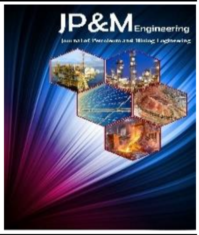
JP&M Engineering

Journal of Petroleum and Mining Engineering



A Survey of Contractors Permitted to Excavate on Historic Sites in Egypt

Shearman, J.[1*], Abbas, A.[2], Hamed, A.[2], and Aly, N.[2]

[1] *VP Operations and Development – Adam Shearman, Inc.*

[2] *Faculty of Petroleum and Mining Engineering, Suez University, Egypt*

*Corresponding author: jpshearman@gmail.com

Article Info

Received 27 Oct. 2020
Revised 7 Dec. 2020
Accepted 9 Dec. 2020

Keywords

Construction; Archaeology; Geophysics; Risk; Preconstruction Planning; FMEA

Abstract

Geophysical surveys are an essential tool in analyzing risks associated with unknown subsurface conditions. In Egypt, excavating on historic sites can be challenging when encounters of archaeological material occurs. For the contractor, delays and work stoppage affect costs. For the archaeologist, encounters risk the chance of damage as well as possible time consuming mitigation. Ten contractors, representing the total population of an ongoing research investigation, that are registered to excavate on historic sites associated with construction projects, were given a survey questionnaire. 100% of the population responded providing reliable data so further determinations can be made. The questions focused on the impact archaeological encounters had on contractor's production and schedule. The results show several problems linked with the two professions of construction and archaeology. This paper will detail the questionnaire results and suggest a modified well established planning tool, utilizing geophysical surveys, that pinpoints anomalies so procedures can be performed during the preconstruction phase (proactive) rather than during construction activity (reactive). The procedure corresponds with current planning practices and can reduce the occurrence of unexpected archaeological encounters causing the contractor delays along with reducing the possible damage to the archaeological material.

Introduction

Planning a construction project entails many components. One of the components is a procedure of risk analysis so that plans and decisions may be generated and implemented with the goal of reducing the risk to the desired level. Several methods to analyse risk including desk-based assessments coupled with geophysics are available. There are several combinations of geophysical applications that are also integrated with non-geophysical methods. Dell'Aversana, et. al. [1], state that Machine Learning (ML) can mitigate risk by integrating multi-disciplinary information like seismic, electromagnetic, gravity, and magnetic data to create a model. Decisions can then be made regarding the output. Lapenna [2] describes a method using algorithms for the tomographic imaging coupled with multi-resolution analysis for subsurface exploration in urban planning. Gomez, et. al. [3], utilized a method combining photogrammetry with ground penetrating radar when analysing volcanic activity. Both trends and evolving technology are improving the evaluation of subsurface analysis.

Nature of the problem

On a historical site, when excavation is part of the scope of work, encounters with archaeological material can cause the contractor delays, work stoppage and claims for additional compensation. For the archaeologist it can cause damage to the archaeological material and impact the time schedule. For both the contractor and the archaeologist, conflicts may arise causing the professions not to cooperate and impair the teamwork spirit.

Methodology

The objective of the research was to obtain reliable data so a comprehensive solution could be designed. A combination of methods was used in the study to validate the reliability factor. They consisted of a literature search, interviews, survey questionnaire, case study and personal experience. In this paper, the focus is on the survey questionnaire taken by the contractors who are registered to excavate on historic sites by the Egyptian Ministry of Tourism and Antiquities. The response from the survey questionnaire matches the data from the other methods used showing the data obtained is reliable.

Results

Of the 10 contractors representing the total population registered to excavate on historic sites, this study received a 100% return (10 out of 10). Due to the fact that the total population was surveyed, there is no need for any statistical inferences in this case. The contractors were also provided inonimity with no mention of their company affiliation so that their responses would be factual. This constitutes a significant response and qualifies as an accurate reflection of actual data. The survey question and response for each query is as follows:

1) Based upon your knowledge, what percentage would you say that archaeological investigation has taken place on your construction sites <u>before</u> construction activities.

With a total of 100% contractor response to this question:

0 responded 0
0 responded 1% to 10%
3 responded 10% to 25%
1 responded 25% to 50%
4 responded 50% to 75%
2 responded to 75% to 100%.

Figure (1) shows the response in bar graph form.

