Geophysical Survey Report for the San Gabriel Mission

By

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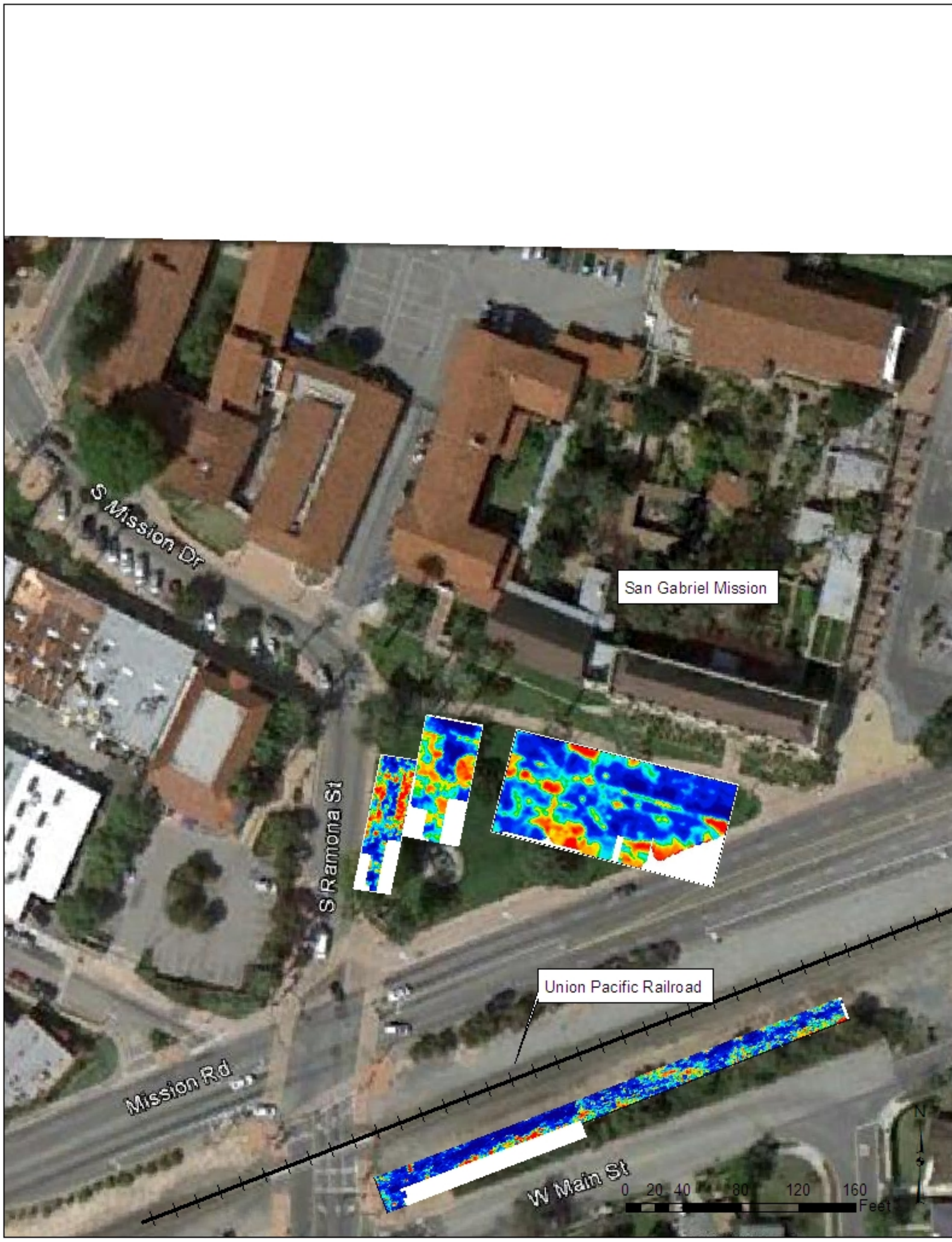
Summary

This report covers the geophysical survey as part of the project is located south of the San Gabriel Mission and Mission Boulevard in the city of Alhambra (Map 1). The purpose of the survey was to map potential subsurface cultural features along the northern edge of Main Street and within the Union Pacific Railroad (UPRR) right of way (Map 2). The area surveyed contains previously identified historic remains of a millrace and another linear feature.

