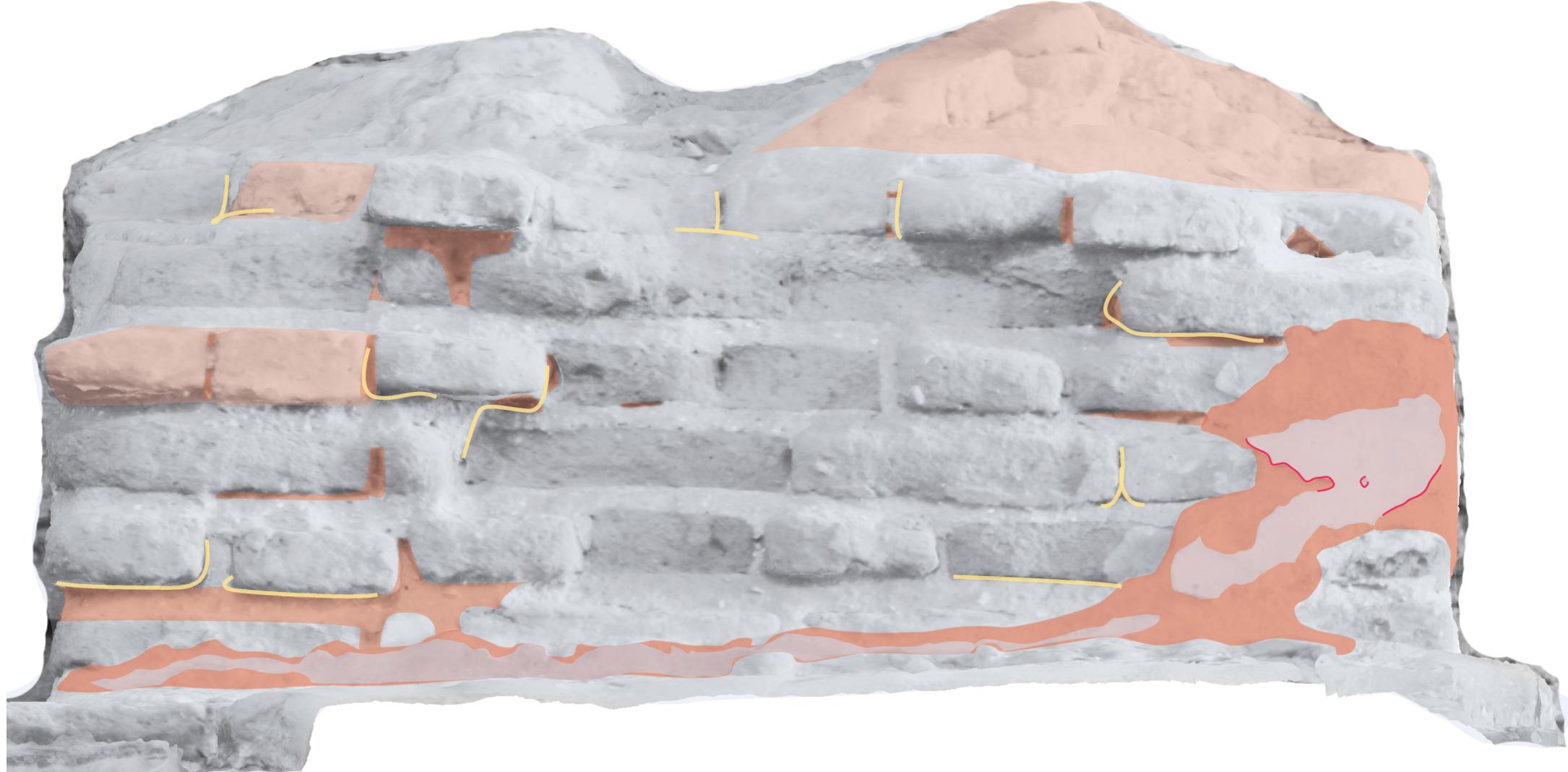
- PLASTER
- FIRED BRICK

LOSS

- PLASTER LAYERS
- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DELAMINATION
- DETACHMENT



PLAN VIEW, KEY

EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS EAST WALL, ALTAR ONE, NORTH VIEW

MATERIALS

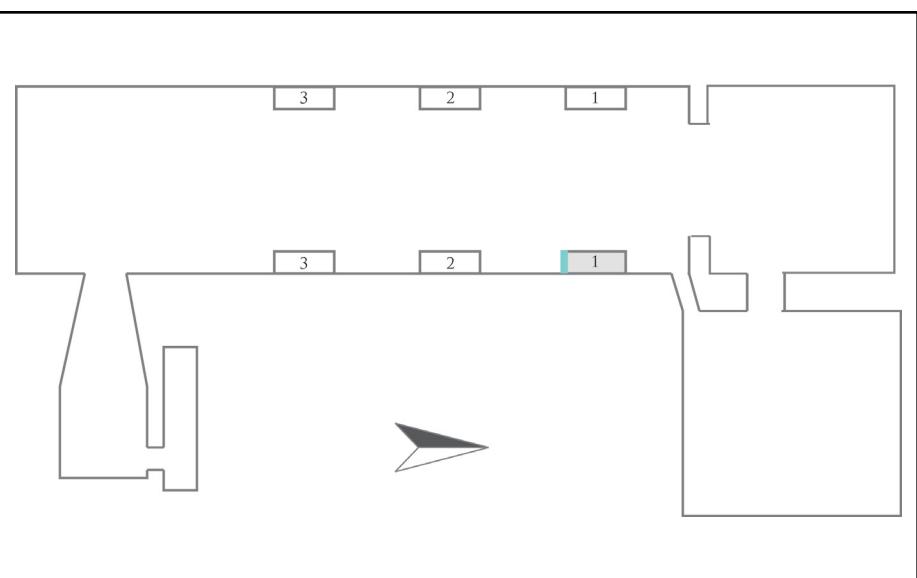
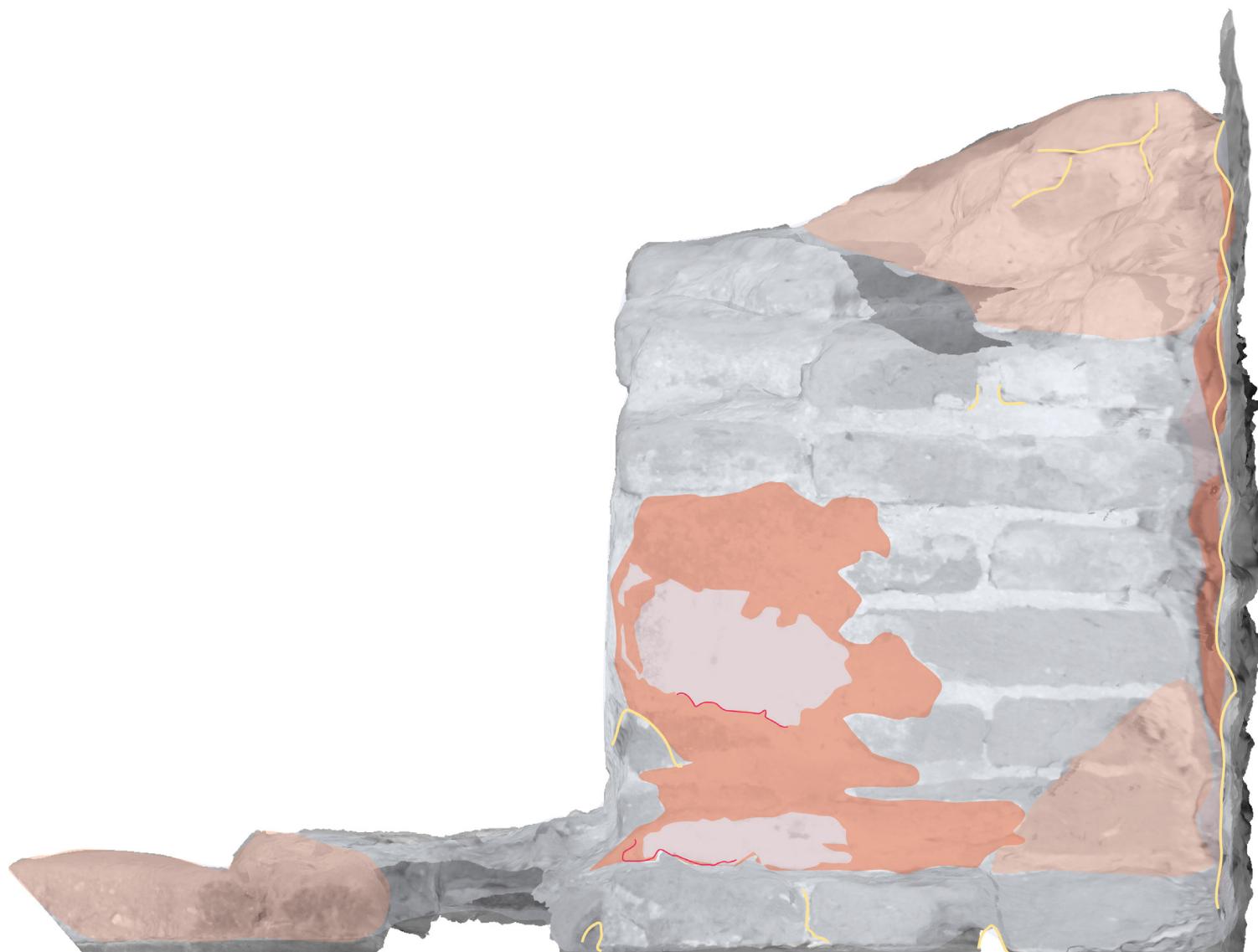
- PLASTER
- FIRED BRICK

LOSS

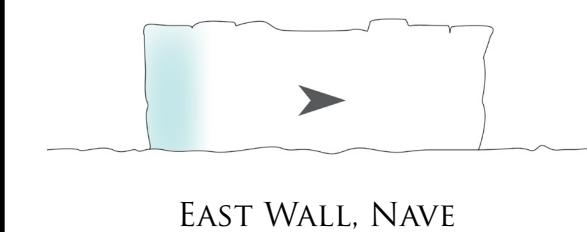
- PLASTER LAYERS
- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DELAMINATION
- DETACHMENT



PLAN VIEW, KEY



EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS EAST WALL, ALTAR ONE, SOUTH VIEW

MATERIALS

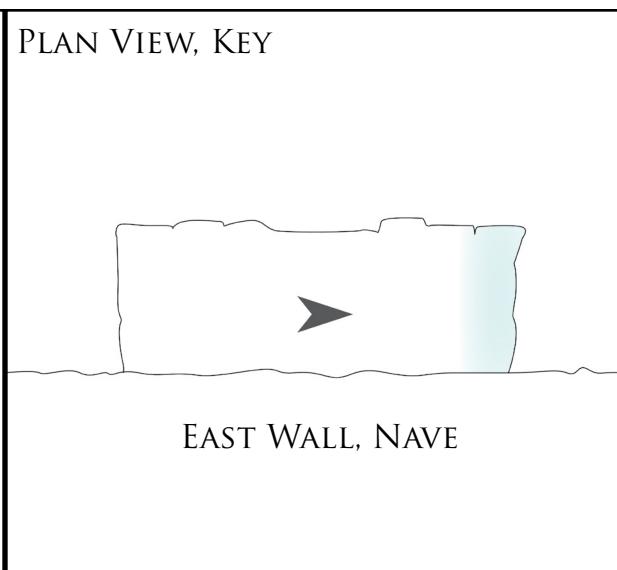
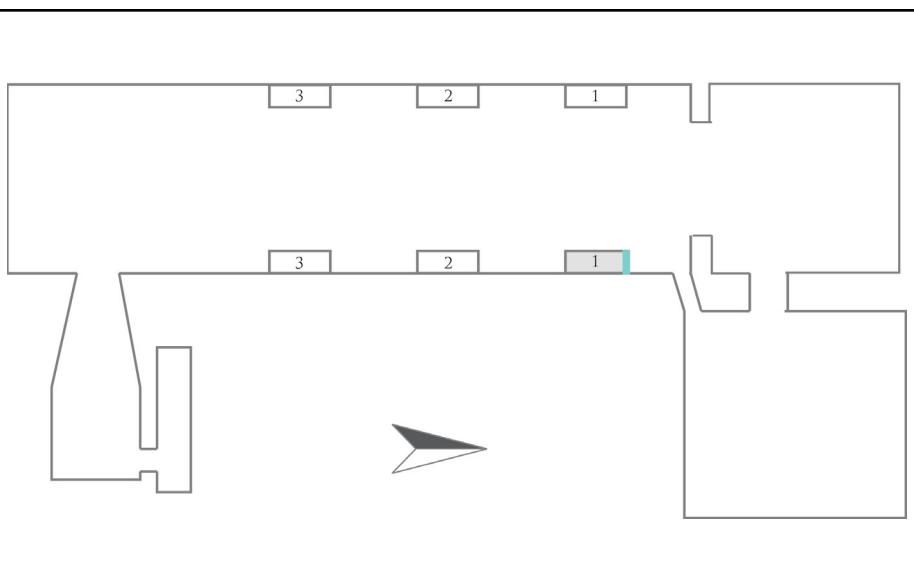
- PLASTER
- FIRED BRICK