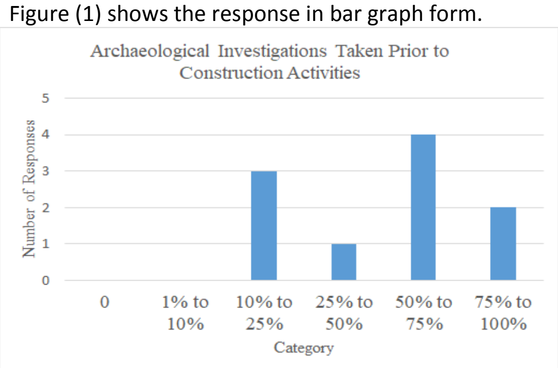


Figure 1 Bar graph of respondents associated with archaeological investigations taken prior to construction.

The information shown in Figure 1 tells us that archaeological investigations prior to construction activities do not happen 100% of the time and seem to vary between contractors.

2) To your knowledge, before construction activities, did you receive any site information of any geophysics survey such as maps, boreholes, GPR or other geophysical investigations?

With a total of 100% contractor response to this question:

2 responded YES
5 responded NO
3 responded OTHER

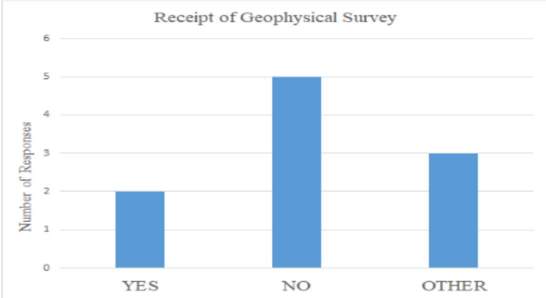


Figure 2 Bar graph showing response to receipt of geophysics survey prior to construction activities

The majority of respondents stated that they did not receive geophysical information prior to construction activities. The OTHER comments are as follows:

- The information is very limited and is due to no site activity for 50 years.
- Obtained information on a test pit that was excavated 7 years ago from a mission that worked on the site.
- Received a report from the owner regarding an unfinished test pit.

3) To your knowledge, before construction activities, did you receive any site information of any archaeological survey such as maps, historical and/or excavation documents?

With a total of 90% contractor response to this question:

1 responded YES
7 responded NO
1 responded OTHER

Figure 3 shows the response in bar graph form.

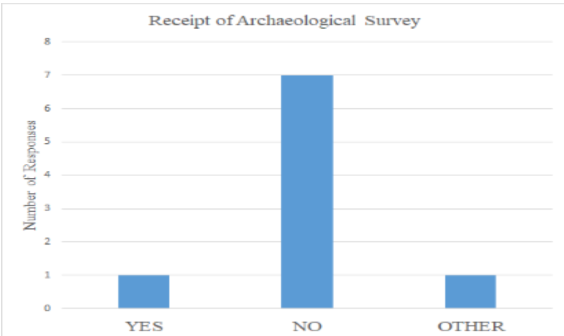


Figure 3 Bar graph showing response to receipt of archaeological survey prior to construction activities

The majority of respondents stated that they did not receive site information on the archaeological survey prior to construction. The OTHER comment is as follows:

- Receives oral orders from the owner and employees.

4) Would you consider encounters with archaeological remains during your company's construction activity substantial or infrequent?

With a total of 100% contractor response to this question:

10 responded SUBSTANTIAL
0 responded INFREQUENT
0 responded OTHER

Figure (4) shows the response in bar graph form.

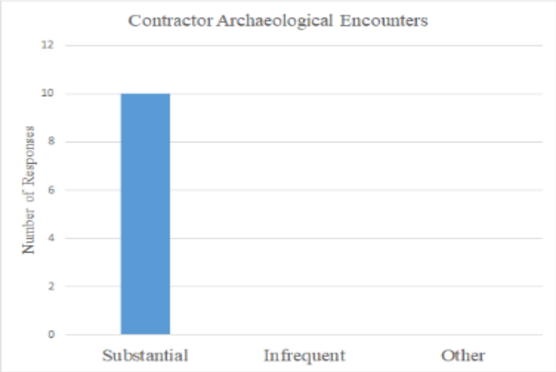


Figure 4 Bar graph showing response to contractor archaeological encounters

The respondents show that encounters with archaeological material is substantial and is a common event.