Summary findings from ground penetrating radar (GPR) were very helpful in further delineating buried portions of both the millrace and the linear feature. Magnetic data collection was attempted, but due to large amounts of metal (e.g., railroad, overhead utility lines and consistent traffic on Mission Boulevard) was halted. GPR data yielded results to a depth of 3.6 meters, though additional calibrating will come after more direct information is received from SWCA field staff excavating the millrace. Three Targets of Interest were identified within the GPR data. They include extensions of the millrace, the linear feature, and possible footings of a yet unidentified structure.

Map1. Project location map.



Map 2. Geophysical Survey Grid Locations.

1. Introduction

This analysis used geophysical survey technologies to maximize the recognition of potential targets consistent with historic sites. The use of multiple technologies is the preferred method when possible (Ambos and Larson 2002 and Kvamme and Ahler 2007). However, due to external magnetic interference from utility lines, rail road tracks, and consistent traffic, themagnetic survey was not conducted.

The initial survey included two grids adjacent to the southern edge of UPRR. Time permitted the collection of data from the park located in front of the San Gabriel Mission. These grids were collected in hopes of locating the continuation of the Millrace across Mission Blvd. to San Gabriel Mission. However, disturbance from modern activities has obscured any trace of the millrace. No further discussion of these additional grids is included, though the time slices have been included in the appendix.

1.1 Target of Interest (TOI)

The exact nature of any given anomaly is unknown until it is exposed, though a range of possible identities can be deduced. In order to determine which anomalies are chosen for further analysis, each anomaly selected for testing must meet a set of criteria which raises it from the (a) unknown (anomaly), to (b) target of interest (TOI), to (c) identification of cultural material through the use of some standard excavation method. It is not until a sufficient portion of the feature is exposed that a final determination is made. The method for determining which anomalies become TOI is as follows:

a.) Identification of patterning within each data set is done through visual inspection of the processed data. In general, patterning can be in the form of a circular, rectangular, or linear shape that matches what would be expected for a house pit, footings, trench, etc.

b.) Once all data has been processed, each dataset is examined side-by-side or overlain to identify anomalies that occupy the same X, Y coordinate space. An anomaly that fits the X, Y criteria or that has patterning is determined to be a target of interest (TOI).

   i. For those TOI that come from the GPR data, a second step may be taken to gain additional information related to the TOI. This step involves an examination of the GPR radargram to determine the type and/or shape of the TOI matches expected outcomes for any of the possible feature types.

   ii. To gain further information, each TOI is tested using a bucket auger to determine if cultural material is present. This minimally invasive approach allows for quick examination of each TOI.

   iii. If a TOI contains cultural data it is recommended for further and more extensive testing to fully examine whether it is an archaeological feature. If nothing is found through the auger process the TOI is removed from further considerations.

As noted previously the magnetic survey was abandoned due to large magnetic fields present in and around the survey area. However, because of first hand evidence of the millrace and garden wall as linear features, the use of TOI is based upon ‘patterning’ and not a comparison of GPR and magnetic results.

TOI may fit an expected feature type (i.e., based on patterning, size, or magnitude) and discussed as such (e.g. looks like the expected geophysical signature for a hearth, pit, etc.). However, no claim is being made during the preliminary testing phase to the actual nature of the TOI. Only after it is examined through visual inspection where a sufficient portion of the TOI is exposed for identification is it given status as a type of cultural feature.

2. Methods

The survey area covered six grids of various sizes (Grid 1, 45 x 8 meters; Grid 2, 47 x 22 meters; Grid 4, 38 x 9 meters; and Grid 5, 38 x 18 meters; and Grid 6, 61 x 5 meters), the total area surveyed of 2,825 square meters. It was hoped data collected across the street would add additional context and though Grid 2-5 were collected results from these grids is not included within the discussion as they fall outside the Area of Direct Impact (ADI), filled with recent disturbances that mask any evidence of the Missions occupation period.

Prior to the remote sensing survey a backhoe removed approximately 0.3 meters of soil from the surface. This decision was reached based on prior testing by SWCA, during Phase II studies. This soil was deemed disturbed and therefore easier to remove prior to mitigation efforts.

