

Kabri-Akko Aqueduct Pipes Building Technique

Nikos Monsein



**ISRAEL
ANTIQUITIES
AUTHORITY**



**רשות
העתיקות**

Contents

Part I - Character Assessment

1.0	Introduction	1
2.0	Environmental Landscape	2
3.0	Building Technology	3
		4

Part II - Dismantling and Conservation Plan

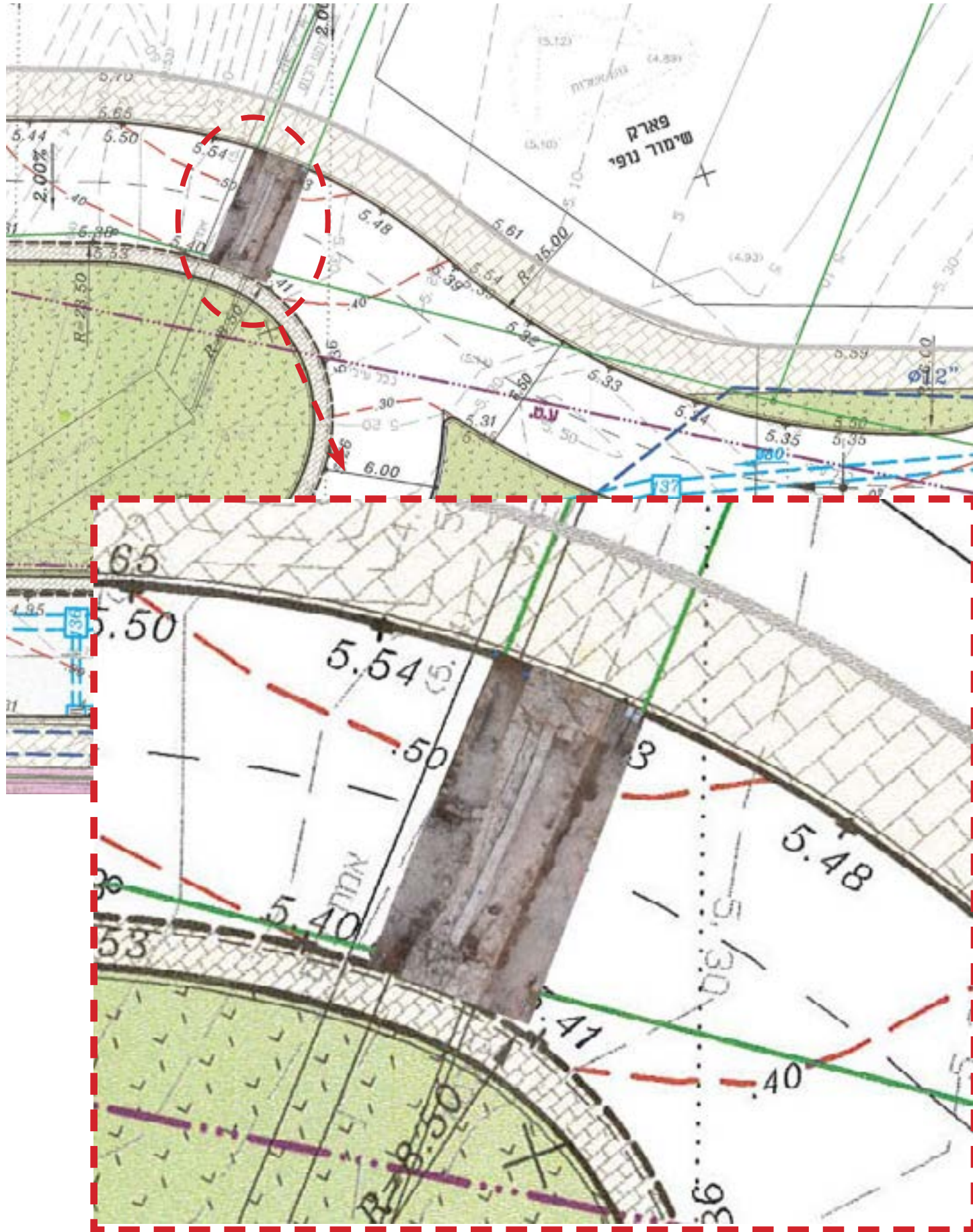
4.0	Plan For Disassembly	
-----	----------------------	--