5) If the answer to question 4 was "SUBSTANTIAL", did the construction activities:

With a total of 100% contractor response to this question:

8 responded that they avoided the archaeological remains by redesigning the excavation route.
8 responded that they accommodated the on-site archaeologist by assisting in the salvage or removal of the archaeological remains.
7 responded that they moved the equipment and worked in another area while others dealt with the archaeological remains.
0 responded that they did not accommodate the archaeological remains and proceeded through the material.
3 responded OTHER

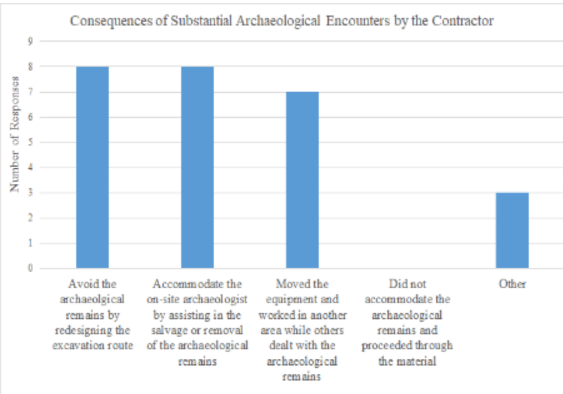


Figure 5 Consequences of substantial archaeological encounters by the contractor.

The responses indicate that several activities were undertaken when encountering archaeological material including redesign, assist the archaeologist and move the equipment to another work location. The OTHER comments are as follows:

- We avoid the historical remains and we redesign the route of the excavation related to the importance of the remains based upon an archaeological committee that decides the significance compared to the construction activities.
- The contractor encounters, documents and avoids the archaeological material and continues the work.
- Archaeological material is documented and re-covered and work above the level of the archaeological material.

6) Concerning contractor encounters with archaeological remains during excavations:

With a total of 100% contractor response to this question:

3 responded that the encounters resulted in delays to construction activities.
5 responded that the encounters resulted in work stoppage to the construction activities.
0 responded that the encounters resulted in damage to the archaeological remains.
8 responded that encounters resulted in adjustment to the construction schedule.
2 responded that the encounters resulted in the contractor claiming additional cost
7 responded that the encounter resulted in the contractor requesting additional time to completion
1 responded that the encounter had no effect at all on the construction operations.
3 responded OTHER

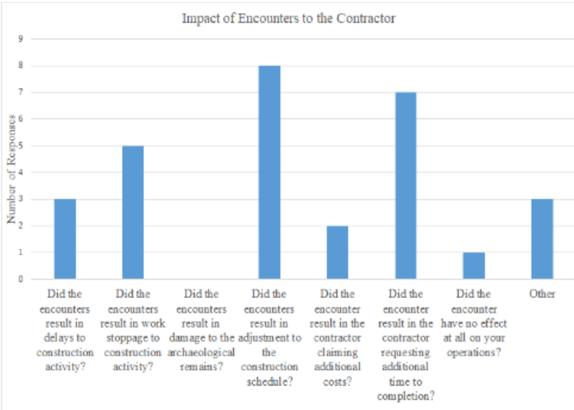


Figure 6 Impact of contractor archaeological encounters.

The response indicates substantial impacts including delays, work stoppage re-scheduling, claims and additional cost. The OTHER comments are as follows:

- The goal behind in requesting more money is to cover the casual labour, equipment and machinery that the owner requests when archaeological material is encountered.
- Request money from the owner relating to workers, material and equipment when encountering archaeological material.
- When the contractor receives complete information, it assists him in completing the project on time.

7) It is assumed that contract language of the agreement specifies what to do when delayed or work is stopped. From your experience, does the contract language usually specify how to obtain reimbursement for claims on delays and/or work stoppage?

With a total of 100% contractor response to this question:

6 responded that the contracts usually specify the procedure to file claims regarding delays or work stoppage.
0 responded that the contracts usually do not allow the contractor to file claims regarding delays or work stoppage.
7 responded that the contractor is usually allowed an extension of time but no monetary reimbursement.
1 responded that the contractor is usually allowed an extension of time and monetary reimbursement.
7 responded that the contractor was allowed to place a contingency as part of the bid to cover delays or work stoppage.
4 responded that the contractor increases unit cost in the bid estimate to cover unexpected delays or work stoppage because contingencies are not allowed as a line item in the estimate.
0 responded OTHER.

Figure (7) shows the response in bar graph form.