LOSS

- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DETACHMENT



COMMENTS:

TUMACACORI MISSION CHURCH
SIDE ALTARS
EAST WALL, ALTAR ONE, PLAN VIEW

MATERIALS

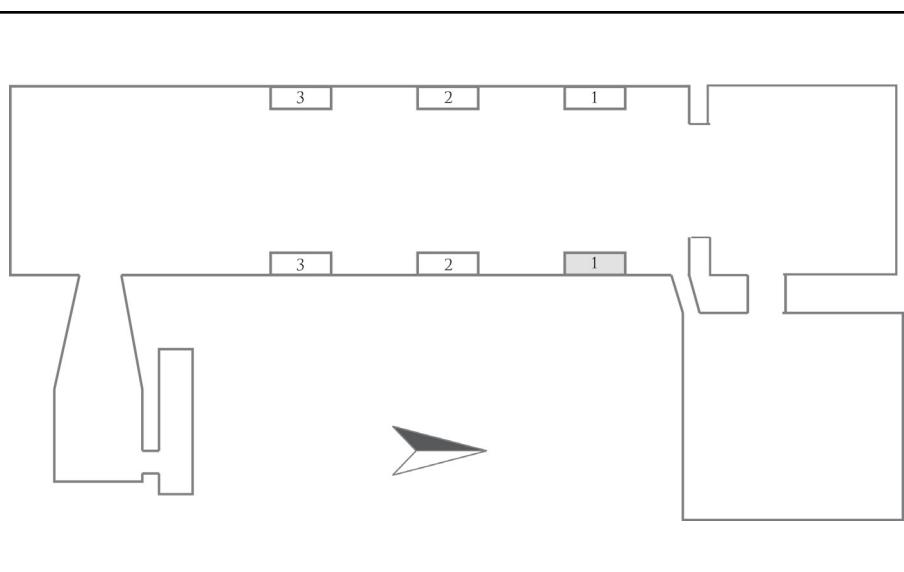
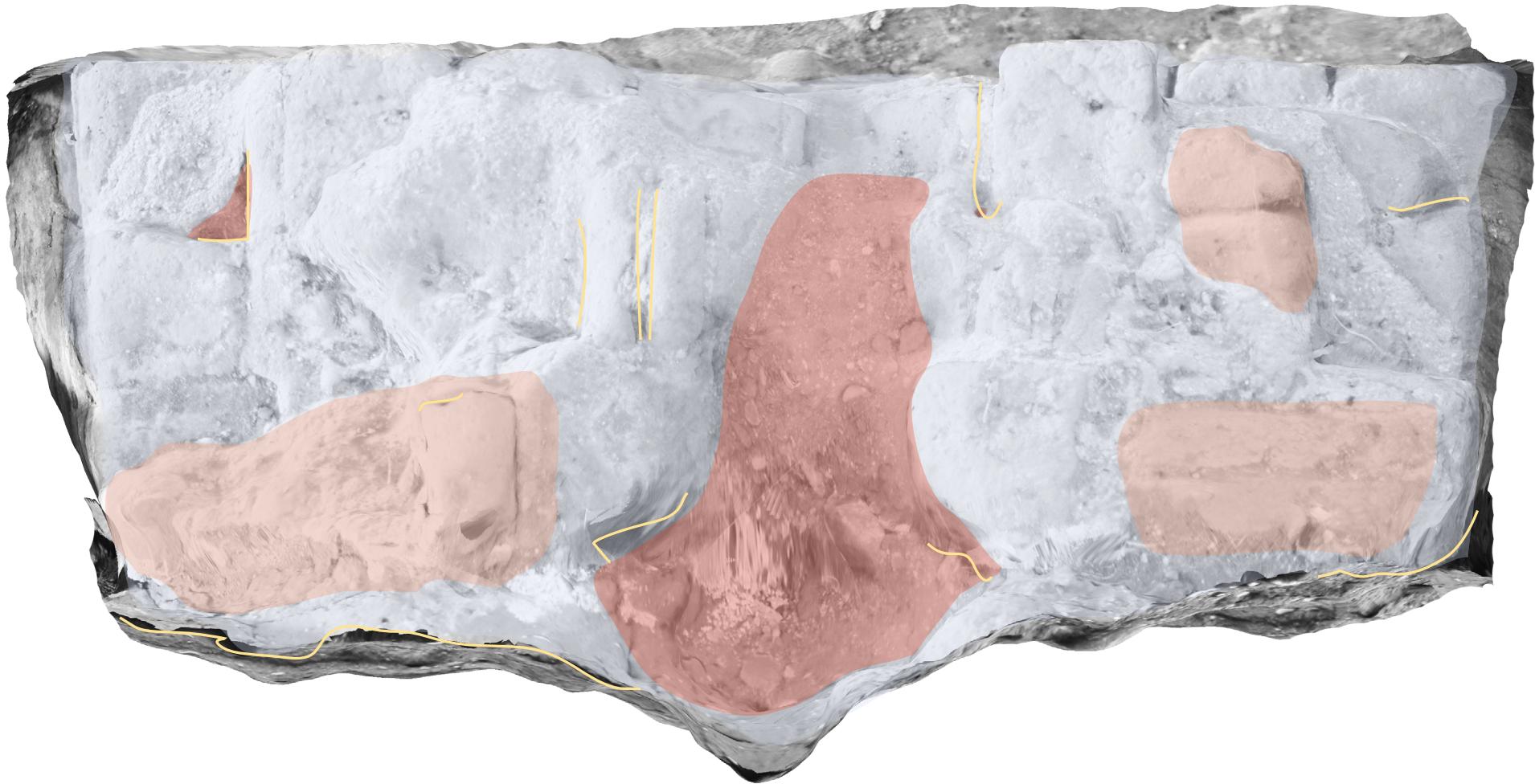
- PLASTER
- FIRED BRICK

LOSS

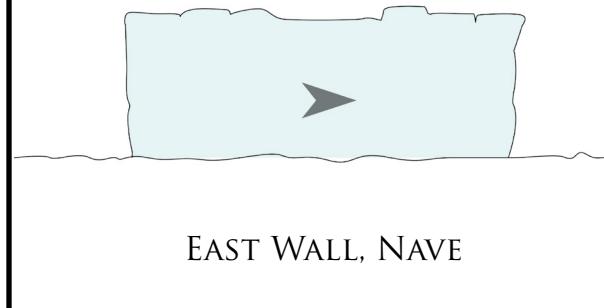
- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- ANIMAL HOLES
- DETACHMENT



PLAN VIEW, KEY



EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

EAST WALL, ALTAR TWO, EAST VIEW

MATERIALS

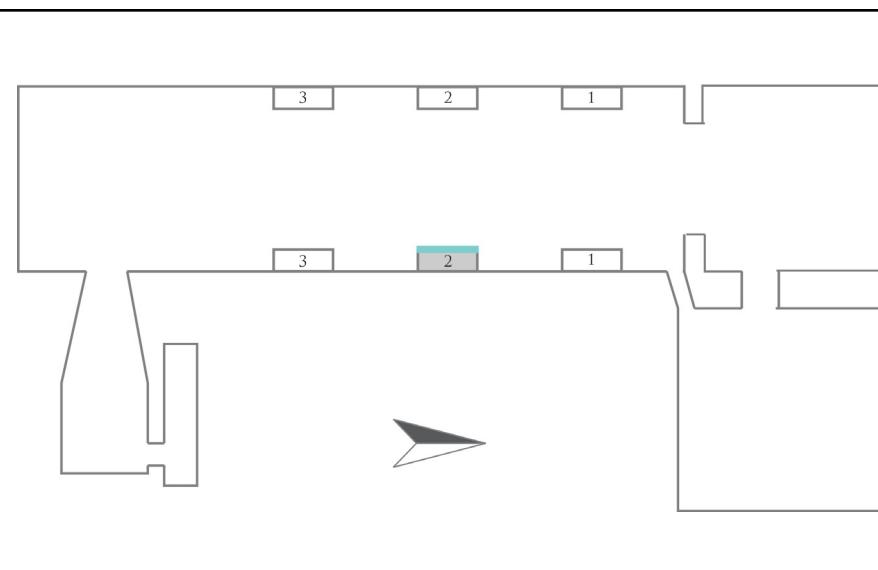
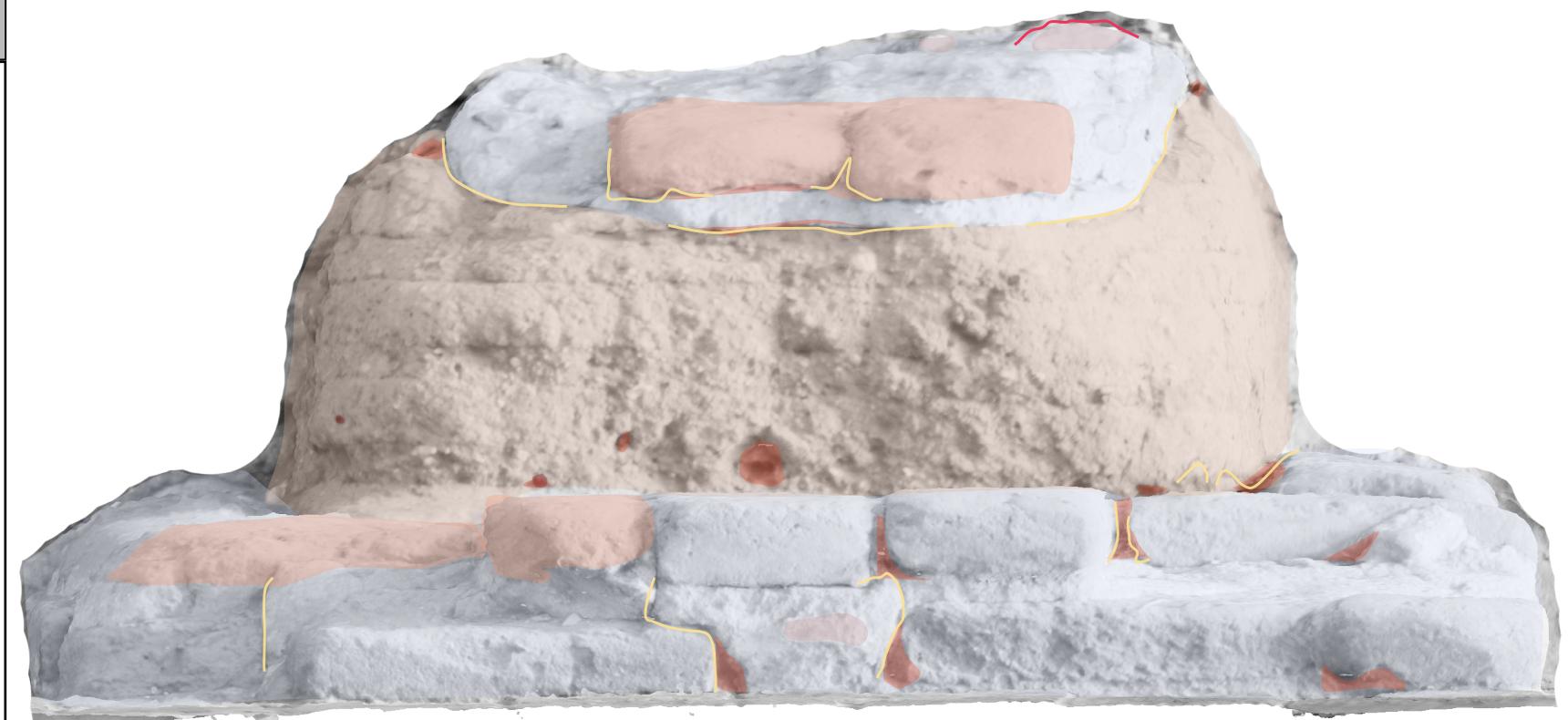
- PLASTER
- FIRED BRICK
- ADOBE