Contact

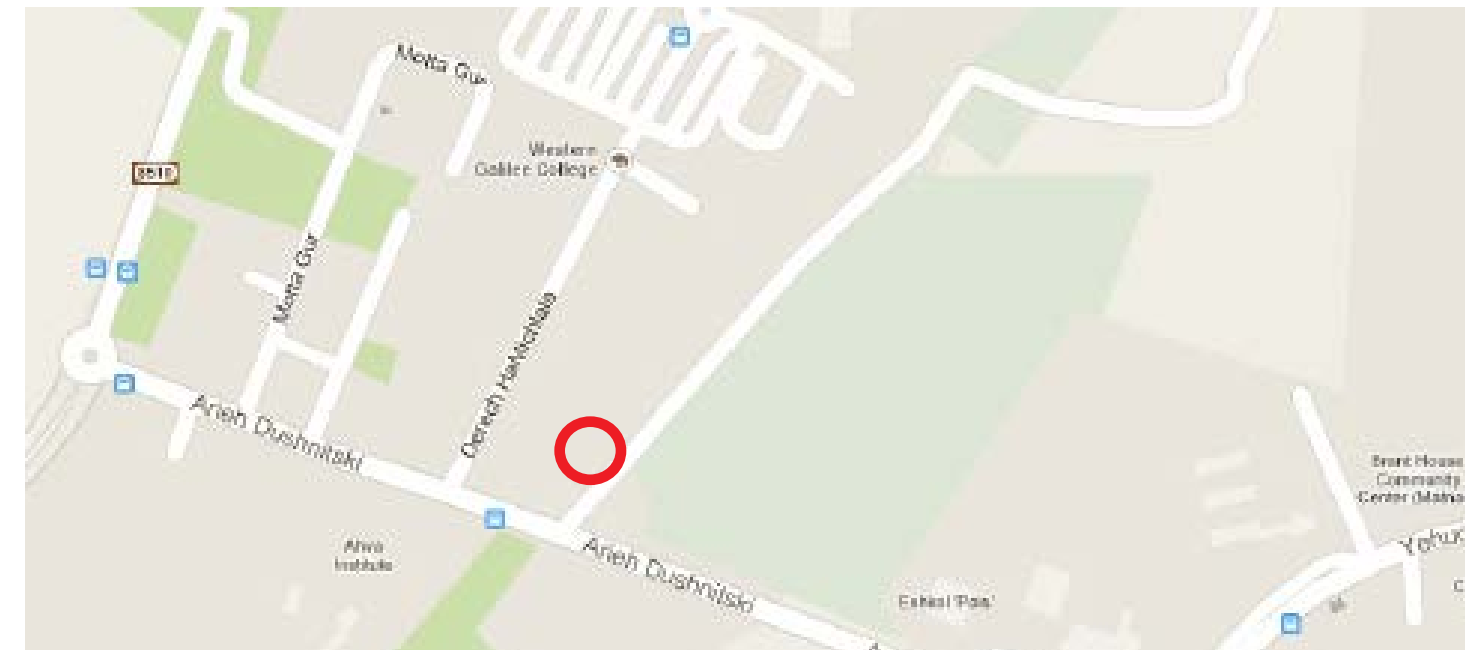
For more information or advice contact:

Nikos Monsein Yurss
Saving the Stones Fall 2013 Intern
International Conservation Center
Akko, Israel
email: nickmonsein@gmail.com
<http://www.antiquities.org.il/>

Construction plan: showing the area used for the analysis of the building technology