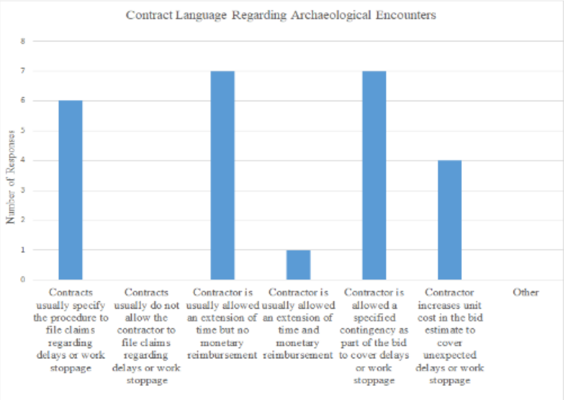


Figure 7 Contract language clauses

The responses indicate that there are generally procedures to follow for claims with a large number stating that extensions of time are usually granted but with no monetary reimbursement. Contingencies seem to cover the monetary reimbursement for claims while some raise unit or line item prices to cover the risk of delays.

8) Generally, when excavating around historic sites, is there an archaeologist assigned to the site?

With a total of 100% contractor response to this question:

10 responded Yes
0 responded No

Figure (8) shows the response in bar graph form.

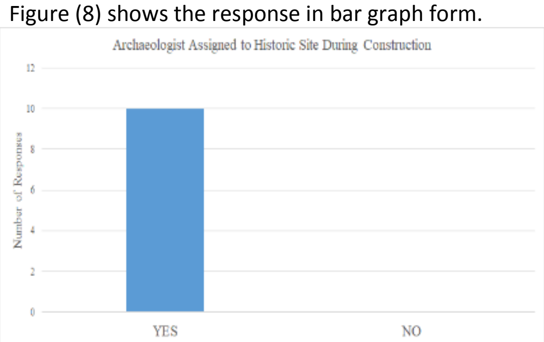


Figure 8 Archaeologists assigned to historic sites during construction activities

All responses indicated that there is always an archaeologist on site when excavating on historic sites.

9) Concerning working with archaeologists on site; were there any conflicts between the archaeologist and the contractor or engineer?

With a total of 90% contractor response to this question:

6 responded YES
2 responded NO
0 responded that they have not worked with archaeologists on site
1 responded OTHER.

Figure (9) shows the response in bar graph form.

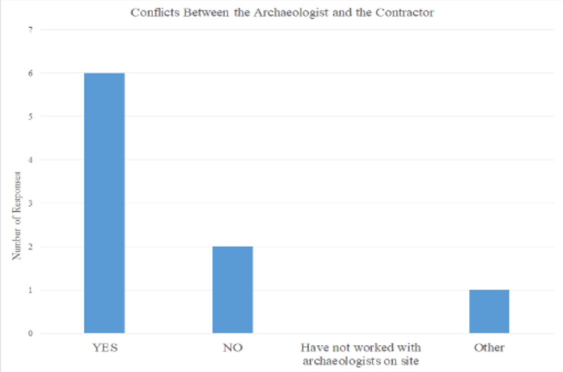


Figure 9 On site conflicts between the archaeologist and the contractor

The responses clearly show that conflicts exist between the archaeologist and contractor or engineer. The OTHER comment is as follows:

- Contractor discusses with the archaeologist on how much time is needed for salvage so the contractor and work productively in another area.

10) If the answer to Question 9 was "YES", how were the disputes resolved?

With a total of 100% contractor response to this question:

0 responded that the conflicts were not resolved
2 responded that some conflicts were resolved
2 responded that the conflicts were resolved directly between the archaeologist and the contractor or engineer.
5 responded that the conflicts were resolved through a 3rd party.
1 responded OTHER.

Figure (10) shows the response in bar graph form.

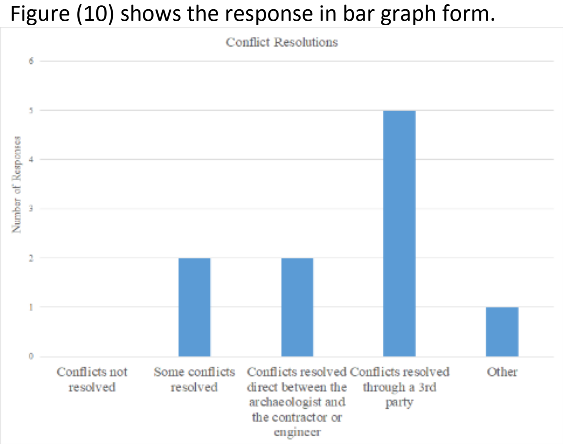


Figure 10 Disputes Resolved

The response shows that most disputes and conflicts between the archaeologist and the contractor or engineer were resolved. The OTHER comment is as follows:

- Full information results in less problems with the archaeologist because they share the information.