LOSS

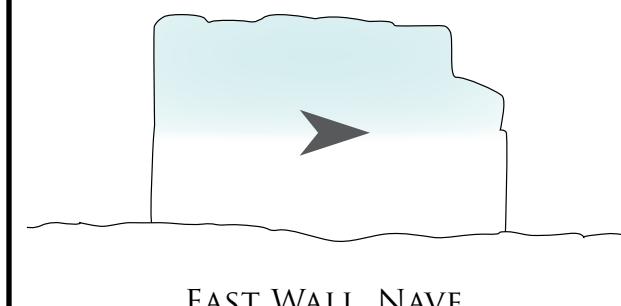
- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DETACHMENT
- DELAMINATION
- ANIMAL HOLES



PLAN VIEW, KEY



EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

EAST WALL, ALTAR TWO, NORTH VIEW

MATERIALS

- FIRED BRICK
- ADOBE

LOSS

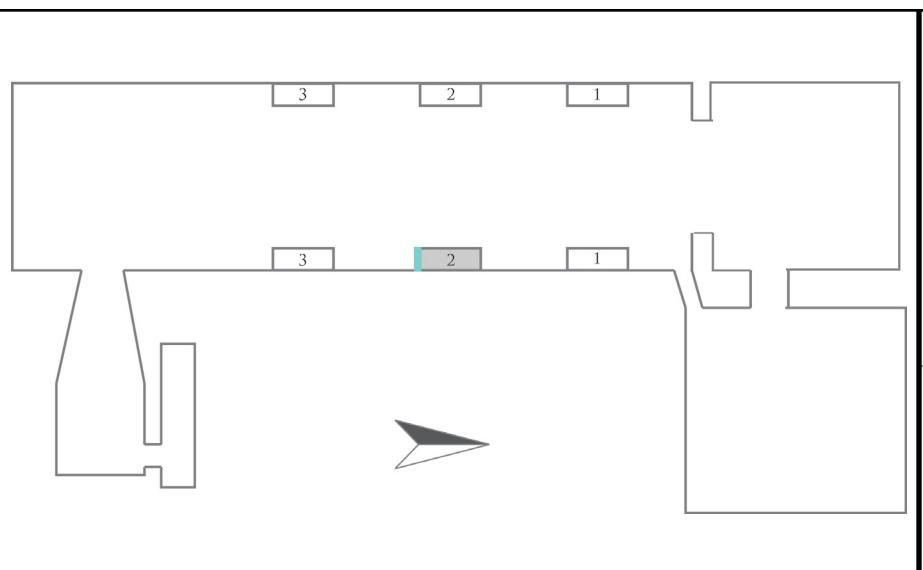
- BRICK SUBSTRATE

REPAIR

- FILL (ADOBE)

CONDITIONS

- FRAGMENTATION
- DETACHMENT



PLAN VIEW, KEY

EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

EAST WALL, ALTAR TWO, SOUTH VIEW

MATERIALS

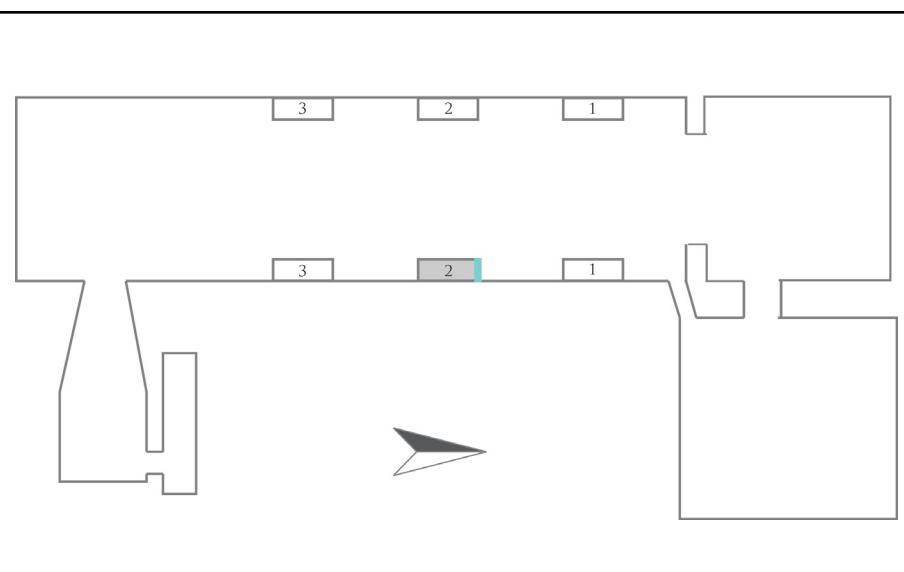
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- FIRED BRICK
- ADOBE

LOSS

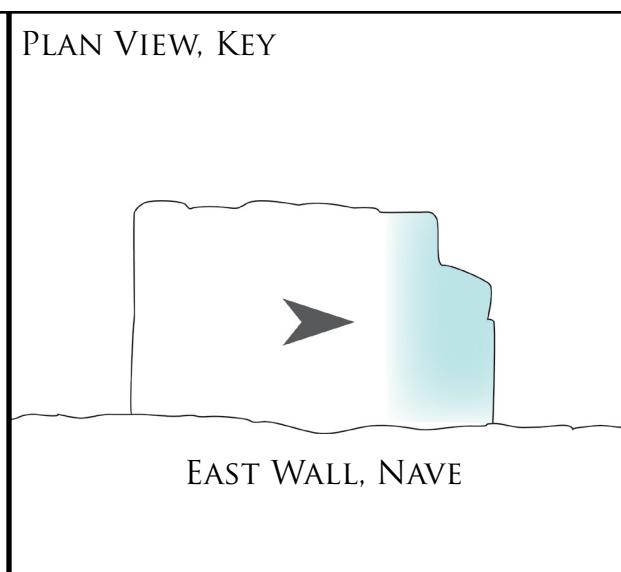
- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DETACHMENT



PLAN VIEW, KEY



EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS EAST WALL, ALTAR TWO, PLAN VIEW

MATERIALS

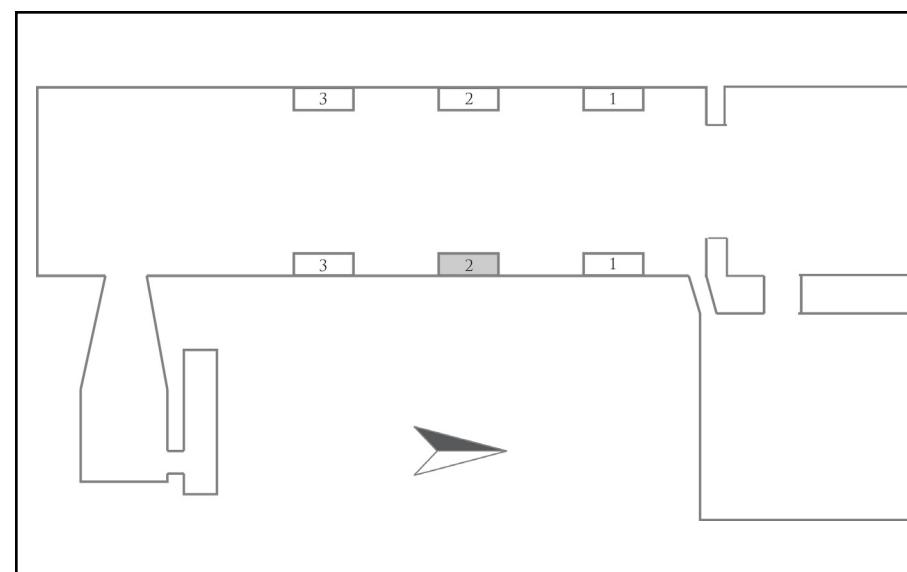
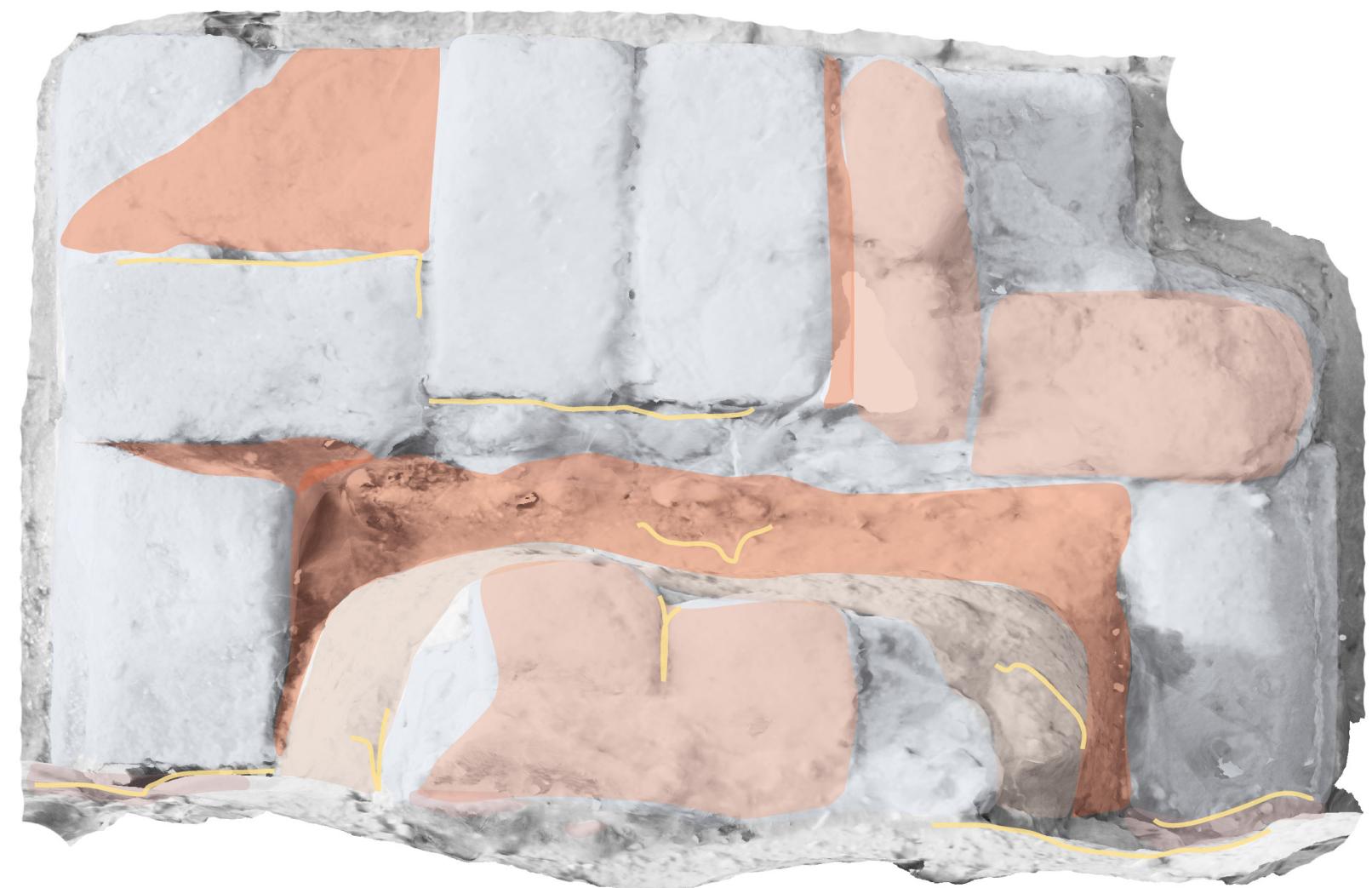
- PLASTER
- FIRED BRICK
- ADOBE

LOSS

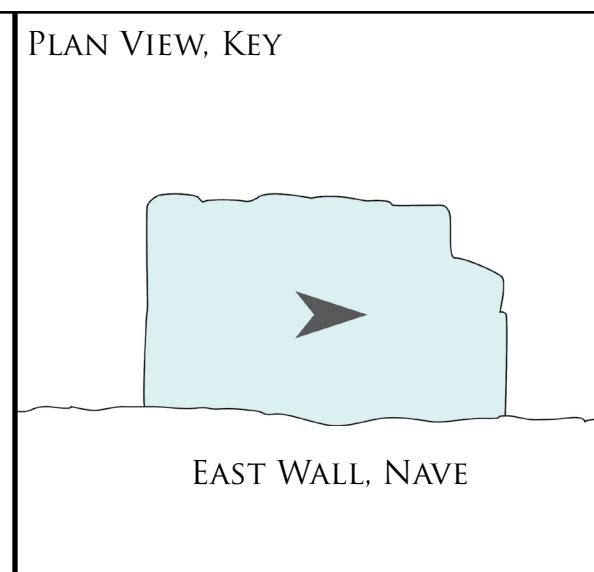
- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DETACHMENT