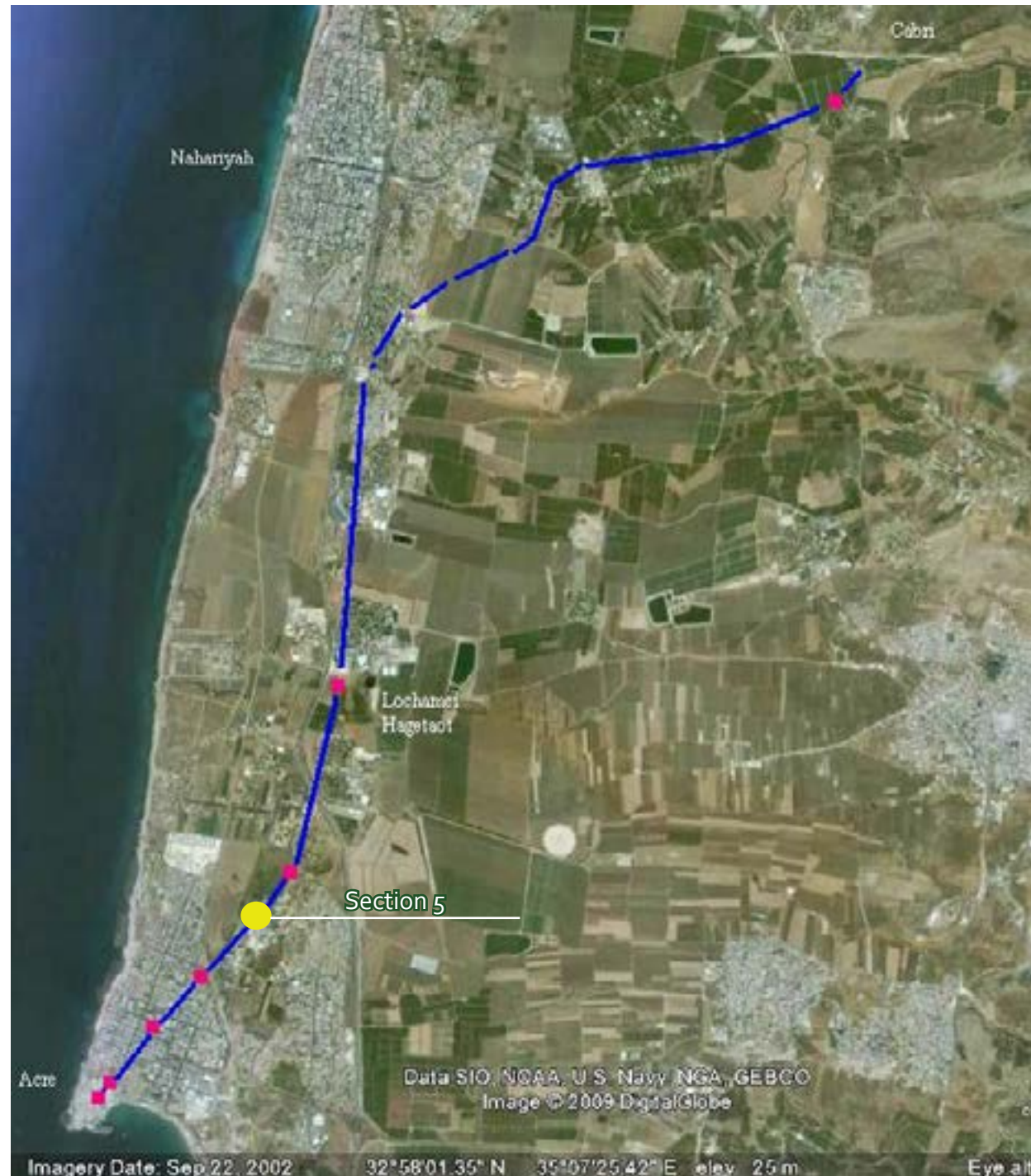
Part I Character Assessment





The purpose of this project was to document with great detail, the process of dismantling a section (known conventionally as segment 5) of the Kabri-Akko Aqueduct. Unfortunately, this project was initiated as a result of an accidental decision to allow development of a roadway through the section of the aqueduct in question. The purpose of the roadway is to provide access to a yet-to-be-constructed housing development. Because of this decision, the main priority of this project was to document the remains of the already damaged historical fabric before it was to be completely dismantled by a crew of students and professionals working together with the Israel Antiquities Authority as part of an educational program sponsored by The International Conservation Center in Akko.

While the circumstances leading up to and involving the dismantlement of this section of the Kabri-Akko Aqueduct are rather unfortunate, it does actually provide a tremendous opportunity for all to learn of the precise construction and technology of this structure.