11) Regarding future coordination between the archaeologist and the contractor, would the contractor prefer:

With a total of 100% contractor response to this question:

9 responded that they would want to obtain data from geophysical site surveys and subsurface mapping prior to estimating or starting a project.
7 responded that they would prefer to coordinate with the archaeologist in the early or preconstruction phase of a project.
8 responded that they would prefer to participate in a set of preconstruction meetings to develop procedures regarding archaeological remains that can be part of any corrective action implemented prior to construction activities.
1 responded OTHER

Figure (11) shows the response in bar graph form.

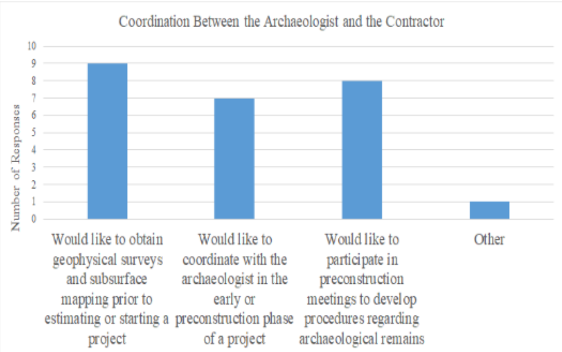


Figure 11 Coordination between archaeologists the contractor

The responses show that it would be desirable for the contractor to have geophysical data prior to construction activity as well as coordinating and meeting with archaeologists to develop procedures. The OTHER comment is as follows:

- Request adding the geophysics survey to the contractor's responsibility.

12) Do you have any other ideas on how to better coordinate the effort between the archaeologist and the contractor?

A total of 90% contractor responded to this question. The following is the responses:

- Hopefully there are fast decisions in new issues that happens on site to reduce the cost and time for the contractor. The fast decision should be from the owner.
- The contractor prefers more flexibility in the specifications and unit pricing in that some of the line items do not represent existing conditions and that activity outside of the line items should be allowed.
- Suggests adding a formal item in the specifications to meet each month to solve site problems between the owner and contractor with all specialists and stakeholders including engineering, archaeologists, conservators and financial to find quick solutions so the work will not be affected by work stoppage or delays.
- 1) Need fast decisions for any new issues or new discoveries to keep the project financially stable and also to keep monthly contractor payments stable for the contractor and to allow the project to be completed in a timely manner.
- 2) Request periodic meeting from all parties to solve problems rather than reactive meetings.
- Request item in the unit pricing and specification added for archaeological work.
- 1) Request adding geophysics to the contractor's contract to save time.
- 2) Request reimbursement for delays from the owner more than additional time.
- Request in the contract documents that the contractor hires the professional archaeologist for better understanding of archaeology and to represent the contractor.
- Request to add contingency to cover delays and work stoppage.
- Request full archaeological study and geophysics survey specifically highlighting specific areas that need preconstruction activities prior to construction.

Important Points of the Survey

One of the most important points is that the survey basically matches the data from the literature review, interviews and case study. It completes the data. It is clear also that the contractors who participated in the survey took the time to add their experience in short notes even though the survey was basically a multiple choice survey. One of the most striking thing of the survey that was revealed is that the total survey population underlined the fact that encounters with archaeological material is substantial and that this cost the contractors time and money. It was also revealed that often the contractor would be allowed an extension of time but not reimbursement for delays or extra work associated with assisting the archaeologist in unexpected finds. Conflicts between the contractor and archaeologist was frequent and if solved it was through a third party such as by the construction manager or owner. Finally, the survey made it quite clear that 90% of the respondents would prefer to have the geophysical site surveys and subsurface mapping prior to estimating or starting a project and that coordination and meetings with the archaeologist and others would be highly desirable. The final question of the survey asked the respondents to add their thoughts of how to improve the participation between the archaeologist and the contractor. 90% of the survey population added their opinions to this question. The answers varied from more timely decision making, improving specifications and bid forms, avoiding delays, more coordination meetings, reimbursements and contingencies and obtaining a complete archaeological and geophysical survey of the site prior to starting the project. These topics cover many of the same themes covered in the literature review.

Discussion

A planning tool to address these issues must be a proven instrument in solving potential risks. A method used mainly in the manufacturing sector is Failure Mode Effect Analysis (FMEA). According Carlson **[4]**, FMEA is a method designed to:

- Identify and fully understand potential failure modes and their causes, and the effects of failure on the system or end users, for a given product or process.
- Assess the risk associated with the identified failure modes, effects, and causes, and prioritize issues for corrective action.
- Identify and carry out corrective actions to address the most serious concerns.