2.1 General Description of the GPR Survey

GPR grids were set up using tape measures. GPR transects were collected bidirectional with transects spaced 0.25-meters apart with internal fiducial marks placed every meter by the GPR survey wheel. A 500 MHz antenna allowed for deep signal penetration (up to 3.6 meters). Grid datum locations varied according to the terrain and grid layout. To help insure data collection integrity, the GPR survey was stopped every so often and individual transects counted to insure the operator was on the correct transect.

BASSS uses a RAMAC/GPR system consisting of an external data collector, a radar control unit, a transmitter, and a receiver antenna. The radar control unit is connected to the receiver antenna and the data collector. The entire system is mounted on a four-wheeled cart, which is manually pushed or pulled. The incoming signal is measured a prescribed number of times per unit of time based upon a measuring wheel connected to the four-wheeled cart. The result of every measurement is a numeral representing a basic sample. A defined number of samples are used to construct a trace. Traces are collected and quantified to develop a profile. During data collection, the whole system is wheeled along the survey line. The result is a continuous profile record of subsurface conditions along a survey line, which is called a radargram. Radargrams are two-dimensional files depicting the subsurface conditions along a single survey transect. The various radargrams, dependent upon survey transect interval and the overall size of the survey grid, are then combined to develop a three-dimensional profile using the GPR-SLICE V6.0 computer software program. This software allows the user to define specific sampling ratios and criteria to develop a subsurface map of known changes in subsurface dialectical properties.

Images use a standard 256 color scale with red representing the higher end of the scale and blue/purple the lower end. So the redder the GPR anomaly appears the denser the material. The term ‘dense’ used here is a relative term and does not denote measurable density just that it is denser than other anomalies measured in the image. In other words one cannot say that one red anomaly in the image is any more dense than another in the same image.

2.2 Basic GPR Signal and Image Processing

The following discussion is adapted from *GPR Methods for Archaeology* (Goodman 2007). The resulting 3-D survey over an archaeological site is really just a collection of radargrams recorded at a finite number of x and y locations at the site, with the reflection time along the individual pulses representing the third dimension in z. To make useful images of these radargrams, several basic processes, referred to as signal processing are necessary to treat or filter the raw data. Once the signal processing of each data set was completed, images were created.

Signal processing involves a suite of mathematical operations applied to the raw radargrams to filter out noise as well as to help map the real locations of the pulses collected from the broad beam antenna. Though there are many signal processes available, the following basic signal datum processes were applied to the GPR data and in the sequence of their performance:

Post Processing Gain: Raw radargrams were re-gained after data collection since the X3M unit records 16 bit un-gained data. [16 bit refers to the digitized pulses represented by the numbers from -32768 + 32767, which can also be written as -2^{15} to $+(2^{15}-1)$]. The later arriving reflections to the GPR antenna, the echoes that travel farther into the ground, are much weaker than the earlier recorded reflections. In order to see them on the computer screen, exponential gain curves were applied to the later arriving raw radar pulses. Commonly the processing gains applied using Caltrans equipment are plus 1 to 4.
DC Drift Removal: Raw regained radargrams contained noise which is caused by the shifting of the entire pulse from the 0 line. This can be caused by a variety of factors, most of which is inherent to electronics dealing with microwave pulses. To remove this, several filters, either applied in the time domain or in the frequency domain, cut out certain frequency bands in the data thus shifting the radargram pulses back to the 0 line.
Hilbert Transform: A Hilbert transform was used to calculate the envelope of the radargram pulse. This envelope of the pulse (computed using a Fast Fourier Transform in which the negative frequencies are shifted by 90 degrees and then an Inverse Fourier Transform is performed) was considered as an operation that develops a plot that connects the (+) peak amplitude responses of the signal. The Hilbert transform radargrams have no minus values, are rectified signals, and are often better for visualizing areas of strong reflection.
Background Removal: The fourth signal process used on raw radar signal was background removal. In this simple process the average radar scan across the profile is computed and then subtracted from every scan. This removes the horizontal banding representing parts of

the pulse that never change across the profile and are considered the background pulse or noises contained with the GPR control unit.

Images were created after each process and examined for the overall effect the process had on the data in relation to the previous processing. After the background removal process was completed, data went through a gridding and slicing process that led to creation of time slice series images representing both horizontal and vertical sections. Individual time slices were then examined for the best representation of the GPR data at each depth in an attempt to identify patterning. Appendix contains a complete set of time slices for both grids. Only a select few of the time slices were used as graphics in this report.