Google Maps Satellite Imagery
Figure 1 - Kabri-Akko Aqueduct Conservation Area

3.0

Building Technology



Fig.#

Aerial View of Site, showing remaining stone and ceramic pipes

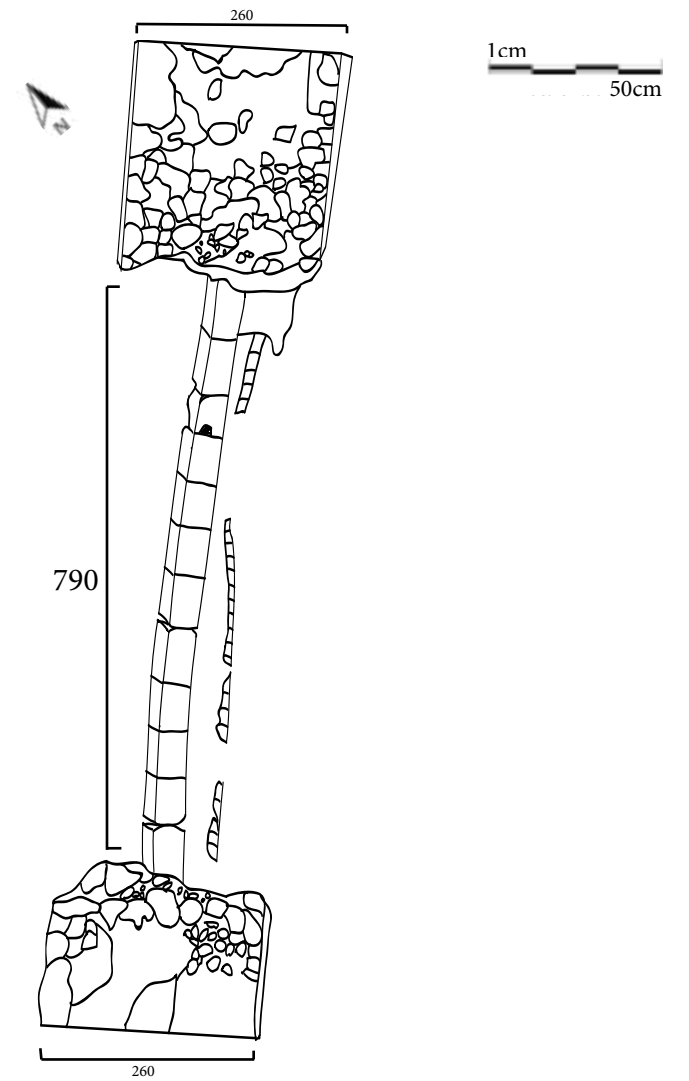


Fig. #

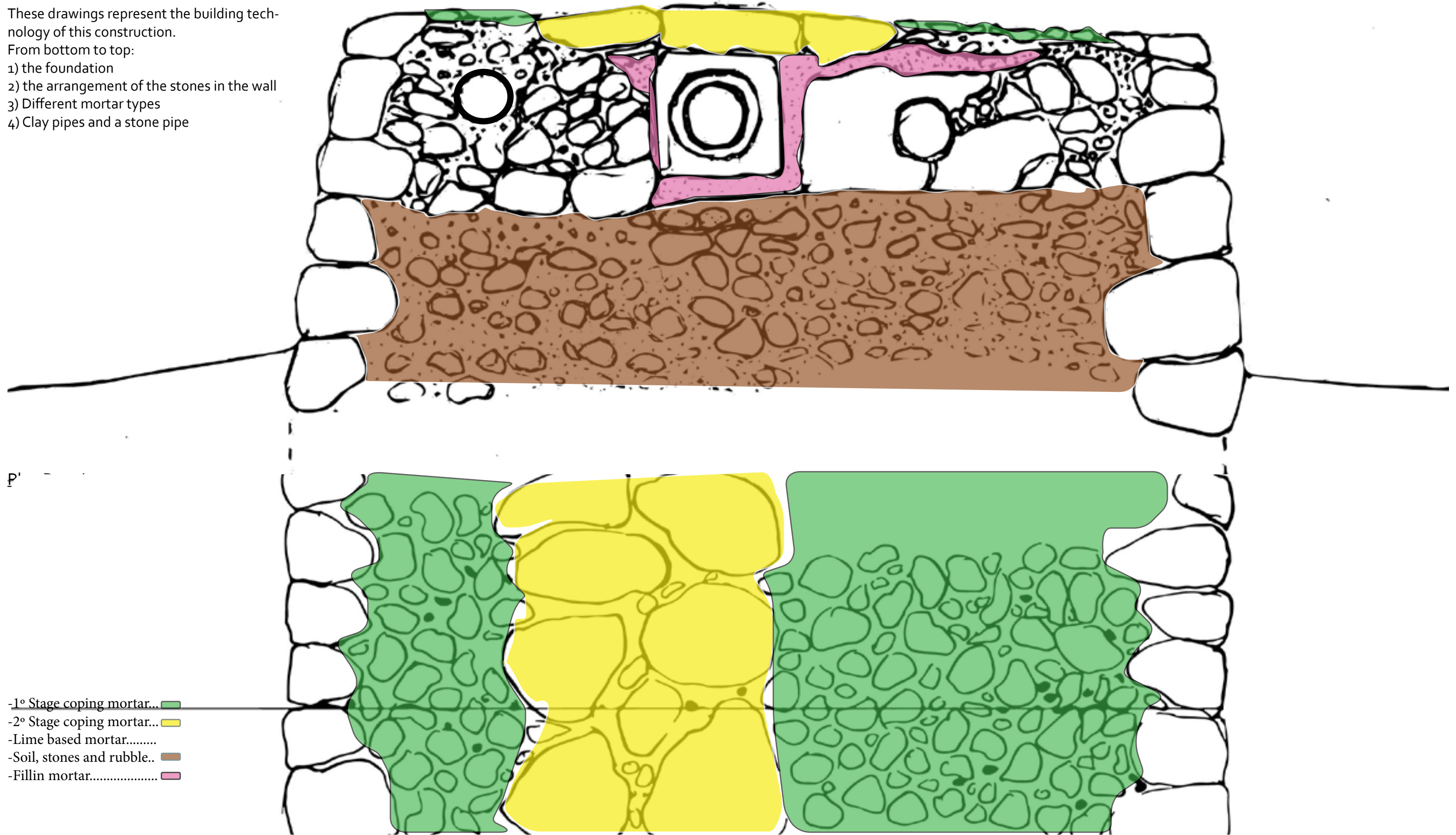
Architectural Plan, showing remaining stone and ceramic pipes

Section drawing

These drawings represent the building technology of this construction.

From bottom to top:

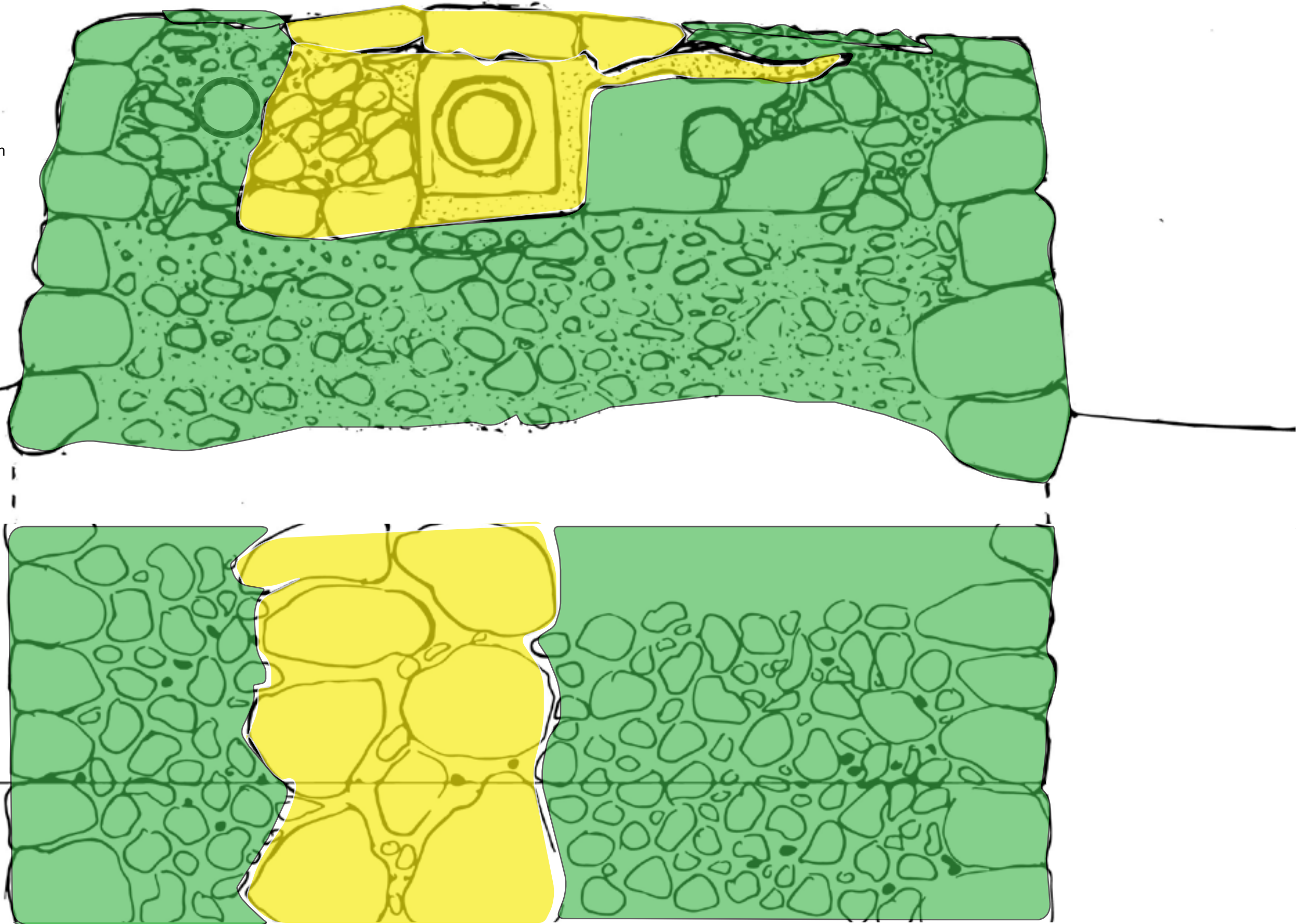
- 1) the foundation
- 2) the arrangement of the stones in the wall
- 3) Different mortar types
- 4) Clay pipes and a stone pipe