A FMEA is an engineering analysis done by a cross-functional team of subject matter experts that thoroughly analyzes product designs or manufacturing processes early in the product development process. Its objective is finding and correcting weaknesses before the product gets into the hands of the customer. A FMEA should be the guide to the development of a complete set of actions that will reduce risk associated with the system, subsystem, and component or manufacturing/assembly process to an acceptable level. A defined by Carbone and Tippett **[5]**, Failure mode and effects analysis (FMEA) has long been used as a planning tool during the development of processes, products, and services. In developing the FMEA, the team identifies failure modes and actions that can reduce or eliminate the potential failure from occurring. Input is solicited from a broad group of experts across design, test, quality, product line, marketing, manufacturing, and the customer to ensure that potential failure modes are identified. The FMEA is then used during deployment of the product or service for troubleshooting and corrective action.

Utilizing the FMEA for analysis of construction risk associated with archaeological encounters, the procedure must be adjusted to fit current Ministry of Tourism and Antiquities practices. This was achieved by adjusting and mixing the FMEA with the U.S. military criticality matrix. The combination resulted in a Production-Preservation Criticality FMEA (PPCFMEA).

PPCFMEA

The PPCFMEA using the Revised Criticality Matrix should be used as a powerful preconstruction planning tool. Using the current ministry practices, a thorough geophysical mapping of the site utilizing several geophysical methods including borings, test pits and other methods could be performed and the excavation areas could be divided into sections as was executed in the example below on the case study of the Kom Ombo Temple project. With a desk-based assessment and the geophysical information, a multi-diversified group would use the PPCFMEA worksheet on each section with the Criticality Matrix to highlight critical anomalies that would need additional action. Since test pits are currently used by the ministry, the subsurface map could assist the group of experts utilizing the PPCFMEA worksheet to determine the critical areas of anomalies where these test pits (or other forms of archaeological investigation) should be designated and perform salvage operations prior to construction operations if necessary to reduce the contractor work stoppage and improve the production factor and reduce the project duration. The authors of a desk-based assessment employed in the case study of Kom Ombo Temple, used pipe runs as one of their identified areas. Fictitious cardinal point and station designations were added for possible significant anomalies as shown in Figure 12 for the purpose of PPCFMEA worksheet explanation. The system can use zones or any other area designations as long as anomaly points can be located. An example of a PPCFMEA worksheet is shown in Figure 13 using the Kom Ombo project desk-based assessment.

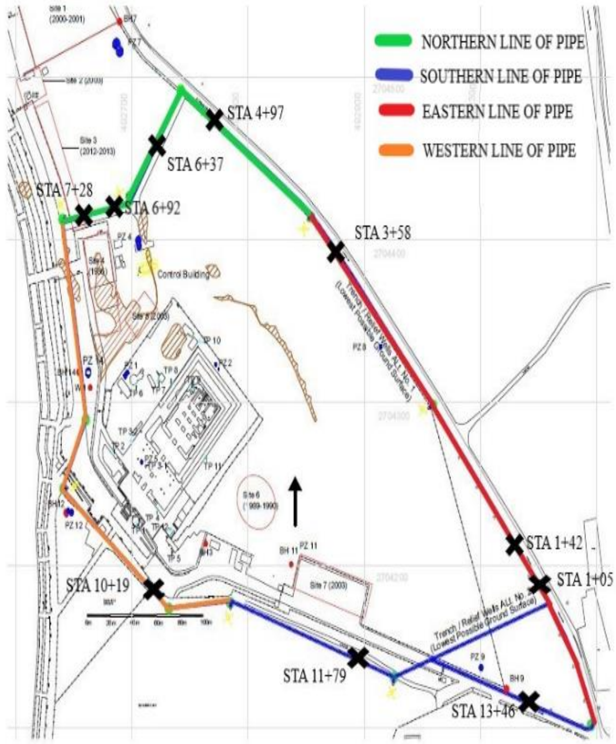


Figure 12 Proposed groundwater collection pipes, manholes and relief wells. Kom Ombo Temple Project. Drawing showing fictitious pipe line identities and stations for anomaly locations. Map source: Sadarangani, et. al. [6]

 DOI: 10.21608/jpme.2020.47899.1055

PPCFMEA WORKSHEET

Core Team:
Design Engineer
Ministry of Tourism and Antiquities
Contractor
Archaeologist
Geophysical Engineer — Surveyor — Historian
Egyptologist — Chief Accountant — Project Manager
Scheduler — Geologist — Superintendent