PLAN VIEW, KEY



COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS EAST WALL, ALTAR THREE, NORTH VIEW

MATERIALS

- PLASTER
- FIRED BRICK

LOSS

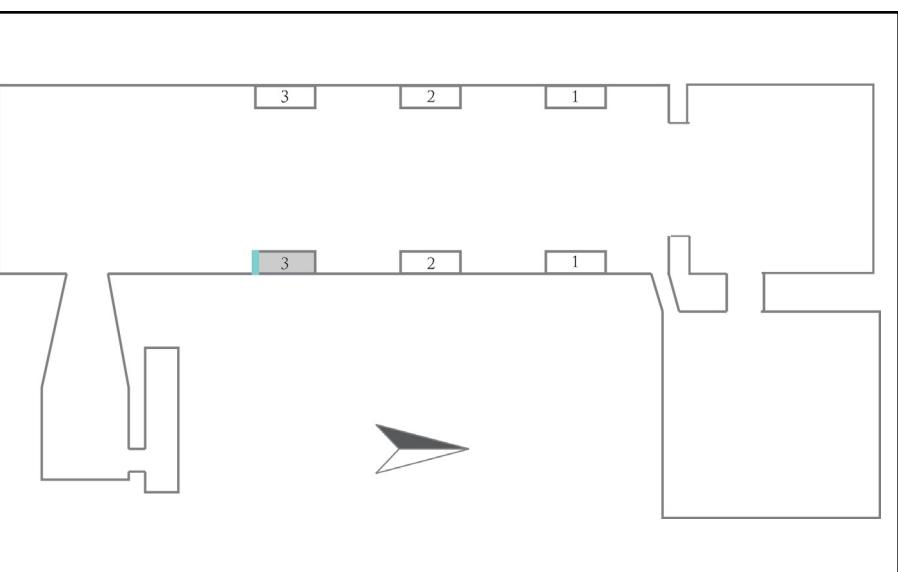
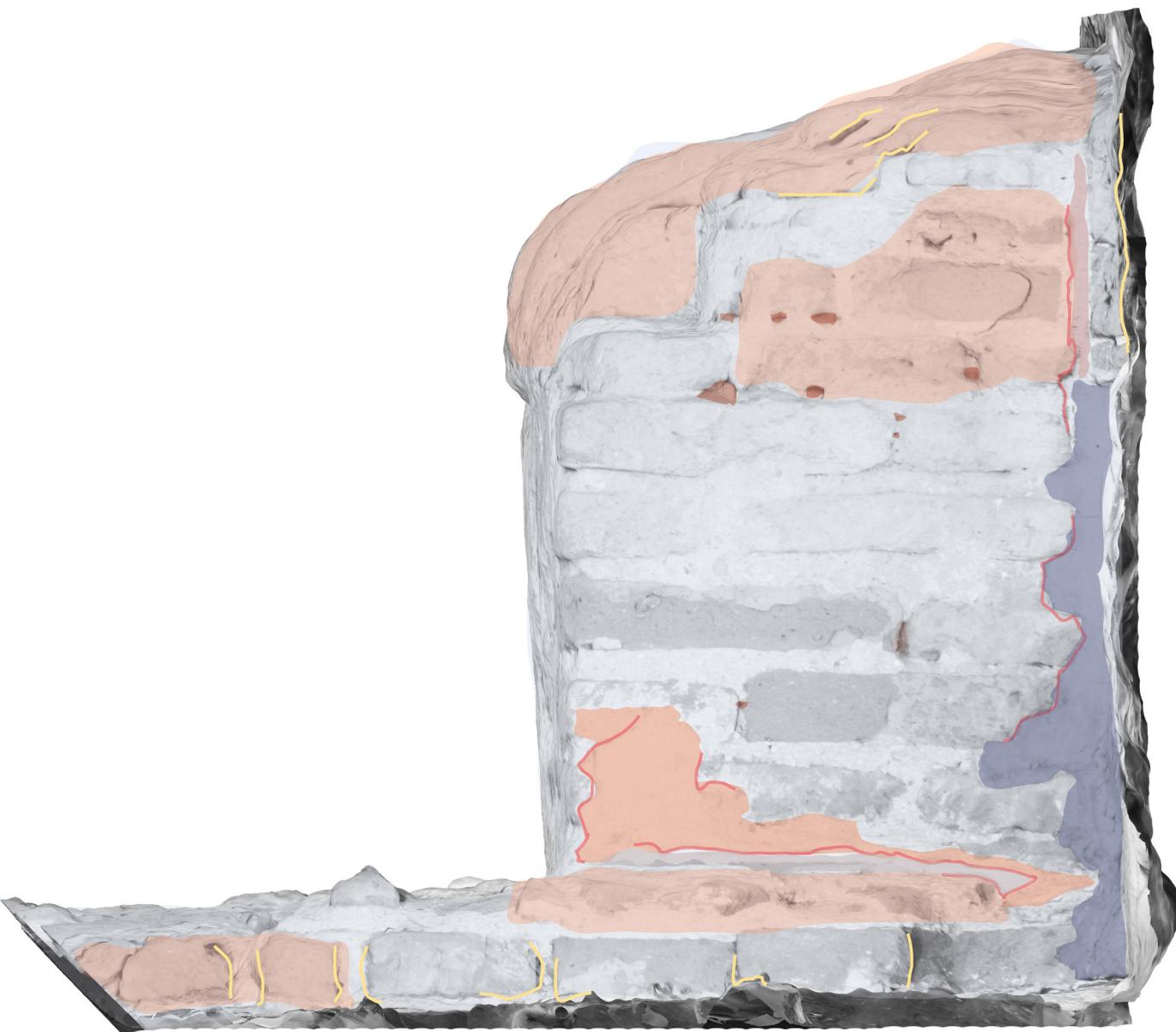
- BRICK SUBSTRATE

REPAIR

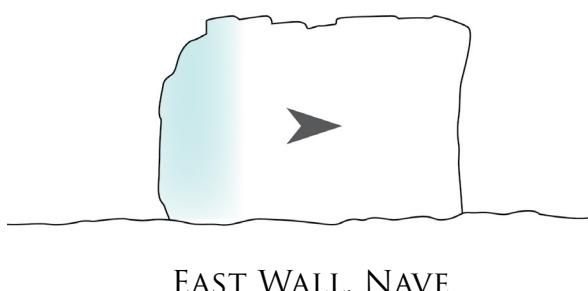
- FILL (SUBSTRATE)

CONDITIONS

- FRAGMENTATION
- DETACHMENT
- DELAMINATION
- ANIMAL HOLES



PLAN VIEW, KEY



COMMENTS:

TUMACACORI MISSION CHURCH

SIDE ALTARS

EAST WALL, ALTAR THREE, SOUTH VIEW

MATERIALS

PLASTER
FIRED BRICK

LOSS

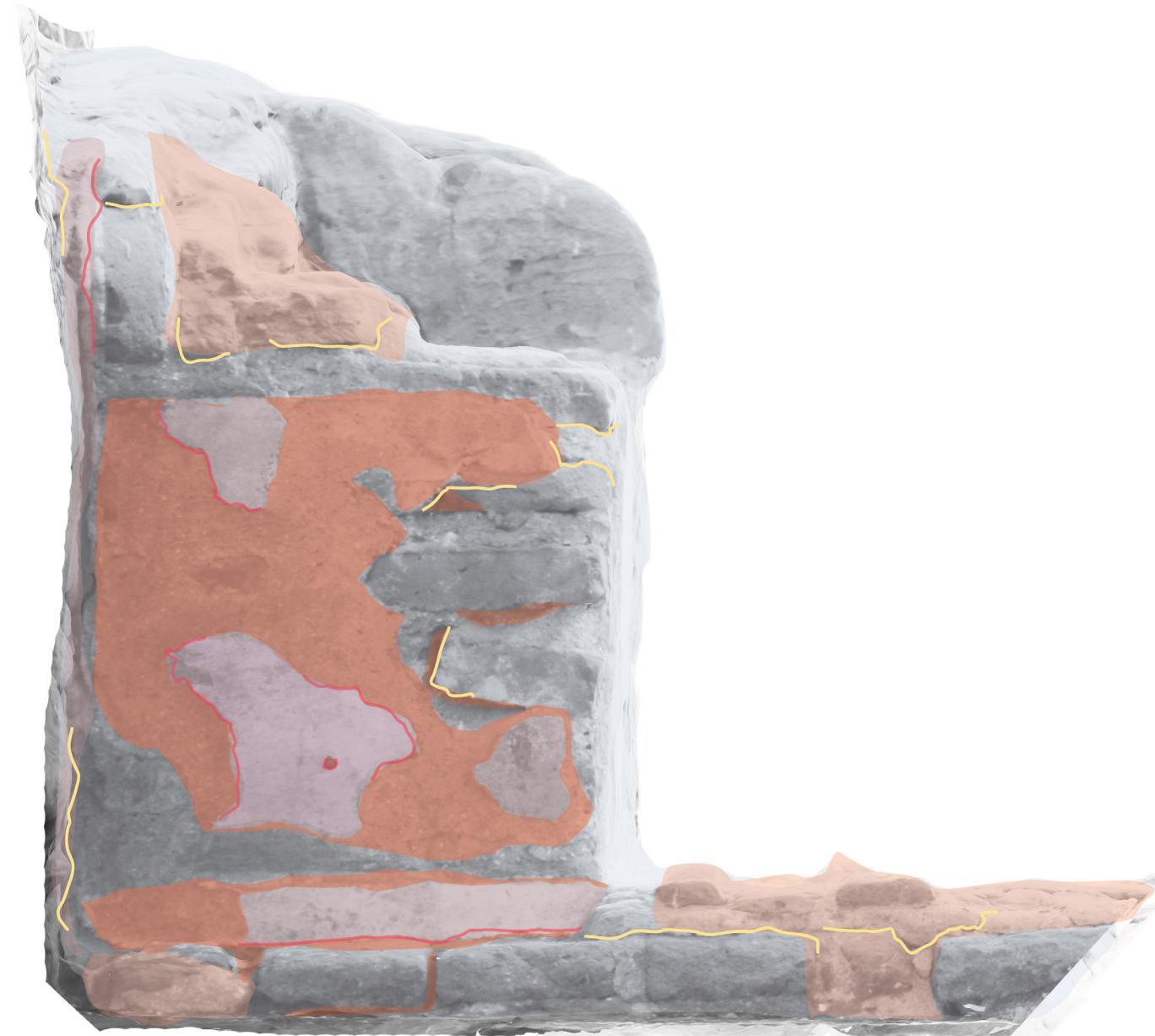
PLASTER LAYERS
BRICK SUBSTRATE

HISTORIC FEATURES

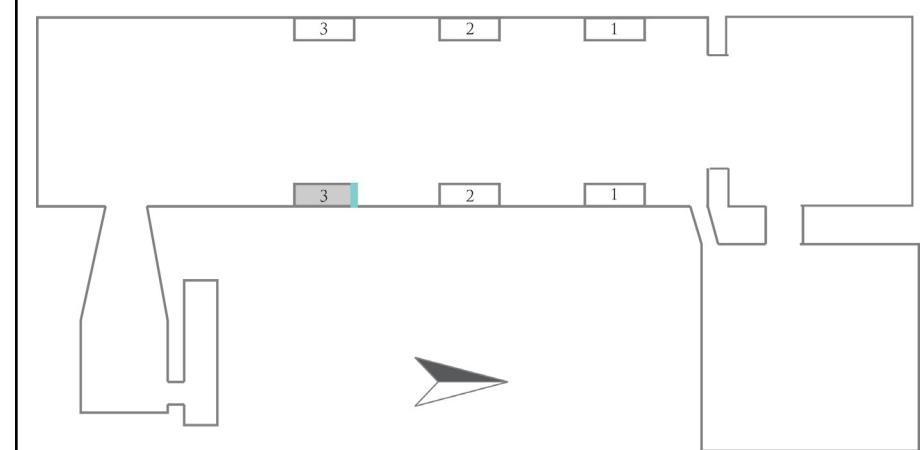
PAINTED SURFACES

CONDITIONS

FRAGMENTATION
DETACHMENT
DELAMINATION
ANIMAL HOLES



PLAN VIEW, KEY



EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH SIDE ALTARS EAST WALL, ALTAR THREE, PLAN VIEW

MATERIALS

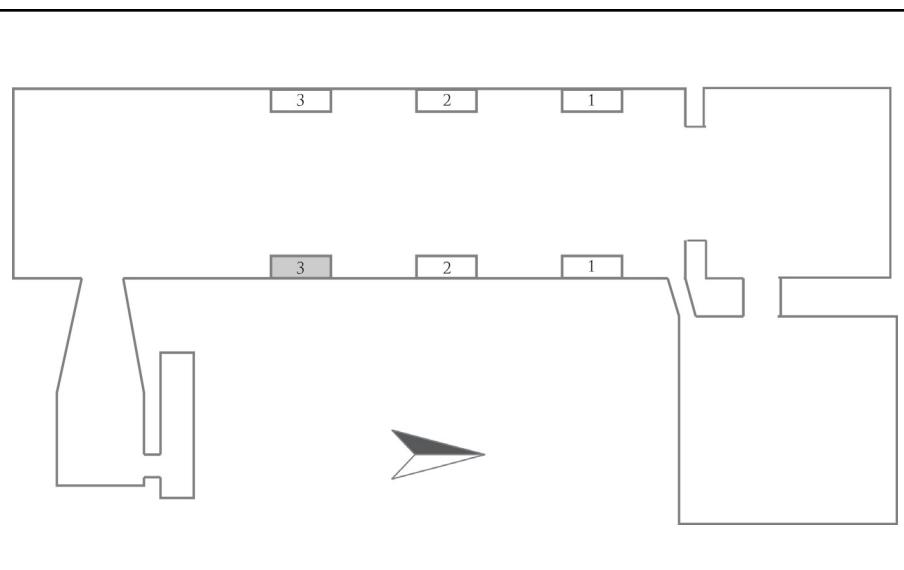
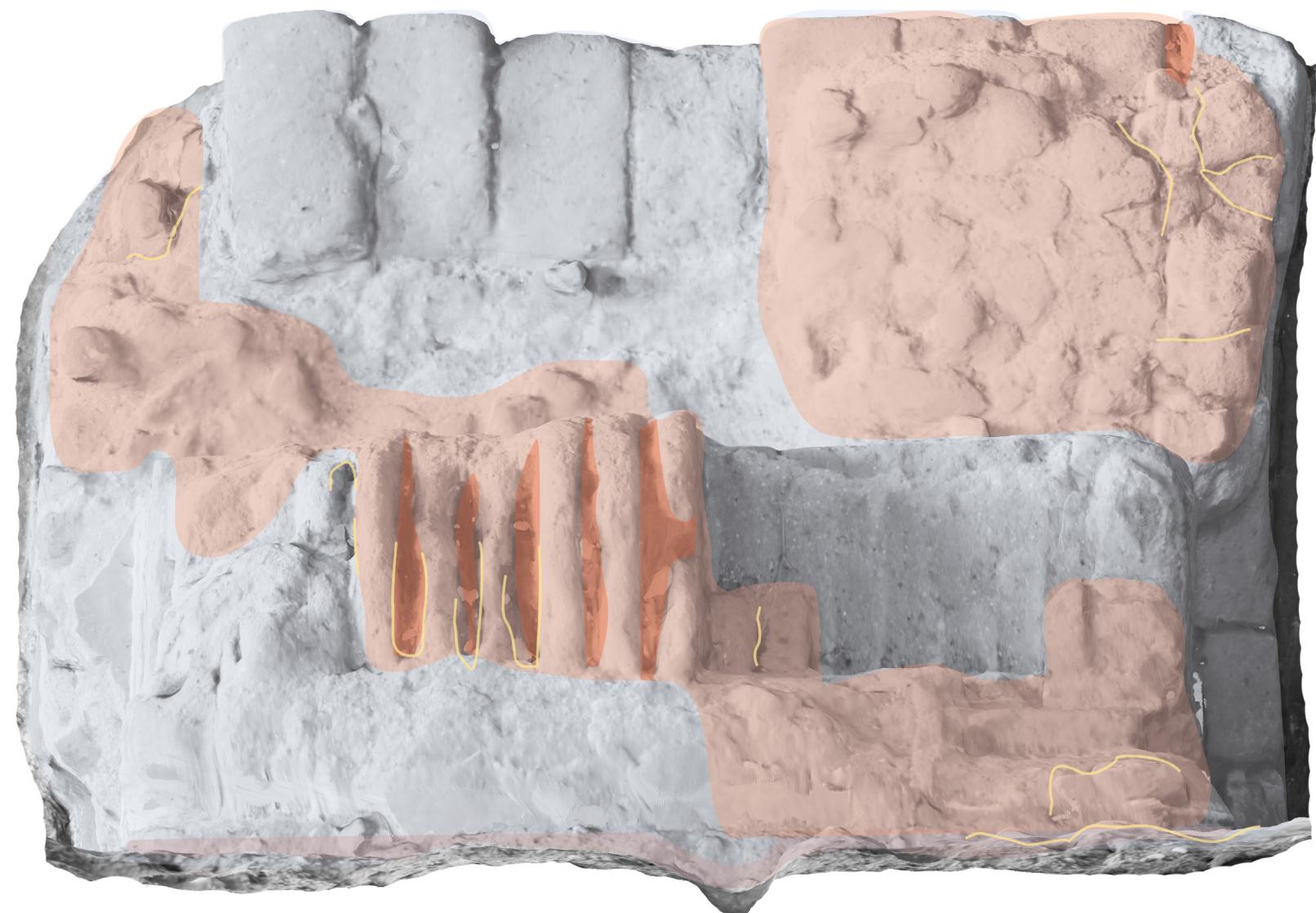
- PLASTER
- FIRED BRICK

LOSS

- BRICK SUBSTRATE

CONDITIONS

- FRAGMENTATION
- DETACHMENT



PLAN VIEW, KEY

EAST WALL, NAVE

COMMENTS:

TUMACACORI MISSION CHURCH

SANCTUARY, WEST WALL:

MATERIAL INTEGRITY

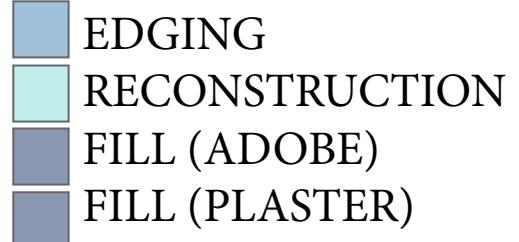
MATERIALS



LOSS



REPAIR



COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, WEST WALL: HISTORIC FEATURES

DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE
- LOSS OF SURFACE FEATURES

ARCHITECTURAL FEATURES

- PUGHOLES

GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, WEST WALL: CONDITIONS

ADOBE

- DISINTEGRATION
- FRAGMENTATION
- DISCOLORATION
- STRUCTURAL CRACK

PLASTER

- VOID
- DELAMINATION
- DETACHMENT
- SURFICIAL CRACK

SURFACE DEPOSITS/ANIMAL ACTIVITY

- RUNNELING
- DROPPINGS
- SMALL HOLES

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, NORTH WALL: MATERIAL INTEGRITY

MATERIALS

- PLASTER
- ADOBE

LOSS

- PLASTER LAYERS
- ADOBE SUBSTRATE

REPAIR

- EDGING
- RECONSTRUCTION
- FILL (ADOBE)
- FILL (PLASTER)

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, NORTH WALL: HISTORIC FEATURES

DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE
- LOSS OF SURFACE FEATURES