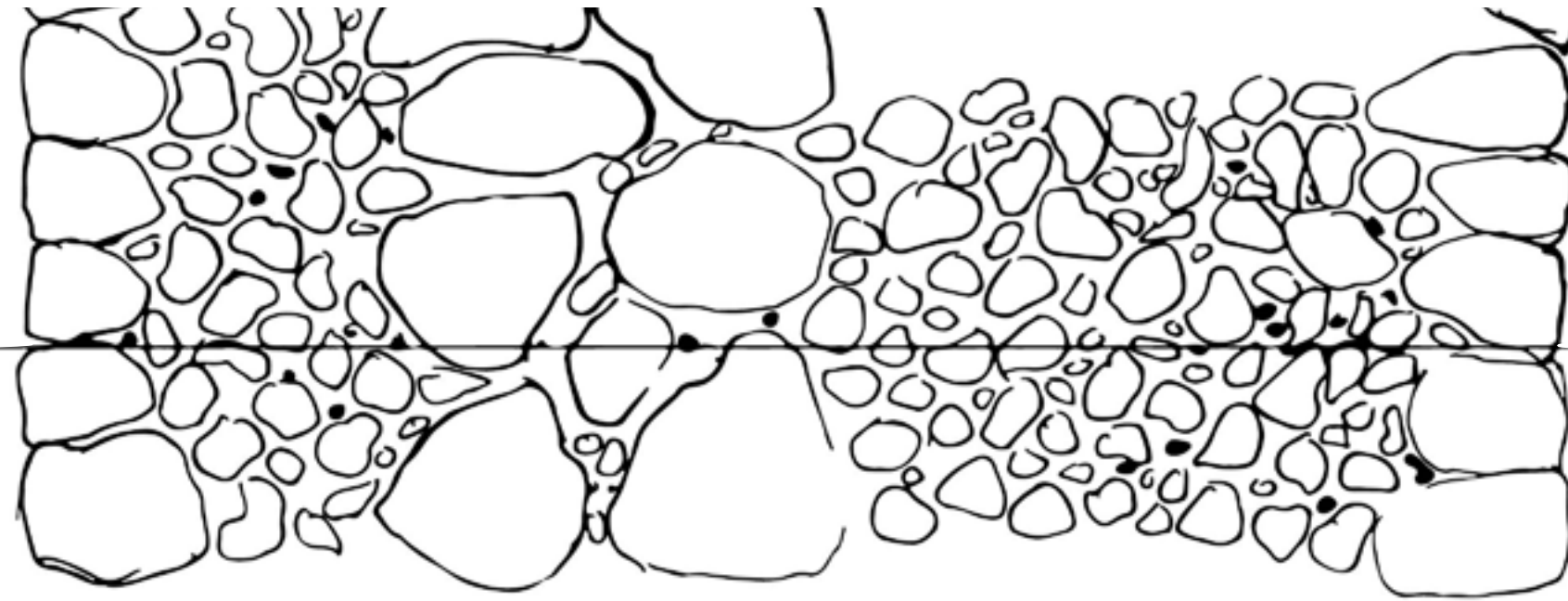


- 1° Stage coping mortar... █
- 2° Stage coping mortar... █
- Lime based mortar..... █
- Soil, stones and rubble.. █
- Fillin mortar..... █

Section drawing

This research has shown that there were 2 different stages of the construction. In the first stage there were 3 clay pipes covered by small stones coping. In the second stage a stone pipe was inserted (1873) to the place of the central clay pipe. So the situation has changed from having 3 clay pipes to having 2 clay pipes on each sides and a stone pipe in the middle.