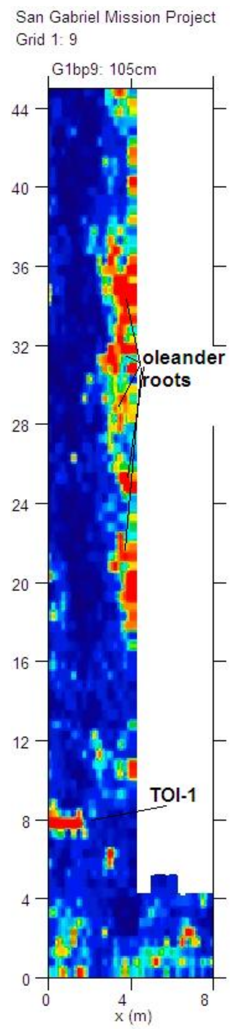
3. Results and Recommendations

3.1 Grid 1

Two distinct linear anomalies are present at the westernmost end of Grid 1. The first likely relates to a linear feature. The wall was intersected as the backhoe was creating an entry road onto the property. TOI-1 aligns very well with this wall (Figure 1). This newly identified portion is located approximately 4.5 meters northeast of the known wall footings. TOI-1 begins at a depth of 1.0 meters below the modified surface (1.3 meters below the actual surface. Previous test excavations that located the wall determined it to be 0.75 meters below surface. At the time of the geophysical survey the wall identified from the backhoe was on a sloping surface. This could explain the disparity between TOI-1 and the known feature.

A second target was located at a much deeper depth than any previously identified historical remains (Figure 2). TOI-2 was identified at 2.0 meters below surface (2.3 when you add the fill that was removed). TOI-2 is also a linear feature that could represent an earlier iteration of the wall or possibly a small structure as there appears to be 2.0 by 1.5 meter rectangular feature attached to the northern extent of TOI-2. Aside from the depth difference TOI-2 runs parallel to TOI-1 and approximately 2.0 meters west.

It is recommended both TOI-1and 2 be exposed to determine if they are related to the known feature. Secondly, determining depth is based upon matching a hypothetical curve to a strong hyperbola within the radargrams. This function tells the software the dielectric properties of the soil, which is then used to determine signal penetration. It is by nature relative to the user’s ability to choose a sufficiently strong hyperbola and the user’s ability to fit a curve correctly. A mismatch of the curve in one direction or another can make the hyperbole appear shallower or deeper. Depth information from test excavations on the other hand is exact. It is recommended that depth information from test excavations be sent to Caltrans and images reprocessed for finalization of all time slices.



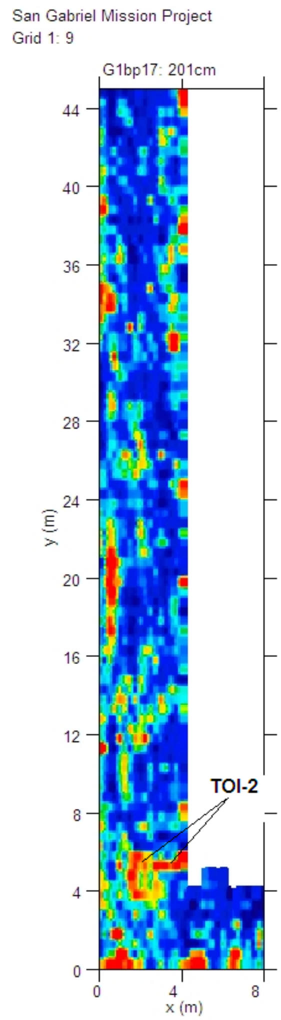


Figure 1 Shows location of TOI-1 Figure 2 Showing location of TOI-2

3.2 Grid 6

Grid 6 is located adjacent to the eastern end of Grid 1. Near the eastern extent of Grid 6 is the location of the millrace, partially exposed at the time of the geophysical survey. TOI-3 is the sole target identified for testing (Figure 3) and appears to be the extension of the millrace as it heads north towards the mission. In side section the millrace appears to have a somewhat v-shaped central portion (Figure 4), likely the duct in which the water travelled to the working gears. The bottom of the potential water portion of the millrace is at 0.77 meters below the surface. Finally the base or footings appears to be at 1.35 meters below the surface (Figure 5). As with TOI-1 and 2 results from test excavations be used to augment the hypothetical curve to determine real depth be given to Caltrans archaeological staff for correcting of GPR data.