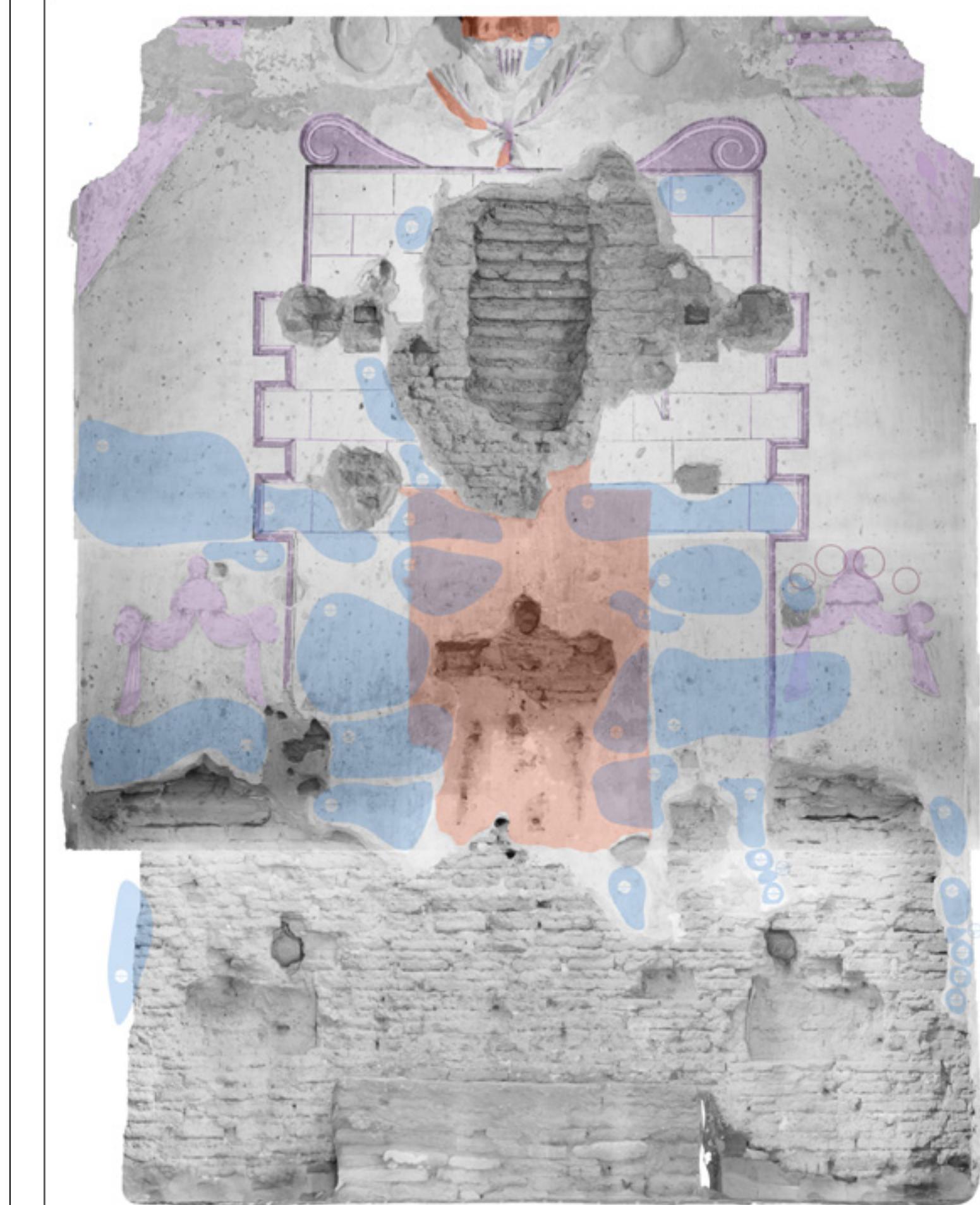
ARCHITECTURAL FEATURES

- PUGHOLES

GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, NORTH WALL: CONDITIONS

ADOBE

- DISINTEGRATION
- FRAGMENTATION
- DISCOLORATION
- STRUCTURAL CRACK

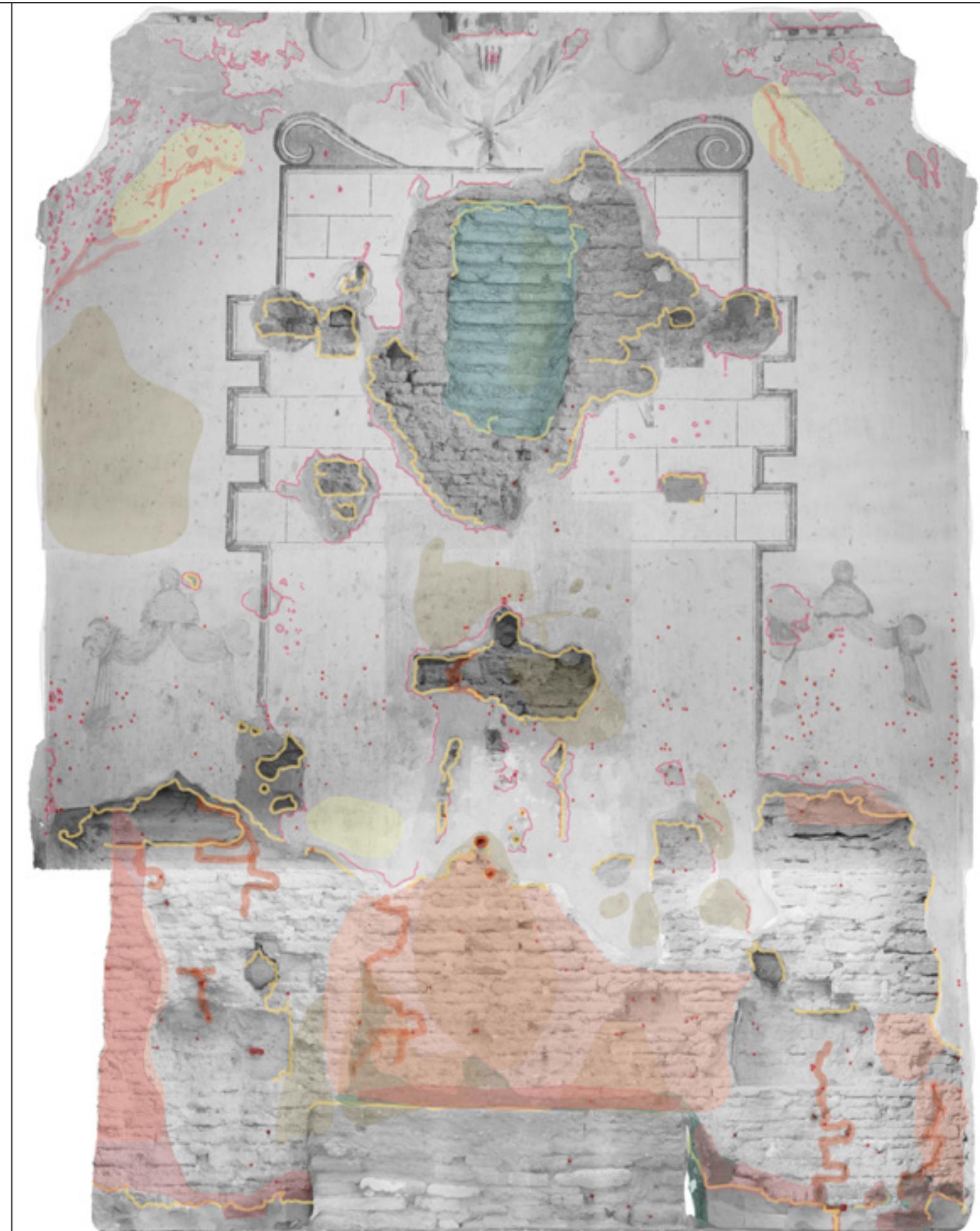
PLASTER

- VOID
- DELAMINATION
- DETACHMENT
- SURFICIAL CRACK

SURFACE DEPOSITS/ANIMAL ACTIVITY

- RUNNELING
- DROPPINGS
- SMALL HOLES

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, EAST WALL: MATERIAL INTEGRITY

MATERIALS

- PLASTER
- ADOBE

LOSS

- PLASTER LAYERS
- ADOBE SUBSTRATE

REPAIR

- EDGING
- RECONSTRUCTION
- FILL (ADOBE)
- FILL (PLASTER)

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, EAST WALL: HISTORIC FEATURES

DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE
- LOSS OF SURFACE FEATURES

ARCHITECTURAL FEATURES

- PUGHOLES

GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, EAST WALL: CONDITIONS

ADOBE

- DISINTEGRATION
- FRAGMENTATION
- DISCOLORATION
- STRUCTURAL CRACK

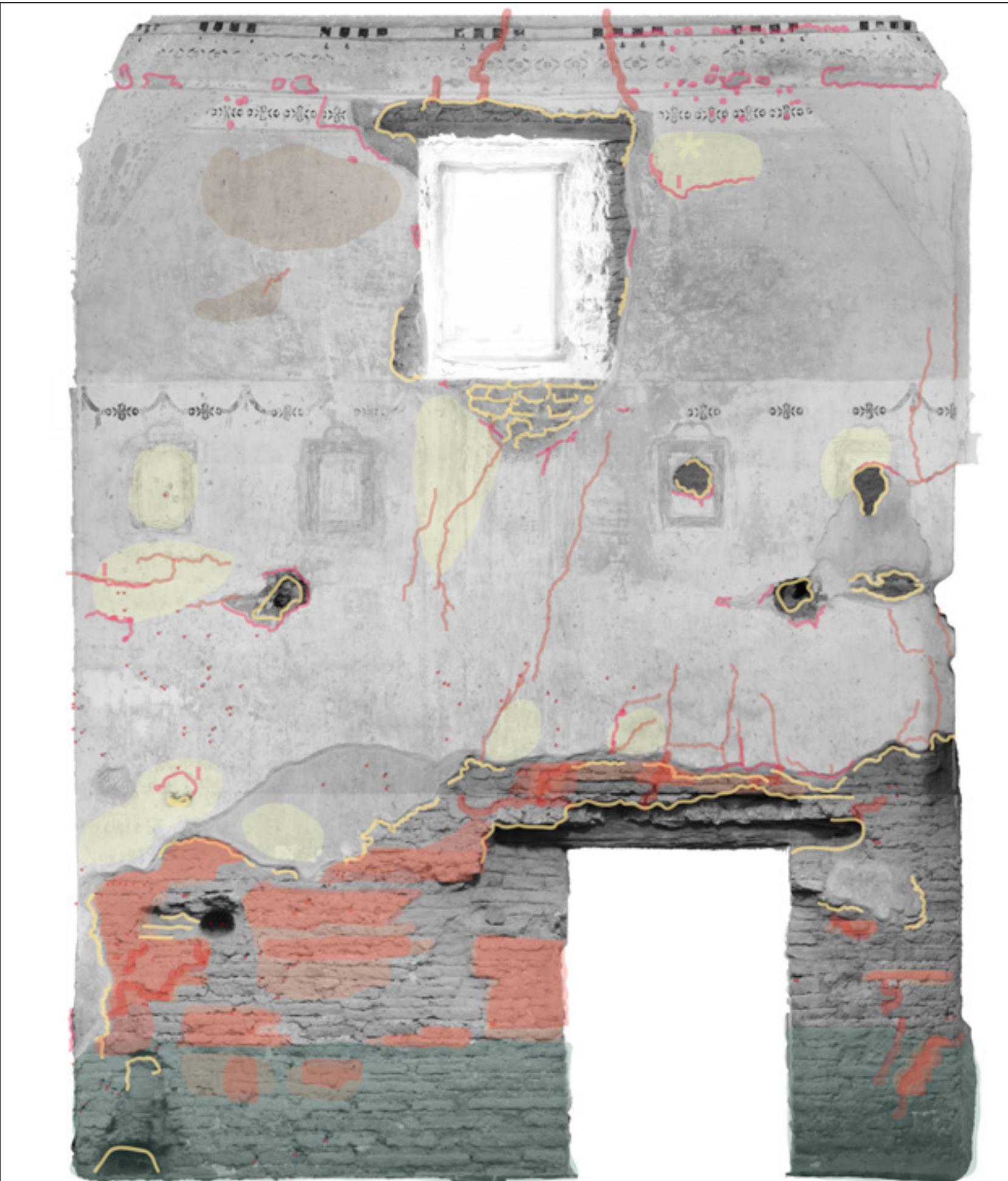
PLASTER

- VOID
- DELAMINATION
- DETACHMENT
- SURFICIAL CRACK

SURFACE DEPOSITS/ANIMAL ACTIVITY

- RUNNELING
- DROPPINGS
- SMALL HOLES

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, SOUTH WALL: MATERIAL INTEGRITY

MATERIALS

- PLASTER
- ADOBE

LOSS

- PLASTER LAYERS
- ADOBE SUBSTRATE

REPAIR

- EDGING
- RECONSTRUCTION
- FILL (ADOBE)
- FILL (PLASTER)

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, SOUTH WALL: HISTORIC FEATURES

DECORATIVE FEATURES

- INCISIONS
- PAINTED SURFACE
- LOSS OF SURFACE FEATURES

ARCHITECTURAL FEATURES

- PUGHOLES

GRAFFITI

- HISTORIC GRAFFITI

COMMENTS:



TUMACACORI MISSION CHURCH SANCTUARY, SOUTH WALL: CONDITIONS

ADOBE

- DISINTEGRATION
- FRAGMENTATION
- DISCOLORATION
- STRUCTURAL CRACK

PLASTER

- VOID
- DELAMINATION
- DETACHMENT
- SURFICIAL CRACK

SURFACE DEPOSITS/ANIMAL ACTIVITY

- RUNNELING
- DROPPINGS
- SMALL HOLES

COMMENTS:



APPENDIX D

TUMACÁCORI HISTORIC GRAFFITI LOG

TUMACACORI INTERIOR GRAFFITI SURVEY LOG 2014

SECTION	GRAFFITI NUMBER	DESCRIPTION
A2_WEST_INT_TUMA	01	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
A2_WEST_INT_TUMA	02	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
A2_WEST_INT_TUMA	03	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
A2_WEST_INT_TUMA	04	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
A2_WEST_INT_TUMA	05	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
A2_WEST_INT_TUMA	06	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
A2_WEST_INT_TUMA	07	MOSTLY ILLEGIBLE; SOME LEGIBLE INITIALS
B2_WEST_INT_TUMA	01	B.J. BROWN; ILLEGIBLE
B2_WEST_INT_TUMA	02	ILLEGIBLE
B3_WEST_INT_TUMA	01	B.J. BROWN; 4 M 09; HLR
BELL TOWER	01	M. LEMON; 1919; WP LEMON
BELL TOWER	02	AR; EA; ER
BELL TOWER	03	PARTIALLY LEGIBLE NAMES
BELL TOWER	04	M. LEMON; 1919; WP LEMON
C2_WEST_INT_TUMA	01	ILLEGIBLE
C2_WEST_INT_TUMA	02	ILLEGIBLE
C2_WEST_INT_TUMA	03	ILLEGIBLE
C2_WEST_INT_TUMA	04	ILLEGIBLE
C2_WEST_INT_TUMA	05	ILLEGIBLE
CL_11_INT_TUMA	01	HB; HY
CL_11_INT_TUMA	02	PARTIALLY LEGIBLE NAMES
CL_21_INT_TUMA	01	"A.R. JENKINS"
CL_21_INT_TUMA	02	F..nk P; Hay: PARTIALLY LEGIBLE NAMES
CL_21_INT_TUMA	03	F..nk P; Hay: PARTIALLY LEGIBLE NAMES
CL_21_INT_TUMA	04	F..nk P; Hay: PARTIALLY LEGIBLE NAMES
CL_21_INT_TUMA	05	F..nk P; Hay: PARTIALLY LEGIBLE NAMES
D2_WEST_INT_TUMA	01	W.F. JACOB; M.C. 1918; ILLEGIBLE
D2_WEST_INT_TUMA	02	OVERLAP: M.C. 1918; ILLEGIBLE
D2_WEST_INT_TUMA	03	SCHI; 1913; ILLEGIBLE
D2_WEST_INT_TUMA	04	FRANK; ILLEGIBLE
D2_WEST_INT_TUMA	05	ILLEGIBLE
D2_WEST_INT_TUMA	06	ILLEGIBLE
D2_WEST_INT_TUMA	07	ILLEGIBLE