Macro pictures of mortars

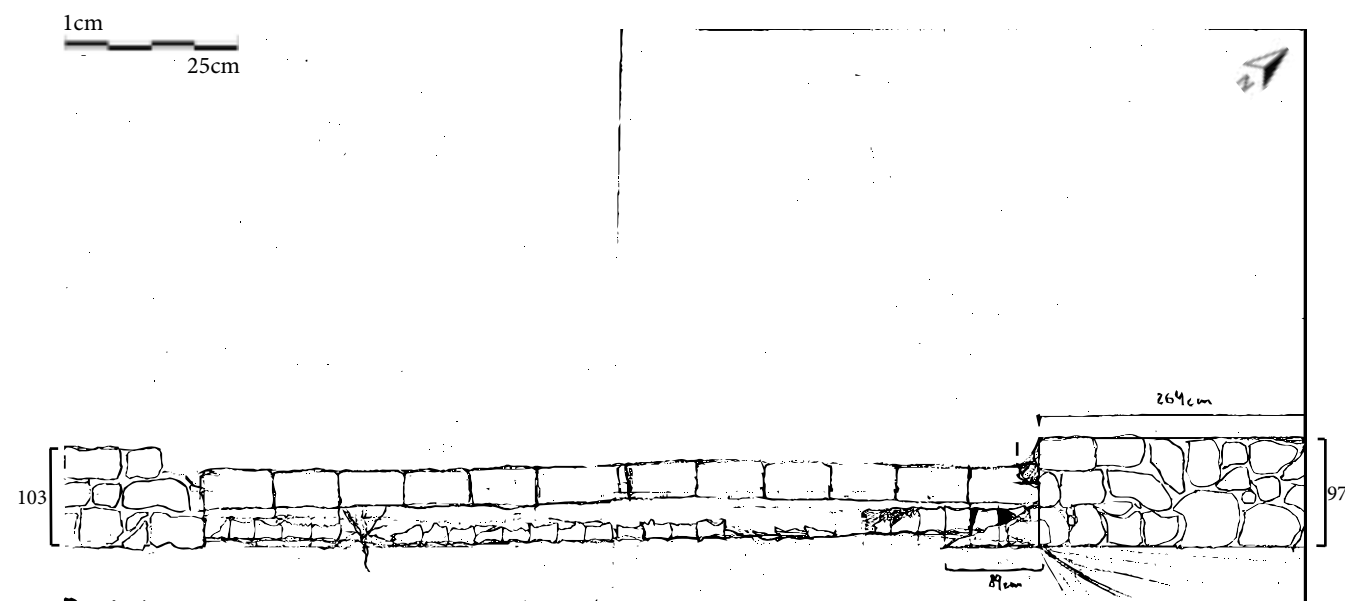




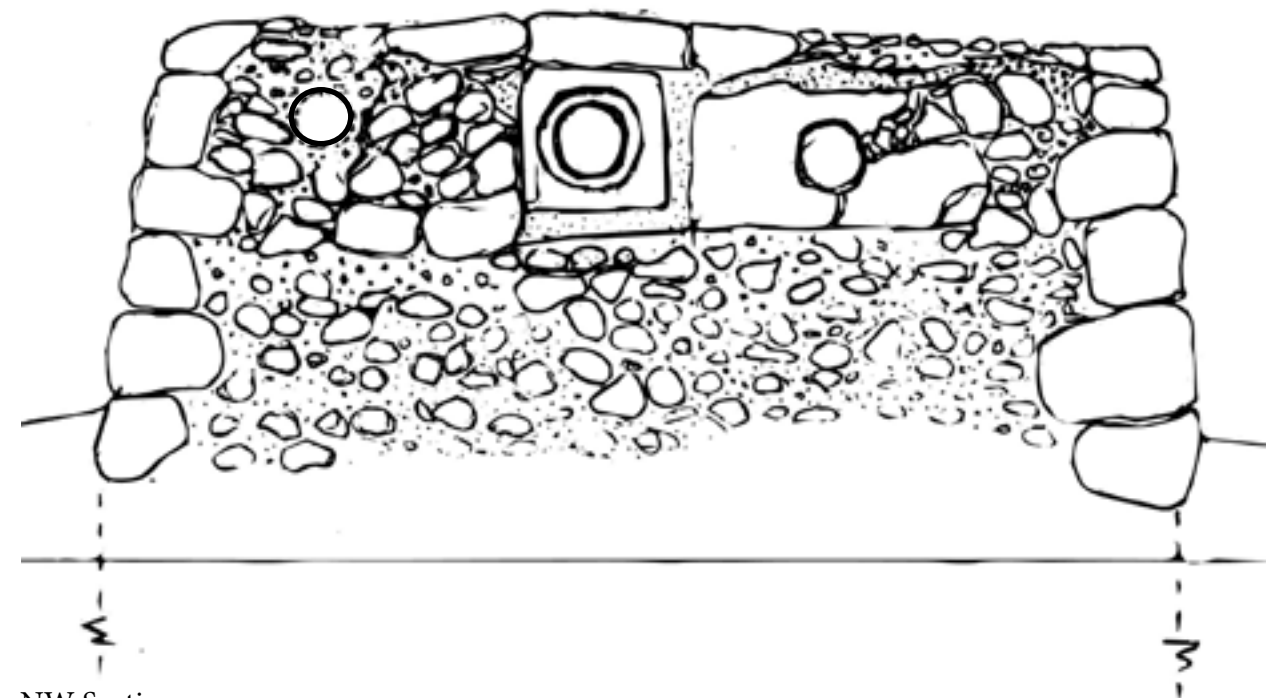
SE Elevation, photograph



Section, photograph



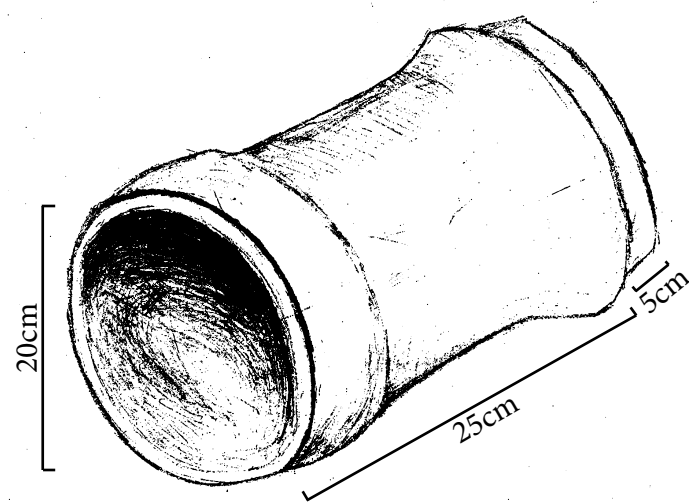
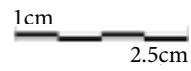
SE Elevation, drawing