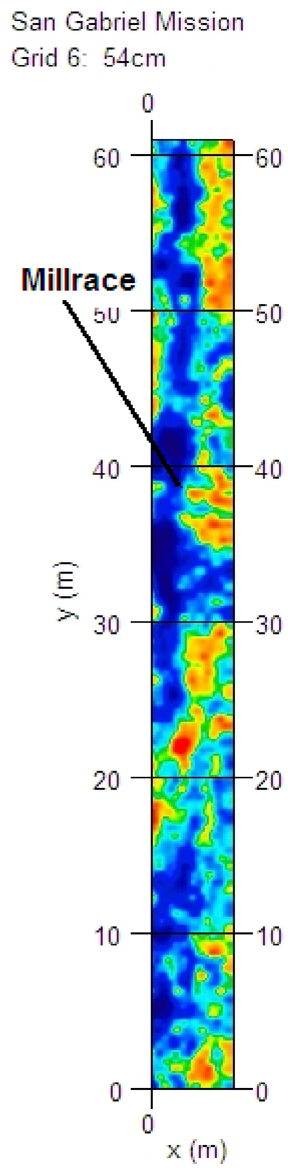


Figure 3. Plan view of GPR time slice at depth of 0.54 m showing location of millrace.

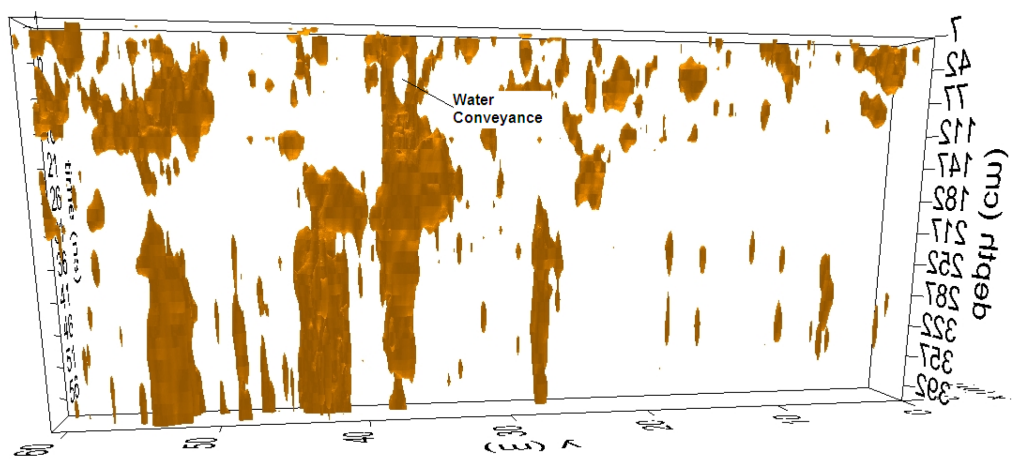


Figure 4. ISO view of the water conveyance system.