TUMACACORI INTERIOR GRAFFITI SURVEY LOG 2014

D2_WEST_INT_TUMA	08 ILLEGIBLE
D2_WEST_INT_TUMA	09 PX; ILLEGIBLE
D2_WEST_INT_TUMA	10 ILLEGIBLE
D2_WEST_INT_TUMA	11 ILLEGIBLE
D3_WEST_INT_TUMA	01 MARY O; 8 1904
E2_WEST_INT_TUMA	01 MB; A; HENDERSON; ILLEGIBLE
E2_WEST_INT_TUMA	02 1915; ILLEGIBLE
E2_WEST_INT_TUMA	03 MB; ILLEGIBLE
E2_WEST_INT_TUMA	04 OVERLAP E2_WEST_INT_TUMA_03
E2_WEST_INT_TUMA	05 OVERLAP E2_WEST_INT_TUMA_01
E2_WEST_INT_TUMA	06 CA; S; HENDERSON; OVERLAP E2_WEST_INT_TUMA_01
E2_WEST_INT_TUMA	07 OVERLAP; ILLEGIBLE
E2_WEST_INT_TUMA	08 OVERLAP; ILLEGIBLE
E2_WEST_INT_TUMA	09 CEOSPER(?); OVERLAP; ILLEGIBLE
E3_WEST_INT_TUMA	01 OVERLAP; SEE F3
F2_WEST_INT_TUMA	01 PVH; ILLEGIBLE
F2_WEST_INT_TUMA	02 ILLEGIBLE
F2_WEST_INT_TUMA	03 ILLEGIBLE
F2_WEST_INT_TUMA	04 LEO; BRIGHT (BRINGT?); CRIPPLE CREEK; 1918;
F2_WEST_INT_TUMA	05 ILLEGIBLE
F2_WEST_INT_TUMA	06 SEE F2_WEST_INT_TUMA_GRAFFITI_01
F3_WEST_INT_TUMA	01 MOORE; ILLEGIBLE
F3_WEST_INT_TUMA	02 LEWIS W. MOORE; TUCSON AB 17; NE
F3_WEST_INT_TUMA	03 LWM
G1_WEST_INT_TUMA	01 (MODERN) MARIA + ALAN = LOVE4 EVER!; M+A= (HEART SYMBOL)
G1_WEST_INT_TUMA	02 W X; E; RAC; B; ILLEGIBLE
G1_WEST_INT_TUMA	03 BU; I
G2_WEST_INT_TUMA	01 FRAN...; (H)OYSTON P; STEWART; ...ESBORO; HMF; LEF; ME; ILLEGIBLE
G2_WEST_INT_TUMA	02 N. SCHULEMAN(?); R; A; ILLEGIBLE
G2_WEST_INT_TUMA	03 ILLEGIBLE
G2_WEST_INT_TUMA	04 N. SCHULEMAN; HMF; LEF; FRAN
I2_EAST_INT_TUMA	01 Joseph G. Schere Dec. 18 1916; E E Smith; TROOP F
I2_EAST_INT_TUMA	02 "G A;" ILLEGIBLE
I2_EAST_INT_TUMA	03 ILLEGIBLE

TUMACACORI INTERIOR GRAFFITI SURVEY LOG 2014

I2_EAST_INT_TUMA 04 ILLEGIBLE
I2_EAST_INT_TUMA 05 ILLEGIBLE
I2_EAST_INT_TUMA 06 E E SMITH; TROOP F; G A
I3_EAST_INT_TUMA 01 "ER"
I3_EAST_INT_TUMA 02 ILLEGIBLE
I3_EAST_INT_TUMA 03 "E"
J2_EAST_INT_TUMA 01 "E," "PI," "ER" (IN HEART), "SPIC," "W," "U," "PH," ILLEGIBLE
J2_EAST_INT_TUMA 02 OVERLAP
J2_EAST_INT_TUMA 03 OVERLAP
J2_EAST_INT_TUMA 04 FABer... 5/14/11 (OR 5/14/10), "Tiog..."
J2_EAST_INT_TUMA 05 OVERLAP
J2_EAST_INT_TUMA 06 OVERLAP
J2_EAST_INT_TUMA 07 "HC," "ALEX," "S," "PO," "HE," ILLEGIBLE
J2_EAST_INT_TUMA 08 OVERLAP
J2_EAST_INT_TUMA 09 "HN," "EEE," "E," OVERLAP
J2_EAST_INT_TUMA 10 "NN" OVERLAP
J2_EAST_INT_TUMA 11 ILLEGIBLE
J3_EAST_INT_TUMA 01 SEE J4_EAST_INT_TUMA
J4_EAST_INT_TUMA 01 "LW"
K1_EAST_INT_TUMA 01 TD; OHU
K3_EAST_INT_TUMA 01 P.H. ANDERSON, A. TILLITSON, J.J. MCMANAWAY; HEADQUARTERS CO. 2ND IDAHO
K4_EAST_INT_TUMA 01 SEE K3_EAST_INT_TUMA
L1_EAST_INT_TUMA 01 SEE K1_EAST_INT_TUMA
L2_EAST_INT_TUMA 01 KEI_ER; R_VER; "S"
L2_EAST_INT_TUMA 02 OVERLAP
L2_EAST_INT_TUMA_V2 01 BEM; LLO (FILLED); WA; ILLEGIBLE
L2_EAST_INT_TUMA_V2 02 M; ILLEGIBLE (OVERLAP 01)
L2_EAST_INT_TUMA_V2 03 LEN; ILLEGIBLE
L2_EAST_INT_TUMA_V2 04 ILLEGIBLE
L2_EAST_INT_TUMA_V2 05 JLR; LEN; R; A; ILLEGIBLE
L2_EAST_INT_TUMA_V2 06 SEE L2_EAST_INT_TUMA
L2_EAST_INT_TUMA_V2 07 SEE L2_EAST_INT_TUMA_V2_01-06
L2_EAST_INT_TUMA_V2 08 SEE L2_EAST_INT_TUMA_V2_01-06
L3_EAST_INT_TUMA 01 SEE K3_EAST_INT_TUMA

TUMACACORI INTERIOR GRAFFITI SURVEY LOG 2014

L4_EAST_INT_TUMA	01 SEE K3_EAST_INT_TUMA
M2_EAST_INT_TUMA	01 VW; (STAR SYMBOL); ILLEGIBLE
M2_EAST_INT_TUMA	02 ILLEGIBLE
M2_EAST_INT_TUMA	03 EM; A; TT; VW; ILLEGIBLE
M2_EAST_INT_TUMA	04 MAX LEVY; LONDON; SGO; ILLEGIBLE
M2_EAST_INT_TUMA	05 SEE M2_EAST_INT_TUMA 01-04
M2_EAST_INT_TUMA	06 SEE M2_EAST_INT_TUMA 01-04
M2_EAST_INT_TUMA	07 SEE M2_EAST_INT_TUMA 01-04
M2_EAST_INT_TUMA	08 SEE M2_EAST_INT_TUMA 04
M2_EAST_INT_TUMA	09 ILLEGIBLE
M2_EAST_INT_TUMA	10 ILLEGIBLE
M2_EAST_INT_TUMA	11 ILLEGIBLE
M3_EAST_INT_TUMA	01 ILLEGIBLE
M3_EAST_INT_TUMA	02 ILLEGIBLE
M3_EAST_INT_TUMA	03 ILLEGIBLE
M3_EAST_INT_TUMA	04 SEE N2_EAST_INT_TUMA; ILLEGIBLE
N2_EAST_INT_TUMA	01 HARTNELL; AOC; BARBER; EIS; W; LIE; EL LOBO; ILLEGIBLE
N2_EAST_INT_TUMA	02 SEE N2_EAST_INT_TUMA-01
N2_EAST_INT_TUMA	03 SEE N2_EAST_INT_TUMA-01
N3_EAST_INT_TUMA	01 MAY '31
N3_EAST_INT_TUMA	02 SEE N3_EAST_INT_TUMA_01
N3_EAST_INT_TUMA	03 SEE N3_EAST_INT_TUMA_01
N3_EAST_INT_TUMA	04 SEE N3_EAST_INT_TUMA_01
O2_EAST_INT_TUMA	01 K...W
O2_EAST_INT_TUMA	02 OVERLAP
S ARCH_EAST_N FACE_1	03 "FLORENCE", ETC
SANCT_EAST_INT_TUMA_1	04
SANCT_EAST_INT_TUMA_2	08
SANCT_NORTH_INT_TUMA_1	03
SANCT_NORTH_INT_TUMA_1	05
SANCT_NORTH_INT_TUMA_1	06
SANCT_NORTH_INT_TUMA_1	07
SANCT_NORTH_INT_TUMA_2	02
SANCT_NORTH_INT_TUMA_2	03

TUMACACORI INTERIOR GRAFFITI SURVEY LOG 2014

SANCT_NORTH_INT_TUMA_2	04
SANCT_NORTH_INT_TUMA_2	05
SANCT_NORTH_INT_TUMA_2	06

APPENDIX E

SOAR INTERIOR DOCUMENTATION REPORT

PMIS 186761A -- Interior Documentation of the Tumacacori Mission Church
NPS Southern Arizona Office
Tumacacori National Historical Park
2014



By Jake DeGayner
Geographer

Tylia Varilek
Archeological Technician

Alex Lim
Exhibit Specialist

Introduction

The purpose of this project component was to use advanced spatial technologies to create condition assessment materials for the interior of the Tumacacori Church, as well as a spatial archival record of the current characteristics of the structure interior. Specifically, these materials consisted of high-resolution scaled orthophotographic wall sheets upon which to annotate condition information, as well as 3D models to aid in visualization of the resource. To create these materials, PMIS 186761 funded the acquisition of terrestrial 3D laser scanning hardware and software at the SOAR Office. This project provided an opportunity to initiate a workflow of creating advanced spatial products in-house at the NPS and compare the costs, challenges, and overall outcome to contract services approaches.

Methodology

Field work was primarily accomplished during four days the week of November 4, 2013. This trip also included the photogrammetric documentation of the nearby Compuerto. A follow-up visit to retake several photographs occurred February 28, 2014. Field work consisted of GNSS data capture, terrestrial photogrammetry, and 3D laser scanning.

GNSS

A set of survey-grade GNSS receivers were used to establish local control and apply global UTM coordinates to other data generated using during this project. A static GNSS occupation of the base control point CP1 (pictured) below combined with rapid static RTK occupations of 10 minutes each provided the georeferencing parameters for the project. The static occupation was uploaded to NGS OPUS to derive a base coordinate.



Static GNSS occupation of base control monument CP1

A formal network adjustment was out of the scope of this project, so all data can be expected to retain global positioning uncertainties equal to the values listed in the OPUS Solution Report (see Appendix). However, very short RTK baselines associated with the acquisition of additional georeferencing control points resulted in an extremely high degree of relative accuracy throughout the project.

3D Laser Scanning

A FARO Focus 3D 120 laser scanner was used to intensively scan the church interior. Due to additional time availability, the exterior of the structure was scanned as well for visualization and archival purposes. The entire scanning project consisted of 63 scans. The FOCUS is a phase-shift based scanner with a maximum range of 120 meters. The advantages of this scanner include portability, measurement speed, and sensor versatility.

Due to the accuracy characteristics of the scanning hardware, the goal of the scanning was to meet or exceed a threshold of 5mm point spacing on interior surfaces. Due to the presence of overlapping scans, this threshold was easily achieved. For areas of primary interest (the Nave and Sanctuary), the scan data was used to create triangulated mesh models of interior surfaces. Since this operation requires sufficient point densities at relatively orthogonal angles, the scanner was elevated on scaffolding platforms to obtain the necessary vantage points. For visualization purposes, all scanning was performed with the color setting activated. This setting adds a set of digital photographs to each scan file following the laser ranging acquisition. The

digital photographs can be applied to the scans in post-processing, resulting in assignment of an RGB color value to each 3D measurement point.

Like most laser scanners, the FARO Focus provides scalable resolution and quality settings. A higher resolution setting results in greater point densities, while a higher quality setting results in greater point accuracy. The optimal resolution and quality settings are primarily contingent on scanning application, and range, and time availability. For this project, all indoor surfaces were scanned at a resolution of 1/8 maximum (approximately 11 million points per scan) at a quality setting of 6x (8x being the maximum). These settings allowed a minimum point spacing threshold of less than 5 mm to be achieved at high quality. Outdoor surfaces were scanned at ¼ resolution (approximately 44 million points per scan) due to the longer ranges required in an outdoor setting.



Operation of the laser scanner using scaffolding in the Sanctuary

Adjacent scans were registered relative to each other using spherical reference targets. When scanned at appropriate ranges from multiple positions, the center of the spherical references can be calculated by post-processing software, in turn determining the position and orientation of scan positions in the project. In certain instances, an insufficient number of references were visible from a scan position. The issue was resolved by manually identifying common features with which to reference scan positions. If this method is used appropriately, this method can successfully aid in scan registration without introducing unacceptable levels of

error into the project. For modeling purposes, any errors introduced by this process can be resolved in iterative shape-based alignment.

The 63 Project scans were registered in FARO SCENE. Following the registration process, the scans were cleaned to remove extraneous points such as reference and other hardware, vegetation and human noise, and scan points which lay outside the areas of interest.