NW Section



Ceramic pipe, photo

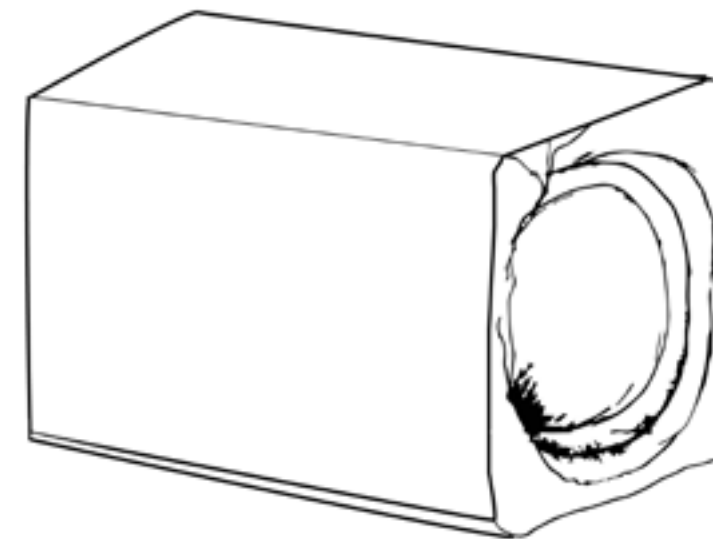


Ceramic pipe, drawing

This is an illustration portraying a section of a ceramic pipe as found in the segment of the aqueduct being studied in this project. The pipes were constructed out of ceramic material and linked together with lime mortar. The ceramic pipes found on site were installed before the original stone pipe was put in place. The size of both clay pipes pieces are more or less the same.



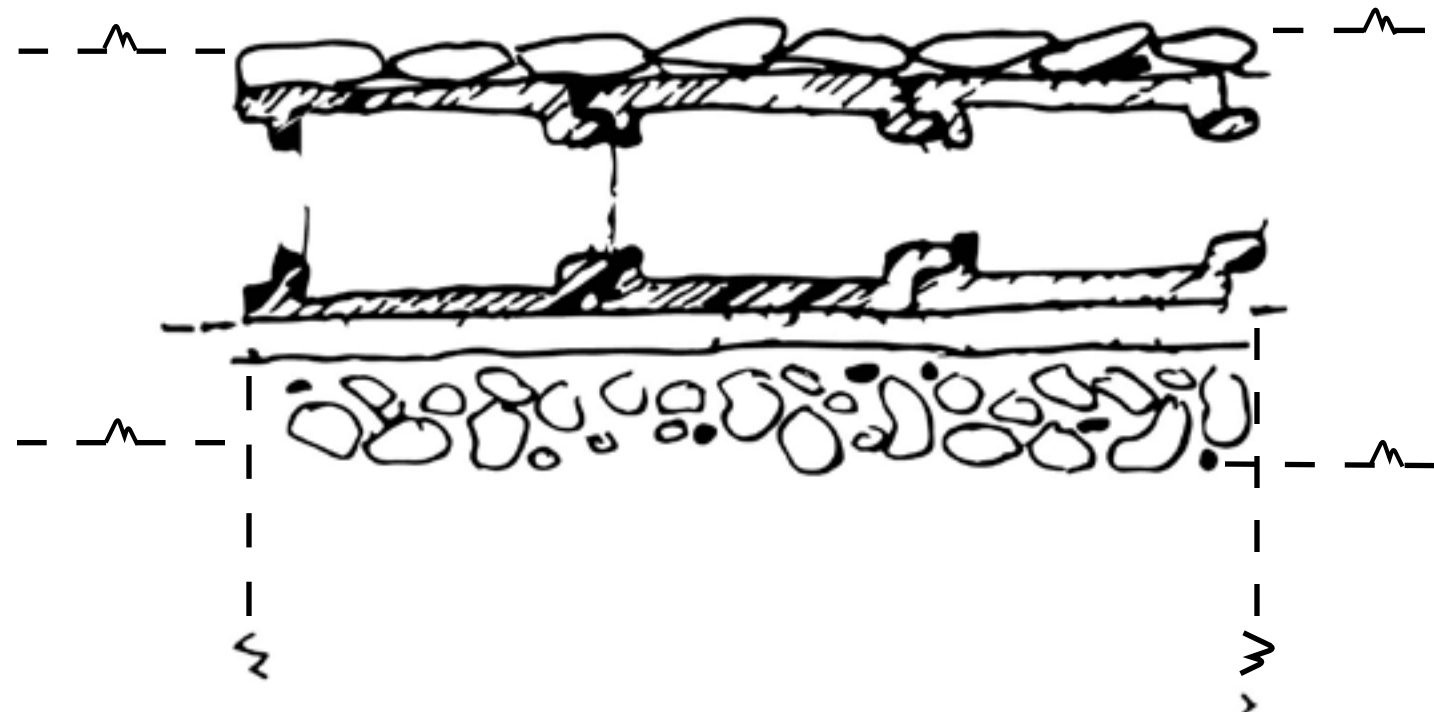
Stone pipe, photo



Stone pipe drawing

This is an illustration portraying a section of a stone pipe as found in the segment of the aqueduct being studied in this project. The pipes were constructed out of a durable stone material and linked together with lime mortar. The stone pipes found on site were installed after the ceramic pipes. These pipes functioned as the main method of water transportation from the Kabri spring to Akko.