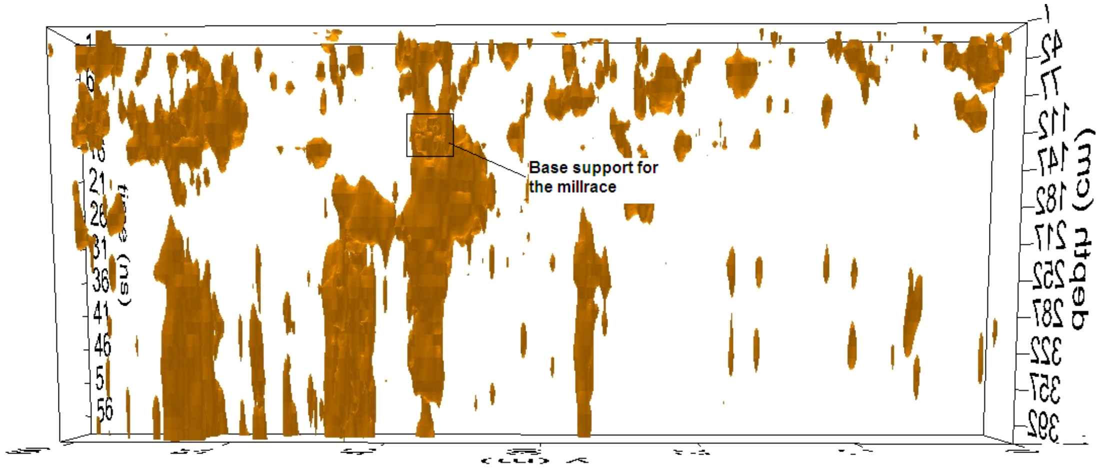


Figure 5. Grid 6, base of millrace at 1.35 m depth.

References

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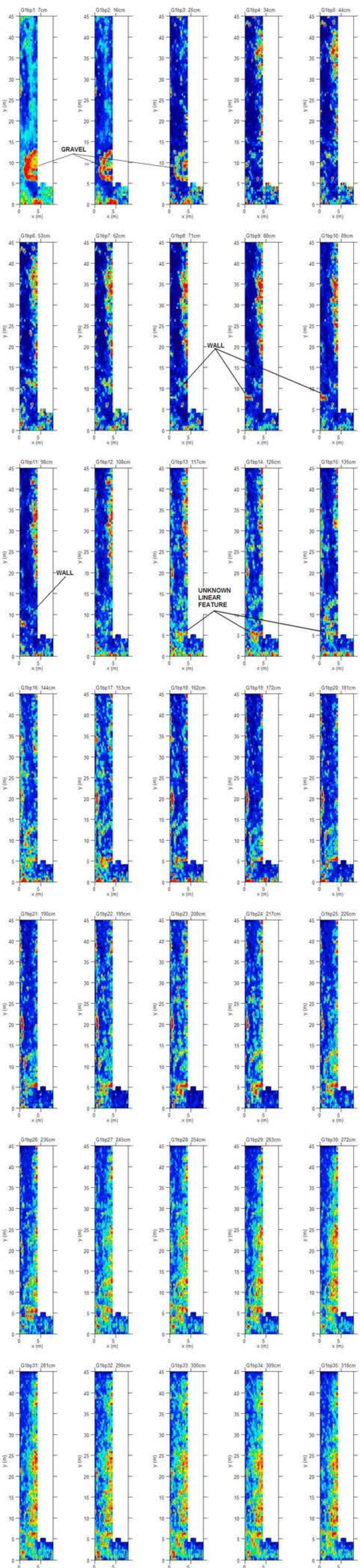
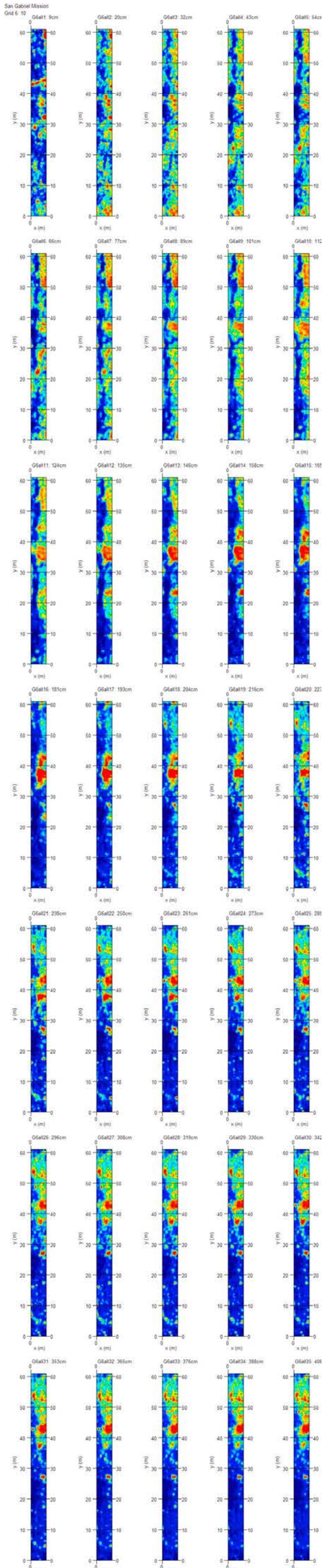
Appendix



All time slices for Grid 1.



All time slices for Grid 6.