Additional post-processing was completed in Innovmetric Polyworks. Selected scans from the Sanctuary and Nave underwent an additional alignment process to further reduce registration errors. Polyworks IMAlign is capable of using an iterative best-fit alignment algorithm which aligns overlapping scans by matching surface points, reducing final registration errors well below scanner ranging capabilities. Following this procedure, 3D triangulated mesh models were created using the IMMerge module of Polyworks. For visualization purposes, the RGB values from the colorized scans were preserved and applied to the output triangles.



Triangulated mesh model of the Sanctuary textured with scanner photographs

Terrestrial close-range photogrammetry

The creation of the orthophotographic sheets and associated 3D models was accomplished using digital photogrammetry. This method was chosen because the color data from the photographs (a Canon 7D 18 megapixel sensor with a variety of lenses) generally

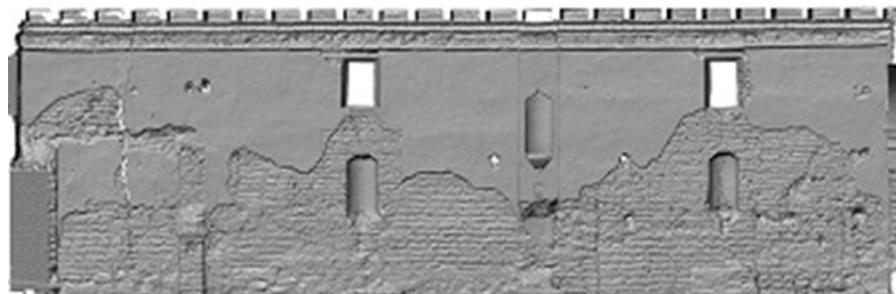
exceeds the color data from the scanner. Terrestrial photogrammetry of this nature technique uses known camera and lens distortion parameters and automated object recognition to extract the 3D dimensions of a subject. Once the shape of the subject has been modeled, an accurate orthographic representation of the subject can be generated, from which measurements can be made. Additionally, when projects are executed properly, the photogrammetric models can achieve geometric model quality superior to that of the laser scanner. Because the photogrammetric models are not capable of automatic scaling, coordinates derived from the 3D scans were used to provide scale and orientation information to the models.

Photogrammetric models were created for all surfaces within the Nave and Sanctuary, and surfaces within the Baptistry and Sacristy are forthcoming as a follow-up product set. To achieve necessary vantage points for overlapping photographs, a telescopic aluminum mast was used to elevate the camera to the required position. Approximately 1,500 photographs were taken to complete the photogrammetric segment of this project. AGISOFT Photoscan Professional Edition was used to process the photographs.

Product Catalog

- *3D laser scan models*

These are triangulated mesh models of the church interior based on the 3D laser scans. To facilitate viewing, these models have been decimated to a variety of sizes.



Snapshot of western Nave interior 3D scan model

- *3D Viewing Software*

This folder contains installation files to install MeshLab and VerifyViewer, two applications which can be used to view and measure 3D models. These versions are current as of March 2014, but may need updates in the future to remain compatible.

- *CAD_and_GIS*

A range of vector and raster CAD and GIS data can be extracted from the laser scan and photogrammetry products created by this project. This folder contains CAD and Esri raster and vector formats which were used in or derived from the scanning and photogrammetry used in this project. At the time this document was written, there are relatively few items residing in this folder. This folder also contains an Esri projection (.prj) file which will assist in restoring truncated coordinates to full UTM values.

- *Orthophoto*

This folder contains TIFF orthophotographs of interior surfaces. Surfaces within the Nave are grouped according to the 1975 HABS/HAER drawing designations for sake of consistency. In this project, sections are generally grouped into pairs for sake of display on a tabloid landscape sheet. As an example illustrating the naming convention, 1975 sections A1 and B1 are displayed in AB1.tif. Sections other than these are grouped by room, basic cardinal direction, and vertical level where applicable. Geometry used for scaling these photographs was defined from the laser scan models. The coordinates of recognizable features in the scan model were applied to the photogrammetric models to provide scale and rotation information. To help preserve an orthogonal view, the global coordinate system was frequently rotated. Therefore, coordinates defined on the sheets are not global, but do provide a real-world scale in meters and an accurate orientation.

- *Photogrammetry Models*

The 3D photogrammetric mesh models of each wall section were exported into two formats for 3D viewing. 3D PDFs were chosen because of the ease of viewing. 3D PDFs do not require specialized viewing software and are very easy to use and disseminate. However, functionality is restrained to viewpoint transformations. Therefore, each section was also exported as a Wavefront OBJ model. These models can be viewed with either of the two applications included among the products, as well as myriad other applications. These models can be used for measurement, editing, and analysis purposes.

- Graphics*

This folder contains maps, elevations, scan data screenshots, and photographs to support this project and report.

Long Term Storage

All data used to create the products for this project will be stored on the WACC bulk data server (\inpwaccms040449\SOAR\Bulk_Data_Project_Archive\TUMA)

Registered and referenced scan point clouds will be exported to ASTM E57 format. At the time of this report, this format and data standard appears to be the most viable option for long-term preservation of the scan data. All photographs used for photogrammetric modeling will be converted to TIFF format and accompanied by a bulk metadata file. All 3D models will be copied to this directory as well, although the long term stability of the files involved is unknown at this time. Discussion is ongoing to develop a stewardship plan for these types of data.

Appendix: Spatial Reference Notes

NAD83(2011) Epoch 2010.0 NAVD88(Geoid12A)

UTM Zone 12 N

These coordinates were derived from a static GNSS occupation near the Tumacacori Church Facade (see documentation photos). This occupation was processed through OPUS (see OPUS output text file below). Additional RTK observations using this coordinate yielded coordinates for three other ground points. Reference to scan point coordinates was accomplished using vertical offsets measured from spherical targets at each of the 4 ground control locations.

All coordinate values for scan data in this project have been truncated in order to reduce file sizes and facilitate display in 3D programs which have difficulty with large coordinate values such as UTM.

All X (Easting values) have been reduced by 495000 meters. To obtain a UTM Zone 12 easting, add 495000 meters to the scan data coordinate.

All Y (Northing values) have been reduced by 3492000 meters. To obtain a UTM Zone 12 northing, add 3492000 to the scan data coordinate.

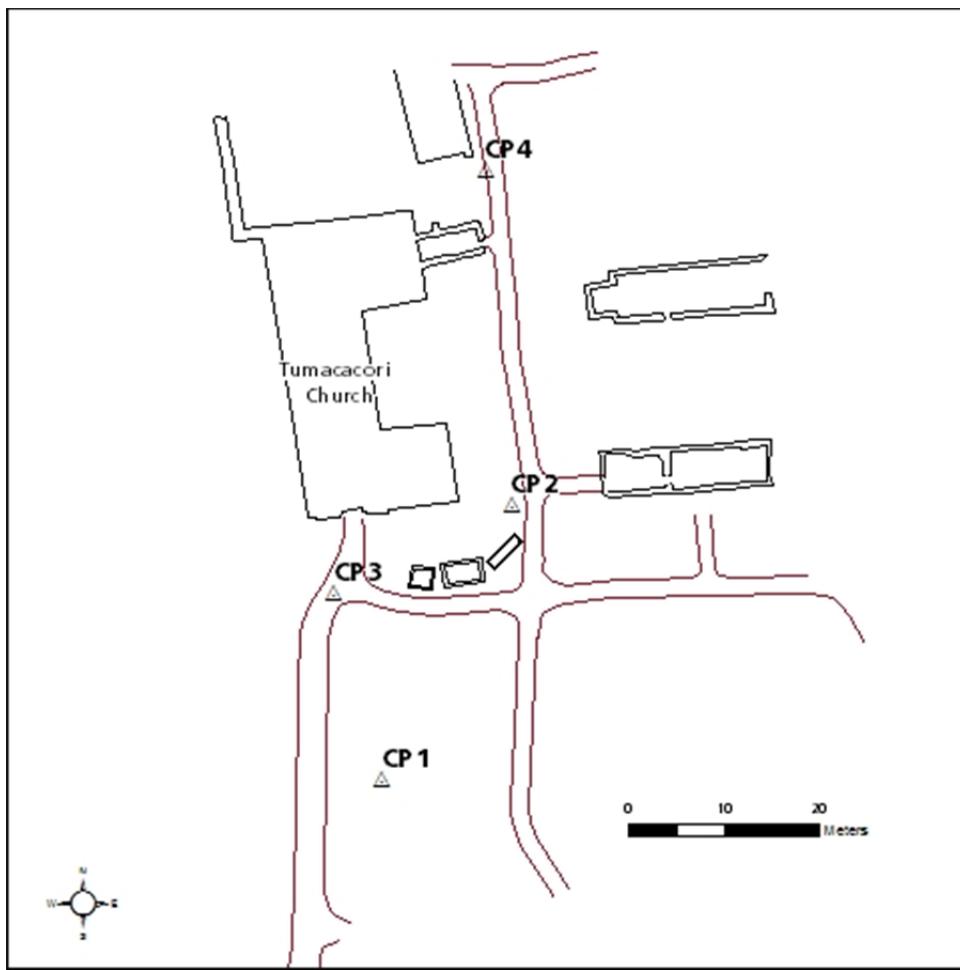
Z (Elevation values) have been unaltered.

The spatial reference of the resulting restored coordinates will be as follows:

NAD83(2011) Epoch 2010.0 NAVD88(Geoid12A)

UTM Zone 12 N

These coordinates were derived from a static GNSS occupation near the Tumacacori Church Facade (see documentation photos). This occupation was processed through OPUS (see OPUS output text file below). Additional RTK observations using this coordinate yielded coordinates for three other ground points. Reference to scan point coordinates was accomplished using vertical offsets measured from spherical targets at each of the 4 ground control locations.



Georeferencing control schema

Control Point Positioning Precisions (95% confidence)

RTK Vector	H Precision	V Precision	Vector Length
CP1-CP3	0.004 m	0.005 m	20.487 m
CP1-CP2	0.006 m	0.007 m	32.241 m
CP1-CP4	0.004 m	0.005 m	65.454 m

FILE: 00283090.13o OP1384024014112

NGS OPUS SOLUTION REPORT

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: jacob_degayner@nps.gov DATE: November 09, 2013
RINEX FILE: 00283090.130 TIME: 19:07:18 UTC

SOFTWARE: page5 1209.04 master51.pl 072313 START: 2013/11/05 14:37:00
EPEHEMERIS: igr17652.eph [rapid] STOP: 2013/11/05 16:45:00
NAV FILE: brdc3090.13n OBS USED: 3392 / 3720 : 91%
ANT NAME: SPP68410_10 NONE # FIXED AMB: 30 / 30 : 100%
ARP HEIGHT: 2.07 OVERALL RMS: 0.012(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2013.8456)

X:	-1954062.715(m)	0.005(m)	-1954063.504(m)	0.005(m)
Y:	-5077038.890(m)	0.006(m)	-5077037.508(m)	0.006(m)
Z:	3320238.982(m)	0.009(m)	3320238.838(m)	0.009(m)

LAT: 31 34 5.55566 0.005(m) 31 34 5.56878 0.005(m)
 E LON: 248 56 56.99313 0.003(m) 248 56 56.94639 0.003(m)
 W LON: 111 3 3.00687 0.003(m) 111 3 3.05361 0.003(m)
 EL HGT: 966.125(m) 0.011(m) 965.192(m) 0.011(m)
 ORTHO HGT: 995.778(m) 0.024(m) [NAVD88 (Computed using GEOID12A)]

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 12)	SPC (0202 AZ C)
Northing (Y) [meters]	3492577.766	63318.733
Easting (X) [meters]	495175.974	295549.426
Convergence [degrees]	-0.02661293	0.45329964
Point Scale	0.99960029	0.99998329
Combined Factor	0.99944867	0.99983161

US NATIONAL GRID DESIGNATOR: 12RVV9517592577(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM2672	PIMA PIMA COMM COLLEGE CORS ARP	N321340.635	W1110107.026	
73228.9				
DL7716	P014 SAHuarita_AZ2007 CORS ARP	N315822.405	W1110554.902	45106.8
DM7129	AZVA SYCAMORE ELEM SCH CORS ARP	N315714.665	W1104613.032	
50376.5				

NEAREST NGS PUBLISHED CONTROL POINT

CG0875	B 432	N313403.6	W1110305.2	83.6
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