Stone pipe section drawing:



Between each part of the pipe there is a very thin layer of hydraulic limestone

Part II Disassembly Plan



4.0

Kabri-Akko Aqueduct

Preperation for Disassembly	
Site Analysis	<ul style="list-style-type: none"> • Before any work could be done, it was necessary that the leaders of the disassembly project (Rob Kesack and Nikos Monsein Yurss) make several visits to the location to assess the condition and status of the site.
Initial Documentation	<ul style="list-style-type: none"> • Measurements were taken in situ and, from there, everything was documented quite meticulously. • Documentation of the site was done via numerous methods to ensure that the highest practical level of detail was recorded. • Methods of documentation used were: rough sketches, detailed architectural drawings and plans, photographs, 3D models produced and rendered via a photogrammetric procedure, and finally this report in which all results and findings have been compiled.
Determing the Necessary Tools	<ul style="list-style-type: none"> • Upon analysis of the observations made during the initial visits, it was determined that certain tools would be necessary to commence with and complete the disassembly of the aqueduct section. • From these visits, it was determined that a delicate and non-electro-mechanical method would best suit the needs of this project. • At least initially, only basic hand tools were to be used to accomplish the task. • The tools assembled and used on site were as follows: Various sizes of chizels, hammers, small and large picks, pick axes, brushes and brooms for cleaning of the stones and surrounding area, shovels and hoes for the removal of large quantities of dirt and rubble which covered the portion of the aqueduct to be worked on, a water hose, water bottles, and sprayers for fine cleaning of the stone after the second phase of hand clean-


Preperation for Disassembly	
	ing was finished.
Safety	<ul style="list-style-type: none"> • Safety materials were also considered, gathered, and brought to the site for the security and well-being of the workers while in situ. • The site is outdoors and thus exposed to the elements, namely, the sun. A tarpin along with rope and wood supports was brought to the site and assembled to block the harmful and oppresive UV rays of the sun. Safety glasses and work gloves were provided for all those involved in the project. Water was of course stressed as a necessity when dealing with such extreme weather conditions on a work site such as this one.



Pictures of the cleaning process



5.1

Kabri-Akko Aqueduct

Dismantlement Procedure	
Disassembly Day One: Preparation of the Site	
<p>Cleaning</p> 	<ul style="list-style-type: none"> The first task at hand for the disassembly crew was to ready the site for the actual disassembly process. To do this, the site needed to be made safe and clean. Phase One of the cleaning process involved the removal of large quantities of dirt and rubble from the immediate area of the aqueduct section in question. Phase Two of the cleaning process was mainly focused on the use of hand tools such as plastic and natural haired brooms and brushes to safely remove the remaining layers of dirt and grime which the shovels and other large tools could not address. Phase Three involved a spray down of water from a hose and pump-action water bottles to remove
<p>Additional Documentation</p>	<ul style="list-style-type: none"> Immediately after the removal of the ceramic pipe, the dismantling of the stone pipe section began. First, an attempt was made to remove the mortar from the extremely narrow, and visually non-existent joints between each stone piece;
Disassembly Day Two: Recapture of Images for Photogrammetric 3D Modeling	
<p>Documentation (2nd Attempt)</p>	<ul style="list-style-type: none"> The lighting conditions were deemed unsuitable for a clear and defined model. The next morning, a crew was dispatched to the site to recapture the images in the morning during more neutral lighting conditions.

Dismantlement Procedure	
Disassembly Day Three: Further Dismantling and Documentation	
<p>Continued Disassembly</p>	<ul style="list-style-type: none"> The day began with further removal of dirt and rubble, as well as some of the lime mortar layer which surrounded the pipes.
<p>Additional Documentation</p>	<ul style="list-style-type: none"> Once the pipes were isolated and left exposed and visually free from the soil and mortar which once surrounded them, another set of photographs were taken and later used to render yet another three-dimensional model.
<p>Removal of Cermaic Pipe</p> 	<ul style="list-style-type: none"> The next task was to carefully remove the mortar between the cermaic pipe sections so that they might be freed and removed from their location in situ. The pipes were easily removed by hand with the aid of small and large picks. Each piece along with surrounding smaller fragments were put aside and kept together in one location. (It was not the goal of this project to catalogue and mark numerically these pieces for reassembly, only to remove with caution and preserve the most intact pieces which demonstrate the original construction and technology.)
<p>Removal of Stone Pipe</p> 	<ul style="list-style-type: none"> Immediately after the removal of the ceramic pipe, the dismantling of the stone pipe section began. First, an attempt was made to remove the mortar from the extremely narrow, and visually non-existent joints between each stone piece; for this, small hand tools such as picks and hammers and chisels were used. weakest stone with the cut and then be able to one-by-one remove the remaining pieces. The hand tools proved inefficient against the strength of construction and integrity of the particular section of pipe. It was decided to incorporate the use of a powered electric Skill saw to cut through the weakest stone in the segment.

Dismantlement Procedure

Removal of Stone Pipe (Cont.)



- The idea behind this strategy was to free the weakest stone in the series and then easily remove the remaining pieces of pipe.
- This method too proved non-effective.
- A rear tractor, otherwise known more commonly as a "backhoe", was brought in to the site to aid in the removal of the stubborn stone pipe.
- The tractor also failed to free the stones from the site and work ceased for the rest of the day.



Disassembly Day Four: Removal and Transportation of the Stone Pipe