Page 1 of 1
Prepared by: John Shearman
Date: January 12, 2015
Modified: March 25, 2015

Process Function Description	Potential Failure Mode	Potential Failure Effect	Severity Rating (1-4)	Potential Failure Cause	Occurrence Rating (1-5)	Preventative Action	Critically Matrix	Recommended Actions	Responsible and Deadline	Action Taken & Completion Date
Eastern Line of Pipe	Construction Delay	Additional Cost and Time	1	Unanticipated Archaeological Finds	3	Test pits for anomaly Station 1+05	Critical Risk	Test Pit. Salvage Archaeology if required	Design Engineer February 24, 2015	Salvaged Inscribed Blocks February 12, 2015
Eastern Line of Pipe	Construction Delay	Additional Cost and Time	1	Unanticipated Archaeological Finds	3	Test pits for anomaly Station 1+42	Critical Risk	Test Pit. Salvage Archaeology if required	Design Engineer February 24, 2015	Salvaged Statue Fragments February 16, 2015
Eastern Line of Pipe	Construction Delay	Additional Cost and Time	1	Unanticipated Archaeological Finds	3	Test pits for anomaly Station 3+58	Critical Risk	Test Pit. Salvage Archaeology if required	Design Engineer February 24, 2015	Salvaged Inscribed Blocks February 18, 2015
Northern Line of Pipe	Construction Delay	Additional Cost and Time	1	Unanticipated Finds	2	Test pits for anomaly Station 6+37	Critical Risk	Test Pit. Salvage Archaeology if required	Design Engineer March 8, 2015	Salvaged Inscribed Blocks February 20, 2015
Northern Line of Pipe	Construction Delay	Additional Cost and Time	1	Unanticipated Finds	2	Test pits for anomaly Station 6+92	Critical Risk	Test Pit. Salvage Archaeology if required	Design Engineer March 8, 2015	Salvaged Uninscribed Block February 28, 2015
Northern Line of Pipe	Construction Delay	Additional Cost and Time	1	Unanticipated Finds	2	Test pits for anomaly Station 7+28	Critical Risk	Test Pit. Salvage Archaeology if required	Design Engineer February March 8, 2015	Salvaged Uninscribed Block February 30, 2015
Western Line of Pipe	Construction Delay	Additional Cost and Time	3	Unanticipated Finds	2	Re-route pipe run to avoid anomaly Station 10+19	High Risk	Re-route pipe run to route with no major anomalies	Design Engineer March 20, 2015	No major anomalies or work stoppage
Southern Line of Pipe	Construction Delay	Additional Cost and Time	3	Unanticipated Finds	2	Test pits for anomaly Station 11+79	High Risk	Test Pit. Salvage Archaeology if required	Design Engineer March 20, 2015	Mud Brick Walls. Preservation by Record
Southern Line of Pipe	Construction Delay	Additional Cost and Time	3	Unanticipated Finds	3	Test pits for anomaly Station 13+46	Medium Risk	Test Pit. Salvage Archaeology if required	Design Engineer March 20, 2015	Non-archaeological material
Discharge Force Main	Construction Delay	Additional Cost and Time	3	Unanticipated Finds	4	Archaeologist Observer	Low Risk	None	Archaeologist Report	Recorded Small Finds No Construction Impact

Severity	Rating	Probability of Occurrence	Rating	Percent Occurrence
Critical	1	Frequent	1	≥ 100%
High	2	Probable	2	50% to 99%
Medium	3	Occasional	3	10% to 49%
Low	4	Remote	4	1% to 9%
		Improbable	5	< 1%

Figure 13 PPCFMEA Worksheet example utilizing FMEA basics as a risk assessment tool for preconstruction planning on improving preservation of archaeological material and contractor production.

Conclusion

We have obtained information from contractors that are registered to excavate on historic sites and have shown that utilizing a modified FMEA planning model for risk reduction of unexpected encounters with archaeological material can improve the contractor's production as well as reduce damage to archaeological material. This planning method places individual professional knowledge in a group setting to produce preconstruction actions to reduce risk. This is a simple planning tool that can be used in current planning procedures. For the future, since the evolution of geophysical methods are improving as time moves on, we should eventually expect future geophysical analysis to connect attributes of subsurface anomalies and artificial intelligence to reveal a more precise reading of the type and size of the object in a geophysical survey. This would reduce the risk further and allow the contractor to proceed with excavations unimpeded as well as provide the necessary information for the archaeologist to decide on the best approach to preservation in the preconstruction stage. In analyzing the data, the following recommendations are suggested:

- A desk-based assessment and other historical data should be generated prior to any design or construction activities.
- A thorough geophysical study of the site should be performed utilizing the correct method for the specific site conditions. This probably entails utilizing several methods to provide a clearer representation of subsurface anomalies.
- A qualified team leader should lead in the assessment.
- A qualified team of multi-disciplined professionals should be employed to meet for risk assessment using the desk-based assessment, geophysical survey and any other pertinent data.
- Utilize a PPCFMEA for preconstruction planning to reduce the risk of unanticipated archaeological encounters and contractor production loss.
- Perform the current ministry procedure of test pits but use the geophysical information along with the expert opinions to designate where the test pits will be placed.
- Perform any other preconstruction activity that will benefit preservation of archaeological material and maintain contractor production prior to construction.
- Document the results for historical information and for possible use of the data on similar anomalies in the future.
- Modify preconstruction planning as needed.

As stated by Lambertucci, [7] while on the one hand it is clear that there is no lack of engineering and technical capabilities as well as of cutting-edge expertise in survey and archaeological methodology, on the other hand there is still no real integration of the worlds of engineering, construction and heritage conservation, which continue to consider each other as a mutual obstacle. However, we have shown that with added focus on preconstruction planning, the gap between the professions of construction and archaeology can be narrowed without a major change in current practices.

Finally, geophysical surveys need to be conducted as a standard part of preconstruction activity to narrow the issues between the contractor and the archaeologist. It is the common denominator between them. Geophysical engineers must also become more involved in the preconstruction planning. This is why focus on education in geophysics is so very important but it needs to be expanded to further to cover social aspects of team planning. To show the importance of geophysics, a recent article by Hoare **[8]** has quoted noted Egyptologist Dr. Chris Naunton that archaeologists look to move away from traditional excavating methods to ground-penetrating radar (GPR) scans and satellite imagery that allow archaeologists to search larger areas. Dr. Naunton goes on to say that much more ground can be covered with non-invasive techniques such as ground-penetrating radar, magnetometry, electrical-resistivity tomography (ERT), and other methods, that allows a much more productive subsurface exploration. Other common geophysical methods that could be mentioned are gravimetry and electrical conductivity. It is quite clear that through the research

 DOI: 10.21608/jpme.2020.47899.1055

conducted for this dissertation, and the fact of continued and evolving improvements in geophysical techniques, that geophysical surveys are essential for any site with the potential for subsurface archaeological material.

Funding sources

This research received no external funding.

Conflicts of interest

There are no conflicts to declare.

Bibliography

[1] P. Dell'Aversana, B. Ciurlo, and S. Colombo, Integrated Geophysics and Machine Learning for Risk Mitigation in Exploration Geosciences, (2018), 80th EAGE Conference & Exhibition 201811-14 June 2018, Copenhagen, DenmarkP

[2] V. Lapenna, Resilient and sustainable cities of tomorrow: the role of applied geophysics, Bollettino di Geofisica Teorica ed Applicata. 58 (4) (2017). p 237-251.

[3] C. Gomez, F. Lavigne, D. Sri Hadmoko, and P. Wassmer, Insights into lahar deposition processes in the Curah Lengkong (Semeru Volcano, Indonesia) using photogrammetry-based geospatial analysis, near-surface geophysics and CFD modelling. Journal of Volcanology and Geothermal Research. 353 (15) (2018). p 102-113.

[4] C.S. Carlson, C.S. (2012). Effective FMEAs : achieving safe, reliable, and economical products and processes using failure mode and effects analysis. John Wiley & Sons, Inc. Hoboken, New Jersey 2012.

[5] T.A. Carbone, and D.D. Tippett, Project risk management using the project risk FMEA. Engineering Management Journal 16(4) (2004). p. 28-35. Taylor & Francis

[6] F. Sadarangani, H. Rekaby, and M.A. El-Khateeb, Desk Based Assessment for the Temple Site of Kom Ombo, Aswan Governorate. Archaeological Assistance to the Groundwater Lowering Projects at Kom El-Shuqafa and Kom Ombo (2015). USAID Grant No. AID-263-G-14-00002. p. 154

[7] F. Lambertucci, Archaeo-mobility. Integrating archaeological heritage with everyday life. Procedia Engineering 165 (2016). p. 104-113.

[8] C. Hoare, Egypt: Two missing ancient cities tipped for discovery as scans bring major breakthrough. Daily Express. September 8, 2020.